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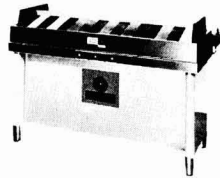


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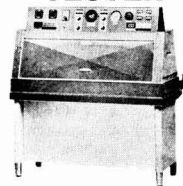
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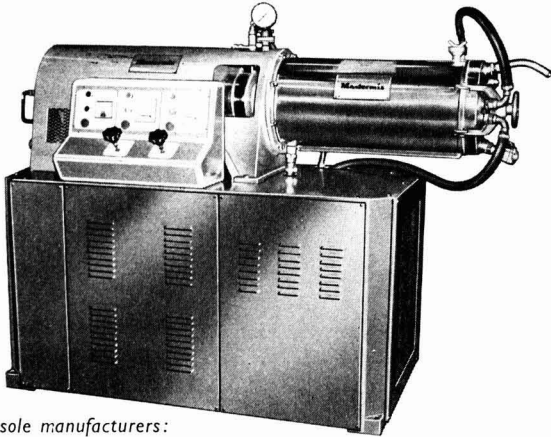
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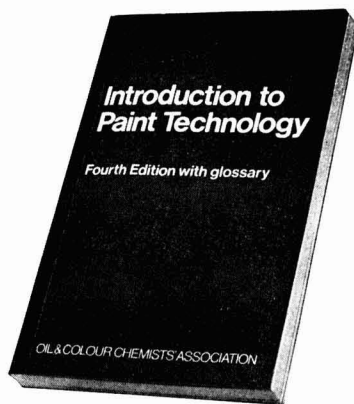
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*Natural resins:* Run gum. Damar resin. Rosin. *Synthetic resins:* Alkyd resins. Manufacture of alkyd vehicles. Phenolic resins. Vinyl resins. Vinyl polymers and copolymers. Solvent soluble vinyl resins. Vinyl chloride dispersions. Styrene containing resins. Polyester resins. Urea resins. Melamine resins. Epoxy resins. Epoxy/pitch media. Polyurethane resins. Acrylic resins. Silicone resins. Coumarone resins. Petroleum resins. Chlorinated rubber. Non-aqueous dispersions.

### 4. Resins as Media for Paints

*Oleo-resinous media:* Alkyd resins as media. Cellulose lacquers and media. Solvents for cellulose lacquers. Manufacture of lacquers. Other solvent-soluble, film-forming high polymers. *Spirit varnishes. Solvent and driers:* solvents, driers. *Some uses of clear finishes:* insulating varnishes, wood finishing by cellulose lacquer. Water-based paints for industrial use.

### 5. Pigments and Extenders

*Dispersion and wetting:* wetting, wetting agents. *Inorganic Pigments:* white pigments: titanium dioxide, antimony oxide, zinc oxide, lithopone, white lead, zinc phosphate. Extenders: barytes, blanc fixe, whiting, precipitated chalk, silica, china clay, bentonite, slate powder, mica, asbestos, talc. Black pigments: carbon blacks, vegetable (lamp) black, bone and drop blacks. Metallic pigments: aluminium, bronze powders, zinc. Oxides of lead: red lead. Natural oxides of iron: red oxides, ochres, siennas, umbers, micaceous oxide of iron. Chemically prepared oxides of iron: yellow hydrated oxides, reds and browns, black oxide. Chrome pigments: lead chromes, zinc chromes, zinc tetroxychromate, strontium chromate. Blue pigments: prussian blue, ultramarine blue. Green pigments: chrome (Brunswick) green. Flooding and floating. Cadmium pigments. Nickel titanate. *Organic pigments:* classification of organic pigments: pigment dyestuffs, toners, lakes. Chemical classification: azo pigments, alkali blue or reflex blue, phthalocyanine pigments, phthalocyanine blues, phthalocyanine greens, vat colours, idanthrone blue, quinacridone pigments, dioxazine pigments. *Luminescent pigments. Testing of pigments:* staining power or tinting strength. Opacity or hiding power. Oil absorption. Water-soluble matter. Lightfastness. Chemical constitution. Purity. Conditions of exposure, measurement of lightfastness. *Pigment hazards:* toxicity, dust.

### 6. Decorative and Structural Paints

*Types of decorative and structural paints. Sealers. Primers:* primers for wood, primers for alkaline and porous surfaces, primers for iron and steel, the mechanism of corrosion, protective mechanism of paint coatings, metal cleaning and pretreatment, blast primers, etch (or wash) primers, zinc-rich primers, zinc silicate primers, zinc phosphate primers, zinc chrome primers, red oxide/zinc chrome primers, red lead/lined oil primers, calcium plumbate primers, primers for galvanised surfaces.

*Undercoats, fillers and stoppers:* stoppers, fillers, undercoats. *Finishes:* alkyd-based finishes. 'Non-drip' or thixotropic finishes, semi-gloss and eggshell finishes, oleoresinous finishes, finishes for structural work, chlorinated rubber finishes, epoxy-resin finishes, epoxy ester finishes, vinyl resin finishes, masonry paints. *Emulsion paints:* nature of emulsions, preparation of polymer emulsions, homopolymers and copolymers, manufacture of emulsion paints, additives, properties and uses of vinyl emulsion paints, acrylic emulsions.

### 7. Industrial Stoving and Cold-curing Finishes, including Marine Finishes

*Industrial finishes.* Table of media used for various purposes, alkyds, alkyd/amino combinations, epoxy and epoxy ester resins, epoxy/pitch combinations epoxy/acrylamide acrylic resins, hydroxylated acrylic/amino resins, hydroxylated acrylic, isocyanate resins, thermoplastic acrylic resins, cellulose finishes, polyurethane finishes, vinyl resin finishes, plastisols and organosol finishes, chlorinated rubber finishes, polyester finishes, non-aqueous dispersion finishes, phenolic resin finishes, water-thinnable finishes, silicone resins, zinc silicate finishes, oil-free polyester finishes. *Stoving Equipment:* convection, infrared radiation, induction, dielectric heating, U.V. curing, electron beam curing. *Paint application:* padding, spraying, airless spraying, electrostatic spraying, hot spray technique, dipping, 'roto-dip' process, flow coating, curtain coating, roller coating, silk screen method, vacuum and pressure impregnation, electro-deposition, powder coatings, strip coating, aerosol spraying.

### 8. Paint Manufacture and Hazards

*Paint milling:* function of paint mills. General principles of paint mills. *Types of mill:* premixers, mixers for pastes, mixers for slurries, paddle mixers, high speed mixers. Dispersing mills. Dispersing mills requiring premixers. Triple roll mills, single roll mills, colloid mills, the sand mill, sealed sand mill, the 'Dyno' mill. Dispersing mills, direct charge: the ball mill, the attritor mill, high speed dispersers, the kady mill. Thinning mixers. Straining. Filling. *Health and fire hazards:* toxicity, pigments, resins, solvents, fire, other fire risks.

### 9. Common Defects of Varnishes and Paints

*Varnishes:* bloom, blushing, pinholing and cissing, silking. *Paints:* blistering, checking, cissing, crawling, dirt collection during drying, flotation, livering, pinholing, pigment sedimentation, rivelling, sagging, curdling and tears, silking, skinning.

### 10. Paint Testing

*Liquid paint:* viscosity, brushability, colour measurement, colour matching, lightfastness, opacity, drying time. *The dried film:* adhesion and elasticity, hardness, gloss, film thickness, wet and dry, fineness of grind, water resistance, humidity resistance, salt spray resistance, durability, weatherometers.

### Glossary—Appendices—Index

### Order form on page xii

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Contents

Vol. 61 No. 8

August 1978

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<i>Council 1978-79 and Committees of Council</i> . . . . .	276
<i>Section Officers and Committees 1978-79</i> . . . . .	278
<i>Transactions and Communications</i>	
<b>Effect of temperature on water absorption and permeation properties of coatings</b> . . . . .	284
<i>M. Yaseen and W. Funke</i>	
<b>Experimental aspects of adhesion testing</b> . . . . .	292
<i>J. Sickfeld</i>	
<b>Recent progress in the physical chemistry of organic pigments with special reference to phthalocyanines</b> . . . . .	299
<i>R. Sappok</i>	
<b>Hygic criteria for exterior paints for the protection of porous building materials</b> . . . . .	309
<i>D. Y. Perera</i>	
<i>Annual Report</i> . . . . .	314
<i>Proceedings of the AGM</i> . . . . .	323
<i>Section Proceedings</i> . . . . .	325
<i>Notes and News</i> . . . . .	325
<i>Information Received</i> . . . . .	328
<i>Register of Members</i> . . . . .	329
<i>Section Programmes for 1978-79</i> . . . . .	332

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# Effect of temperature on water absorption and permeation properties of coatings

By M. Yaseen and W. Funke\*

Regional Research Laboratory, Hyderabad, India

\*Forschungsinstitut für Pigment und Lacke, Stuttgart, Germany

## Summary

Fairly large differences have been observed between water vapour permeation data obtained from dry cup (50-0 per cent RH) tests and wet cup (100-50 per cent RH) tests. On the basis of these observations it has been suggested that it would be preferable to conduct the tests in wet cup conditions for the routine testing of water vapour permeability of organic coatings. Temperature and high humidity have pronounced effects on rates of permeation. In the case of some pigmented coatings, a 10-12 fold increase in rates has been observed when data obtained from tests conducted at 23°C and 50-0 per cent RH, are compared with those at 40°C and 100-50 per cent RH.

## Keywords

### *Types and classes of coatings and allied products*

clear coating  
pigmented coating  
microvoid coating

### *Equipment primarily associated with analysis, measurement or testing*

permeability cup

The relatively greater amount of water being absorbed in the coating in tests conducted at 100-50 per cent RH provides a greater source of vapour for permeating through coatings, in addition to helping the movement of vapours. Hence, the increase in rates of permeation at high humidities is directly proportional to the relative increase in the amount of water absorbed in the coating. Absorption of water in coatings, being independent of the rate of movement of vapour, is found to be less affected by temperature.

### *Properties, characteristics and conditions primarily associated with dried or cured films*

permeability  
water vapour permeability  
water vapour transmission  
water absorption

### *Miscellaneous terms*

free film

## L'influence de température sur les caractéristiques de revêtements à l'égard de l'absorption et de la perméation d'eau

### Résumé

On a observé des différences assez importantes entre les données sur la perméation de vapeur d'eau rendues par les essais effectués à une humidité relative entre 50 et 0% (dry cup), et celles rendues par les essais à 100-50% H.R. (wet cup). En vue de ces observations, on a suggéré qu'il serait préférable d'effectuer les essais de routine de la perméabilité à vapeur d'eau des revêtements organiques sous les conditions d'humidité relative élevée (wet cup). La température et l'humidité élevée exercent les influences notables sur les taux de perméation. Dans le cas de certains revêtements pigmentés on a noté une augmentation de 10 à 12 fois des taux, où l'on compare les données rendues par les essais effectués à 23°C et 50-0% H.R.

auprès de celles obtenues à 40°C et 100-50% H.R.

La quantité d'eau relativement plus grande qui est absorbée par les revêtements au cours des essais à 100-50% H.R. assure une source de vapeur plus importante pour pénétrer dans les revêtements, et elle facilite d'ailleurs le déplacement de la vapeur. Ainsi, l'augmentation des taux de perméation aux humidités élevées est proportionnelle à l'augmentation relative de la quantité d'eau absorbée par le revêtement. Etant donné que l'absorption d'eau par les revêtements est indépendante du déplacement du vapeur, elle se montre moins influencée par la température.

## Der Einfluss von Temperatur auf Wasserabsorptions- und -Durchlässigkeitseigenschaften von Anstrichmitteln

### Zusammenfassung

Ziemlich grosse Unterschiede werden zwischen Wasserdampfdurchlässigkeitswerten bei Trockenbecher- (50-0% rel. Feuchtigkeit) und Nassbecherversuchen (100-50% rel. Feuchtigkeit) beobachtet. Auf Grund dieser Beobachtungen wurde vorgeschlagen, routinemässige Prüfung auf Wasserdurchlässigkeit organischer Beschichtungsmittel vorzugsweise unter Nassbecher-Bedingungen durchzuführen. Temperatur und hohe Feuchtigkeit wirken sich stark auf das Mass der Durchlässigkeit aus. Bei einer Anzahl pigmentierter Anstrichmittel wurde 10-12 fache Erhöhung der Durchlässigkeit beobachtet, wenn die Werte bei Versuchen erhalten wurden, die bei 23°C und 50-0% rel. Feuchtigkeit durchgeführt und mit solchen bei 40°C und 100-50% rel. Feuchtigkeit verglichen die werden.

Die bei Versuchen bei 100-50% rel. Feuchtigkeit verhältnismässig grössere, im Anstrich absorbierte Wassermenge sorgt dafür, dass eine grössere Quelle von Dampf durch den Anstrich dringt, und zusätzlich trägt sie zur Bewegung von Dämpfen bei. Daher ist die Erhöhung von Durchlässigkeitsgraden bei hohen Feuchtigkeiten direkt proportional zu der relativen Erhöhung der in den Anstrichen absorbierten Wassermenge. Es wurde gefunden, dass Absorption von Wasser in solchen Anstrichen, welche vom Grad der Dampfbewegung abhängig sind, weniger von der Temperatur beeinflusst wird.



**Introduction**

Refs. 1-7

Organic coatings absorb moisture, gases and other materials which may be in contact with them. Some of the absorbed materials promote corrosion and damage the substrate, especially under humid and hot weather conditions. Therefore, the corrosion resistance properties of organic coatings depend greatly on the climatic conditions and the level of pollution at the site of exposure. Water in the form of rain or humidity is always in contact with coatings. Hence, the study of water absorption and permeation properties of coatings is essential for assessing their durability and performance.

**Absorption**

In the early stages of absorption, only the surface regions and the imbalanced forces acting there are involved, whilst the chemical potential of the system remains almost unchanged. However, the absorbates do not remain on the surface only; they move to the internal spaces wherever they can be accommodated within the structural matrix of the coating<sup>1</sup>. Absorption of water by organic coatings is generally independent of adsorption forces because the process is found to be reversible, with or without the development of hysteresis<sup>2</sup>.

Water molecules, being strongly hydrogen bonded, are likely to be absorbed in greater numbers and more strongly in coatings having polar groups. No simple correlation is usually observed between the amount of water absorbed and the polar groups present in the coating<sup>3</sup>. This is because absorption is governed by the degree of ordering of the polymer molecules, the accessibility of polar groups to water molecules, and also by relative strengths of intermolecular forces between water and polar groups and water-water interactions<sup>4,5</sup>.

**Permeation**

Absorption of water in the coating ceases when a state of concentration equilibrium is attained with respect to the vapour pressure in the surroundings. Conversely, in permeation there is a continuous movement of absorbed vapour from higher to lower concentration levels. In the case of coatings for exterior use, permeation is considered to be an important property. Because of the high resistance to the permeation of vapours condensed at the coating-substrate interface, some coatings develop blisters and suffer premature failure<sup>6</sup>.

In a steady state of permeation, the concentration gradient of absorbed vapour follows a linear pattern from high to low pressure. The relationships between the processes of diffusion, permeation and absorption can be described by the following steady state equation<sup>7</sup>:

$$P = DS \dots \dots \dots (1)$$

Where *P*, *D* and *S* represent the coefficients of permeation, diffusion and solubility respectively.

**Effect of temperature**

Refs. 8-10

The temperature dependence of rate phenomena, such as permeation and diffusion, over a small change in temperature can be expressed by a Arrhenius type of equation<sup>8</sup>:

$$P = P_o.e^{-Ep/RT} \dots \dots \dots (2)$$

Here, *P<sub>o</sub>* is a pre-exponential factor related to the openness of the structure. *Ep* is the apparent energy of activation for permeation, *R* and *T* are the gas constant and temperature respectively. A similar relationship holds good for the solubility coefficient.

$$S = S_o.e^{-\Delta H_s/RT} \dots \dots \dots (3)$$

The heat of solution  $\Delta H_s$  can also be expressed in terms of molar heat of condensation,  $\Delta H_{con}$  and the heat of mixing  $\Delta H_m$ :

$$\Delta H_s = \Delta H_{con} + \Delta H_m \dots \dots \dots (4)$$

$\Delta H_s$  is usually found to be negative in the case of vapours which condense easily. Therefore, solubility coefficients of organic coatings for such vapours decrease with an increase in temperature<sup>9,10</sup>.

Data presented in this paper illustrates the effect of temperature on the rate of permeation and on the amount of water absorbed in the coating under controlled condition of vapour pressure.

**Experimental**

**Materials**

Details of the compositions and baking of coating materials listed in Table 1 are given in the technical literature supplied by the manufacturers. The clear formulations were pigmented with a single pigment, TiO<sub>2</sub> RN57\* (rutile). Free clear and pigmented films were prepared by a tin amalgamation technique.

**Determination of water vapour permeation**

Refs. 11, 12

The conventional cup method, with some modifications, was used for the determination of water vapour permeation (Fig. 1). Cups filled with either desiccant or with water were closed with a test specimen and placed in a humidity cabinet having 50±1.5 per cent RH at the temperature of the experiment. The test cups were weighed inside the cabinet every 24 hours without disturbing the conditions of temperature and humidity. The determinations were conducted in triplicate.

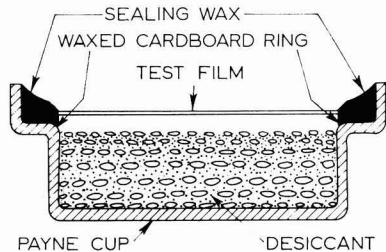


Fig. 1. Schematic diagram of the permeation cup

In the case of cups holding water, vapour permeates continuously from the cup to the cabinet, whilst both the sides of the coating remain in humid condition, i.e., wet cup

\*Trade name

Table 1  
Compositions of coating formulations in parts by weight

Formulations	Solids	wt.	Additives	Solvents	wt.	Temperature and stoving time
1. Lacquer-1 (clear)	<i>Alkydal R 35W*</i> <i>Resydrol WM501</i>	55% 168 63% 37	<i>Tegopren*</i> 10% in water 1.5	Ethylglycol Methoxy butanol n-Propanol	12 12 12	130 C, 30 min.
2. Lacquer-1 (pigmented)	"		"	"		"
3. Lacquer-2 (clear)	<i>Maprenal WL*</i> (Melamine resin) <i>Resydrol VVY 23*</i>	100% 27 70% 89	<i>Tegopren*</i> 10% in water 1.5 <i>Polysolvan 0*</i> 5	Butylglycol Diacetone alcohol Dimethylethanolamine Ethylglycol Water	24 24 6 11 65	150 C, 30 min.
4. Lacquer-2 (pigmented)	"		"	"		"
5. NC-Lacquer (clear)	<i>NC E 510*</i> dried (Nitrocellulose) Castor oil Diocetylphthalate	120 28 72	—	n-Butanol Cyclohexanone MEK MIBK	72 80 160 268	—
6. NC-Lacquer (pigmented)	"		"	"		"
7. Vinyl-Lacquer (clear)	<i>Vinylite VY HH*</i>	160	—	Methylglycolacetate MIBK Toluol	80 280 280	50 C, 24 hours.
8. Vinyl-Lacquer (pigmented)	"		"	"		"
9. Alkyd-melamine (clear)	<i>Alkydal F251*</i> <i>Maprenal NPX*</i> (Melamine resin)	75% 512 55% 216	—	Ethyl glycol Xylol	24 48	140 C, 30 min.
10. Alkyd-melamine (pigmented)	"		"	"		"
11. Lacquer-3 (clear)	<i>Alkyd L52*</i> <i>Cellulose nitrate E510*</i>	50 50	<i>Palatinol 0*</i> 15	Ethyl acetate	—	Air drying
12. Lacquer-3 (microvoids)	"		"	Ethyl acetate + non solvent		"
13. Lacquer-4	<i>Alkynol 1363 W*</i> <i>Resydrol WM501*</i>	63% 150 63% 30	<i>Tegopren*</i> 10% in water 1.5	Dimethylethanolamine n-Propanol Water	6.5 6 50	130 C, 30 min.
14. Electrodeposition paint						

\*Registered trade name.

N.B.: Clear lacquers, formulation Nos. 1, 3, 5, 7 and 9 were pigmented with TiO<sub>2</sub> RN 57\* (rutile).

condition. In the other case, where desiccant is contained in the cup, the surface of the coating facing the desiccant remains dry, i.e., dry cup condition.

### Measurement of water absorption

An apparatus consisting of a quartz spring balance is used for determining the amount of water absorbed in the free film of coating (Fig. 2). A test specimen mounted on a platinum carrier is loaded at the lower end of the quartz spring hanging freely in a glass tube<sup>11</sup>. The part of the tube holding the test sample is kept immersed in a water bath at a constant temperature ( $T \pm 0.05^\circ\text{C}$ ).

Test samples are first subjected to several cycles of water absorption and desorption to remove from the coating traces of solvents and degradation products formed during the drying process<sup>12</sup>. The constant weight of the coating under vacuum finally attained is taken as its initial weight. Water vapour from a source at the desired vapour pressure is admitted to the system. The amount of water absorbed in the coating at an absorption equilibrium at constant temperature is measured by the increase in the length of the spring.

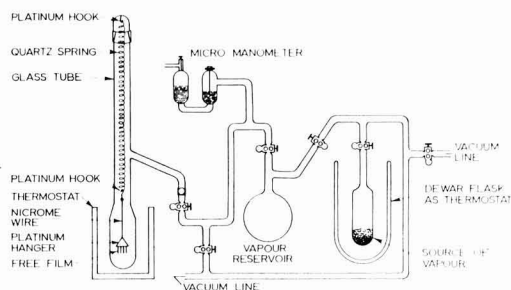


Fig. 2. Schematic diagram of the vapour pressure absorption apparatus

### Results

The permeability cup is filled with either the desiccant or water to a level a little below the brim, so that the space under the coating is fairly small in volume. Under such conditions, in the dry cup test, the vapour permeated through the coating is absorbed by the desiccant effectively and the

pressure of vapour inside the cup is almost negligible; for purposes of calculation it is taken as zero, and in wet cup test, the vapour pressure under the coating has been taken to be 100 per cent RH. As the relative humidity in the cabinet being maintained at  $50 \pm 1.5$  per cent, the vapour pressure differential  $\Delta p$ , across the test specimen is the same in each case, i.e., 50 per cent RH in both dry and wet cup conditions.

The rate of permeation ( $R$ ) is expressed in terms of amount of water vapour ( $g$ ) permeated in one hour ( $h$ ) through a square meter ( $m^2$ ) area of a one mil thick coating:

$$R \text{ (g/h/m}^2\text{/mil)} \dots \dots \dots (5)$$

The permeability coefficient  $P$  is expressed as:

$$P \text{ (g.cm}^{-1} \text{ sec}^{-1}\text{/mm Hg)} \dots \dots \dots (6)$$

The amount of water absorbed in the coating at equilibrium has been expressed in terms of the percentage absorbed by weight. The solubility coefficient is calculated in terms of the amount of water ( $g$ ) absorbed in unit volume ( $cm^3$ ) of the coating under unit vapour pressure differential (mm Hg):

$$S \text{ (g/cm}^3\text{/mm Hg)} \dots \dots \dots (7)$$

**Discussion**

The rates of permeation of water vapour through coatings are found to be greater in the wet cup test than those observed in the dry cup test (Table 3). Here, in both the tests, the

humidity vapour finds the passage less resistant when permeating through coating. In the dry cup test, the surface of coating in contact with vapour at 50 per cent RH absorbs a smaller amount of water than when the surface is in contact with 100 per cent RH (wet cup test). As more water is being absorbed in wet cup test, it acts as a greater source of vapour for permeation, in addition to facilitating the movement of vapour through coating. This explains the high rates of permeation of water vapour observed in the case of wet cup tests, whether the coating is clear or pigmented.

Results reported in Table 3, show that in the dry cup test, permeation rates through pigmented coatings are relatively

Table 3  
Effect of temperature on rate of permeation:  
Dry and wet cup test conditions

Coating formulations	Rate of permeation, g/m <sup>2</sup> /h/mil*					
	Dry cup test, 50 to 0 per cent RH			Wet cup test, 100 to 50 per cent RH		
	23°C	30°C	40°C	23°C	30°C	40°C
1.	0.96	1.71	3.60	1.27	2.76	6.04
2.	0.93	1.59	3.41	2.91	5.34	11.62
3.	4.92	8.26	16.01	6.91	13.49	26.08
4.	3.24	5.48	11.06	6.41	10.96	22.46
5.	2.40	4.03	8.08	3.47	6.38	14.43
6.	2.48	4.28	8.54	3.97	7.51	14.70
7.	1.04	1.58	2.92	1.33	1.94	3.87
8.	0.89	1.29	2.30	1.66	2.96	5.27
9.	1.33	2.48	5.37	2.23	4.30	10.46
10.	1.18	2.17	4.67	1.74	3.80	8.25
11.	1.20	2.43	4.80	1.72	3.55	8.24
12.	13.61	22.00	49.17	20.86	34.02	85.50
13.	2.99	5.48	11.24	3.95	8.49	19.94
14.	0.63	1.11	2.46	1.34	2.72	6.87

\*Thickness of film, 1 mil = 25 μm

lower than those observed in the case of clear coatings of the same binders. But, in the wet cup test, the rates of permeation through pigmented coatings are found to be greater than those of clear coatings. This indicates that in an atmosphere of high humidity, the rate of permeation through a homogeneous system such as a clear coating is affected only by the interaction between water molecules and the polar groups present in the coating; whereas, the rate of permeation through a heterogeneous system, such as a pigmented coating, is affected simultaneously by physical interactions, as, for instance, water-pigment, water-binder, pigment-binder, water-pigment-binder, water-polar groups, etc. The magnitudes of these interactions is greater at high humidity so they are more active in promoting the rate of permeation in wet cup tests.

Usually, it is observed that during outdoor exposure some clear coatings develop blisters on account of having a high resistance to the permeation of water vapour present at the coating-substrate interface. The pigmented coatings containing the same binder perform much better as exterior coatings and do not show any sign of blister formation, even in humid and hot weather, because the vapour at the coating-substrate interface is able to permeate conveniently through the coating during the heat of the day.

driving force, i.e., concentration gradient or vapour pressure differential across the coating is same in magnitude (50 per cent RH), but the conditions in which permeation takes place differ widely. In the wet cup test, vapour permeates through the coating being exposed to 100 and 50 per cent RH. In the dry cup test, the side of the coating facing the desiccant remains almost dry whilst vapour at 50 per cent RH permeates through it.

When a certain amount of water has been absorbed in the coating, it facilitates the further permeation of vapour from high to low concentration; absorbed water makes it easier for polymer segments to move and also reduces the rigidity in the structural matrix of the coating. Therefore, at high

Table 2  
Densities of free films of coatings, determined by ASTM D-1963, 61, using Hubbard pycnometer

Formulations	Density g/cc
1. Clear coating of lacquer 1	1.222
2. Pigmented ,, ,,	1.626
3. Clear coating of lacquer 2	1.152
4. Pigmented ,, ,,	1.532
5. Clear coating of NC-lacquer	1.226
6. Pigmented ,, ,,	1.628
7. Clear coating of Vinyl lacquer	1.232
8. Pigmented ,, ,, ,,	1.675
9. Clear coating of Alkyd-Melamine	1.187
10. Pigmented ,, ,,	1.620
11. Clear coating of lacquer 3	1.275
12. Microvoid ,, ,,	0.719
13. Clear coating of lacquer 4	1.235
14. Coating electrodeposited paint	1.287

### Effect of temperature on permeation

The change in temperature of the surroundings greatly influences the rate of permeation and also the performance of coatings. The tests conducted in dry and wet cup conditions illustrate the effect of temperature on permeation properties of coatings at low and high humidity. Some pigmented coatings exhibit a 10-12 fold increase in the rate of permeation of water vapour when the conditions are changed from 50 per cent RH at 23°C to 100 per cent RH at 40°C (Table 3). But, under similar experimental conditions, the maximum increase in permeation rates observed in the case of clear coatings is only 6 fold. These observations indicate that an increase in temperature and humidity does not affect permeation through clear coatings as much as it does in the case of pigmented ones. On account of such permeability properties, pigmented coatings perform better during exterior exposure. Usually, they do not fail in service by losing adhesion at weak points because the vapour pressure built up at the interface does not exceed the adhesive forces.

The effect of temperature on the permeability coefficient of coatings for water vapour shows a similar pattern to that exhibited by the rates. In the case of permeability coefficients, the pressure of vapours at the temperature of experiment is also allowed for in the calculations. Hence, the change in permeability coefficient with respect to temperature indicates that the effect is due only to temperature and not to vapour pressure. A knowledge of the effect of temperature on rates of permeation is useful when making a choice of binders or paints, according to the weather conditions at the exposure site, whereas the data on permeability coefficient are of academic interests.

The values of the apparent energy of activation for permeation ( $E_p$ ) of water vapour through coatings, are calculated from the slope of the plot of  $\log P$  versus  $1/T$  and are given in columns 5 and 9 of Table 4. In dry cup tests, the  $E_p$ -values of clear and pigmented binders are almost identical in magnitude, whereas in wet cup tests, the  $E_p$ -values for clear coatings are much lower than those for pigmented coatings. These observations indicate that the rates of permeation

through pigmented coatings are largely activated by the increase in temperature and humidity.

### Water absorption

A linear increase in the amount of water absorbed in a coating with increasing relative humidity indicates its inertness with respect to water. The data on absorption of water in these coatings at 23°C and relative humidity ranging from 50 to 98.5 per cent do not exhibit the linear increase with the RH. This is because the affinity of water molecules for polar groups and water sensitive additives present in the coating increases with the RH; therefore, at high humidities the amount of water absorbed in the coating is greater than a linear increase with RH.

The amount of water absorbed in the unpigmented vinyl coating is found to be lowest (Table 5). The relatively greater amount of water absorbed in the pigmented vinyl coating is due to absorption of some water by the pigments and also by the additives used in the formulation. It may also be partly due to physical interactions of pigments with the resin which alter the rigid structure of vinyl coatings.

Table 5  
Effect of relative humidity on water absorption in coatings at 23°C

Coating formulations	Weight per cent water absorbed in the coating				
	50	per cent relative humidity			98.5
		65	80	94.5	
1.	0.71	1.02	1.40	1.87	1.99
2.	.63	1.00	1.51	2.22	2.44
3.	.64	.91	1.27	1.67	1.80
4.	.56	.84	1.20	1.62	1.74
5.	.47	.72	.98	1.28	1.40
6.	.30	.41	.53	.66	.72
7.	.10	.14	.19	.25	.27
8.	.51	.71	.95	1.21	1.30
9.	.51	.76	1.06	1.51	1.63
10.	.39	.56	.77	1.02	1.08
11.	.68	.90	1.14	1.45	1.55
12.	.69	.93	1.19	1.47	1.57
13.	1.18	1.69	2.31	3.02	3.23
14.	.99	1.36	1.77	2.21	2.40

Table 4  
Effect of temperature on permeability coefficient ( $P$ ): Dry and wet cup test conditions

Coating formulations	Dry cup test, 50 to 0 per cent RH				Wet cup test, 100 to 50 per cent RH			
	$P \times 10^{12}$ g/cm/sec/mm Hg			Energy of activation K cal/mole	$P \times 10^{12}$ g/cm/sec/mm Hg			Energy of activation K cal/mole
	23°C	30°C	40°C		23°C	30°C	40°C	
1.	6.30	7.45	9.05	3.92	8.38	12.06	15.17	6.43
2.	6.15	6.95	8.56	3.58	19.17	23.31	29.16	4.54
3.	32.41	36.05	40.20	2.33	45.58	58.88	65.50	3.93
4.	21.37	23.90	27.76	2.84	42.25	47.83	56.37	3.12
5.	15.82	17.60	20.27	2.68	22.86	27.86	36.23	4.99
6.	16.37	18.66	21.43	2.91	26.20	32.76	36.89	3.71
7.	6.87	6.87	7.32	0.69	8.74	8.47	9.71	1.14
8.	5.54	5.61	5.78	0.46	10.92	12.93	13.24	2.08
9.	8.79	10.80	13.47	4.62	14.67	18.77	26.25	6.30
10.	7.76	9.48	11.71	4.46	11.48	16.59	20.71	6.39
11.	7.92	10.62	12.00	4.50	11.35	15.51	20.60	6.30
12.	89.90	97.16	123.00	3.40	137.67	148.67	212.75	4.74
13.	19.71	23.91	28.22	3.91	26.03	37.05	50.06	7.08
14.	4.18	4.84	6.17	4.21	8.85	11.86	17.24	7.22

### Effect of temperature on absorption

In the initial stages of absorption, vapours diffuse into the coating and finally attain a state of absorption equilibrium at constant vapour pressure and temperature. Any increase in temperature does accelerate the rate of diffusion, but it has no significant effect on the amount of vapour absorbed in the coating because absorption concentration equilibrium is not governed by the kinetics of diffusion. The data obtained from experiments conducted at 50 per cent RH and at different temperatures do not show any significant effect of temperature on absorption of water in coatings (Table 6). The small increase in the amount of water absorbed at high temperatures could be due to the activated state of the polymer segments and the physical interactions between water molecules and the polar groups.

Table 6  
Effect of temperature on water absorption in coatings at 50 per cent relative humidity

Coating formulations	Weight per cent of water absorbed in the coating				
	11.7°C	17.2°C	23.0°C	28.3°C	33.9°C
1.	0.66	0.70	0.71	0.73	0.76
2.	.61	.62	.63	.63	.64
3.	.60	.62	.64	.65	.67
4.	.54	.54	.56	.59	.61
5.	.45	.46	.47	.51	.53
6.	.28	.28	.30	.34	.36
7.	.10	.10	.10	.12	.13
8.	.47	.49	.51	.53	.55
9.	.49	.49	.51	.53	.55
10.	.38	.38	.39	.43	.47
11.	.65	.67	.68	.69	.70
12.	.65	.67	.69	.70	.71
13.	1.11	1.12	1.18	1.22	1.27
14.	.96	.97	.99	1.01	1.03

### Solubility coefficient

In the case of an ideal system, the value of solubility coefficient remains constant with a change in concentration; any deviation from its constant value with a change in concentration indicates the non-ideal behaviour of the system. The values of solubility coefficients of individual coatings determined at 23°C and relative humidity ranging from 50 to 98.5 per cent show that the coatings do not behave as ideal systems in the case of water absorption. The difference between solubility coefficient values determined at 50 per cent RH and 98.5 per cent RH indicates the level to which a coating becomes solvated in 98.5 per cent RH (Table 7).

The values of solubility coefficients for coatings decrease with an increase in temperature. This is because the amount of water absorbed in the coating at a constant temperature is proportional to the relative humidity and not to the vapour pressure at that temperature. In the case of experiments conducted at 50 per cent RH and 33.9°C, the pressure of vapour is 3.8 times greater than that in the case of tests made at 50 per cent RH and 11.7°C but the difference in the amounts of water absorbed in a coating at the two temperatures is relatively small (Table 8). Therefore, the value of solubility coefficient expressed in terms of the amount of water absorbed in one cubic centimeter of coating at 1mm Hg pressure of vapour, decreases in the same order as the pressure of vapour at 50 per cent RH increases with the increase in temperature.

Table 7  
Effect of relative humidity on solubility coefficient of coatings at 23°C

Coating formulations	Solubility coefficient $S \times 10^4$ g/cm <sup>3</sup> /mm Hg				
	50	Per cent relative humidity			
		65	80	94.5	98.5
1.	8.35	9.22	10.28	11.63	11.88
2.	9.78	12.03	14.66	18.41	19.37
3.	7.06	7.85	8.76	9.80	10.10
4.	8.25	9.52	11.05	12.63	13.02
5.	5.58	6.53	7.22	7.96	8.38
6.	4.73	4.94	5.18	5.49	5.72
7.	1.22	1.31	1.43	1.55	1.59
8.	8.19	8.80	9.57	10.32	10.60
9.	5.81	6.68	7.56	9.13	9.45
10.	6.13	6.71	7.50	8.37	8.54
11.	8.34	8.49	8.74	9.44	9.65
12.	4.74	4.95	5.15	5.36	5.50
13.	14.07	15.45	17.15	18.99	19.48
14.	12.51	12.86	13.70	14.50	15.08

Table 8  
Effect of temperature on solubility coefficient of coatings at 50 per cent relative humidity

Coating formulations	Solubility coefficient $S \times 10^4$ g/cm <sup>3</sup> /mm Hg				
	11.7°C	17.2°C	23.0°C	28.3°C	33.9°C
1.	15.74	11.57	8.35	6.20	4.66
2.	19.39	13.72	9.78	7.12	5.26
3.	13.47	9.62	7.06	5.21	3.88
4.	15.94	11.30	8.25	6.25	4.74
5.	10.76	7.73	5.58	4.31	3.30
6.	8.84	6.26	4.73	3.84	2.97
7.	2.28	1.67	1.22	1.02	0.79
8.	15.44	11.04	8.19	6.13	4.66
9.	11.20	7.92	5.81	4.38	3.32
10.	11.91	8.41	6.13	4.83	3.82
11.	16.22	11.55	8.34	6.07	4.50
12.	9.12	6.50	4.74	3.47	2.59
13.	26.57	18.79	14.07	10.45	7.69
14.	23.96	16.92	12.51	9.00	6.70

### Absorption and permeation

In water vapour permeation tests, the steady state of permeation is obtained 48 hours after the cups are placed in a cabinet maintained at constant temperature and relative humidity. It also takes about 48 hours for the absorption of water in the coating to reach the state of equilibrium under the controlled condition of vapour pressure and temperature. These observations show that steady state of permeation basically depends on an absorption equilibrium. Hence, permeation, apart from being a rate dependent phenomenon, also depends on the amount of water absorbed in the coating.

In diffusion tests, the rate of diffusion of water vapour in the coating, slows down with time because the driving force, the vapour pressure differential, decreases with the absorption of vapour in the coating and ultimately a state of absorption equilibrium is attained by the system. In initial stages, the rate of diffusion is found to be directly proportional to rate of permeation. For this reason, this relationship is used for determining diffusion coefficients by using the permeation

data obtained from experiments conducted before the steady state is attained. These observations illustrate the interdependence of the processes of diffusion, absorption and permeation.

#### Diffusion coefficient, calculated from known values of P and S

The theoretical values of  $D$  calculated from practically determined values of  $S$  at 50 per cent RH and the values of  $P$  in dry cup tests, indicate the effect of temperature on diffusion coefficients. The values of  $D$  at 23°C, calculated from  $S$  values at 50 and 98.5 per cent RH and  $P$  values from dry and wet cup tests, show the effect of humidity on them (Table 9). The result shows that the diffusion coefficient of the coating is accelerated more than its coefficient of permeation by a rise in temperature. This is because the solubility coefficient of the coating decreases with the increase in temperature, therefore, the coefficient of permeation, being a product of  $D$  and  $S$ , does not show so much increase as is found in the case of diffusion coefficient.

Table 9

Diffusion coefficient  $D$ , calculated from known values of  $P$  and  $S$  at different temperatures and humidities

Coating formulations	Diffusion coefficient $D \times 10^8 \text{ cm}^2/\text{sec}$				
	Values of $P$ from dry cup test and values of $S$ at 50 per cent RH are taken for calculating $D$			Values of $S$ at 50 RH for $P$ values from dry cup and $S$ at 98.5 RH for $P$ in wet cup, at 23°C	
	23°C	30°C	40°C	$D$ , dry cup	$D$ , wet cup
1.	0.75	1.31	2.51	0.75	0.71
2.	.63	1.06	2.20	0.63	0.99
3.	4.59	7.51	13.18	4.59	4.51
4.	2.59	4.27	7.71	2.59	3.25
5.	2.84	4.46	7.51	2.84	2.73
6.	3.46	5.33	8.40	3.46	4.58
7.	5.63	7.63	12.20	5.63	5.50
8.	0.68	1.00	1.60	0.68	1.03
9.	1.51	2.67	5.00	1.51	1.55
10.	1.27	2.16	3.90	1.27	1.34
11.	0.97	1.90	3.38	0.97	1.17
12.	19.13	30.36	53.48	19.13	25.03
13.	1.40	2.52	4.96	1.40	1.34
14.	0.34	0.58	1.28	0.34	0.59

The values of  $D$ , calculated from data at 23°C and relative humidity corresponding to dry and wet cup conditions, are listed in the last two columns of Table 9. The interesting feature of the observations is that the change in humidity does not have much influence on diffusion coefficient in the case of clear coatings. This indicates that the excess amount of water absorbed in the coating facilitates only the vapour permeation through the coating, whilst the process of diffusion remains almost unaffected by the increase in humidity. However, this feature is not observed in the case of pigmented coatings where the theoretically calculated values of  $D$  are found to be greater in the case of wet cup tests than those calculated for dry cup tests. The results suggest that the structural matrix of the binder is influenced greatly by the interaction between pigment and the binder.

#### Microvoid coatings

Ref. 13

The coating formulations listed as 11 and 12 in Table 1 are identical in composition. The only difference is that the clear coating was prepared by using the recommended solvents, and the microvoid coating by using a combination of solvents and non-solvents. Non-solvents trapped form a finely divided non-coherent phase in the coating during its fast drying, leaving microvoids after delayed evaporation. Consequently, the coating appears opaque and white.

In any conventional water immersion tests, the amount of water absorbed in a microvoid coating is found to be increased, because the microvoid is partially filled with water. But in the apparatus used in this study, the microvoids in the coating are filled only with the vapour. The pressure of vapour in microvoids and in the tube holding the coating being the same, the amount of water absorbed in the coating is independent of the vapour filling the microvoids. The amount of water absorbed in clear and in microvoid coatings is almost the same, at all temperatures and relative humidities studied.

The difference between the densities of clear coating (1.275 g/cc) and microvoid coating (0.719 g/cc) illustrates the effect of microvoid formation. When the same microvoid coating is kept immersed in water for a period more than 24 hours, the density is found to increase from 0.72 to 0.95 g/cc, because the voids become partially filled with water. This observation illustrates that in a conventional water absorption test, where the coating is kept immersed in water for 24 hours, the microvoid coating will show fairly large amount of water absorbed in it.

The results show that at 23°C, the permeability coefficient of the microvoid coating (89.90) is more than 11 times greater than that of the clear coating (7.92); but both the coatings are prepared from the same binder. This indicates that the individual rates of permeation through thin layers of microcellular structure control the resultant rate of permeation through coating. The coefficient of permeation of a coating composed of physically attached layers (micro cells or microvoids) can be expressed by an equation suggested by Barrer<sup>13</sup>:

$$l/P = l_1/P_1 + l_2/P_2 + l_3/P_3 + \dots$$

Here,  $P$  and  $l$  are the permeability coefficient and thickness of the composite film (microvoid coating),  $P_1$ ,  $P_2$ ,  $P_3$ , ... and  $l_1$ ,  $l_2$ ,  $l_3$ , ... corresponding to individual layers. This expression explains the enormously high rates of permeation observed in the case of microvoid coatings.

#### Conclusions

The following conclusions can be drawn from the data obtained in the various tests:

- (1) More useful information regarding water permeability properties of organic coatings are obtained from wet cup tests than from dry cup tests.
- (2) Water already absorbed facilitates the permeation of water vapour. In an atmosphere of high relative humidity, the increase in permeability coefficient is directly related to the high percentage of water absorbed in the coating.
- (3) In highly humid and hot weather, pigmented coatings having low resistance to the permeation of water vapour

at the coating-substrate interface are likely to perform better than clear coatings.

(4) The amount of water absorbed in organic coatings is basically proportional to the relative humidity and not to the vapour pressure at the temperature of the experiment.

(5) At a given relative humidity, the amount of water absorbed in the coating is only slightly affected even by a fairly large change in temperature.

(6) The rate dependent coefficients of diffusion and permeation increase with temperature, but the coefficient of solubility, being independent of rate, decreases with an increase in temperature.

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# Experimental aspects of adhesion testing

## A IUPAC study\*

By J. Sickfeld

Bundesanstalt für Materialprüfung (BAM), Unter den Eichen 87, D-1000 Berlin 45

### Summary

In the present study, the influence of a number of test-parameters on the results obtained with adhesion testing by the pull-off method were investigated. The arrangement and diameter of test cylinders, testing-area isolation and coating thickness were studied. Whilst there is no dependence on the separation of the test area or the test cylinder diameters, provided that the test cylinders are geometrically similar, the breaking strength is strongly dependent upon the stress distribution in the test assembly, and decreases

with increasing coating thickness. Furthermore, pull-off test results were compared with torque-wrench results: The breaking strength values were of the same order, with a tendency towards higher values with the wrench method and 15mm studs in the case of cohesive failures. The results of the investigations demonstrate the fact that a true evaluation of test results is possible only by including a statement on the nature of the failure.

### Keywords

*Equipment primarily associated with analysis, measurement or testing*  
adhesion tester

*Properties, characteristics and conditions primarily associated with materials in general*  
adhesion

*Specifications, standards and regulations*

DIN  
ISO  
IUPAC

## Les aspects expérimentaux des méthodes d'essais d'adhérence

### Résumé

Au cours de cette étude on a examiné l'influence qu'exerce une gamme de paramètres sur l'adhérence en termes des résultats rendus par les essais qui comprennent l'arrachement d'un morceau de ruban adhésif. On a étudié à la fois l'influence de la disposition et le diamètre des mandrins, de l'écartement des zones d'essai et de l'épaisseur du film. Pourvu que les mandrins soient géométriquement semblables, la résistance à la rupture ne se dépend pas de la séparation de la zone d'essai ni du diamètre des mandrins, mais elle se dépend fortement de la répartition des forces dans le dispositif

d'essai; et elle diminue à mesure que l'épaisseur du film s'augmente. D'ailleurs on a fait une comparaison des résultats de l'essai d'arrachement auprès de ceux rendus par l'essai utilisant la clé tarée. Les valeurs de la résistance à la rupture étaient du même ordre, avec une tendance, dans le cas des échecs cohésifs, à des valeurs plus élevées où il s'agit de la méthode utilisant la clé tarée et des goujons de 15mm. Les résultats de ces études démontrent que la juste évaluation des résultats n'est possible qu'en ajoutant une constatation de la nature de l'échec.

## Experimentelle Gesichtspunkte bei der Haftfestigkeitsprüfung

### Zusammenfassung

In der vorliegenden Arbeit wird der Einfluß einer Anzahl von Versuchsparametern auf die Ergebnisse bei Haftfestigkeitsprüfungen nach der Abreißmethode untersucht: Versuchsordnung und Prüfstempeldurchmesser, Trennung der Prüffläche vom Untergrund und Anstrichdicke. Ein Einfluß einer Prüffächentrennung bzw. verschiedener Prüfstempeldurchmesser war nicht festzustellen, vorausgesetzt daß die Prüfstempel geometrisch ähnlich waren. Dagegen hingen die Trennfestigkeiten in starkem Maße von der Spannungsverteilung in der Prüfanordnung ab und

nahmen mit steigender Anstrichdicke ab. Außerdem wurden Ergebnisse von Abreißversuchen verglichen mit Ergebnissen von Torsionsverschervungen: Die Trennfestigkeitsergebnisse lagen in der gleichen Größenordnung mit einer Tendenz zu höheren Werten bei der Schermethode mit 15mm-Bolzen im Falle von Kohäsionsbrüchen und zu niedrigeren Werten bei Adhäsionsbrüchen. Durch die Versuche wird auch demonstriert, daß eine sinnvolle Auswertung der Versuchsergebnisse nur unter Berücksichtigung einer Aussage zum Bruchbild möglich ist.

## Introduction

Refs. 1-3

During recent years the pull-off test for assessing the adhesion of coatings has become of increasing interest and importance. The need for a more sophisticated method for testing the adhesion, as one of the most important properties of coatings, has culminated in Germany in the elaboration and edition of DIN 53 232 "Measurement of the adhesion of paint coatings and similar coatings according to the pull-off method", in April 1973. In an earlier publication D. Wapler<sup>1</sup> reported on a number of results concerning the influence of various factors inherent in the instrumentation and of the operational modes on the results of adhesion measurement by pull-off tests. The main aim of this paper was the demonstration of the importance and the influence of stress distribution in

various test assemblies on the test results. Whilst in DIN 53 232 there is a recommendation as to the diameter of the test cylinders, there is no guidance regarding the shape of the cylinders. However, the necessity to observe the influence of stress distribution as a function of the shape of the test cylinders has recently been emphasised by E. Hosp in a cooperative paper on holographic investigation of stress distribution in plane models of test cylinders.<sup>2</sup>

Currently, the knowledge of the influence of stress distribution in various test assemblies on test results is of topical interest, as in the international field the Draft International Standard DIS 4624 "Pull-off test" was on the agenda of the ISO/TC 35/SC 9 meeting in Philadelphia in April 1977. From the text of the draft and the comments of various countries, stating for instance, that:

\*International Union of Pure and Applied Chemistry (IUPAC) Working Party: *Supported polymer films*.

“the testing device is aimed at applying stress *uniformly* to the test area”,

“if desired the face of the cylinder in contact with the coating may be reduced in area, because this might help to ensure that failure occurs at the coating rather than the reverse side of the test piece”,

“results obtained with test cylinders of different diameters are in principle not comparable with each other”,

it was obvious that the problems related to stress distribution in the test assemblies in practice were not taken into account.

In continuation of the investigations just mentioned<sup>1</sup> and with regard to the working project on adhesion of the “Supported polymer films group” within the IUPAC Macromolecular Division, additional work was carried out in order to investigate the influence of some experimental aspects in connection with the ISO 4624, now passed with a number of modifications.

Another objective of the present paper is to point out the merely relative value of *numerical* test results and to demonstrate the necessity to examine the nature of failure with *every* test. Only in the case of adhesive failure between substrate and first coat or between two different coats can the numerical results of pull-off tests be called “adhesive strength” of a particular coat. In all other cases, where cohesive failure is involved, the numerical test results only represent some cohesive strength of the coating under test, and the actual adhesion of the coating on the substrate is higher than that of the test results obtained.

Finally, it was of interest to compare the results obtained by pull-off tests with those obtained by quite a different test method, the torque wrench test, which has achieved some interest with the construction of a new commercially available equipment.<sup>3</sup> The operation of this equipment offers certain advantages compared with the performance of the pull-off test, so it was justifiable to examine whether test results obtained by the different methods are comparable.

**Influence of test assembly**

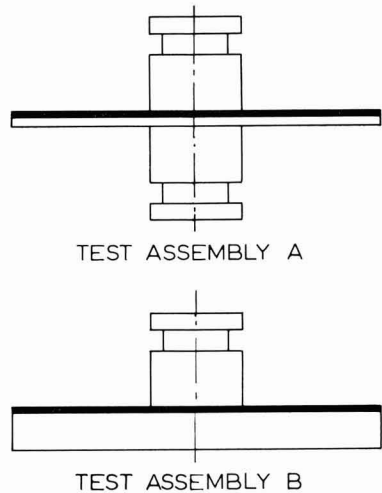
*Refs. 2, 4*

In the German standard DIN 53 232 as well as in the ISO 4624 “Pull-off test”, in principle, two different test assemblies are specified which can be represented schematically by the test assemblies *A* and *B* of Fig. 1:

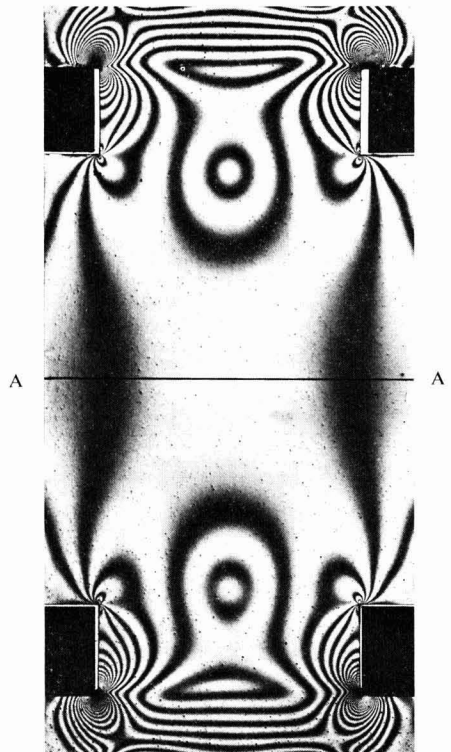
Test assembly *A* (sandwich method) consists of a substrate painted on one or both sides, and test cylinders with a specified diameter are applied coaxially on the test face and the reverse.

Test assembly *B* consists of a rigid substrate coated on one side, and only one test cylinder is applied, to the test face. This test assembly is the only practicable possibility for performing adhesion testing in the field.

In order to demonstrate the differences in stress distribution to be expected between these two different test assemblies during the performance of the tensile tests reference is made to the isopachic and isochromatic patterns published by E. Hosp<sup>2</sup> (Figs. 2 and 3).



**Fig. 1.** Influence of test assembly on the breaking strength results: Schematic representation of the test assemblies used



**Fig. 2.** Isochromatic pattern representing stress distribution in test assembly *A*. Section *A-A* indicates the portion of the coating used for testing. (The pattern is reproduced from reference 2 with kind permission of Curt R. Vincentz Verlag)

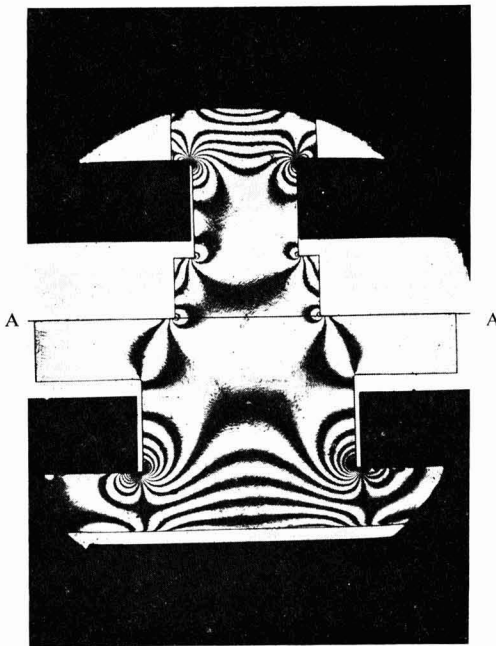


Fig. 3. Isopachic pattern generated by holography, demonstrating the stress distribution according to test assembly *B*. Section *A-A* indicates the portion of the coating used for testing. (The pattern is reproduced from reference 2 with kind permission of Curt R. Vincentz Verlag)

Fig. 2 shows an isochromatic pattern for two equally shaped test cylinders showing smooth stress distribution in the region where the coating layer should be situated (section *A-A*), without stress peaks in this region. For simplification, the models were made of *one* plane piece of epoxy-resin, *i.e.*, neglecting the discontinuity caused by the coating layer.

Fig. 3 gives the isopachic pattern generated by holography, demonstrating the stress distribution for a test assembly

consisting of a small test cylinder applied on a comparatively large cylindrical substrate. This assembly is representative of test assembly *B* as described above. The pattern shows strong stress peaks in the region of the supposed coating layer periphery (section *A-A*).

Taking the very unfavourable stress distribution of test assembly *B* as represented by Fig. 3 into account, a marked influence on test results would be expected. In order to confirm this prediction, a number of comparative pull-off tests were carried out with the following experimental details:

Test assembly *A* with 2 mm steel panels coated on one side, test cylinders with a diameter of 20 mm and length of the cylindrical part of 12 mm, coaxially fixed to the test face and the reverse.

Test assembly *B* with 8 mm steel panels coated on one side and one test cylinder fixed to the test face as described above.

In order to avoid systematic differences in breaking strength caused by surface pretreatment or coating application, the 2 mm and 8 mm steel panels were of the same composition, the pretreatment of the substrates by blasting with corundum, the coating application and especially coating thickness being identical.

The tests were carried out at a temperature of  $23 \pm 2^\circ\text{C}$  and a relative humidity of  $50 \pm 5$  per cent increasing the tensile stress at a rate of 0.47 MPa/s. The results listed in Table 1 represent the mean value of six determinations.

The reduction of breaking strength obtained with test assembly *B* compared with the results obtained with test assembly *A* amounts to 19 per cent as a minimum and 59 per cent as a maximum. As can be seen from Table 1, adhesive failure (*A*, DIN 53 232) was observed only with the coating systems V and VIII. With system V this was induced by an anti-adhesion additive to the coating material. Coating system VIII was a sample of bad adhesion as a consequence of deficient surface pretreatment.

In all tests the reduction of breaking strength with a test assembly causing very unfavourable stress distribution is very distinct. Furthermore, unfavourable stress distribution

Table 1  
Breaking strength as a function of the test assembly

Test No.	Coating system	Thickness $\mu\text{m}$	Breaking strength ( $\text{N}\cdot\text{mm}^{-2}$ ) Test assembly*		Reduction of <i>B</i> compared with <i>A</i>	Nature of failure, DIN 53232**
			<i>A</i>	<i>B</i>		
I	EP-resin, normally cured	365	$28.2 \pm 2.3$	$18.3 \pm 2.6$	35%	<i>C</i>
II	EP-resin, with a 25% excess of hardener	350	$20.3 \pm 1.5$	$13.2 \pm 1.4$	35%	<i>B resp. C</i>
III	EP-resin, with a 50% excess of hardener	350	$21.5 \pm 2.2$	$16.9 \pm 1.4$	21%	<i>C</i>
IV	alkyd resin	60	$21.1 \pm 1$	$13.4 \pm 1.4$	36%	<i>C</i>
V	alkyd resin with 6% anti-adhesion additive	65	$18.3 \pm 2$	$10.7 \pm 1.7$	42%	60% <i>A</i>
VI	anticorrosion primer	30	$25.2 \pm 2.5$	$10.4 \pm 2.9$	59%	<i>C</i>
VII	synthetic resin	45	$12.0 \pm 2.3$	$9.7 \pm 1.2$	19%	<i>B</i>
VIII	EP-resin on galvanized substrate	250	$12.6 \pm 2.3$	$7.7 \pm 3$	39%	<i>A</i>

\*see Fig. 1.

\*\*nature of failure *A*: adhesive failure between substrate and first coat.

*B*: cohesive failure in the first coat just above the substrate, leaving only a very thin film of the coating on the substrate.

*C*: cohesive failure.

in most cases results in a greater relative variation of test results.

At present it cannot be judged how far the reduction of test results obtained with test assembly *B* is also influenced by bending moments. Berger<sup>4</sup> has investigated breaking strength of different coatings as a function of substrate thickness up to 10 mm. From his results it can be seen that there is still some tendency for test results to increase with substrate thickness when this is greater than 8 mm. Nevertheless, it is intended to investigate this influence in somewhat greater detail taking into account the isochromatic patterns.

#### Influence of test cylinder diameter with test assembly A

In the course of the discussion concerning ISO 4624, the opinion was expressed that results obtained with test cylinders of different diameters are not comparable with each other. D. Wapler<sup>1</sup> has shown, however, that this is *not* true for test cylinders of different diameters, but of geometrically similar shape, that is provided that the stress distributions in the region of the coating layer are comparable for test cylinders of the different diameters.

In order to stress these results, a number of additional tests were performed, Table 2 listing the recent results together with those cited in reference 1.

#### Influence of testing-area isolation

The investigation of the influence of cutting the coating round the circumference of the test cylinder through to the substrate is of some interest as there are differences in the respective recommendations in DIN 53 232 and ISO 4624. Whilst DIN 53 232 only demands this paint cutting with a coating thickness exceeding 1 per cent of the cylinder diameter, ISO 4624 does not mention such a limit. Furthermore, this cutting procedure demands a special cutting device, and especially with harder coating materials also a certain amount of skill.

Test results with a number of different coatings are listed in Table 3. Comparing the results with and without cutting the coating through to the substrate it can be seen that there is no influence at all with lower thicknesses of coatings.

Thus, the corresponding recommendations of DIN 53 232 are sensible. This result was also to be expected from the fact that the tensile component of the complex stress is reduced from the centre of the test assembly to the periphery, and so will not be effective outside the adhesive joint of the test cylinder. The force necessary to tear the coating disc of the test assembly from the surrounding coating is apparently insignificant.

Only with the higher coating thickness of the epoxy resin-coatings is the breaking strength somewhat higher without cutting the coating, the fracture indicating a somewhat more distinct cohesive failure than with cutting.

It is possible that scores or cracks are produced at the periphery of such a hard coating by cutting it through to the substrate and that this might be one of the causes for the reduction of cohesive strength of thick coatings, as measured by pull-off test, compared with the results obtained without cutting. Another possibility is the exudation of excessive adhesive beyond the circumference of the test cylinder which enlarges the joint area by about 10 per cent.

#### Influence of coating thickness

*Refs. 1, 3, 5*

The general experience with adhesive joints is that the breaking strength is reduced with increasing thickness of the joint. There are many theories for explaining this phenomenon taking into account continuum mechanics, mechanics of microstructure and atomistic mechanics. There are also suggestions of stronger inherent stresses with increasing thickness.

In the course of the present investigations, it was of interest to see if the general experience with adhesive joints can be transferred to the adhesive or cohesive properties of coatings. This problem is also of interest in view of the normal fluctuation of coating thickness as caused by the method of coating application (brushing, spraying *etc.*).

In order to avoid difficulties with solvent retention, which can severely influence the cohesive strength of coatings, at first two different solventless reactive coating materials applied in a single layer were selected.

Table 2  
Breaking strength as a function of test cylinder diameter\*

Coating system	Thickness μm	Breaking strength (N/mm <sup>2</sup> ) diameter of test cylinder				Nature of failure DIN 53 232	
		10 mm	14 mm	20 mm	28 mm		
multicoat alkyd resin system	100	15.7±1.6	15.0±2.1	16.0±0.4	15.0±0.4	C	
multicoat PUR-system	130	22.2±1.1	22.3±2.0	21.1±1.3	22.0±1.5	C	
alkyd resin with 4% anti-adhesion additive	40	16.6±3.8	16.1±1.3	16.5±0.7	—	A	
alkyd resin with 8% anti-adhesion additive	40	12.3±1.5	15.4±1.4	12.2±1.8	15.2±1.8	A	
blue stoving enamel of traffic signs	80	27.0±1.6	25.6±2.1	25.5±2.3	18.8±2.6	C	
blue stoving enamel with clear coat	95	18.9±1.1	17.4±1.1	15.2±1.5	15.6±0.9	C	
incompatible PVC top-coat on EP-ground coat	180	6.6±0.8	6.8±0.5	6.9±0.6	7.3±0.3	A	
different foils for traffic signs	I	275	1.4±0.2	1.5±0.2	1.7±0.7	1.3±0.1	C
	II	265	2.0±0.2	2.1±0.2	1.8±0.1	1.7±0.2	C
	III	265	3.2±0.4	2.9±0.2	2.9±0.2	2.9±0.2	C
	2×III	2×265	2.1±0.5	2.6±0.1	2.5±0.2	2.5±0.1	C
	solventless PUR-floor coating	110	18.9±2.1	18.5±1.0	18.7±0.9	16.4±0.6	C
„	800	12.4±2.1	11.5±0.9	12.3±1.3	11.8±0.8	C	

\*See reference 1 for the shape of the test cylinders.

Table 3  
Investigation of the influence of cutting the coating through to the substrate (test assembly A\*\*)

Coating system	Thickness $\mu\text{m}$	Breaking strength (N/mm <sup>2</sup> )		Change of B compared with A %	Nature of failure DIN 53232
		(A) with cutting the coating through to the substrate	(B) without		
EP-resin, with a 50% excess of hardener (fuel tank coating)	800	13.0 $\pm$ 1.0	14.7 $\pm$ 1.2	+13	C
"	609	16.7 $\pm$ 0.1	—	—	C
"	454	18.3 $\pm$ 2.3	19.7 $\pm$ 1.6	+ 8	C
"	113	21.5 $\pm$ 1.6	21.2 $\pm$ 1.9	- 1.4	C
PUR-clear coating solventless (floor coating)	890	12.5 $\pm$ 1.3	12.3 $\pm$ 1.3	- 1.6	C
"	480	14.5 $\pm$ 1.2	14.7 $\pm$ 0.5	+ 1.1	C
"	250	18.8 $\pm$ 1.7	18.1 $\pm$ 0.7	- 3.7	C
"	135	20.2 $\pm$ 0.7	18.7 $\pm$ 0.9	- 7.4	C
PUR-system, consisting of 3 layers	119	18.3 $\pm$ 0.6	18.3 $\pm$ 0.6	$\pm$ 0	C
PUR-system, consisting of 2 layers	80	19.0 $\pm$ 1.9	19.1 $\pm$ 1.1	+ 0.5	C
PUR-system, consisting of 1 layer	40	18.3 $\pm$ 3.0	>20*	—	>50%A
alkyd resin with 4% anti-adhesion additive	40	17.6 $\pm$ 2.5	17.2 $\pm$ 1.6	- 2.3	A
alkyd resin with 8% anti-adhesion additive	37	11.9 $\pm$ 2.3	12.2 $\pm$ 1.8	+ 2.5	A
blue stoving enamels of	I } 95	17.0 $\pm$ 3.2	14.9 $\pm$ 1.5	-14	C
traffic signs	II } 90	13.5 $\pm$ 1.6	14.9 $\pm$ 2.0	+ 9	C
	III } 80	20.4 $\pm$ 2.2	20.2 $\pm$ 1.2	- 1	C
Scotchcal foil	I } 260	2.1 $\pm$ 0.4	2.1 $\pm$ 0.2	$\pm$ 0	A
"	II } 260	2.0 $\pm$ 0.1	1.8 $\pm$ 0.1	-10	C
"	III } 260	1.4 $\pm$ 0.2	1.6 $\pm$ 0.3	+14	A

\*separation of test cylinder from the reverse.

\*\*see Fig. 1.

As one-layer epoxy resin coatings with a thickness range between 100 and more than 1000  $\mu\text{m}$  are usually applied for fuel tank coatings, such a material is a good example for investigating the thickness influence. Another system was a polyurethane-coating. The results are listed in Table 4.

Table 4  
Influence of coating thickness on the breaking strength

Coating system	Thickness $\mu\text{m}$	Breaking strength (N/mm <sup>2</sup> )
EP-resin, with a 50% excess of hardener (fuel tank coating)	800	13.0 $\pm$ 1.0
"	609	16.7 $\pm$ 0.1
"	454	18.3 $\pm$ 2.3
"	113	21.5 $\pm$ 1.6
PUR-clear coating, solventless (floor coating)	890	12.5 $\pm$ 1.3
"	480	14.5 $\pm$ 1.2
"	250	18.8 $\pm$ 1.7
"	135	20.2 $\pm$ 0.7
intermediate coat, consisting of 3 layers	360	7.2 $\pm$ 0.8*
same as before, consisting of 2 layers	250	7.7 $\pm$ 0.7*
same as before, consisting of 1 layer	120	9.4 $\pm$ 1.2*
same as before	85	10.6 $\pm$ 1.7*
same as before	55	20.2 $\pm$ 1.6*

\*without cutting the coating through to the substrate

It can be seen that, in agreement with the expectation, breaking strength is significantly reduced with increasing coating thickness. All the tests resulted in cohesive failures. Nevertheless, a closer inspection showed that the surfaces of the fractures appear very different with different coating thickness. With the lowest coating thickness (113  $\mu\text{m}$ ) the fractures occurred in the uppermost parts leaving only a very thin film of the coating on the adhesive joint of the test cylinder. With higher thicknesses the fracture, especially in the neighbourhood of the coating periphery, propagated into deeper parts of the coating. On the face of the test cylinder a thicker residue of the coating was to be seen, concentrated near the cylinder periphery and this residue increased with increasing coating thickness.

A microscopic inspection of the surface of fracture showed that these cohesive failures were caused by inhomogeneities which, of course, are always present in such coatings, caused for example by tiny air bubbles. These discontinuities seem to affect the cohesive strength of the coating increasingly with increasing thickness, possibly due to different stress distributions.

For an ordinary solvent containing coating, an alkyd resin based highly pigmented material was selected which is normally used for intermediate coats. It was applied in one to three layers. In order to avoid increasing solvent retention with increasing thickness, the test specimens were aged at a temperature of 50°C for 2 hours. The results listed in Table 4 again demonstrate the same influence of thickness as with solventless coatings. With the lower coating thicknesses (from 55 to 120  $\mu\text{m}$ ) the fractures occurred as a cohesive failure just above the substrate with a slight amount of the coating re-

maining on the substrate, and at higher thicknesses, the fracture propagated into deeper parts of the coating. An adhesive failure between two layers of the coating was never observed.

### Comparison of pull-off test and torque-wrench test

*Refs. 1, 3, 6*

The stress exerted on the coating during pull-off test (perpendicularly to the coating surface) does not conform to the usual stress on the coating. In practice, the coating is more often affected by peeling or shearing forces. Experiments carried out to compare the adhesion as measured by pull-off test with peeling resistance as measured by a specific peeling test<sup>1</sup> have shown that there is no relation between the results obtained by the two different methods even for coatings with adhesion deficiencies. Another difficulty is that peeling tests are only applicable with certain specific precautions.

In contrast to peeling tests, shearing tests can be carried out easily by means of commercially available equipment.<sup>3</sup> Small cylindrical metal studs, one end ground flat and machined to an annular surface, the other end manufactured with a hexagonal section socket, are glued to the coated surface.

When the adhesive has set, a torque-wrench with a hexagonal section end is fitted on to the cylinder and rotated automatically at a uniform rate until the joint is broken.

The theory for measuring torsional strength is well known in materials testing.<sup>5</sup> If the test is assumed to be a pure shear test, the breaking strength can easily be calculated from the torque to break the joint and the dimensions of the annulus of the metal stud.

From a literature survey concerning this problem only *one* publication could be found describing comparative results obtained by the pull-off test and by a manual torque-wrench test.<sup>6</sup> The latter results are systematically 10 to 20 per cent lower than those obtained with the pull-off test. Epprecht<sup>3</sup> reports only one comparative value obtained with pull-off

test which is in the same order as that obtained by means of an automatically operated torque-wrench test.

The author's results obtained with metal studs of 15 mm and 12 mm outside diameter are listed in Table 5, together with the results of the respective pull-off tests without cutting the coating through to the substrate.

Comparing the results obtained with different diameters of the metal studs it can be stated that there is a more or less pronounced tendency towards lower results with the smaller diameter studs. This tendency is especially true for the one layer EP-resin-coating, possibly because of a stronger sensitivity of this coating to scores and cracks, which are the more harmful the larger the ratio of circumference to joint area. Another possible cause is that at the same angular velocity the shear rate at the circumference of the metal stud is greater with the higher diameter.

It is important to note that the nature of failure observed with the torque-wrench test is essentially the same as that observed with the pull-off test except for the PUR-system, where the cohesive failure in the intermediate coat observed in pull-off test is changed into a mixture of failure in the glue, cohesive failure in the intermediate coat and adhesive failure. Thus the results given by Bullett,<sup>6</sup> who mainly cites adhesive failures, cannot be confirmed.

Comparing the torque-wrench results obtained with the 15 mm studs with those obtained with the pull-off test, it is obvious that the values with the torque wrench are higher in the case of cohesive failure, and lower in the case of adhesive failure, which means that the numerical results obtained with the torque-wrench test conform better to the general expectation.

On the basis of the present results, the torque-wrench test as performed with commercially available equipment, seems to provide a useful method. Nevertheless, the general objections to the usefulness of breaking strength values for the characterisation of the adhesion of coatings remain valid with this shear method, because the results for the coatings with

Table 5

Comparison of breaking strength obtained with pull-off test without cutting the coating through to the substrate with torque-wrench test using metal studs of different diameters.

Coating system	Thickness μm	Breaking strength (N/mm <sup>2</sup> )			Nature of failure DIN 53232
		pull-off test	torque wrench test, diameter		
			15 mm	12 mm	
EP-resin, with a 50% excess of hardener	800	14.7 ± 1.2	19.3 ± 1.6	15.3 ± 1.1	C
"	609	16.7 ± 0.1	19.2 ± 1.2	15.8 ± 1.0	C
"	450	19.7 ± 1.6	20.3 ± 1.9	15.7 ± 0.8	C
"	110	21.2 ± 1.9	24.2 ± 2.5	20.4 ± 2.3	C
PUR-system, consisting of 3 layers	119	18.3 ± 0.6	21.6 ± 1.0	21.7 ± 1.2	C
PUR-system, consisting of 2 layers	80	19.1 ± 1.1	21.1 ± 1.7	23.3 ± 2.1	C
PUR-system, consisting of 1 layer	40	18.3 ± 3.0	23.9 ± 2.1	24.3 ± 1.7	C
alkyd resin with 4% of anti-adhesion additive	40	17.2 ± 1.6	13.9 ± 1.2	13.4 ± 1.5	A
alkyd resin with 8% of anti-adhesion additive	37	12.2 ± 1.8	10.7 ± 0.6	9.5 ± 0.4	A
blue storing enamel of traffic signs	95	14.9 ± 1.5	27.0 ± 1.4	19.3 ± 3.3	C
	90	20.2 ± 0.2	25.1 ± 3.2	20.2 ± 3.9	C
Scotchcal-foil	250	2.1 ± 0.2	1.9 ± 0.4	—	A
incompatible PVC top-coat on EP-ground coat	180	6.5 ± 0.5	4.4 ± 0.5	—	A

anti-adhesion additive, *i.e.*, coatings with a bad adhesion, are relatively high.

### Summary

The results of the present investigations can be summarised as follows:

1. Comparing the influence on the test results of two special test assemblies for pull-off test cited in DIN 53 232 and ISO 4624 the results obtained with a test assembly consisting of only one test cylinder applied on a rigid substrate are about 20 to 60 per cent lower than the values obtained with the better test assembly consisting of two coaxially aligned test cylinders. The reason is a less uniform stress distribution in the first assembly.
2. There is no systematic influence of test cylinder diameter on breaking strength results, provided that the test cylinders are geometrically similar.
3. With thin coatings there is no effect on the test results from cutting the coating through to the substrate. The influence with thick coatings is negligible and possibly due to structural deficiencies introduced by the cutting procedure.
4. With increasing coating thickness the breaking strength decreases and the appearance of the fracture gradually changes. This is probably due to a growing negative influence on the cohesive strength of structural discontinuities in the coating.

5. The comparison of pull-off test results with the torque wrench results does not indicate any strong advantage of one method over the other. The nature of failure observed with the two methods is essentially the same, and the breaking strength values are of the same order, with a tendency towards higher values with the wrench method, and 15 mm studs in the case of cohesive failures, and to lower values in the case of adhesive failures. So the numerical torque-wrench test results give a slightly better distinction in the case of deficient adhesion. The fact remains that a true evaluation of test results is possible only by including a statement on the nature of failure. An adhesive failure can only be expected in the case of deficient adhesion. With good adhesion of a coating to the substrate, the pull-off test as well as the torque-wrench test will always result in cohesive failures, which means that the resulting strength values are lower than the true adhesion of the coating.

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# Recent progress in the physical chemistry of organic pigments with special reference to phthalocyanines

By R. Sappok

BASF AG, 6700 Ludwigshafen, Germany

## Summary

Particle shape as well as size can influence the properties of organic pigments. The quantitative dependency is illustrated for  $\beta$ -copper phthalocyanines as an example. Acicular shaped particles are blue and cleaner in comparison with isometric ones. The surface

character is more hydrophobic for the acicular than for the isometric pigment particles. The anisotropy of these organic solids is the origin of the observed effects.

## Keywords

*Raw materials for coatings*

*prime pigments and dyes*

phthalocyanine pigment

*Properties, characteristics and conditions primarily associated with materials in general*

particle size

particle shape

colour

chroma

hue

crystallinity

*raw materials for coatings and allied products*

tinting strength

*Processes and methods primarily associated with analysis, measurement or testing*

adsorption

## Progrès récent dans le domaine de la chimie-physique des pigments organiques à l'égard particulier des phtalocyanines

### Résumé

La forme autant que la grandeur particulaire sauraient exercer une influence sur les caractéristiques des pigments organiques. A titre exemplaire, on démontre cette dépendance quantitative dans le cas des  $\beta$ -phtalocyanines de cuivre. Les particules aciculaires donnent des couleurs plus bleues et plus pures en comparaison avec

les particules isométriques. La surface est plus hydrophobe dans le cas des pigments aciculaires que des particules isométriques. L'origine des effets observés se trouve dans l'anisotropie de ces solides organiques.

## Neuere Fortschritte in der physikalischen Chemie organischer Pigmente unter besonderer Bezugnahme auf Phthalocyanine

### Zusammenfassung

Die Teilchengröße kann zusätzlich zur Teilchenform die Eigenschaften organischer Pigmente beeinflussen. Der quantitative Zusammenhang wird am Beispiel von  $\beta$ -Kupferphthalocyaninen dargestellt. Stangenförmige Teilchen sind rotstichig- blau und

reiner im Vergleich zu isometrischen Teilchen. Der Oberflächencharakter ist hydrophober für die stangenförmigen als für die isometrischen Teilchen. Die Anisotropie dieser organischen Festkörper ist die Ursache dieser Effekte.

## Introduction

*Refs. 1-7, 10, 11, 13, 15*

The colour properties of pigments and of organic pigments in this context are firstly determined by the chemical structure of the molecules and their respective electronic structures. In technical applications, the particle size of the pigments is a second parameter of almost comparable importance. This has been demonstrated by many authors in the past, especially with respect to their colour properties<sup>1-7</sup>. It is further known that the surface character of the particles influences colloidal behaviour, such as the flocculation and the rheological

properties of dispersions (a review of investigations is given in reference 10). The shape of the pigment particles is a further parameter. This has been anticipated in the past and some results are reported in the literature<sup>11</sup>. More recently the effect was demonstrated for one of the most important organic pigments,  $\beta$ -copper phthalocyanine<sup>10,13,15</sup>. Colour as well as surface properties can be quantitatively correlated with the particle shape of the pigments.

In the first section of this paper the influence of particle shape on colour will be considered. The surface characterisation of organic pigments in general, and the particle shape effect will be discussed in the second section.



## Particle shape and colour properties of $\beta$ -copper phthalocyanine pigments

Refs. 1-7

In the past, the optical and the colour properties of pigmented systems such as lacquers and printing inks have been related to the particle size of the pigments in the actual dispersion<sup>1-7</sup>. The results could be described in terms of scattering theories. The optical constants necessary for these correlations were experimentally determined on pellets from compressed pigment powders. This is strictly valid only in the case of cubic crystals and random distribution of the particles in the pellet.

Most organic pigments, however, should be optically anisotropic because of the low symmetry of crystal structures. It is to be expected that the particle shape of pigments also influences the colour to some extent. The anisotropy of the optical constants of some azo-pigment single crystals was measured long ago by Hannam and Patterson<sup>12</sup>. In these experiments no correlation with the behaviour of the corresponding pigments was attempted. In recent studies, this correlation has been established in case of  $\beta$ -copper phthalocyanine pigments<sup>13</sup>.

## Experimental

Ref. 11

Pigments having primary particles of different shapes were produced by special methods in the laboratory. An illustration of two series of almost isometric and acicular pigments with specific surface areas ranging from 40 to 80 m<sup>2</sup>/g is shown by the electronmicrographs in Figure 1.

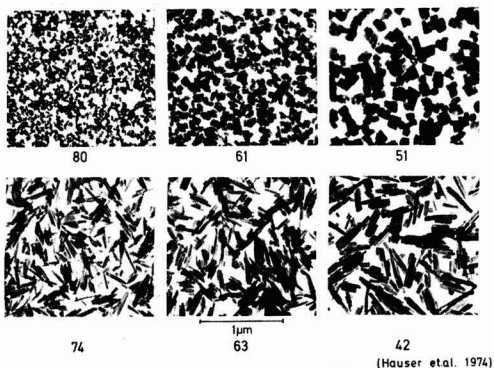


Fig. 1. Electron micrographs of  $\beta$ -copper phthalocyanine ( $\beta$ -CuPc) pigments of isometric and acicular particle shape (figures are BET specific surface areas)

The pigments were dispersed in a linseed oil base on a three roll mill by several passes at 10 and 80 bar respectively and the actual particle sizes which determine the colour of the paint were measured by the Joyce Loebl disc centrifuge as usual in such investigations. In case of the extremely acicular pigments, the length to width ratio was reduced from 10 : 1 to 5 : 1 by this procedure. For further details, especially for the particle size determination of the acicular pigments, reference should be made to reference 11. The characteristic colouristic values—colour strength, hue and chroma—were calculated by the FIAF-method<sup>14</sup> in reduction with titanium dioxide at 1/9 standard depth of shade and were expressed in the units used in the CIE system.

## Results of the colour investigations

Refs. 6, 13

The colour strength expressed as the ratio,  $AV$ , of white to blue pigment is plotted as a function of the particle sizes at the mode of the size distributions (Fig. 2.) There is no significant difference between pigments with isometric and acicular particle shapes.

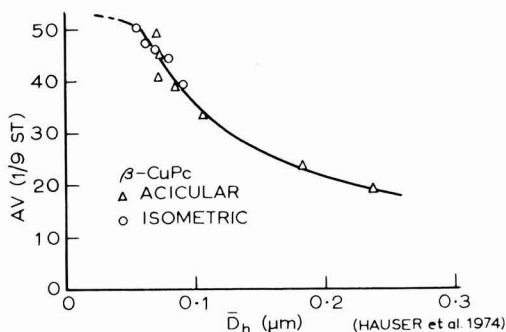


Fig. 2. Colour strength,  $AV$ , as a function of particle size  $\bar{D}_h$ . (at mode of distribution)

Because of the problems of particle size determination in case of acicular pigments<sup>13</sup>, hue,  $T$ , and chroma,  $S$ , of the pigments are expressed as a function of colour strength. This also leads to the results relevant in practical applications. Fig. 3 shows the dependence of the hue values on  $AV$ . At the high values of colour strength (40 to 50), only a particle shape effect is observed, the isometric pigments having a greener shade by 0.2 units (0.02 units can be recognised visually). This difference, therefore, is considerable, bearing in mind that chemical structure as well as modification are identical for both particle shapes. For  $AV$ -values smaller than 40, in the case of acicular particles, the hue is shifted towards the red in accordance with previous findings<sup>6</sup>.

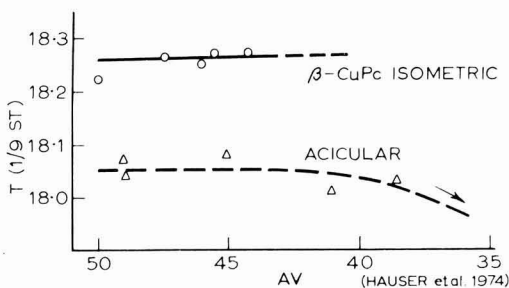


Fig. 3. Hue  $T$  related to colour strength,  $AV$

In Figure 4 the difference in hue of the two  $\beta$ -CuPc pigments is demonstrated in comparison with the other five phases of copper phthalocyanine<sup>15</sup> to illustrate the order of magnitude of the effect. It is, in this particular case, as great as that between the  $\alpha$ - and  $\epsilon$ - or  $\delta$ -types of CuPc.

The chroma of the two particle species is also different. This is illustrated in Figure 5. The chroma of the acicular pigments is 0.1 units higher than that of the isometric pigments. (0.01 to 0.02 units are the lower limits of visual detection). The chroma decreases with decreasing colour strength similarly for both pigment species.

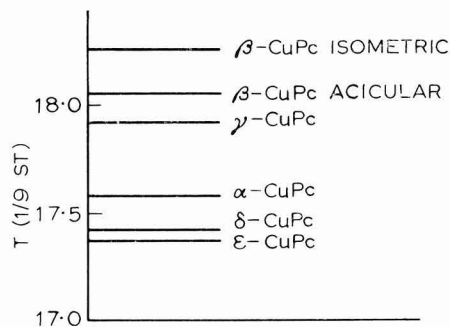


Fig. 4. Hue  $T$  of pigments of the five known modifications of copper phthalocyanine (particle shape and size are comparable)

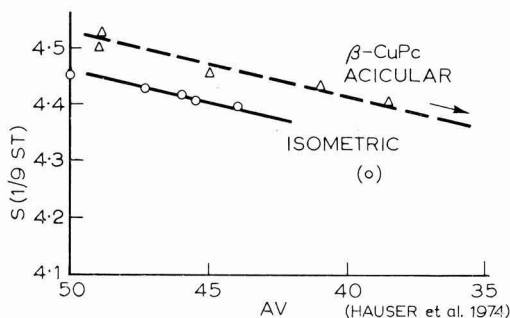


Fig. 5. Chroma  $S$  related to colour strength,  $AV$

Between these two limiting values of hue intermediate, values can be achieved by varying the extent of particle symmetry (Fig. 6). As the results indicate, a small deviation from the isometric form causes quite a change in hue (sample  $A$  to  $B$ , Fig. 6). Beyond a length to width ratio of 3:1 the  $T$  value remains constant (samples  $C$  and  $D$ , Fig. 6).

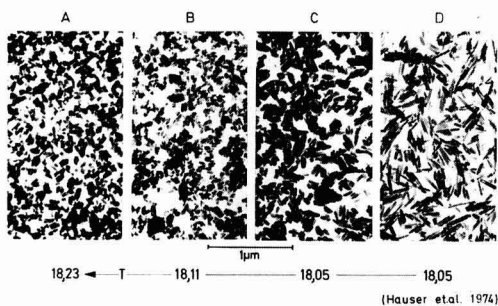


Fig. 6. Particle form and hue  $T$  of copper phthalocyanine pigments of comparable specific surface area

#### Optical anisotropy as the origin of the effect

Refs. 13, 15

The optical anisotropy is normally measurable only on single crystals. These optical properties can be determined by a very simple method on the tiny pigment particles<sup>15</sup>. The

powders for this purpose were dispersed in polyethylene or polyvinylalcohol and films were formed from them after pigmentation. By stretching these films, anisometric particles, such as the acicular pigments, were aligned in the direction of the stretching. In this particular case, this is synonymous with the alignment of the majority of the  $b$ -axes of the particles of the monoclinic  $\beta$ -CuPc. The films were then investigated spectroscopically. The theoretical details of the measurements and especially the interpretation of the results are not given in this paper, but are available in reference 15. Some of the most significant findings only are discussed here.

Spectra in the visible region of a film pigmented with an acicular pigment are shown in Fig. 7. The spectra obtained with unpolarised light at (1) transmissions parallel and (2) perpendicular to the needle axis are plotted in Fig. 7A. The observed frequency shift of (1) in comparison with (2) appears as a shift of hue from reddish to greenish blue if viewed by the human eye.

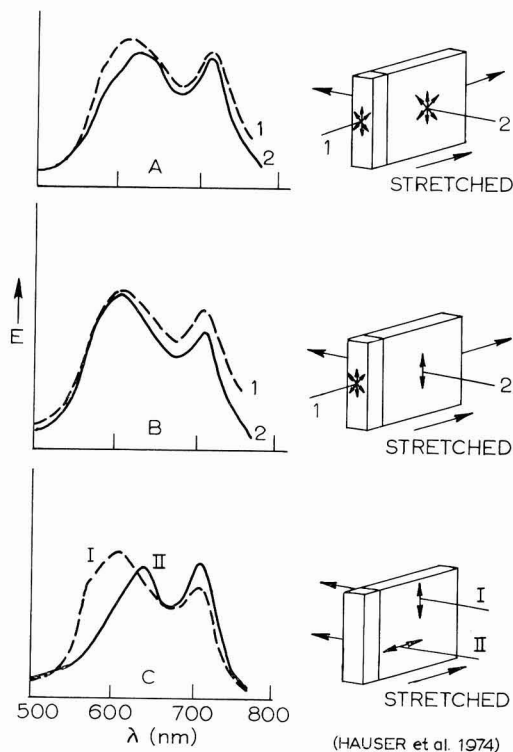


Fig. 7. Experimental determination of dichroism of  $\beta$ -CuPc pigments in stretched films

As shown in Fig. 7B and C, a further simplification of the measurement is achieved by using polarised light. The transmission spectra with light polarised perpendicular to the direction of stretching in Fig. 7B(2) are in agreement with those measured parallel to this direction in Fig. 7B(1) with unpolarised light. The absorption spectra for perpendicular and parallel to the needle axis polarised light most clearly demonstrate the dichroic behaviour of these films. (Fig. 7C I and II). The treatment described here is a simplification of the overall problem. In actual paints the pigment particles are usually distributed randomly and the light due to

manifold scattering by the white pigment is isotropic. Nevertheless, it is the observed optical anisotropy which gives rise to the effect, as can be explained by a simple model<sup>13</sup> (see Fig. 8).

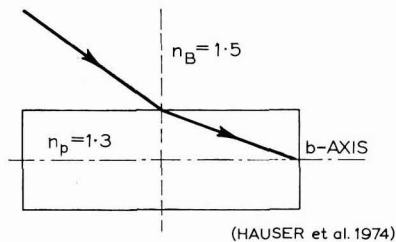


Fig. 8.

In the spectral region from 520 to 580nm the refractive index of  $\beta$ -copper phthalocyanine is lower than that of the carrier material ( $n_p = 1.3$  in comparison to  $n_B = 1.5$ , see Fig. 8). The incident light is, therefore, bent in the direction of the needle axis which is the  $b$ -direction of the  $\beta$ -CuPc lattice. As was proved by the results of studies of the dichroism, the colour of this transmission, parallel to the  $b$ -axis, is reddish blue in comparison to that of the perpendicular transmission. This preferential transmission in case of the acicular pigments is ultimately the explanation for the difference in hue, even in isotropic illumination in the usual application.

Only  $\beta$ -CuPc pigments of all of the five known modifications exhibit this dependence on hue on particle shape. This again is a cause of the optical properties of the particle. In contrast to  $\beta$ -CuPc, there is no frequency shift in the dichroic spectra of the other modifications if acicular pigment particles of comparable size are investigated (Fig. 9). Only intensity changes are observed, which as far as is known at present cannot influence the hue of the pigments in paints, lacquers, etc.<sup>15</sup>.

### Surface chemistry and physics of organic pigments; influence of particle shape

Ref. 10

The surface energy is an inherent property of a dry powder. It becomes evident when an interface with a medium is formed, for instance, when wetting occurs. The study of these interfaces leads to parameters characteristic of the pigment surface itself. Thermodynamic quantities, such as the enthalpy of immersion, heats of adsorption, surface free energies, etc. can be determined. A survey of the pertinent investigations with organic pigments is given in a recently published book entitled "Characterisation of powder surfaces"<sup>10</sup>. Adsorption and heats of immersion studies appear most useful in view of the results published. Therefore, these methods will be discussed in detail in the following section to demonstrate their scope in characterising pigment surfaces. The effect of particle shape on wetting properties is also outlined.

### Results of adsorption studies

Refs. 9, 10, 16, 17

The adsorption from the gas phase of molecules of different polarity acts as molecular probes and offers a straightforward method for the characterisation of the pigment surface. The

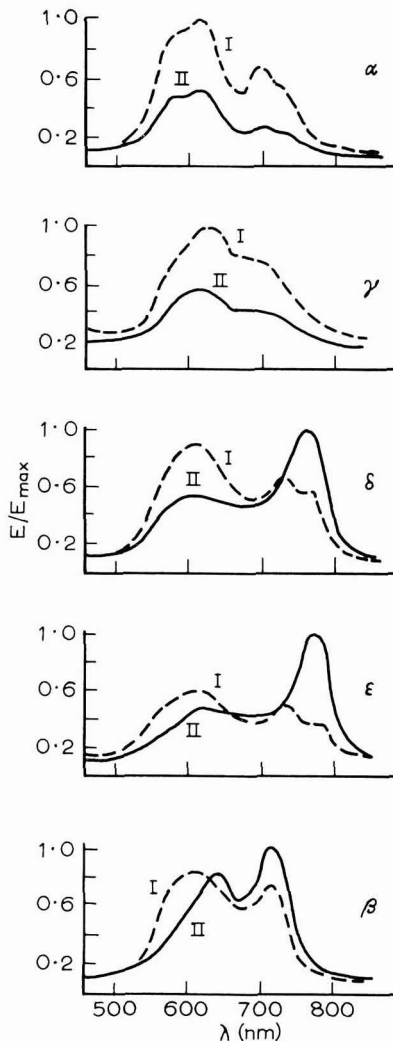
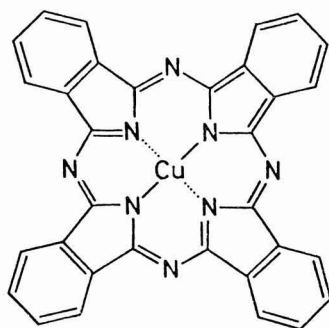


Fig. 9. Dichroic spectra of acicular pigment particles of the five modifications of copper phthalocyanine (Horn et. Honigmann 1974)

evaluation of the isotherms obtained at different temperatures is possible by thermodynamic treatments as used by some Russian authors<sup>16</sup>. Isoteric heats of adsorption, as a function of surface coverage are obtained. Less laborious, but still giving useful information, is the BET evaluation of the isotherms of the different molecules at one temperature. In addition to the  $\beta$ -copper phthalocyanine pigments with acicular and isometric particles, a quinacridone pigment in the  $\gamma$ -form and with isometric particles was also investigated. This pigment, having carbonyl and imino groups in its molecule, serves as a model of a polar organic pigment. The chemical structures of these two model substances are given in Fig. 10. Two important inorganic pigments—titanium dioxide in the rutile form and  $\gamma$ -iron oxide were included in the studies to illustrate the difference of organic and inorganic pigments<sup>9,10</sup>.



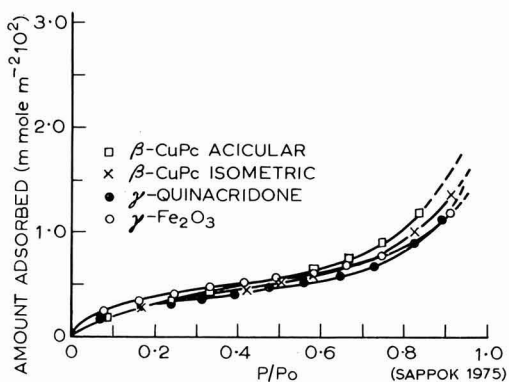
copper phthalocyanine



linear-trans-quinacridone

Fig. 10.

The adsorption isotherms for the nonpolar *n*-hexane on the pigments mentioned is shown in Fig. 11. The various pigments have different specific surface areas as determined by the standard nitrogen-adsorption method. The amount of other gases adsorbed is, therefore, expressed in terms of the amount per square unit.

Fig. 11. Adsorption isotherms of *n*-hexane (20°C)

On this scale almost the same amount of the nonpolar *n*-hexane is adsorbed on very different pigments. This holds good even for the highly polar  $\gamma$ - $\text{Fe}_2\text{O}_3$  to a first approximation.

Two polar substances, methanol and water, behave differently (Figs. 12, 13). At low relative pressures (up to 0.2) where the BET equation is applicable, the amount adsorbed is in the order which would be expected from the

constitution of the pigments. It is further worth mentioning that there is also a marked difference for two CuPc pigments, the acicular adsorbing less than the isometric one.

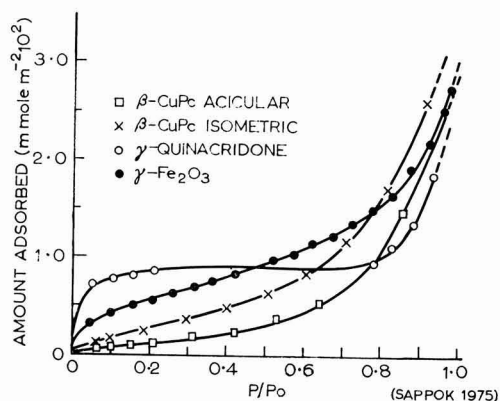


Fig. 12. Adsorption isotherms of methanol (20°C)

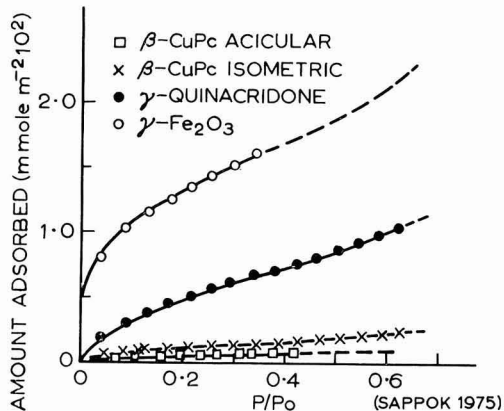


Fig. 13. Adsorption isotherms of water (25°C)

The qualitative results are transformed to numerical values by the BET treatment (Table 1).

Reasonable agreement is found between nitrogen and *n*-hexane adsorption. Using the accepted cross-sectional areas for these molecules, almost the same geometrical surface is accessible. The picture is different with the polar molecules and especially with water.

The apparent monolayer surface coverage depends on the pigment. In case of water it increases from only 3.6 per cent for the most hydrophobic pigment, the acicular  $\beta$ -CuPc, to 70 to 80 per cent for the highly hydrophilic inorganic pigments. The ratio of apparent surface area determined by water to that by nitrogen is the so called *hydrophilicity* as defined by Zettlemoyer<sup>17</sup>. As illustrated, it is a good measure of the overall polarity of a surface, provided the adsorption is only physical in nature. Using the molecular monolayers, and assuming a one to one ratio of adsorbed water molecules to adsorption sites, their number can be calculated. Good agreement between these values from adsorption and those from other direct analytical determinations of hydrophilic centres was found earlier<sup>18</sup>.

Table 1  
Surface characterisation of pigments by adsorption measurements

Pigment	$S_{N_2}$	$S_{n\text{-Hexane}}$	$S_{\text{Methanol}}$	$\frac{S_{\text{Methanol}}}{S_{N_2}} \%$	$S_{H_2O}$	Hydrophilicity $\frac{S_{H_2O}}{S_{N_2}} \%$
$\beta$ -Copper phthalocyanine acicular	70	72	14	20	2.5	3.6
$\beta$ -Copper phthalocyanine isometric	73	70	21	29	4.6	6.3
Polychlorinated copper phthalocyanine	97	114	39	40	5.7	5.9
$\gamma$ -Quinacridone	61	68	48	79	8.2	13
$\gamma$ - $Fe_2O_3$	15	17	13	87	10.1	68
TiO <sub>2</sub> -rutile	5	5.5	4.6	92	4.0	80
Cross-sectional Area (nm <sup>2</sup> )	0.162	0.510	0.220	—	0.105	—
$S$ = specific surface areas (m <sup>2</sup> g <sup>-1</sup> )						

(Sappok, 1976)

The adsorption method is sensitive enough to detect even the differences between the two particle species—acicular and isometric—of the  $\beta$ -CuPc. The effect is again correlated with the crystal structure of CuPc which normally crystallises as needles. There are mainly two types of crystallographic planes, as is easily recognised from the arrangement of the molecules (Fig. 14).

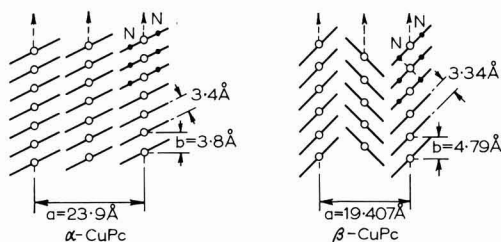


Fig. 14. Crystal structures of copper phthalocyanine

In the planes parallel to the  $b$ -axis, mainly hydrophobic benzene rings are to be expected (prismatic planes), whereas in planes in other directions, the systems of the ring with the copper atom (basal planes) are to be found. The pigment with the isometric particles, therefore, has a larger amount of the latter kind than that with the acicular particles and the higher hydrophilicity, as well as the methanol adsorption, indicate that the hydrophilic centres are more or less identical with these basal planes.

This can be proved by a quantitative evaluation of the electronmicroscope photographs by which the ratio of the two kinds of crystallographic planes is estimated. From the experimental isotherms, the specific isotherms were calculated. The results are shown in Figs. 15 and 16. They confirm the expectations. The adsorption of the polar molecules actually occurs in the basal planes.

#### Results of heat of immersion studies

Refs. 8-10, 17, 19, 20

In principle, similar thermodynamic quantities can be obtained by the calorimetric method as by adsorption or contact angle studies. It is advantageous, however, because experimentally a far wider series of substances can be studied by calorimetry. A determination of the different molecular

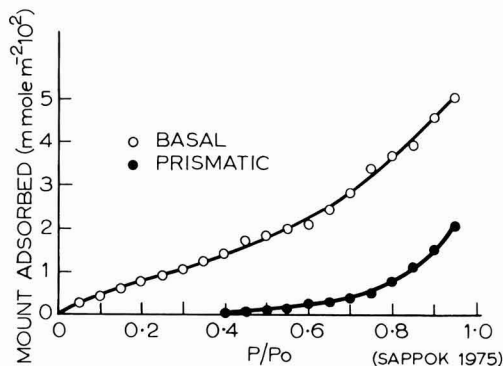


Fig. 15. Adsorption of methanol on different crystallographic planes of  $\beta$ -CuPc pigments (calculated from two isotherms at 20°C)

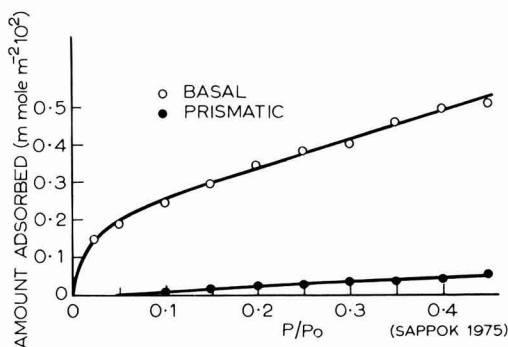


Fig. 16. Adsorption of water on different crystallographic planes of  $\beta$ -CuPc pigments (calculated from two isotherms at 25°C)

interactions, such as Van der Waals, dipole—dipole forces or hydrogen bonding is possible. This is achieved by selection of wetting liquids of known structure. A correlation of the molecular parameters with the enthalpies of immersion finally yields the information on the type and magnitude of the interactions occurring<sup>8,9,10</sup>.

A schematical representation of the wetting process illustrates the possibilities (Fig. 17).

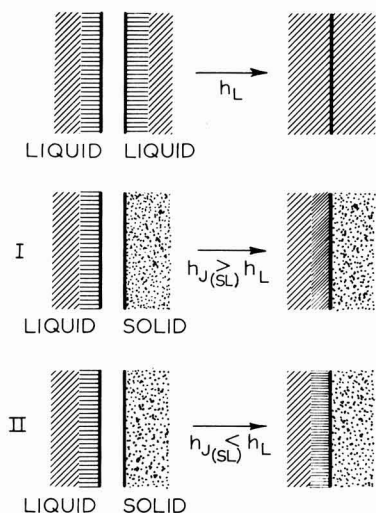


Fig. 17. Wetting process schematically

Wetting, hypothetically, a unit area of a liquid with the same liquid yields as enthalpy  $h_L$ , which is the surface enthalpy of the liquid. If one half of the liquid is substituted by an equivalent surface of a solid, two possibilities exist. The enthalpy of wetting  $h_J(SL)$  is higher than the enthalpy of the wetting liquid  $h_L$ . This occurs in the case of similar or additional interactions between liquid and solid. It can be smaller if the interactions are very different in nature, for instance if hydrogen bonding of the liquid with the solid surface is impossible.

The difference between the enthalpy of immersion and the enthalpy of the wetting liquid, therefore, is a sensitive measure for the solid/liquid interaction. The difference is termed the net enthalpy of adsorption  $NA$  and has been used

successfully in several studies by Zettlemoyer and his collaborators<sup>19</sup>.

As in Zettlemoyer's studies<sup>19</sup>, homologue series of aliphatic hydrocarbons and some benzene compounds were used as the molecular probes. Some representative results for the model organic pigments expressed in  $NA$  values are listed in Table 2. For comparison, results of two important inorganic pigments are given as well.

From these values several conclusions on the types of interaction forces and on the polarity of the pigment surfaces can be drawn. The very hydrophobic  $\beta$ -copper phthalocyanines, especially the acicular form, show small  $NA$  values, mostly around  $35\text{mJm}^{-2}$ , with all the wetting liquids, independent of their polarity. This indicates that the solid/liquid interaction is mainly by van der Waals forces. The fluctuation of the results is partly caused by experimental errors. There are, however, other reasons, such as breakdown of the structure of the liquid during wetting, and entropy effects.

Similar behaviour is exhibited by the laboratory samples of polychlorinated copper phthalocyanine. The situation changes when there are active groups in the molecule, as in the case of  $\gamma$ -quinacridone which possess  $-\text{NH}$  and  $-\text{CO}$  groups on its surface. The small rise in the  $NA$  values observed with hydrocarbons is drastically increased with the polar liquids. The interaction forces in the case of the organic pigments investigated are small in comparison with the two inorganic pigments. Thus, the most hydrophobic pigment, acicular  $\beta$ -copper phthalocyanine, gives roughly one third in the case of the hydrocarbons and almost one tenth in the case of the polar liquids, of the corresponding values given by the inorganic pigments. This picture applies to these organic pigments, which form molecular crystals. The situation would be slightly different when salt-like pigments such as the lithol pigments are investigated, but so far no results are available for such compounds. In principle, the analysis of the data could be extended and the average electrostatic field forces calculated. It might also prove practicable to take one pigment, for instance the acicular  $\beta$ -copper phthalocyanine, as a standard and compare the differences with the other pigments. Some of the heat effects related to the wetting liquid can be eliminated, to give quantities characteristic of the pigment

Table 2  
Net integral enthalpies of adsorption  $NA$  calculated from the enthalpies of immersion  $h_J(SL)$

Wetting Liquid	$-NA(\text{mJm}^{-2})$				
	$\beta$ -Copper phthalocyanine acicular	Poly-chlorinated copper phthalocyanine	$\gamma$ -Quinacridone	$\gamma\text{-Fe}_2\text{O}_3$	$\text{TiO}_2$ (rutile)
<i>n</i> -hexane	38	37	56	84	101
benzene	33	31	51	112	143
1- <i>n</i> -butanol	32	32	73	276	353
1- <i>n</i> -butylchloride	36	42	82	334	328
1- <i>n</i> -butylnitrile	30	44	121	390	357
1- <i>n</i> -butylamine	16	—	212	480	298
bromo-benzene	28	—	56	—	—
nitrobenzene	19	—	63	—	—
aniline	27	—	130	—	—

(Sappok, 1976)

surface only. It could be demonstrated this way, for instance, that the isometric  $\beta$ -copper phthalocyanine pigment is more polar than the acicular one. It is further to be noted that the amines, *n*-butylamine as well as aniline, have much higher values than would be expected from their dipole moments. This may be attributed to the ability of these substances to form hydrogen bonds ( $\gamma$ -quinacridone) or complexes with free electron pairs ( $\beta$ -copper phthalocyanine isometric). Again, more information will become available when further wetting liquids have been tested. Ultimately, a better understanding will be gained of the interaction forces in the solid/liquid interface on a molecular scale.

A detailed analysis of the data of the isometric and acicular  $\beta$ -copper phthalocyanine pigments enabled the estimation of the specific enthalpies of immersion to be made, with respect to the *NA* values of different crystallographic planes in the same manner as with adsorption data. The results of the evaluation are listed in Table 3. The very low values for the prismatic planes clearly demonstrate their hydrophobic character. The basal planes are, on the contrary, slightly polar, specific interactions occurring with the amines. This behaviour should be more or less pronounced with most organic pigments, because of their low crystallographic symmetry and resulting high crystal anisotropy.

Table 3  
Calculated net enthalpies of adsorption of prismatic and basal planes of  $\beta$ -CuPc

Wetting Liquid	$-NA(\text{mJm}^{-2})$	
	prismatic	basal
<i>n</i> -hexane	36	36
benzene	34	34
1- <i>n</i> -butanol	27	83
1- <i>n</i> -butylchloride	29	107
1- <i>n</i> -butylnitrile	24	81
1- <i>n</i> -butylamine	-13	290
bromo-benzene	20	109
nitrobenzene	10	100
aniline	16	134

(Sappok, 1976)

Finally, the results of some of the adsorption studies can be compared with those from the calorimetric measurements<sup>9</sup>. An almost linear relationship between the BET monolayer values and the net enthalpies of adsorption is found in the case of water (Fig. 18). The results with methanol from the two methods can also be correlated (Fig. 19).

From all the results obtained in these investigations, a comparison of the surface properties of pigments and solids in general is possible. A multi-dimensional description taking all the different interactions into account would be desirable. For practical purposes, a type of polarity scale can be set up if water only is used as the wetting liquid as proposed by Zettlemoyer<sup>17</sup> and later by Schmitz<sup>20</sup> with special reference to inorganic pigments. In Fig. 20 the enthalpies of immersion

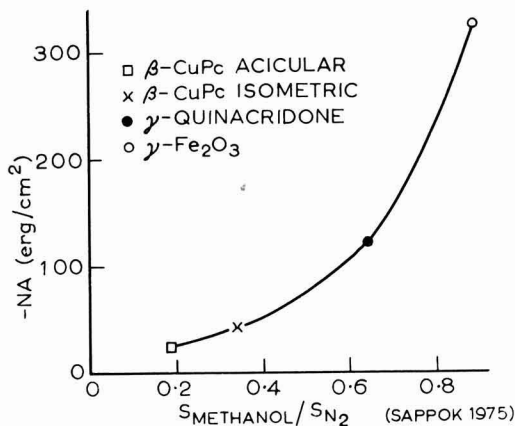


Fig. 18. Correlation of net enthalpies of adsorption of methanol to methanol adsorption data

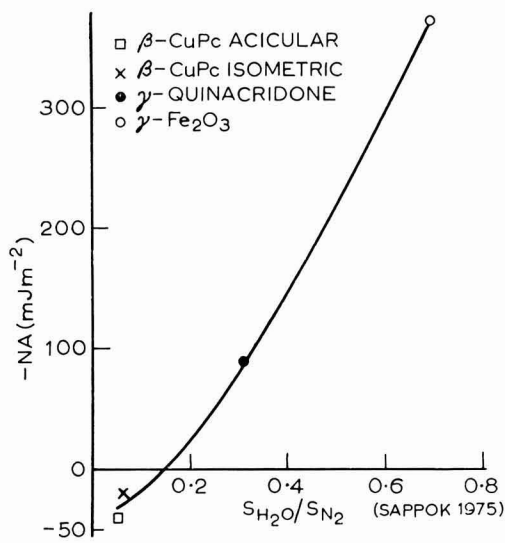


Fig. 19. Correlation of net enthalpies of adsorption of water to hydrophilicity

of the pigments investigated are plotted in terms of this scale. In addition, the values of some graphitic carbons and of diamond are included. These solids are prototypes of the aromatic and aliphatic organic solid states, respectively. Teflon as the most hydrophobic body is noted too.

The organic pigments are grouped in the lower part of this scale and are very similar to the carbon blacks and to diamond. In the case of these substances, functional groups such as  $=C=O$ ,  $>C-OH$  or  $-COOH$  increase the interaction with the wetting liquid, as is observed with  $\gamma$ -quinacridone. Particle shape will further influence the wetting properties as exemplified by the two copper phthalocyanine pigments.

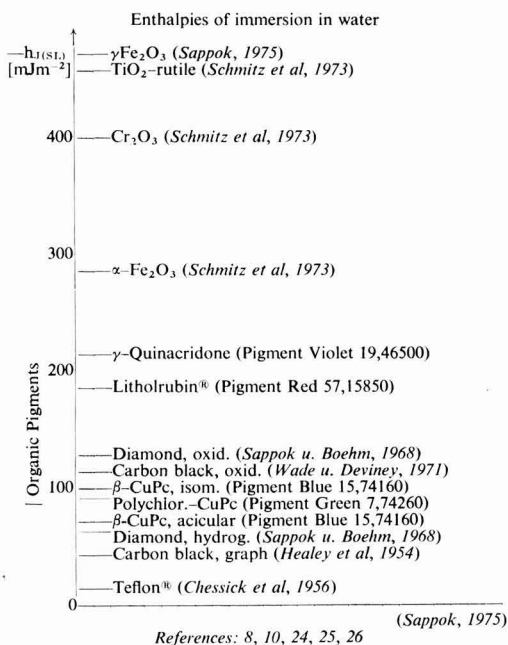


Fig. 20. Polarity scale of pigment surfaces

### The significance of surface properties of organic pigments in practical applications

Refs. 10, 20-23

Most of the characteristics of pigmented vehicles, such as flocculation, flow properties, wetting etc. are closely related to the adsorption of the binder on the pigment surface<sup>21</sup>. The smaller number of active sites present on most organic pigments compared with inorganic ones results in a lower

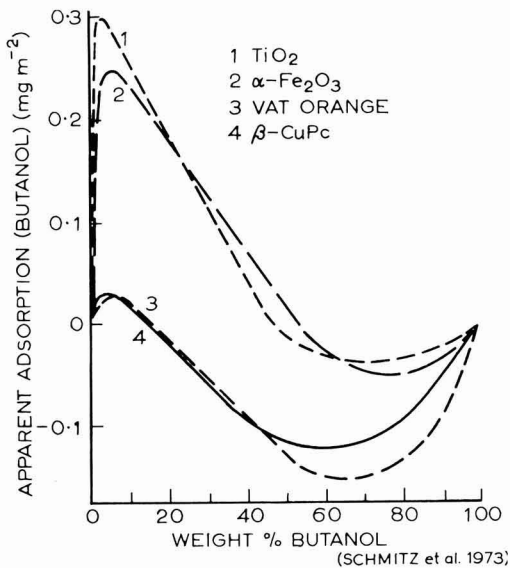


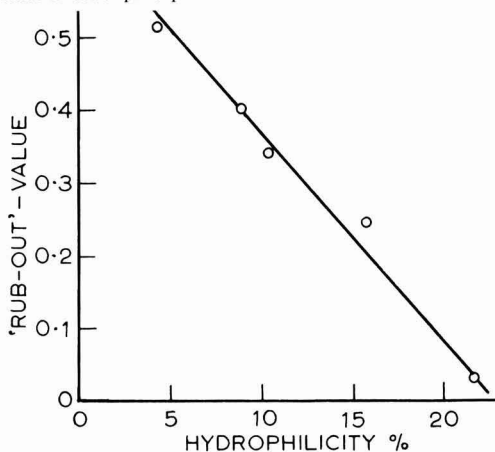
Fig. 21. Adsorption of butanol from toluene solutions

adsorption of the polymer. The difference was demonstrated for a system of butanol/toluene, in which the measurement can be performed more easily than with polymer solutions<sup>20</sup>.

The composite isotherms are given in Fig. 21. The maximum of the apparent amount adsorbed, which is a measure of preferential adsorption of the polar butanol, increases with increasing polarity of the pigment surface.

A second example illustrates the importance of the surface properties in paint performance.

The poor adsorptive properties of the hydrophobic phthalocyanines can be enhanced by the physical adsorption of polar derivatives of soluble copper phthalocyanines<sup>22,23</sup>. Recent studies have revealed a correlation between heats of immersion in methanol, i.e. the hydrophilicity of modified copper phthalocyanine pigments and "rub-out behaviour" ("rub-out" is a flocculation phenomenon in paints containing more than one pigment in a lacquer base) (Fig. 22). In this case, increasing the number of hydrophilic centres on the pigment surface diminishes the "rub-out" value and which leads to better paint-performance<sup>10</sup>.

Fig. 22. Rub-out and surface character of modified  $\beta\text{-CuPc}$  pigments

### Conclusions

Particle shape certainly is an additional parameter which influences pigment properties. The effects have been demonstrated only in a few examples so far. It may be concluded, however, that this phenomenon will be encountered in many organic pigments because of the low symmetry of their crystal lattices. Its magnitude will vary from one pigment to another.

### Acknowledgment

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# Hygric criteria for exterior paints for the protection of porous building materials\*

By D. Y. Perera

Laboratoire I.V.P., 1342 Limelette, Belgium

## Summary

An attempt was made to formulate, as quantitatively as possible, the hygric criteria required for an organic coating system to protect a porous building substrate without itself suffering deterioration.

The criteria take into consideration the hygric properties of the substrate and the moisture sources to which a paint system is exposed. The practical application of these criteria is discussed.

## Keywords

### *Types and classes of coatings and allied products*

architectural finish  
masonry finish  
exterior wood finish  
house paint

### *Types and classes of structures or surfaces to be coated*

masonry  
wood  
concrete  
brick

### *Properties, characteristics and conditions primarily associated with materials in general*

permeability  
porosity  
moisture content  
moisture vapour transmission

### *dried or cured films*

permeability  
porosity  
moisture content  
moisture vapour transmission

### *the environment*

ambient temperature  
relative humidity  
wind velocity  
exterior exposure  
hygric criteria

## Les critères hygriques des peintures à l'extérieur pour la protection des matériaux de construction poreux

### Résumé

On a tenté de postuler, aussi quantitativement que possible, les critères hygriques requis, afin qu'un système de revêtements organiques protège sans être altéré lui-même, les supports poreux qu'utilise l'industrie de construction. Les critères rendent compte

des caractéristiques hygriques du support et aussi des sources d'humidité auxquelles le système de peintures est exposé. On discute l'application dans la pratique de ces critères.

## Hygric Kriterien (kritisches Verhalten bei Gegeawart von Feuchtigkeit) für Anstrichmittel für Aussen zum Schutze poröser Baumaterialien

### Zusammenfassung

Es wird versucht die hygric Kriterien so quantitativ wie möglich zu formulieren, welche für ein organisches Beschichtungssystem erforderlich sind um poröses Baumaterialsubstrat zu schützen, ohne selbst angegriffen zu werden. Die Kriterien ziehen die hygric Eigen-

schaften des Substrates und die Feuchtigkeitsquellen, denen ein Anstrichsystem ausgesetzt ist, in Betracht. Die praktische Auswertung dieser Kriterien wird besprochen.

## Introduction

Refs. 1-16

Buildings made from porous materials are painted for aesthetic and/or protective reasons. Among the factors causing these materials to deteriorate (e.g. chemical agents, industrial and air pollution from traffic, mechanical erosion, etc.), moisture is one of the most important<sup>1</sup>. Briefly, water movement due to an absorption/desorption process causes displacement of soluble materials present in a porous material, resulting in a continuous modification of its composition. A high moisture content is essential for the development of micro-organisms

and damage due to freezing. The thermal insulation of materials is unfavourably affected by an increase in their moisture content.

It is generally accepted<sup>2-5</sup> that organic coatings used to protect porous building materials have on the one hand to allow the evaporation of excess moisture present in the substrate, and on the other hand to offer maximum resistance to the penetration of liquid water coming from the exterior. Due to the complexity of moisture transport in organic coatings and porous materials<sup>6-8</sup> this requirement is of qualitative importance only.

\*The hygric properties<sup>9, 10</sup> describe the characteristics of a material with respect to moisture, for example the coefficients of permeability, diffusion, solubility, water vapour resistance, the different critical moisture contents, etc.

As far as the author knows, the only quantitative approach to the formulation of hygric properties for paints was made by Kunzel<sup>11</sup>. From experiments carried out with numerous dispersion paints on cellular concrete in the Holzkirchen-Freiland region in Germany, he derived empirically three conditions in order to prevent moisture accumulation in the substrate due to driving rain. These conditions were later applied, without any modification, to other climates and substrates<sup>12,13</sup>.

In this paper an attempt is made to establish the criteria which would enable an organic coating system to protect a porous building material against moisture without itself undergoing deterioration.

These proposed criteria are based on the results of a study on the mechanism of moisture transport in fifteen paints and three types of concrete, i.e. ordinary, light and cellular<sup>1, 14, 15</sup>.

It is obvious that in addition to the hygric properties, an organic coating must, in order to present a good durability, possess other qualities (e.g. good adhesion<sup>16</sup>, adequate mechanical properties, etc.), but these are not discussed here.

**Theoretical**

In order to formulate the hygric criteria, the hygric properties of the coating and the substrate, and the environment in which it is placed were taken into consideration.

The first function, viz. the hygric properties of materials, implies a knowledge of the various mechanisms of moisture transport, whilst the second function, the environment, requires essentially a knowledge of the moisture sources to which the coating is exposed.

**Moisture transport**

*Refs. 1, 17, 18*

In general, the moisture transport can be described<sup>17</sup> by:

$$F = -(D_H \text{ grad } H + D_T \text{ grad } T) \dots \dots \dots (1)$$

where *F* is the flux and *D<sub>H</sub>* and *D<sub>T</sub>* represent the diffusion coefficients related to the moisture and temperature gradients, respectively.

From (1) it follows that, depending on the environmental conditions, the moisture transport can be determined by one of these gradients alone or by their combined effect, i.e. the flux will be the result of the magnitude and the direction of the two gradients. Some examples are discussed in reference 1.

Although (1) is valid for a porous\* as well as for a non-porous material, the mechanisms of moisture transport are different. In the case of a non-porous material the flux is molecular, individual and random, whereas in porous materials the flux is mainly a viscous flow process. Consequently, for a non-porous material, if the moisture transport measurements are carried out under identical equilibrium conditions, the phase of the water will not affect the transfer process. If the material is porous, *D<sub>H</sub>* and *D<sub>T</sub>* in (1) are given by:

$$\begin{aligned} D_H &= D_{H1} + D_{Hv} \\ D_T &= D_{T1} + D_{Tv} \dots \dots \dots (2) \end{aligned}$$

\* (1) assumes that the moisture transport due to the movement of air and salts present in a porous material is negligible<sup>18</sup>.

These equations show that the moisture transport in a porous material can take place in liquid phase (*l*), in vapour phase (*v*), or in a combination of both.

**Sources of moisture**

In the case of an organic coating/porous substrate-system the following sources of moisture were taken into consideration:

- (1) moisture coming from the side of the wall opposite to the painted side (the water vapour pressure acts as the driving force).
- (2) moisture coming from outside as liquid water (e.g. rain).
- (3) excess of moisture in the substrate due to its fabrication, or other sources.
- (4) accidental moisture (e.g. water infiltration due to presence of fissures, etc.).

**Hygric criteria**

As already mentioned, in order to obtain the maximum protection of buildings constructed with porous materials against moisture by means of paints, without the paints undergoing deterioration, it is considered that the coating has to be formulated according to:

- (a) the moisture transport mechanism in the substrate, and
- (b) the moisture sources to which the coating is exposed.

The following criteria are proposed:

- (1) With reference to the source of moisture arriving from the inside of the wall (opposite to the painted side), it is required that the flux of water vapour across the paint (*F<sub>p</sub>*) should be higher, or at least equal to, the flux across the substrate (*F<sub>s</sub>*), that is:

$$F_p \geq F_s \left( \frac{\text{Kg}}{\text{h.m}^2} \right)$$

- (2) The second criterion takes into consideration the moisture coming from outside as liquid water, and requires that the moisture taken up by the paint/substrate system during the humidification period desorbs during the drying period.

As expected, protection increases as water absorption decreases. In addition, a low absorption of water also causes a reduction of moisture movement in the substrate, thus diminishing the occurrence of some types of damage, e.g. efflorescence.

- (3) The third criterion is related to substrates which may contain excess moisture, due for example to the water used during construction. This criterion implies that the coating should not be applied before the rate of moisture loss from the unpainted substrate becomes smaller or at least equal to, water vapour flux through the coating in the condition to be expected following its application.

**Practical application of hygric criteria**

*Refs. 1, 6, 7, 8, 19-22*

In this paper, the hygric criteria used refer to the climatic conditions at Uccle (Belgium), but they can be used for all climates, if the necessary meteorological data are available.

To apply the *first criterion*, the moisture flux across the substrate has to be known. This implies a knowledge of (a) the mathematical equation describing the moisture transport in the substrate and (b) the limiting conditions i.e. the climate to which the painted substrate will be exposed. For this purpose, (1) and the limiting conditions shown in Table 1 were used.

Table 1

Mean values of exterior and interior temperature (*T*) and relative humidity (*RH*), difference in water vapour pressure across a wall ( $\Delta p$ ) and flux of moisture (*F*) through a cellular concrete (*Cc*) 0.2 m thick

Months	Exterior		Interior		$\Delta p$	<i>F</i> ( <i>Cc</i> ; <i>L</i> =0.2m)
	<i>T</i> (°C)	<i>RH</i> (%)	<i>T</i> (°C)	<i>RH</i> (%)(Pa)		
XII,I,II,III	3.5	85	20	52	552	3.6
IV,V	11	70	20	55	367	2.1
VI,VII,VIII	16.6	73	21	70	346	2
IX	14.5	80	20	60	90	0.6
X,XI	8	86	20	52	293	1.9
mean values	9.7	79	20	58	388	2.4

The exterior climatic conditions represent the mean values of temperature and relative humidity at Uccle<sup>19</sup> for different months of the year during the last 20 years. The conditions inside the building were those found for the Netherlands<sup>17,20</sup> and are very similar to those existing in Belgium. The last column shows approximate mean values of flux, *F*(Kg/m<sup>2</sup>h), for a cellular concrete of a thickness (*L*) of 0.2 m, calculated from (1) by using values of *D<sub>H</sub>* and *D<sub>T</sub>* derived from the work of van der Kooi<sup>17,20</sup> and the limiting conditions described in Table 1.

It can be seen that, due to the temperature gradient, the moisture transfer always takes place from the inside to the outside of the building.

It should be noted that in Table 1 the mean values of *F* are somewhat different from the real ones because:

- (1) they are calculated for a steady state, a situation which seldom occurs in practice,
- (2) the diffusion coefficients used in the calculations are those for the highest moisture content in the substrate for a given situation, and
- (3) the limiting conditions considered in calculations are those of a non-coated substrate, which in reality would be coated.

In order to comply with the first criterion, the water vapour flux across the paint should be higher or at least equal to, the moisture flux across the substrate. It is clear that the higher the difference in the flux values, the better the paint will comply with this criterion. For this purpose it might be considered that the mean is 2.4 10<sup>-4</sup> Kg/m<sup>2</sup>h, or, for a comfortable margin of safety, the highest moisture flux across the substrate is 3.6 10<sup>-4</sup> Kg/m<sup>2</sup>h. Therefore it is suggested that the water vapour flux across the paint systems should be measured under conditions of a difference in water vapour pressure ( $\Delta p$ ) corresponding to one or both cases mentioned above (388 and/or 552 Pa) at a temperature to which the paints are exposed in practice (i.e. the outside temperature (*T*) : 9.7 and/or 3.5°C). It means that :

$$(F_p)_T \geq F_s$$

Unfortunately, water vapour flux measurement at a temperature lower than that of a room, i.e.  $\approx 21^\circ\text{C}$ , is not always

possible in all laboratories due to lack of air conditioning equipment.

However, from data found in the literature<sup>6, 7</sup> it transpires that, in most cases, the permeability coefficient is only slightly dependent on temperature within the range considered above.

Bearing in mind that, in general, the permeability coefficient *P<sub>x</sub>* at a temperature *T<sub>x</sub>* can be calculated from (3)\* :

$$\ln P_x = \ln P_i + \frac{E_p}{R} \left( \frac{1}{T_i} - \frac{1}{T_x} \right) \dots \dots \dots (3)$$

$$E_p = Ed + \Delta H$$

if the permeability coefficient at a temperature *T<sub>i</sub>* and *E<sub>p</sub>* (the sum of the energy of activation (*Ed*) and the heat of solution ( $\Delta H$ )) are known. In some cases, *E<sub>p</sub>*-values can be found in the literature<sup>21</sup>.

From calculations carried out with varnishes, it was found that *P* decreases from 20°C to 3°C from 1.5 to 4.5 times while the tests made with 3 different types of paint showed a decrease of 2.1 maximum<sup>6</sup>. In consequence, when difficulties arise in carrying out the measurements at a low temperature, it is suggested that they should be made at room temperature under conditions of  $\Delta p$  close to reality and the results obtained converted to the real outdoor temperature. If, for example,  $\Delta p = 388$  Pa at a room of 20°C,  $\Delta RH(\%) = 17$  ; the water vapour permeability tests can then be performed by maintaining a *RH*(%) of 80 to 90, on one side of the sample and a *RH*(%) of 63 to 73 on the other side.

Unfortunately, for other types of substrate (ordinary concrete, brick, wood, etc.) the moisture flux cannot be calculated in the way used for cellular concrete. This is due to the lack of data relating to the moisture transport under a temperature gradient. For such cases it is suggested that the moisture flux is calculated from :

$$F = P' \frac{\Delta p}{L} \dots \dots \dots (4)$$

In (4), *P'* represents the coefficient of permeability determined under highly unfavourable conditions (e.g. high moisture content), whilst  $\Delta p/L$  is the water vapour pressure gradient closest to reality.

The *second criterion* refers to moisture coming from outside as liquid water, and requires that the moisture penetrating a coating/substrate system during the humidification period evaporates during the drying period. In order to verify that a coating complies with this criterion, absorption/desorption tests should be carried out.

Although the manipulation of such tests is relatively simple, the choice of the experimental conditions, and in particular for desorption, is difficult. This is because the desorption process<sup>8</sup> is dependent on both climatic conditions (wind velocity, relative humidity, temperature of the air and of the evaporation surface) and internal factors (moisture content and its distribution in the material). Therefore, in order to obtain representative and reproducible results, the measurements have to be performed with substrate samples having the same history (i.e. previously submitted to identical conditioning) and well-defined dimensions. Thus, in order to reduce the influence of the moisture distribution, it is suggested

\* (3) cannot correctly predict *P<sub>x</sub>* for paints in which water transport is strongly dependent on water concentration and in which the glass transition temperature lies within the range of temperature under investigation.

that the thickness of the substrate should not exceed a few centimetres (viz. about 3 cm). Depending on the type of substrate, prior to paint application substrate samples should first be humidified under vacuum until saturation (e.g. for ordinary and light concrete) or completely dried in a stove (e.g. for cellular concrete, brick), and then conditioned at a relative humidity as close as possible to that of the environment until a constant weight is obtained.

To carry out absorption tests the samples, prepared as previously described and with the lateral faces water proofed, are immersed with the painted surface in water. They should be removed periodically, blotted free from superficial water, and weighed immediately.

As soon as the absorption measurements are completed, the samples are placed in a well-defined environment and the desorption process recorded.

The duration of absorption and desorption, as well as other experimental conditions, such as temperature, relative humidity and ventilation, must represent as closely as possible the climate to which the paint system will be exposed.

Thus, at Uccle it was found that<sup>19</sup> :

- (a) the mean duration of rain, recorded for the last 10 years, is 603 hours/year.
- (b) the mean velocity of wind, for a period of 30 years, is 14 Km/h.
- (c) the mean air temperature for one year is 9.7°C.
- (d) the mean relative humidity for one year is 79%.

For such an environment, it is suggested that the desorption measurement be made at 9.7°C,  $RH(\%) = 79$  and a ventilation comparable with that of a wind velocity of 14 Km/h, during a period of time ( $t_{des}$ ) given by :

$$t_{des} = a \times 13.5$$

where  $a$  is the absorption time and 13.5 the ratio for one year between the drying period (8157 hours) and that of raining (603 hours). Thus if the absorption time is, for example, two days, in order for a paint system to comply with the second criterion, the water taken up during the absorption period has to desorb within 27 days. It should be stressed that, when a more accurate verification of this criterion is necessary, the absorption/desorption measurements should include the dew period and the temperature of the paint/substrate system when exposed to solar radiation. Kunzel's conditions, mentioned above, represent, in the author's opinion, a specific case of the second criterion.

The *third criterion*, as already mentioned, requires that an organic coating should not be applied until the rate of moisture loss in a non-painted substrate becomes smaller, or at least equal to, the water vapour flux through the coating. In practice, this implies a knowledge of the moisture content in the substrate at different depths and periods of time. Unfortunately, the determination of the moisture content in porous building materials is not an easy matter. This is because the non-destructive methods used on-site (microwaves, capacitance, fast neutron bombardment, etc.) give only approximately global values.

It seems that the destructive method of taking samples at different depths in a substrate and then gravimetrically or volumetrically determining the moisture, still remains the only valid method.

From laboratory measurements<sup>1</sup> carried out with ordinary concrete, 0.185 m thick at 21°C and  $RH(\%) = 60$ , using electrical and gravimetric methods, it could be seen that the requirement of this criterion is met after a drying period of 2 or 3 months, even for relatively impermeable paints.

On-site, this criterion is met after a much longer period of time. Moreover, it is also undesirable to paint a freshly-prepared concrete for other reasons, which are known only too well (lack of stability due to the shrinkage process, high alkalinity of concrete surfaces, etc.).

The accidental moisture (e.g. an accumulation of water at the paint/substrate interface due to the presence of fissures in the substrate, faulty design of the building, etc.), is in many cases the cause of paint deterioration. When such humid conditions are combined with a higher temperature<sup>22</sup>, the paint deterioration is even more accelerated due to the increased water vapour pressure. In view of the criteria formulated above, it appears unreasonable to expect a paint system to both protect a substrate against an excess of moisture penetration and resist the deteriorating effects of the accidental moisture.

However, if only the moisture transport is considered, so as to avoid some forms of paint deterioration (e.g. blister formation), it is necessary for the liquid water flux across the coating system  $Fp(1)$  to be higher, or at least equal to, that across the substrate  $Fs(1)$  of a thickness of a few centimetres (1 to 4 cm) :

$$Fp(1) \geq Fs(1)$$

The exact thickness of the substrate to be taken into account in liquid water permeation measurements, can be determined by carrying out absorption tests.

It is obvious that only very permeable coatings can be used in such cases with all the disadvantages this involves (low thermal insulation, efflorescence, etc.)

## Conclusions

Depending upon the types of substrate and moisture sources, paint systems should comply with one, two or all three of the hygric criteria in order to protect porous building materials against moisture:

- (1) The flux of water vapour across the paints should be higher, or at least equal to, the moisture flux across the substrate ( $Fp \geq Fs$ )
- (2) The moisture taken up by the paint/substrate system during the humidification period should desorb during the drying period
- (3) A coating should not be applied before the rate of moisture loss in a non-coated substrate becomes smaller, or at least equal to, the water vapour flux through the coating.

The practical application of these criteria requires a knowledge of the moisture transport across the substrate and the climatic conditions to which the coating will be exposed. If some hygric data are unobtainable, the problem may still be solved by making certain assumptions as to water transport mechanism.

A confirmation of the validity of criteria previously described was obtained by observing, over a period of five years, the behaviour of 15 paint systems of different hygric proper-

ties applied on three concrete bridges located in different regions of Belgium. The paints, in agreement with all three criteria, behaved well and prevented moisture accumulation in the substrate. Damage (blistering, detachment) was only observed close to fissures and other defects in the concrete for relatively impermeable paints and for very permeable paints, the latter showing a strong tendency to swell.

It should be stressed that the hygric properties should not be determined only with freshly prepared coatings, since in some cases these properties can change drastically once the coatings have been exposed to weathering. When important changes are noticed, a margin of safety should be considered.

### Acknowledgments

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## Next month's issue

The Honorary Editor has accepted the following papers for publication, and they are expected to appear in the September issue of the *Journal*:

**Electroinduced polymer coatings** by *J. D. Scantlebury, V. Ashworth and B. Yap*

**Molecular weight fractionation experiments with alkyds** by *J. D. Frazee*

**Mechanisms of effluorescence resistance in paint films** by *J. Boxall*

**The photocatalytic oxidation of liquid phase propan-2-ol by pure rutile and titanium dioxide pigments** by *R. B. Cundall, B. Hulme, R. Rudham and M. S. Salim*

**The role of the Diels-Alder reaction in the curing of drying-oil alkyd-melamine systems** by *K. Holmberg*

**The mechanism of the acid catalysed curing of alkyd-melamine resin systems** by *K. Holmberg*

# Annual Report of the Council for 1977

Adopted at the Sixteenth Annual General Meeting of the Incorporated Association held at the Piccadilly Hotel, London W1, at 3.05 p.m. on 21 June 1978.

## General

By far the most important event which took place during the year was the purchase of Priory House as the Association's own headquarters office building. The acquisition of such a property had long been the wish of many members of the Association and the fact that the Council were able to effect the purchase without the necessity of a bank loan or a mortgage gave even greater pleasure. The building contains office accommodation together with a small Committee room, which has been used for this purpose by the Association since it first negotiated a lease in December 1972. The Council wishes to place on record its thanks to the following Sections of the Association who made contributions to the Premises Fund arising from surpluses on Section activities:— Newcastle, Manchester, London and West Riding. The Council stresses that there will still be a necessity for funds to carry out the re-furnishing of Priory House and the re-equipment of the offices in the next few years.

In the last Annual Report, attention was drawn to the new Divisions of the Association and the granting of Section status to the Ontario Branch. The activities of the Sections overseas had continued and there are now two Branches operated by Sections in the South African Division, the Eastern Cape Branch of the Cape Section and the Rhodesian Branch of the Transvaal Section.

Council was pleased that it was possible to arrange for a paper to be presented on behalf of the Association at the Convention of the Federation of Societies for Coatings Technology in October when the Chairman of the Ontario Section, Mr W. Fibiger, gave a paper entitled "Oil absorption of organic pigments".

The twenty-ninth Technical Exhibition took place at Alexandra Palace, London N.22, from 22 to 25 March and attracted exhibitors from sixteen countries and visitors from fifty countries. A report appears later under the heading "Exhibition Committee", and a review appeared in the May issue of the *Journal*.

The Fifteenth Annual General Meeting of the Incorporated Association took place at the Grand Hotel, Eastbourne, on 18 June 1977. Mr A. McLean was elected President and the following Vice-Presidents were elected:—

Mr D. E. Hopper  
Mr D. Pienaar  
Dr H. Rechmann  
Dr F. M. Smith  
Mr A. R. H. Tawn  
Mr D. S. Newton  
Mr P. F. Sharp

The Honorary Officers were elected as follows:

Honorary Secretary	.. ..	Mr D. J. Morris
Honorary Treasurer	.. ..	Dr H. R. Hamburg
Honorary Editor	.. ..	Mr S. R. Finn
Honorary Research and Development Officer	.. ..	Mr C. N. Finlay

The report of the Auditors on the scrutiny of the postal votes was received and it was announced that the following members had been elected to the Council for the year 1977-1978:

Mr L. H. Silver  
Mr D. Eddowes  
Mr A. C. Jolly

Votes of thanks to retiring President, Council members, Honorary Officers and the Director & Secretary were carried with acclamation.

The Annual General Meeting took place on 18 June 1977 at the end of the final session of the Association's Biennial Conference at Eastbourne on the "Conservation of energy, materials and other resources in the surface coatings industry". An innovation was attempted this year in order to gauge whether there would be greater support for Conferences held at the weekend, than for the previous pattern, when Conferences had assembled on the Tuesday evening and dispersed on the Saturday morning. Although the Conference was one of the happiest which members could recall, the Technical Sessions were all well-attended and the discussion periods were lively, Council was disappointed that the arrangements made to attract young members, either for one day, or for the whole period of the Conference, did not result in a larger attendance. A full report of the Conference appeared in the August issue of the *Journal* and the papers presented, together with the discussions, appeared in the September to December issues.

Mr D. J. McConnell represented OCCA at the Association International de la Couleur Conference at Troy, U.S.A., in July 1977.

During the year a Commendation Award was presented to Mr G. H. Hutchinson of the Scottish Section in recognition of his work on behalf of the Association over a long period. Mr Hutchinson presented a paper on behalf of the Association to the Convention organised at Canberra by the Oil & Colour Chemists' Association Australia in September.



In the course of the year Sections of the Association have organised Symposia, including the Scottish Section's student meeting on 2 December on "Fundamentals of paint technology". The London Section held a joint Symposium with the London Region of the Society of Dyers & Colourists on "Printing on textiles" at the Thames Polytechnic on 9 February, and the London Section also held a day Symposium on "The influence of solar radiation on paint films" at the same venue on 16 November. From 14 to 15 September the Newcastle Section held a highly successful second International Symposium on "Ultraviolet polymerisation" at Durham University.

The fourteenth New Zealand Convention was held from 28 to 31 July at Rotorua and attracted a total attendance of over 200, including wives.

On the occasion of the Silver Jubilee of Her Majesty's accession to the Throne the Association presented a loyal address of greeting and a reply was received in acknowledgment from the Secretary of State for the Home Department.

During the year, Council was saddened to learn of the death of the following members who had rendered distinguished service to the Association:

Mr T. Drummond Kerr in March  
Mr H. R. Wood (the sole surviving Founder Member) in July  
Mr I. C. R. Bews (Hon. Editor and Hon. Secretary) in November  
Mr C. J. A. Taylor (Editor-in-Chief of the Paint Technology Manual) in December

Obituary notices have appeared or will appear in the *Journal* in the early issues of 1978.

In the Annual Report for 1976 mention was made that Mr C. A. Taylor, Assistant Editor, would be leaving the Association early in 1977, and at the beginning of the year Mr D. M. Sanders was appointed to succeed him as Assistant Editor. It has still not been possible to employ either an Assistant Secretary or Administrative Assistant, and the Association records its thanks to the Director & Secretary for his continued efforts on behalf of the Association.

### Membership of the Association

Section	Ordinary	Associate	Honorary	Student	Total
Bristol	59	13	—	—	72
Hull	53	6	—	1	60
Irish	39	15	—	—	54
London	533	50	4	8	595
Manchester	327	32	2	14	375
Midlands (including Trent Valley Branch)	162	18	—	5	185
Newcastle	110	6	—	9	125
Scottish (including Eastern Branch)	98	15	—	3	116
Thames Valley	93	14	—	3	110
West Riding	65	13	—	8	86
Auckland	124	38	—	1	163
Wellington	59	27	—	2	88
Cape	41	11	—	—	52
Natal	77	19	1	2	99
Transvaal	113	24	—	2	139
Ontario	77	15	—	1	93
General Overseas	375	25	2	3	405
<b>Total 1977</b>	<b>2405</b>	<b>341</b>	<b>9</b>	<b>62</b>	<b>2817</b>
<b>Total 1976</b>	<b>2384</b>	<b>341</b>	<b>9</b>	<b>49</b>	<b>2783</b>
Net increase/decrease during 1977	+ 21			+ 13	+ 34

### The Council

During the calendar year the Council has met four times, the average attendance being 24. All meetings were held in London.

### Committees of the Council

The Committees of Council met as set forth below:

Exhibition Committee	..	..	..	2
Finance Committee	..	..	..	2
Liaison Committee	..	..	..	—
President's Advisory Committee	..	..	..	4
Professional Grade Committee	..	..	..	3
Publications Committee	..	..	..	1
Technical Committee	..	..	..	1
Jordan Award Committee	..	..	..	1

### Exhibition Committee

Chairman: The Honorary Treasurer, Dr H. R. Hamburg

The Twenty-ninth Technical Exhibition was held at Alexandra Palace, London, N.22, and exhibitors were drawn from sixteen countries and visitors from fifty overseas countries. A full report of the Exhibition, including a review of the stands, appeared in the May issue of the *Journal* and the Exhibition Committee recorded its thanks to Mr S. R. Finn, the Honorary Editor, who prepared the review, and to Mr G. H. Hutchinson who again helped with the visits by school parties.

This was the second successive Exhibition to be held at Alexandra Palace by the Association, although the Exhibition had been held there from 1965-69. The site has proved so congenial that it is intended to continue to hold the Exhibitions there for future years. An innovation in 1977 was the permission to exhibitors to serve alcoholic refreshments on their stands to visitors. This was widely welcomed and particularly helped the staff of smaller companies, since it enabled them to remain on the stands during the hours of the Exhibition.

On the opening day a buffet luncheon was held for principal officers of other societies and special guests and in the afternoon the Exhibition Committee conducted them round the stands.

The direct underground line from Heathrow Airport to Turnpike Lane Station was opened during December and this should facilitate travel to the 1978 Exhibition.

### Finance Committee

Chairman: The Honorary Treasurer, Dr H. R. Hamburg

In 1977, two Sections were able to make contributions to the Premises Fund – the London and West Riding Sections – and the Committee expresses its appreciation of this continued support from Sections.

It gave the Committee much pleasure to report the purchase of Priory House as the Association's Headquarters offices in the summer of 1977. Approximately one third of the Association's equities were realised for the purchase, thus avoiding the necessity of a bank loan, and it is now the intention of the Committee to build up these resources once again.

The attention of members is drawn to the market value of investments at the end of the year, since it will be appreciated that approximately one-third of the equities were realised in order to purchase Priory House. It is not possible to give a direct comparison for the equity holding with the market value at the end of 1976 for this reason, but it will be seen that the equities retained still stand at £5832 above their purchase price. The market value of the British Government securities was £86 below their purchase price compared with £219 at the end of 1976.



*Jordan Award Committee*

Chairman: The Honorary Research & Development Officer,  
Mr C. N. Finlay

The Committee, having studied the applications received, agreed to make the award on this occasion to Dr J. C. Reid for his paper on "A fracture mechanics approach to lacquer cracking" which had been published in the August 1976 issue of the *Journal*. The President presented the certificate and a cheque for £100 to Dr Reid at the Annual General Meeting on 18 June at Eastbourne.

*Liaison Committee*

Chairman: The President

The Liaison Committee has not met during the year but the opportunity was taken of the visit by Mr Neil Estrada, the President of the Federation of Societies for Coatings Technology, to the Eastbourne Conference to discuss matters relating to liaison between the FSCT and OCCA represented by Mr A. T. S. Rudram and Mr R. H. Hamblin. As already noted in the earlier part of this report, a paper was presented on behalf of the Association at the Federation of Societies for Coatings Technology Convention in Houston, Texas.

*President's Advisory Committee*

Chairman: The President

For the 1977/78 session Mr McLean invited the Chairmen of the Manchester Section, Mr J. E. Mitchell; the Midlands Section, Mr R. J. King; and the Scottish Section, Mr J. D. W. Davidson, all of whom were in their second year of office, to serve on the Committee, together with the Honorary Officers of the Association.

*Professional Grade Committee*

Chairman: The President

The Professional Grade Committee were particularly encouraged by the high level of applications received during the year which have included a Past President of the Federation of Scandinavian Paint and Varnish Technologists and the Federation of Societies for Coatings Technology. They also draw attention to the successful application by two members in the Licentiate Grade for re-grading to the Associateship Grade. A pleasing feature has been the number of times the Professional Grade has been mentioned in advertisements for appointments which have appeared in the Association's *Journal*.

A full list of Members admitted to the various grades appeared in the December 1977 issue of the *Journal* and the table shows the position in the various categories of the Professional Grade at the end of the year.

Representatives of the Paintmakers Association's Training & Technical Education Committee attended the meeting of the Professional Grade Committee held in October to discuss the courses for the new Technician Education Council and co-operation on this matter will continue.

Information had been received from the Australian Federal Committee concerning the introduction of professional gradings for members of OCCA Australia. The original proposal was that the same designatory letters as for this Association should be used but, after consultation, it was agreed that a differentiation should be made.

*Technical Committee*

Chairman: The Honorary Research & Development Officer,  
Mr C. N. Finlay

The Technical Committee met in November in order to prepare the format for the 1979 Biennial Conference and to consider the holding of symposia during 1978-79. Details of the subject for the Technical Sessions for the 1979 Conference to be held at Stratford-upon-Avon, 20 to 23 June, will be published in the January 1978 issue of the *Journal*.

*Technical Education Committee*

Chairman: The President

In view of the work of the new Technician Education Council liaison has been maintained particularly with the Paintmakers Association, the CAPITB and the Technical Colleges.

*Publications Committee*

Chairman: The Honorary Editor, Mr S. R. Finn

This Committee met on one occasion during the year, when a number of routine matters were discussed, but the most important subject was the future of the Paint Technology Manuals. It had become clear earlier in the year that Chapman and Hall Ltd, the publishers, did not wish to produce any further new editions of the existing manuals, although they had made additional copies of Part III by binding printed sheets, which had remained from the last edition.

The revision of Part IV had been completed and would have been ready for submission to the publishers. A decision was, therefore, necessary on the future of Part IV and any possible other revisions. Part VII of the Manuals had been published first in the *Journal* as a series of Student Reviews, additional pages being printed for binding into a separate volume. This had needed twelve issues of the *Journal* to complete and there was little doubt that such prior publication reduced the numbers of bound volumes subsequently sold, but on the other hand the independent publication of a Manual would have been too expensive to be a viable project and this situation remained.

The alternative method seemed to be to publish in the *Journal* a series of shorter, self-contained monographs, covering selected parts of the Manuals and more advanced reviews, with additional pages being printed for binding into separate booklets, on the lines of the collected edition of the Newcastle Section's symposium on UV curing. It was appreciated that the revision of a Manual was a major operation because of the many authors involved, some of whom might no longer be able to revise their chapters; the shorter, more restricted

	Applications received	Applications transferred between grades	Successful	Awaiting fulfilment of regulations	Not accepted	Resignations and deaths	Upgradings	As shown in December 1977 <i>Journal</i> *
Fellowship	220	Less 45 Add 7	172	6	4	10	—	162
Associateship	301	Less 18 Add 50	288	25	20	17	4	267
Licentiatehip	42	Less 5 Add 11	15	24	9	—	4	11
	563	—	475	55	33	27	8	440

\*Including the United Kingdom and Ireland, 39 countries are represented in the list of successful candidates published in the December 1977 issue of the *Journal*.

monographs would, therefore, be much easier to revise when necessary. Nevertheless, if a useful series of either manuals or monographs were to be established within a reasonable time, it would mean that about one quarter of the available space in the *Journal* would be required on an almost permanent basis, because five parts of the Manuals were completely out of stock and further space would be needed for any more advanced reviews.

Accordingly, a circular letter was sent to all members of the Publications Committee asking for their opinions on the use of *Journal* space for the regular production of Manuals or Monographs or whether only occasional review type articles should be published. This matter was further discussed at the meeting of the Committee, which suggested that neither manuals nor monographs should be published regularly in the *Journal* and the space available should be used almost exclusively for original papers, as at present. Review type articles at the student or more advanced levels will be inserted as the opportunity arises.

The sale of the Association's publications has continued to be reasonably satisfactory, with the exception of the Consolidated Index 1966-1975. The Publications Committee remained convinced that this was a most useful adjunct to the *Journal*, for which there should have been a large demand.

The Hon. Editor wishes to thank the Hon. Publications Officers for their accounts of Section Proceedings and all those who have contributed to Book Reviews.

The number of pages in Volume 60 (1977) of the *Journal* amounted to 415 which is about 30 more than in the two previous volumes. The pages devoted to Transactions and Communications was 342 (66%) and about the same as in recent years. The number of Book Reviews was rather less than usual (8) and the amount of correspondence again disappointing. One paper was received which was considered to be suitable as a Student Review and was published as such with the consent of the author.

*Survey of published papers.* Forty-nine technical papers and one Student Review were published, of these 19 arose from sectional meetings, 15 being from symposia. All the papers (14) from the Eastbourne Conference were published during

September-December. Thus in all 33 papers originated from the Association's events and 16 papers were submitted directly to the Hon. Editor. Twenty-five papers were from overseas sources, if those presented at UK events are included. Five papers from the Manchester Section on "Films - formation and behaviour" which could not be included in the previous volume were published, as well as papers from the South African Division's and London Section's symposia.

A pleasing feature has been the high quality of many of the papers received during the year, not all of which could be included in the 1977 volume. These include the Newcastle Section's second symposium on UV curing and a number of directly submitted papers. It is hoped to publish all of these in the first half of 1978.

### Representation on other organisations

The Association was represented on other organisations as follows:

Technical Training Board for the Printing Ink and Roller Making Industry: Mr H. C. Worsdall and Mr N. Locke until October, Mr W. R. Moon from October 1977.

The Parliamentary and Scientific Committee: The President and the Director & Secretary.

The British National Committee for Chemistry: Dr R. C. Denny.

City and Guilds Advisory Committee for the Chemical Technicians Certificate: Dr J. G. Gillan.

East Ham Technical College Consultative Committee for the Science Department: Mr R. M. W. W. Wilson.

Association of Exhibition Organisers: The Director & Secretary.

Programme Liaison Committee: The Honorary Programmes Officer of the London Section and the Director & Secretary.

The Paintmakers Association Training and Technical Education Committee: Mr A. T. S. Rudram, the Honorary Secretary and the Director & Secretary.

The Paintmakers Association Hazardous Substances Advisory Panel and Technical Committee: Mr A. T. S. Rudram from October 1977.

The Society of Dyers and Colourists Terms and Definitions Committee: Mr J. T. Tooke-Kirby, and Mr J. T. Hurst until October, Mr D. M. Varley from October 1977.

The Society of Dyers and Colourists "Review of Coloration Progress" Committee: Mr J. T. Tooke-Kirby.

The Colour Group (Great Britain): Mr I. Ford.

Institution of Corrosion Science and Technology Education Committee: Dr J. B. Harrison until July and Mr D. S. Newton.

Institute of Metal Finishing Technical Education Committee: Mr A. R. H. Tawn.

Scottish Technician Education Council Sub-Committee: Mr R. F. Hill until July, Mr H. B. Smith from July 1977.

### Papers originating from Section symposia and lectures:

	1975	1976	1977
Bristol	—	—	—
Hull	—	2	—
Irish	—	—	—
London	4	1	5
Manchester	—	6	6
Midlands	—	—	—
Newcastle	—	13	2
New Zealand Division	—	1	—
Ontario	—	—	—
Scottish	—	—	—
South African Division	5	—	5
Thames Valley	—	—	1
West Riding	2	1	—
	11	24	19

### Papers submitted directly:

United Kingdom	8	9	5
Overseas	9	10	11
Conference	12	3	14
Association symposium	3	—	—
	32	22	30
<b>Total</b>	<b>43</b>	<b>46</b>	<b>49</b>

**British Standards Institution:**

- PVC Pigments, Paints & Varnishes Industry Committee: *Dr J. B. Harrison* until March, *Mr R. G. J. Toms* from March
- PVC/1 Pigments: *Mr H. G. Cook* until July, *Mr E. A. Peters* from July
- PVC/1/11 Extenders: *Mr S. A. Ray*
- PVC/1/18 Zinc Dust Pigments: *Mr D. S. Newton*
- PVC/3 Paints Media and Related Products: *Mr G. H. Hutchinson*
- PVC/3/5 Test Methods for Paint Media: *Dr L. A. O'Neill*
- PVC/4 Lac: *Dr B. S. Givani*
- PVC/6 Cement Paints: *Mr W. O. Nutt*
- PVC/8 Plastic Wood: *Mr V. P. Gellay*
- PVC/10 Test Methods for Paints: *Mr A. N. McKelvie*
- PVC/11 Glossary of Paint Terms: *Mr S. A. Ray*
- PVC/14 Colour Schedules *Mr A. B. Lock*
- PVC/15 Water Paints and Distempers: *Mr T. W. Wilkinson*
- PVC/16 Ready Mixed Oil Paints: *Mr A. T. S. Rudram*
- PVC/19 Bituminous Paints: *Mr J. Rogers*
- PVC/20 Calcium Plumbate Priming Paints: *Mr M. Pettit*
- PVC/23 Zinc Rich Paints: *Dr D. Atherton*
- PVC/24 Water Thinned Wood Priming Paints: *Mr J. H. Sparrow*
- PVC/25 Organic Finishes for Aluminium Windows: *Mr D. E. Hopper*
- LGL/9 Artificial Daylight for Colour Matching: *Mr I. Ford*
- C/17 Viscosity: *Mr A. N. McKelvie*
- C/17/2 Revision of BS188 (Drafting): *Mr A. N. McKelvie*
- CHE/43/1 Sieves, Sieving and other Sizing Methods: *Mr M. J. F. Meason* until July, *Mr D. S. Newton* from July 1977.
- CHE/43/2 Test Methods for Powder Properties: *Mr D. S. Newton*
- CIC/4 Solvents and Allied Products: *Mr A. R. H. Tawn*
- CIC/6 Glycerol: *Mr W. A. Ledger*
- OFC/7 Sampling Oilseeds, Oils and Fats: *Mr N. F. Lythgoe*
- OFC/12 Vegetable Oils: *Mr N. F. Lythgoe*
- OFC/24 Analysis of Oilseeds, Oils and Fats: *Mr N. F. Lythgoe*
- GEL/16/53/6 Varnishes *Mr N. H. Seymour*
- ACE/44 Aircraft Finishes *Mr J. B. G. Lewin*
- BLCP/18 Code of Practice—Painting: *Mr J. E. Mitchell*
- RDB/25 Road Marking Compounds: *Mr T. R. Bullett*
- DOS/3/10 Chemistry and Chemical Technology: *Mr J. Orpwood*

Reports submitted by representatives may be seen by members at the Association's Offices.

The Association was also represented on overseas organisations as follows:

**South Africa**

- Natal College for Advanced Technical Education, Science and Education Advisory Committee . . . Mr K. R. McDonald and Mr K. M. Engelbert
- Council of the Natal Association of Scientific and Technical Societies . . . Mr L. F. Saunders.
- SABS Specification—Non Toxic Coatings . . . Mr R. E. Rouse
- SAPMA Witwatersrand Technical Education Committee for Paint Science . . . Mr P. A. J. Gate and Mr H. Bosman.

**Appendix****Report of the Council in accordance with the Companies Act 1967**

- The Council presents herewith the audited accounts of the Association for the year ended 31 December 1977.
- Results**  
The results for the year and the appropriation thereof are set out in the Income and Expenditure Account on page (9).
- Principal activities\*of the Association**  
The Association has continued in its work of furthering the development of the science and technology of the oil and colour industries.
- Changes in fixed assets**  
The movement in fixed assets during the year is set out in the Table on page (10).

**5. The Council**

- The following were members of Council at 31 December 1977:
- A. McLean, BSc, ARCS, FRIC, FTSC  
A. T. S. Rudram, FTSC  
D. J. Morris  
S. R. Finn, BSc, FRIC, FTSC  
L. J. Brooke, ATSC  
J. Foxton (co-opted as President of the Oil & Colour Chemists' Association Australia, October 1977)  
H. C. Worsdall, FTSC  
R. J. King, BSc, AWP, ATSC  
T. Entwistle, FTSC  
M. H. Prigmore  
M. J. Cochrane  
T. W. Wilkinson, AMCT, FTSC  
D. J. Pienaar, MSc  
J. T. Tooke-Kirkby, F Inst Pet, FTSC  
J. E. Mitchell, BSc, FRIC, FTSC  
D. E. Hopper, ACT (Birm), ATSC  
C. N. Finlay, ATSC  
K. V. Hodgson, FTSC  
J. D. W. Davidson, FIPE, FIWM, FTSC  
F. Sowerbutts, BSc (Tech), FTSC  
G. Willison, FRIC  
F. M. Smith, BSc, PhD, MRIC, FTSC  
A. R. H. Tawn, FRIC, F Inst Pet, FTSC  
H. R. Hamburg, PhD  
J. R. Bourne, FTSC  
F. B. Redman, ATSC  
J. Smethurst, AMCT, FTSC  
P. Magee (Miss)  
E. G. Warman  
E. P. Wright  
E. N. Harper (Mrs)  
R. Brooks  
R. C. Somerville  
D. A. Bayliss  
F. Hellens  
I. R. McCallum  
H. Rechmann, PhD, FTSC  
R. A. Ness, BSc, ATSC (elected 7 April 1977)  
C. Gooch (elected 30 March 1977)  
W. Fibiger (elected 20 April 1977)  
L. F. Saunders, FTSC (elected 28 March 1977)  
A. McWilliam, CChem, MRIC, FTSC (elected 24 June 1977)  
J. A. Burns (elected 22 April 1977)  
M. G. Bentley, ATSC (elected 19 April 1977)  
G. V. Hill, BSc, ATSC (elected 21 April 1977)  
P. F. Sharp, BSc, ATSC (elected 18 June 1977)  
D. S. Newton, AMCT, CGIA (elected 18 June 1977)  
L. H. Silver (elected 18 June 1977)  
D. Eddowes, BSc (elected 18 June 1977)  
A. C. Jolly, BSc, FTSC (elected 18 June 1977)

In addition the following were members of Council at 1 January 1977 and served during the year; the date shown after each name denotes when during 1977 service on Council terminated:

- J. F. Beachen, MSc, ATSC (18 June 1977)  
C. Butler, LRIC, FTSC (18 June 1977)  
M. J. Heavers (18 June 1977)  
R. F. Meek (7 April 1977)  
H. G. Cook, MA, FTSC (24 June 1977)  
L. P. Goodale (22 April 1977)  
D. J. House (28 March 1977)  
P. Birrell, BSc, FCIC, FTSC (20 April 1977)  
J. L. Inshaw, ATCT, FTSC, MRIC (21 April 1977)  
R. P. Bartrum (19 April 1977)  
O. W. Brett, BSc (30 March 1977)  
W. J. Nunn (Co-opted as President OCCAA until October 1977)

**6. Auditors**

In accordance with Section 14(1) of the Companies Act 1976, a resolution will be proposed at the general meeting to reappoint the auditors, Coopers & Lybrand.

By Order of the Council

ROBERT HAMBLIN  
Director & Secretary

1 January 1978

## OIL AND COLOUR CHEMISTS' ASSOCIATION

## BALANCE SHEET as at 31 December 1977

1976		1977		1976		1977	
£	£	£	£	£	£	£	£
61,642		71,308				FIXED ASSETS—(Note 1)	
—		5,100		10,926		Furniture, Fittings, Office Machines and Motor Car at cost . . . . .	
9,666		76,408		(8,420)		. . . . . 11,618	
4,000		35,575		2,506		Less Accumulated Depreciation . . . . .	
75,308		111,983		—		. . . . . (9,662)	
76,938		50,853		8,128		Freehold Property at cost . . . . .	
21,704		14,849		(1,808)		Less Accumulated Depreciation . . . . .	
98,642		65,702		6,320		. . . . . 73,631	
				8,826		. . . . . (500)	
						. . . . . 73,131	
						Leasehold Property at cost	
						Less Accumulated Amortisation . . . . .	
						. . . . . —	
						. . . . . —	
						75,087	
						QUOTED INVESTMENTS—	
				12,110		British Government Securities at cost . . . . .	
						. . . . . 12,110	
						(Market value £12,024)	
						(Market value 1976	
						£11,891)	
				28,202		Other Investments at cost . . . . .	
						(Market value £25,051)	
						(Market value 1976	
						£35,037)	
				40,312		. . . . . 19,219	
						. . . . . —	
						. . . . . 31,329	
						CURRENT ASSETS—	
				5,221		Stock of unsold publications at cost (Note 7) . . . . .	
				3,723		. . . . . 2,392	
				38		Paper stock in hand at cost (Note 7) . . . . .	
				10,621		. . . . . 1,659	
						Stock of ties (Note 7) . . . . .	
						. . . . . —	
						Debtors and Payments in Advance . . . . .	
						. . . . . 6,793	
						Balance at Bankers and Cash in Hand in United Kingdom and Overseas Sections . . . . .	
				105,209		. . . . . 60,425	
				124,812		. . . . . 71,269	
£173,950		£177,685		£173,950		£177,685	

## REPORT OF THE AUDITORS TO THE MEMBERS

1. We report on the accounts set out on pages 7 to 11. These have been prepared according to the historical cost convention.
2. The accounts incorporate the unaudited accounts of United Kingdom and overseas sections for the year ended 31 December 1977. We have not verified any of the accounts prepared by these sections which, at 31 December 1977, reported net assets amounting in total to £16,840 (1976 £13,853), the only figures of significance being cash which amounted to £19,328 (1976 £15,366) and creditors which amounted to £2,513 (1976 £1,518).
3. With this reservation, in our opinion, the accounts give a true and fair view of the state of the Association's affairs at 31 December 1977 and of its results and source and application of funds for the year ended on that date, according to the historical cost convention, and comply with the Companies Acts 1948 and 1967.

COOPERS &amp; LYBRAND

London, 14th March 1978

Chartered Accountants

Note: The page references given in the paragraph above are equivalent to pages 319 to 323 in this *Journal*.

## STATEMENT OF SOURCE AND APPLICATION OF FUNDS FOR THE YEAR ENDED 31 DECEMBER 1977

	Year ended 31.12.77	Year ended 31.12.76
	£	£
<b>SOURCE OF FUNDS</b>		
Unappropriated surplus for year .. .. .	36,675	10,666
<i>Deduct</i> profit on sale of investments and fixed assets .. .. .	(20,568)	
Adjustment for item not involving the movement of funds:		
Depreciation and amortisation .. .. .	1,742	1,594
<b>TOTAL GENERATED FROM OPERATIONS</b> .. .. .	<u>£17,849</u>	<u>£12,260</u>
<b>FUNDS FROM OTHER SOURCES</b>		
Proceeds from the sale of investments and fixed assets .. .. .	30,396	307
	<u>£48,245</u>	<u>12,567</u>
<b>APPLICATION OF FUNDS</b>		
Purchase of fixed assets .. .. .	68,003	14
Purchase of investments .. .. .	843	699
	<u>68,846</u>	<u>713</u>
<b>INCREASE/(DECREASE) IN WORKING CAPITAL</b> .. .. .	<u>£(20,601)</u>	<u>£11,854</u>
<b>INCREASE/(DECREASE) IN WORKING CAPITAL comprises—</b>		
Increase/(decrease) in stocks .. .. .	(4,931)	5,097
Increase/(decrease) in debtors and payments in advance .. .. .	(3,827)	(150)
(Increase)/decrease in current liabilities .. .. .	32,940	(33,397)
Movement in net liquid funds:		
Increase/(decrease) in balance at bankers and cash .. .. .	(44,783)	40,304
	<u>£(20,601)</u>	<u>£11,854</u>

## OIL AND COLOUR CHEMISTS' ASSOCIATION

## INCOME &amp; EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1977

£	1976 £	£						£	1977 £	£
			<b>INCOME</b>							
			MEMBERSHIP AND GENERAL INCOME—							
		30,552	Subscriptions .. .. .	..	..	..	..	31,011		
		123	Professional Grade Registration fees .. .. .	..	..	..	..	251		
		1,111	Entrance fees .. .. .	..	..	..	..	941		
		2,306	Publications .. .. .	..	..	..	..	4,190		
		1,410	Sundry Income .. .. .	..	..	..	..	2,001		
		421	Profit on sale of investment and fixed assets .. .. .	..	..	..	..	20,568		
		2,462	Section Surplus (Note 5) .. .. .	..	..	..	..	642		
		—	Conference .. .. .	..	..	..	..	210		
		8,028	Investment Income .. .. .	..	..	..	..	6,383		
	46,413								66,197	
			JOURNAL RECEIPTS—							
		16,509	Advertising .. .. .	..	..	..	..	23,250		
		24,736	Sales .. .. .	..	..	..	..	25,179		
		3,018	OCCA Australia .. .. .	..	..	..	..	2,076		
		1,123	Reprints .. .. .	..	..	..	..	1,500		
	45,386								52,005	
	133,265	41,466	EXHIBITION RECEIPTS .. .. .	..	..	..	..		66,687	
									184,889	
			<b>EXPENDITURE</b>							
			MEMBERSHIP AND GENERAL EXPENSES—							
		14,791	Administration expenses (Note 4) .. .. .	..	..	..	..	16,627		
		14,668	Journal .. .. .	..	..	..	..	18,047		
		7,893	Postage, printing and stationery .. .. .	..	..	..	..	9,142		
		441	Notices .. .. .	..	..	..	..	277		
		7	Council Reunion Dinner .. .. .	..	..	..	..	68		
		4,026	General expenses, inc. accountancy .. .. .	..	..	..	..	4,624		
	41,826								48,785	
			JOURNAL EXPENSES—							
		14,792	Administration expenses (Note 4) .. .. .	..	..	..	..	16,627		
		17,929	Printing and publication .. .. .	..	..	..	..	22,058		
		874	Reprints .. .. .	..	..	..	..	1,241		
		5,925	Postage and stationery .. .. .	..	..	..	..	6,983		
		1,266	General expenses .. .. .	..	..	..	..	1,743		
	40,786								48,652	
			EXHIBITION EXPENSES—							
		23,929	Direct expenses .. .. .	..	..	..	..	32,406		
		14,792	Administration expenses (Note 4) .. .. .	..	..	..	..	16,628		
		1,266	General expenses .. .. .	..	..	..	..	1,743		
	122,599	39,987							50,777	
	10,666		Surplus for the year .. .. .	..	..	..	..		148,214	
									36,675	
	1,000		APPROPRIATION—							
			London and West Riding contributions to Premises Fund .. .. .	..	..	..	..		1,100	
	£9,666		Surplus for the year carried forward .. .. .	..	..	..	..		£35,575	

## STATEMENT OF RETAINED RESERVES

1976 £						1977 £
9,666	Surplus for the year .. .. .	..	..	..	..	35,575
61,642	Balance at 1 January .. .. .	..	..	..	..	71,308
—	Add Transfers from Premises Fund .. .. .	..	..	..	..	5,100
£71,308	Balance at 31 December .. .. .	..	..	..	..	£111,983

## NOTES ON THE ACCOUNTS

## 1. Fixed Assets

	Furniture, Fittings, Office Machines and Motor Car		Freehold Property	Lease- hold Property
	£	£	£	£
<b>Cost</b>				
At 1 January 1977 ..	10,926	—	—	8,128
Additions .. ..	692	—	73,631	—
Disposals .. ..	—	—	—	(8,128)
	<u>11,618</u>	<u>—</u>	<u>73,631</u>	<u>—</u>
<b>Depreciation</b>				
At 1 January 1977 ..	8,420	—	—	1,808
Disposals .. ..	—	—	—	(1,808)
Charged to Income and Expenditure Account .. ..	1,242	—	500	—
	<u>9,662</u>	<u>—</u>	<u>500</u>	<u>—</u>
<b>Net Book Value at 31 December 1977 ..</b>	<u>£1,956</u>	<u>—</u>	<u>£73,131</u>	<u>—</u>

Depreciation of fixed assets is calculated so as to write off the assets over their expected useful lives.

## 2. Foreign Currencies

Overseas Section income, expenditure, assets and liabilities have been converted to Sterling at the following rates ruling at 31 December 1977:

	1976	1977
New Zealand .. ..	\$1.7927	\$1.8683
South Africa .. ..	R1.4805	R1.6690
Canada .. ..	\$1.7194	\$2.100

## 3. The Ethel Behrens Fund and the Jordan Award Fund

The Ethel Behrens Fund and the Jordan Award Fund have not been incorporated in the Association Income & Expenditure Account and Balance Sheet, but have been shown as separate accounts.

## 4. Administration Expenses

Administration expenses have been equally apportioned between the three main headings of expenditure in the Income & Expenditure Account. The appropriation has been calculated on the basis of estimated staff time involved. These expenses are:

1976		1977	
£		£	
25,606	Salaries including pensions .. ..	34,661	
9,104	Agency staff .. ..	3,503	
472	Welfare .. ..	527	
6,716	Rent, rates, lighting and telephone .. ..	6,295	
500	Audit fee .. ..	575	
—	Provision for obsolete stock .. ..	1,616	
480	Administration of Pension Fund 1975 and 1976 .. ..	240	
1,594	Depreciation and amortisation of fixed assets .. ..	1,737	
303	Bad debts .. ..	228	
—	Sixtieth Anniversary 1978 provision .. ..	500	
(400)	Less provision released for Paint Technology Manuals .. ..	—	
<u>£44,375</u>		<u>£49,882</u>	
The charge to each heading is therefore:			
14,791	Membership .. ..	16,627	
14,792	Journal .. ..	16,627	
14,792	Exhibition .. ..	16,628	
<u>£44,375</u>		<u>£49,882</u>	

## Employees' Emoluments

The emoluments of the Director and Secretary were £11,183.

## 5. Section Surplus

The Section surplus is as follows:

1976		1977	
£		£	
72	*Bristol .. ..	(2)	
18	*Hull .. ..	(4)	
(208)	†Irish .. ..	(224)	
892	*London .. ..	(815)	
2,278	*Manchester .. ..	10	
(14)	*Midlands .. ..	(254)	
16	*Trent Valley Branch .. ..	23	
(200)	*Newcastle .. ..	4,402	
335	*Scottish .. ..	824	
(184)	*Thames Valley .. ..	(174)	
344	*West Riding .. ..	9	
(234)	*Auckland .. ..	(1,114)	
(250)	†Wellington .. ..	(1,860)	
269	*Natal .. ..	(294)	
(282)	*Cape .. ..	94	
22	†Transvaal .. ..	587	
(412)	*Ontario .. ..	(566)	
<u>£2,462</u>		<u>£642</u>	

## NOTES:

(1) \*unaudited returns incorporated in the accounts 7.2.78

(2) †estimated returns included in the accounts 7.2.78

(3) Nett surpluses are shown without brackets  
Nett deficits are shown inside brackets

## 6. Limited by Guarantee

The liability of the members of the Association is limited by guarantee.

## 7. Stocks

The value is determined on the basis of the lower of cost and net realisable value. Cost is determined on a first-in, first-out basis.

**ETHEL BEHRENS FUND**

## INCOME &amp; EXPENDITURE ACCOUNT to 31 December 1977

1976		Expenditure		1977	1976		Income		1977
£				£	£				£
103	Income Tax on Investment	.. .. .		103	245	Interest on Investment (Gross)	.. .. .		245
142	Surplus	.. .. .		177		Distribution	.. .. .		35
<u>£245</u>				<u>£280</u>	<u>£245</u>				<u>£280</u>

## BALANCE SHEET as at 31 December 1977

1976		Liabilities		1977	1976		Assets		1977
£				£	£				£
2,635	Accumulated Fund	.. .. .		2,777	2,446	British Government securities at cost	.. .. .		2,446
142	Add Surplus	.. .. .		177		(Market value £2,633)			
					331	Balance at Bank	.. .. .		508
<u>£2,777</u>				<u>£2,954</u>	<u>£2,777</u>				<u>£2,954</u>

**JORDAN AWARD FUND**

## INCOME &amp; EXPENDITURE ACCOUNT to 31 December 1977

1976		Expenditure		1977	1976		Income		1977
£				£	£				£
—	Awards	.. .. .		100	65	Interest on Investment (Gross)	.. .. .		138
—	Certificate	.. .. .		4	8	Profit on Sale of Investment	.. .. .		—
73	Surplus	.. .. .		34					
<u>£73</u>				<u>£138</u>	<u>£73</u>				<u>£138</u>

## BALANCE SHEET as at 31 December 1977

1976		Liabilities		1977	1976		Assets		1977
£				£	£				£
1,152	Accumulated Fund	.. .. .		1,225	1,007	British Government securities at cost	.. .. .		1,007
73	Add Surplus	.. .. .		34		(Market value £1,357)			
					218	Balance at Bank	.. .. .		252
<u>£1,225</u>				<u>£1,259</u>	<u>£1,225</u>				<u>£1,259</u>

## Proceedings of the Annual General Meeting

The Sixteenth Annual General Meeting of the Incorporated Association was held on 21 June 1978 at 3.05 pm at the Piccadilly Hotel, London, W1, with the President (Mr A. McLean) in the Chair.

There were 33 Members and 3 visitors present.

The notice convening the meeting was read.

### Apologies

Apologies for absence were received from Mr I. C. Sellars, Mr H. R. Hug, Mr J. L. Inshaw, Dr J. L. Scott, Mr B. D. L. de Antonissen, Mr C. N. Finlay, Mr R. H. E. Munn, Mr C. H. Morris, Mr J. E. Mitchell, Mr T. Entwistle, Mr D. J. Morris and Mr H. H. Lavell.

### Minutes

The President asked the meeting to take as read the Minutes of the Fifteenth Annual General Meeting held on 18 June 1977, as printed and circulated in *JOCCA*, pp 320-322 inclusive, August 1977. There being no comments, the adoption of the Minutes was put to the meeting and carried unanimously.

### Report of the Auditors to the Members

The Report of the Auditors to the Members was read.

### Annual Report of the Council for 1977

Mr S. R. Finn (Honorary Editor) moved and Mr H. R. Hamburg (Honorary Treasurer) seconded the adoption of the Annual Report of the Council and the Statement of Accounts for 1977.

Mr A. R. H. Tawn congratulated the Association upon the acquisition during the year of the headquarters building at Priory House, without the necessity of a bank loan, due to the careful realisation of part of the Association's equities.

Dr F. M. Smith, Dr L. Valentine, Mr N. W. Piper and Mr A. R. H. Tawn asked questions and commented on the format and content of future Association Conferences, and were advised that these matters were being looked into by the relevant Committee and Council. Dr Smith commented that in the Exhibition Committee Report, the venue at Alexandra Palace might better be described as convenient. Mr H. C. Worsdall pointed out that at the moment there were no viable alternative venues for the Exhibition, and felt that it should be made clear to members that all aspects of the annual exhibition were reviewed by the Exhibition Committee. Mr



A. McWilliam mentioned the announcement by another organisation of a "Resin & Pigment Exhibition" to be held later in the year.

There being no further questions or comments on the Annual Report of the Council and Statement of Accounts, these were formally adopted by the meeting.

#### Appointment of President Designate

Mr McLean stated that, as indicated on the Agenda, Dr F. M. Smith had been appointed by the Council as President Designate of the Association and he now asked the Annual General Meeting to show their approval.

This was carried unanimously with acclamation.

Dr Smith thanked the meeting for the honour bestowed upon him and stated that he would do his utmost to uphold the interest of the Association in the period of change which he foresaw in the coming years.

#### Election of Vice-Presidents of the Association

The President read the nominations of the Council as printed on the Agenda and asked the meeting to accept them *en bloc*. This was agreed. The following were then elected as Vice-Presidents:

- (i) Mr P. F. Sharp
- (ii) Mr P. A. J. Gate
- (iii) Mr D. S. Newton
- (iv) Mr J. L. Inshaw
- (v) Mr R. C. Somerville
- (vi) Mr H. K. R. Nielsen
- (vii) Mr T. W. Wilkinson

#### Election of Honorary Officers of the Association

It was unanimously agreed to elect the Honorary Officers as follows:

Honorary Secretary .. .. .	Mr D. J. Morris
Honorary Treasurer .. .. .	Dr H. R. Hamburg
Honorary Editor .. .. .	Mr S. R. Finn
Honorary Research and Development Officer .. .. .	Mr C. N. Finlay

#### Announcement of election of three Elective Members to Council 1978-80

The President read the following report which had been received from the Auditors:

*We have scrutinised the voting papers for the three elective members of the Council received from the members in the United Kingdom, Irish and General Overseas Sections, and certify that the votes cast, including those notified by letter from the Ontario Section and by telex from the Transvaal Section, show that the following obtained the largest number of votes:*

J. R. TAYLOR    C. H. MORRIS    J. D. W. DAVIDSON

6 voting papers were rejected as not being in order.

London  
19 June 1978

COOPERS & LYBRAND  
Chartered Accountants

#### Chairmen of Sections for the coming session

The names of the Section Chairmen for the coming year were given as follows:

Auckland .. .. .	Mr R. A. Ness
Bristol .. .. .	Mrs E. N. Harper
Cape .. .. .	Mr A. R. Byrns
Hull .. .. .	Mr R. Brooks
Irish .. .. .	Mr K. Callaghan
London .. .. .	Mr D. A. Bayliss
Manchester .. .. .	Mr A. McWilliam
Midlands .. .. .	Mr J. A. Burns
Natal .. .. .	Mr L. F. Saunders
Newcastle .. .. .	Mr F. Hellens
Ontario .. .. .	Mr W. Fibiger
Scotland .. .. .	Mr I. R. McCallum
Thames Valley .. .. .	Mr G. V. Hill
Transvaal .. .. .	Mr A. G. Shepherd
Wellington .. .. .	Mr C. Gooch
West Riding .. .. .	Mr M. J. Cochrane

#### Reappointment of Auditors and fixing the remuneration thereof

It was proposed by Mr B. Jacob that Coopers & Lybrand (Chartered Accountants) be reappointed Auditors of the Association and that their fee for 1978 be £575. This was seconded by Mr E. Sangster and carried unanimously.

#### Vote of thanks to retiring Council Members

The President called upon Dr L. Valentine to propose a vote of thanks to members retiring from Council.

Dr Valentine thanked all those members both at home and overseas, who were retiring from Council after service in various capacities as Vice-Presidents, Elective Members, Section Chairmen and Section Representatives. He particularly wished to mention Mr A. T. S. Rudram (Immediate Past President) who was retiring from Council after a very long period of service. This vote of thanks was carried with acclamation.

#### Vote of thanks to Honorary Officers of the Association

In proposing a vote of thanks to the Honorary Officers, Mr L. P. Goodale drew attention to the work of the Honorary Officers in their various spheres and asked the meeting to show its gratitude to the Honorary Officers. This was carried with acclamation.

#### Vote of thanks to Chairman of meeting

In proposing the vote of thanks to the Chairman of the meeting, Mr B. F. Gilliam thanked the President for his work during his first year of office and wished him a successful second year. This vote of thanks was carried unanimously.

Mr A. McLean thanked the meeting for their good wishes and asked that the meeting demonstrate its thanks to the Director & Secretary (Mr R. H. Hamblin) and his staff for their work on behalf of the Association. This was carried unanimously.

#### Any other competent business

There being no other competent business, the President declared the meeting closed at 3.40 pm.

# Scottish

### Co-operative research project on wood primers

To date, the Scottish Section co-operative research project on "Wood primers" has looked at the following systems:

*Reference primer*—control sample made to BS.2521 i.e. white lead primer.

#### *Non-aqueous primers*

##### (a) Media

- (i) Long oil alkyd
- (ii) Medium oil alkyd
- (iii) Short oil alkyd
- (iv) Styrenated alkyd
- (v) Vinyl toluenated alkyd
- (vi) Urethane alkyd
- (vii) Linseed oil
- (viii) Vinyl acrylic/chlorinated paraffin
- (ix) Epoxy ester
- (x) Phenolic/linseed oil cooked blend

##### (b) PVC levels—10 and 15 per cent less than the CPVC.

##### (c) Titanium dioxide—20 per cent of total pigment plus extender volume.

##### (d) Extenders—ratios used at both PVC levels.

- (i) Barytes/talc 1:1 by volume
- (ii) Talc alone
- (iii) Barytes/whiting/talc 3:3:2 by volume
- (iv) Barytes/whiting 1:1 by volume

#### *Aqueous primers*

##### (a) Media

- (i) Styrene acrylic copolymer emulsion
- (ii) Vinyl acetate ethylene copolymer emulsion
- (iii) Vinyl acetate homopolymer emulsion
- (iv) Acrylic copolymer emulsion
- (v) Vinyl acetate versatate emulsion
- (vi) Acrylic copolymer emulsion

##### (b) PVC ladder at 30, 37 and 45 per cent.

##### (c) Pigmentation—titanium dioxide and whiting.

The level of titanium dioxide was reduced pro rata with increasing PVC commensurate with considerations of cost and opacity.

Each panel was coated with primer and half the panel with an undercoat and top coat. A second series of panels were given two coats of primer and half the panel completed as above.

The 198 panels have now been exposed at 45°S for 3½ years and this section of the project is virtually finished; these panels are now on view at the Ciba-Geigy Laboratories at Paisley. Anyone interested in looking at these panels should contact Mr J. Toovey, Hon. Research Officer (Tel: 041-322 5817) or Mr T. L. M. Humphrey, Chairman, Co-operative Research Project (Tel: 041-887 1144).

Since the project started in 1972, two new specifications have been issued, i.e. BS.5082 and BS.5358. Further work on the type of panels specified in both of these is in progress and the exposure should be completed by early 1979. It is hoped that a full report will be completed by mid-1979.

J. T.

## Notes and News

### Obituary

**K. J. Day, DSC, MBIM, FICORT, F, FTSC**

Julyan Day, a member of the Association for 23 years, died on 5 June after a year's poor health.

Born in 1917, and educated at Haileybury School, he served as radar officer on H.M.S. Belfast, attained the rank of Lt. Commander R.N.V.R., participated in many naval engagements including the sinking of the "Scharnhorst" and was awarded the Distinguished Service Cross.

His first employment in the paint industry was with Thos. Hubbeck, after the war becoming works manager. Later he joined Associated Lead Manufacturers Ltd and was active in the promotion of calcium plumbate anti-corrosives. After a period of service with Robert Bowran Ltd, he started in 1963 that part of his career which had major impact on the paint and painting industries. In that year he joined British Inspection Engineers Ltd to initiate a protective coating inspection service for consulting engineers. The success of this activity led to the formation of B.I.E. Anti-Corrosion Ltd, in which company he held the post of Managing Director.

In 1972 he set up as consultant in the field of corrosion protection, believing that only through the service of an independent

consultant could conflicting attitudes or inadequate knowledge of involved parties be resolved.

Amongst the many projects in the U.K. and Middle East on which he was engaged special mention should be made of the Mersey Tunnel and the Thames Barrier.

He was an active member of OCCA and the Institute of Corrosion Science & Technology; he was closely involved with the work of the British Standards Institution, his final contribution being the drafting of the inspection section of Code of Practice, BS5493; 1977. He was also closely associated with the Construction Industries Research & Information Association and N.A.C.E.

Behind these activities was his determination to ensure that the full potential value of protective coatings was achieved by bringing together paint manufacturer, consultant engineer, client and contractor at an early stage to select and define the type of protective system and the condition of usage.

His crusading influence in this field was undoubtedly successful and will, for long, continue to be a benefit.

His work extended to the educational field, in that whilst at B.I.E. he organised many seminars for the training of site inspectors, recognising that continuous independent inspection at site was an essential component of the overall objective.

To all those who were fortunate enough to know Julyan, will be the recognition that his success was as much ensured by his quiet, pleasant and unassuming manner as by his expertise and tenacity of purpose.

At a Memorial Service held on 18 July at the Church of the Holy Sepulchre, Holborn, the Association was represented by Alan Newnam, a past Chairman of the London Section.

H. A. N.

## London Section

### Ladies' night

The Ladies' night of the London Section will be held at the Selsdon Park Hotel, Fanderstead, South Croydon, Surrey on Friday 27 October 1978 at 7 p.m. for 7.30 p.m. The hotel has easy access from North of the Thames and especially from West and South London. The hotel, which is situated in a park having its own golf course, tennis courts etc., has ample car parking space and accommodation will be available at a reduced rate for those wishing to stay overnight. Further details can be obtained from Mr H. C. Worsdall, Worsdall Chemical Co. Ltd, Sole Street, Cobham, Kent DA13 0XY.



# OCCA-31 Exhibition

Alexandra Palace, London, 3-6 April 1979

Many enquiries received from  
home and overseas

Closing date for applications for  
stand space: **31 OCTOBER 1978**

Applications for stand space now being received

## Arrangements for OCCA-31

The Exhibition Committee announces that the thirty-first annual exhibition of raw materials, plant and equipment for the paint, printing ink, colour, polymer, adhesive and allied industries organised by the Association will be held at Alexandra Palace, London N22 from 3-6 April 1979.

The aim of the Exhibition is the presentation of technical and commercial information relating to advances in the surface coatings industries. The Committee stipulates that a technically trained person who has knowledge of the products displayed be available on the stand throughout the Exhibition.

Whilst the Committee naturally encourages the showing of new products, it does not stipulate that a new product has to be shown each year, since it fully appreciates that this is not possible. Accordingly, the Committee draws attention to the fact that new technical data on existing products is regarded as acceptable subject matter.

## Motif for the Exhibition

The motif, designed by Robert Hamblin, emphasises the unique aspect of the OCCA Exhibitions, which annually provide an international focal point for the surface coatings industries. In 1978, exhibitors were drawn from 16 countries and visitors from over 50 countries. The colours of the motif shown on the advertisement on the back outside cover of the *Journal* will be carried throughout the publicity leading up to the Exhibition. The two main colours of the motif, green and yellow, will be incorporated on the facias of the stands and

it is intended to organise complementary floral displays in the Exhibition Hall. The use of these colours will create a pleasing contrast as visitors move from corridor to corridor at the Exhibition, as the green colour will be used from north to south and the yellow colour from east to west.

## Dates and hours of opening

The Exhibition will be open as follows:

Tuesday 3 April ..	09.30 to 17.30 hrs.
Wednesday 4 April ..	09.30 to 17.30 hrs.
Thursday 5 April ..	09.30 to 17.30 hrs.
Friday 6 April ..	09.30 to 16.00 hrs.



Visitors to the OCCA-30 Exhibition came from over 50 countries. A view of one of the crowded corridors at the Exhibition is shown above, and below is a view of the Information Centre and one of the seating areas in the foreground.

## Invitation to Exhibit

Copies of the Invitation to Exhibit have been despatched to companies and organisations in the UK and overseas which have shown at previous OCCA Exhibitions or have requested information for the first time for the 1979 Exhibition. Completed application forms for stand space must be returned to the Director & Secretary of the Association not later than 31 October 1978.

The interest shown in the OCCA-31 Exhibition as a direct result of the highly successful OCCA-30 Exhibition held in April this year has been considerable, and already companies have asked for larger stands than they have had in previous years. Additionally, several companies who have not previously shown at OCCA Exhibitions as well as some who were not able to be present at OCCA-30 have contacted the Association requesting that sites be reserved for them.

The Exhibition Committee was particularly pleased to see the large number of exhibits at OCCA-30 from companies new to the Exhibition, both from the UK and many overseas countries, and this emphasises the continuing importance of this annual Exhibition to the world surface coatings industry and demonstrates its international character.

Visitors to OCCA-30 are known to have come from over 50 countries and admissions by season tickets of over 10000 were recorded at the turnstiles at the entrance to the Exhibition. Several Sections of the Association organised parties to the Exhibition, and it is hoped that these will also be arranged for OCCA-31.

## Facilities at Alexandra Palace

The Association has full use of the facilities at Alexandra Palace during the period of the Exhibition which include a restaurant bars, a cafeteria and a private exhibitors' bar. Another facility which is of considerable benefit to those travelling to the Exhibition by car is the ample free car parking space within the Palace grounds.

For visitors travelling to the Exhibition on the underground system, the Association will once again be running a free bus shuttle service to and from the Exhibition, this year from Wood Green Station on the Piccadilly Line. The extension of the Piccadilly Underground Line to the Heathrow Central terminal was opened in late 1977, and this now provides a direct link for travellers arriving at the airport to both





central London and to Wood Green Station and the bus shuttle service to the Exhibition.

### Improvements at Alexandra Palace

In July 1978, work was started on a comprehensive refurbishment of the facilities at Alexandra Palace including the completion of the work to the exterior, the repainting of the West Corridor and the walls of the Great Hall, and the redecoration of the restaurants and bars. The floor of the Great Hall has already been resurfaced, and the remainder of the work is scheduled to be completed by the late summer this year. These improvements will add to the pleasantness of the venue, set in the extensive parklands, and will provide an excellent setting for this international focal point.

### Information in foreign languages

As in previous years, the Association will be circulating information leaflets in six languages which will contain application forms for those wishing to purchase copies of the *Official Guide* and season admission tickets before the Exhibition. Interpreters will once again be in attendance at the Information Centre at the Exhibition to assist foreign exhibitors and visitors with their queries.

### Hotel accommodation

In order to facilitate the booking of hotel accommodation by visitors, the Grand Metropolitan Hotels Ltd will again be publishing a special leaflet for OCCA-31.

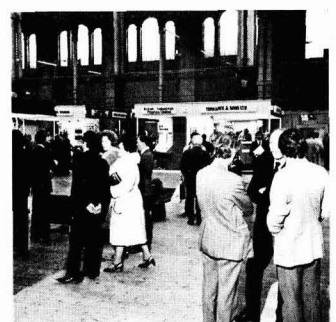
Any organisation wishing to receive details of OCCA-31 should write to the Director & Secretary of the Association at the address on the Contents page to receive a copy of the Invitation to Exhibit.

### Official Guide

This unique publication contains descriptions of all companies and their exhibits at the Exhibition and is issued to each member of the Association at home and abroad as well as to all visitors to the Exhibition with their admission tickets. It is published several weeks in advance of the dates of the Exhibition to allow visitors the maximum opportunity to plan the itinerary of their visits. In 1978, for the first time, the *Official Guide* contained a chart classifying the products on show into the various types, and it is intended to produce a similar chart for the *Official Guide* to OCCA-31. This chart is invaluable to visitors, especially those who have only a limited amount of time available, as it provides a quick, easy reference of all the companies present who are displaying the products in which they are interested.

### Advertising facilities

Advertising space is available in the *Official Guide*, both to companies who will be exhibiting at the Exhibition, and also to other organisations. This important publication is constantly referred to both before the Exhibition and afterwards as a convenient record of the latest developments in the industry. Consequently, organisations wishing to take advertising space in the *Guide* should book their requirements as soon as possible in order to ensure a prominent position. Details of the advertising rates and media data are available from Mr D. M. Sanders at the address on the Contents page.



Admissions by season ticket of over 10,000 were recorded at the entrance to the OCCA-30 Exhibition in April this year. Shown left and right are some of the stands at OCCA-30, with throngs of visitors circulating and discussing their requirements.

# Association Annual General Meeting and Luncheon Lecture

A Reception for members and visitors was held on 21 June 1978 at the Piccadilly Hotel, London, W1 at 12.30 pm in the Prince Edward Room, which was followed by luncheon.

After the meal the President (Mr A. McLean) welcomed the Association's principal guest, Dr D. Davies, Chief Scientist of the Department of Industry, who was to deliver a lecture entitled "Resource problems in the down-stream chemical industries". He congratulated Mr D. A. Bayliss, Chairman of the London Section, upon the arrangements for the lecture.

Mr McLean extended a warm welcome to two other guests who were present at the function, Mr J. Oates, the President and Mr F. Borrelle, the Executive Vice-President of the Federation of Societies for Coatings Technology. Mr Oates and Mr Borrelle both thanked the Association and expressed pleasure at being guests of the



Shown at the recent FATIPEC Congress in Budapest are (left to right): Dr B. Andersson (SLF), Mr A. McLean (OCCA), Mr J. Oates (FSCCT), and Mr F. Borrelle (FSCCT)

President, who they had had the pleasure of meeting at the FATIPEC Congress in Budapest.

Following the speeches the assembled company moved to the Princess Elizabeth Room and the President introduced Dr Davies who delivered his lecture, which it is hoped will appear in a future issue of the *Journal*.

At the conclusion of the lecture Mr Bayliss moved a vote of thanks to Dr Davies for his lively and incisive presentation and commented that he was sure all those present would benefit by examining the challenges they faced with the new techniques he had suggested.

The Association then held the Sixteenth Annual General Meeting of the Incorporated Association, a full report of which appears elsewhere in this issue.

## Bristol Section

### Annual Dinner Dance

The Bristol Section Annual Dinner Dance was held at the Mayfair Suite, New Bristol Centre on Friday 31 March. The function, attended by 180 members and guests, again provided an opportunity for meeting old friends, a convivial drink and even the occasional dance.

The Top Table, graced by the lady Chairman, Mrs E. N. Harper, accompanied by her husband, was honoured by the presence of the Association President, Mr A. McLean, the President of the Birmingham Paint, Varnish and Lacquer Club, Mr G. H. Tennant, and three Section Chairmen, Mr M. J. Cochrane (West Riding), Mr J. D. W. Davidson (Scottish), and Mr J. E. Mitchell (Manchester), all accompanied by their

wives. Last but not least, the Section was pleased to welcome the Director & Secretary, Mr R. H. Hamblin.

The toast of welcome to the guests was given by Mrs Harper, who commented on the good fortune of having not one but two Presidents as guests. She thanked those who had assisted her during her first year of office, and concluded by thanking Mr A. Lague for making the usual excellent arrangements for the evening.

Mr A. McLean responded to the toast on behalf of the guests with his, by now well known Scottish wit. Dancing followed until the small hours of Saturday morning and was concluded with the traditional Auld Lang Syne — it may have been imagination, but the "Scottish flavour" of this part of the evening seemed more pronounced than usual.

B. C.

## News of Members

Mr J. L. Taylor, an Ordinary Member attached to the Hull Section, has been appointed chief chemist of E. Hardman, Son & Co. Ltd, manufacturers of oleoresinous varnish media for the paint industry.

Dr W. Carr, an Ordinary Member attached to the Manchester Section and a Fellow in the Professional Grade, has retired from his position at Ciba-Geigy Ltd after 39 years with the company. He will continue, on a part-time basis, his work at the Colour Chemistry Department of the University of Leeds.

## Information Received

### Main agency

The Barron Electrical Group have been appointed a main agent for Lewis & Holtzman Ltd for their range of electronic variators, timers and monitoring equipment for the anodizing and plating industries. Barron Electrical will also be handling the Lewis & Holtzman portable electrical colour analyser and reference meter, with applications in the printing, painting and paint manufacture, plastics and dyeing industries, where accurate colour matching is necessary.

### Spectroradiometric standards

High accuracy standards of spectral irradiance are now available from Glen Creston. 45,200 and 1000 watt lamp standards based on the National Bureau of Standards scale of spectral irradiance are available and can be supplied with calibrations of spectral irradiance, total irradiance and illumination.

### Bulk supplies

The Chemicals Division of Degussa can now offer users of paraformaldehyde

granulate, granuform, pentaerythrite R and D and calcium formate a new form of packaging which facilitates handling. The new packages are 1,000kg disposable "Big Bags" consisting of a polyethylene inner sack with a strong cover of polypropylene, which reduces the risk of damage during transportation.

### Storage tanks

Kenneth Forbes (Plastics) Ltd have available their Maxitanks which have found applications for the storage of materials for emulsion paints. Constructed as a laminate of polypropylene/glass, the tanks have good impact resistance and the emulsions do not adhere to its surface. The Maxitanks are available up to 40,000 galls capacity.

### New dyes and pigments

BASF has supplemented its range of Typophor and Neozapon dyes with new blacks Typophor Black L and Neozapon Black L which have excellent solubility and have applications in many fields of surface coatings. Also available is a new supplement to the range of pigments for plastics,

Paliotol Yellow 0961K which is a brilliant greenish-yellow and is easily dispersible, having good light and weather fastness properties.

## New products

### New reel handler

ACR Lift Truck Ltd, has available a new reel handler manufactured by Ernst Wagner. This pedestrian controlled battery electric truck is suitable for handling such items as cable drums, wire spindles, paper reels, barrels etc.

### Super Microlap

Ion Tech Ltd have announced the introduction of a new advanced ion beam thinning unit called the Super Microlap which incorporates the latest water cooled Saddle Field Ion Source Model B11W. Two of these ion sources are built into the Super Microlap and are accurately controlled by a current regulated power supply unit to produce ion beams ranging in intensity from a few microamps to 500 microamps



per source. For sensitive specimens, the low ion current and water cooling, guarantees freedom from ion source heat transfer and ion beam damage. The specimen can be mounted on a water cooled or liquid nitrogen cooled stage.

#### Heavy duty sprayer

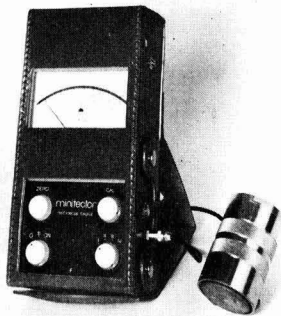
A new machine, said to be the only one in Europe developed specially to spray apply textured coatings, is available from Exit Industrial Products (UK) Ltd. The machine, named Exitec, makes possible the spray application of high-build stone textured elastomeric coatings with aggregate up to 7mm in size. By means of a simple conversion the machine can also be used as an ordinary paint spray unit.

#### Elemental analyser

A new improved version of Perkin-Elmer's 240 Elemental Analyser is now available. Named the Model 240B, it features ease of operation, maintenance and overall reliability. Improvements include faster heating combustion furnace, a new detector designed with better temperature control for increased stability, and an external programmer index wheel.

#### New coating thickness gauge

Elcometer Instruments Ltd have available the Elcometer 150 F3M (Metric) and F3E (Imperial) coating thickness gauges, which have been developed for the accurate measurement of non-conductive coatings of up to 25mm on ferrous substrates. The



The new coating thickness gauge from Elcometer Instruments Ltd

meters are battery operated and have been designed around well proven electronic techniques, giving advantages of long-term reliability and accuracy. Measurements can be taken rapidly by a single contact probe which incorporates balanced sensing coils which are affected by proximity to ferrous metals.

#### Conferences, courses etc.

##### Intermediate chemicals catalogue

Albright & Wilson Ltd has published a new illustrated catalogue describing their

aromatic and organophosphorus intermediate chemicals. The catalogue in English, French and German lists products in chemical groups with synonyms, structural formulae and typical physical properties.

##### Particle size course

A one week course on sampling, particle size analysis and surface area determination will be held at the University of Bradford from 11-15 September 1978.

##### Silicones applications index

Hopkin & Williams has produced a catalogue of over 100 Dow Corning silicones and maintenance products which includes an applications index to help potential users of silicones to spot possible uses in their industry.

##### Surface contamination

The International Committee of Contamination Control Societies is organising a Symposium on "Surface contamination: its genesis, detection and control", to be held in Washington D.C. from 10-13 September 1978.

#### Erratum

##### OCCA-30 Review

It is regretted that on page 216 of the June issue of *JOCCA*, **Instrumental Colour Systems Ltd** was incorrectly referred to as Industrial Colour Systems Ltd.

## Register of Members

The following elections to membership have been approved by Council. The Section to which each new Member is attached is given in italics.

#### Ordinary Members

- ASHFORD, ROBERT DOUGLAS, PhD, Shell Chemicals NZ Ltd., PO Box 2091, Wellington, New Zealand. (*Wellington*)
- AULD, VICTOR ALBERT, LRIC, 128 South West Avenue, Bollington, Macclesfield, Cheshire. (*Manchester*)
- BARNES, HAROLD, Taceuber & Corfsen (1958) Pvt. Ltd, PO Box 3190, Salisbury, Rhodesia. (*Transvaal*)
- BERESFORD, MARTIN WILLIAM, C Chem MRIC, Croda Premier Oils Ltd, Ann Watson Street, Stoneferry. (*Hull*)
- BREWER, PAUL ELLIS, BSc, ICI (NZ) Ltd, PO Box 1592, Wellington, New Zealand. (*Wellington*)
- DAVIS, ALISTAIR INGRAM, P Bag 6621, Kopje, Salisbury, Rhodesia. (*Transvaal*)
- DU PLESSIS, CORNELIUS MARTINUS, Top Paints (Pty) Ltd, PO Box 525, Meyerton 1960, South Africa. (*Transvaal*)
- EYLLERS, PETRUS GERARDUS, W I Chester Gardens, Cnr. Charles Meath Road, Avondale West, Salisbury, Rhodesia. (*Transvaal*)
- GIBSON, DAVID WILLIAM, Willowvale Motor Industries (Pvt) Ltd, PO Box ST 497, Southerton, Salisbury, Rhodesia. (*Transvaal*)
- HEATH, JEFFREY, Usher Walker Ltd, Canal Street, Kirkintilloch, Glasgow. (*Scottish*)
- HUDSON, ARTHUR, 18 Shortheath Road, Chisiptic, Salisbury, Rhodesia. (*Transvaal*)
- HUNTER, CRAIG LINDSAY, BSc, Mobil Oil (NZ) Ltd, PO Box 38073, Petone, New Zealand. (*Wellington*)
- JEFFINOS, MUKARO, Alka Paint Industries Ltd, PO Box 3843, Salisbury, Rhodesia. (*Transvaal*)
- KITCHEN, DEREK, BSc, Jaclin (Pvt) Ltd, Box 662, Salisbury, Rhodesia. (*Transvaal*)
- NEWTON, BRIAN, Hempel's Marine Paints WLL, PO Box 1077, Dammam, Saudi Arabia. (*General Overseas*)
- PETERS, HAROLD, BSc, Von Riebeck Paints (Pty) Ltd, Private Bag 131, Kuilsriver 7580, South Africa. (*Cape*)

- SNOWDON, DEREK RAYMOND, PO Box ST 92, Southerton, Salisbury, Rhodesia. (*Transvaal*)
- STRATMORE, JOHN BENSON, BSc, 111 Naenae Road, Box 35136, Naenae, Lower Hutt, New Zealand. (*Wellington*)
- THOMSON, BRUCE OLIVER, Dulux Rhodesia Ltd, Box ST 92, Southerton, Salisbury, Rhodesia. (*Transvaal*)
- VAN CAMPFORT, JOE, Expandite Ltd, PO Box 38079, Petone, New Zealand. (*Wellington*)

#### Associate Members

- BLACKSTOCK, PATRICK IAN, 6 Westminster Avenue, PO Avondale, Salisbury, Rhodesia. (*Transvaal*)
- BOOK, MICHAEL, 58 8th Avenue, La Rochelle, Johannesburg, South Africa. (*Transvaal*)
- BOTHA, C T J, 279 Wellfreer Road, Bluff, Durban 4001, South Africa. (*Natal*)
- CHAMBERS, JOHN, Resene Paints Ltd, PO Box 36-006, Moera, Lower Hutt, New Zealand. (*Wellington*)
- GILHOOLEY, GERARD JOHN, 50 Hozier Street, Blackburn BB1 3JP. (*Manchester*)
- HENSHAW, JOHN DOUGLAS, Dulux Paints, PO Box ST 92, Southerton, Salisbury, Rhodesia. (*Transvaal*)
- JARRETT, MURRAY ROYDEN, A C Hatrick (NZ) Ltd, PO Box 51005, Tawa, New Zealand. (*Wellington*)
- JONES, HUGH MERVYN, Willowvale Motor Industries (Pvt) Ltd, Box ST 497, Southerton, Salisbury, Rhodesia. (*Transvaal*)
- PACKER, MICHAEL PATRICK, 2 Herbert Street, PO Box 30 148, Lower Hutt, New Zealand. (*Wellington*)
- RAMA, SHIRISH, Resene Paints Ltd, PO Box 36-006, Moera, Lower Hutt, New Zealand. (*Wellington*)
- ROMMENS, KEITH, 1 Barlow Close, Glen Lorne, Salisbury, Rhodesia. (*Transvaal*)

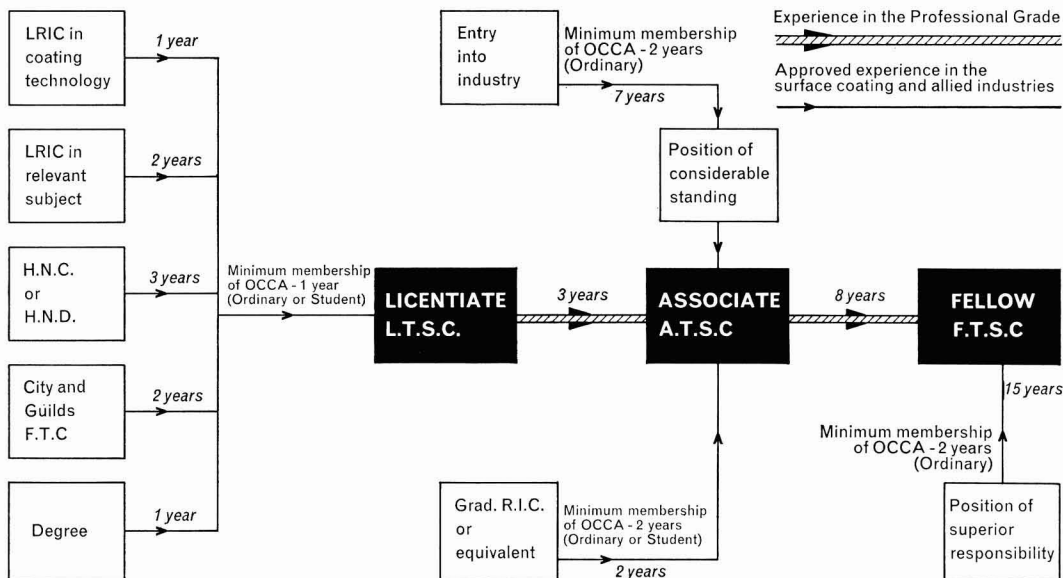
#### Registered Student

- SIMPSON, DAVID JOHN, 9 Hurstfold Avenue, Burnage, Manchester M19 1RE. (*Manchester*)

# Optional Professional Grade for Ordinary Members

The innovation of the Professional Grade has proved to be most successful, as evidenced by the impressive list of names in the December 1977 issue of the *Journal*. For the convenience of potential applicants, a chart indicating different routes to the various grades is shown below.

## Routes to the Professional Grades



Note: At present there is no restriction on Students up to 21; between 21 and 25 a certificate from the employer or college confirming the course being taken is required.

## Regulations for admission to the Professional Grade

Note: For the sake of simplicity, reference is made only to UK examinations etc., but equivalent qualifications overseas will naturally be accepted.

### A. Licentiate

1. Shall be an Ordinary Member of the Association and have been an Ordinary Member or Student of the Association for not less than one year.

2. Shall have attained the age of 22.

3. (a) Shall be a Licentiate of the Royal Institute of Chemistry in Coatings Technology (*viz.* Higher National Certificate + Endorsement in coatings technology + 1 year approved experience in the science or technology of coatings after passing the endorsement examination).

OR (b) Shall be a Licentiate of the Royal Institute of Chemistry in another relevant subject such as advanced analytical chemistry, colour chemistry or polymer science, and shall

have two years' approved experience of coatings since so qualifying.

OR (c) Shall hold the Full Technological Certificate of the City and Guilds of London Institute in a relevant subject as approved by the Professional Grade Committee and shall have two years' approved experience in the science or technology of coatings since gaining the FTC.

OR (d) Shall have passed Higher National Certificate or Higher National Diploma with three years' approved experience in the science or technology of coatings since qualifying, but two years' approved pre-qualification experience shall be deemed equivalent to the third post-qualification year.

OR (e) Shall be graduate in relevant subject with not less than 1 year's approved experience.

OR (f) Shall have passed such other qualifications as approved by the Professional Grade Committee from time to time.

4. Shall be required to satisfy the Professional Grade Committee, or some other body approved by the Professional Grade Committee in a *viva voce* examination and submit a dissertation on a topic previously approved by the Professional Grade Committee.

5. Shall normally be sponsored by three Ordinary Members of the Association in the professional grade (either Associate or Fellow) at least one of whom must be a Fellow.

6. Shall have paid the fee stipulated by the Council and have paid the current subscription payable by an Ordinary Member.

**B. Associate, being already a Licentiate**

1. Shall, since his election to the Licentiate-ship, have practised the science or technology of coatings for not less than three years.
2. Shall provide evidence acceptable to the Professional Grade Committee of his superior professional skill and maturity.
3. Shall hold the City & Guilds of London Institute Insignia Award OR shall submit a thesis or dissertation of comparable level on a topic previously approved by the Professional Grade Committee OR shall have published work which, in the opinion of the Professional Grade Committee, is of comparable merit.
4. MAY be required to satisfy the Professional Grade Committee or some other body as approved by the Professional Grade Committee in a *viva voce* examination.
5. Shall normally be sponsored by three Ordinary Members of the Association in the professional grade (either Associate or Fellow) at least one of whom must be a Fellow.
6. Shall have paid the fee stipulated by the Council and have paid the current subscription payable by an Ordinary Member.

**C. Associate, not already a Licentiate****EITHER**

1. Shall be not less than 24 years of age.
2. Shall be an Ordinary Member of the Association and have been an Ordinary Member or Student of the Association for not less than two years.
3. Shall hold the Graduateship of the Royal Institute of Chemistry or Council of Physics or a University or Council of National Academic Awards degree recognised by the Royal Institute of Chemistry or Institute of Physics as giving full exemption from the Graduateship examination.
4. Shall have not less than two years' approved post-graduate experience in the science or technology of coatings.
5. Shall normally be required to satisfy the Professional Grade Committee or some other body approved by the Professional Grade Committee, at a *viva voce* examination.
6. Shall normally be sponsored by three Ordinary Members of the Association in the professional grade (either Associate or Fellow) at least one of whom must be a Fellow.
7. Shall have paid the fee stipulated by the Council and have paid the current subscription payable by an Ordinary Member.

**OR**

8. Shall be not less than 30 years of age.
9. Shall be an Ordinary Member of the Association and have been an Ordinary Member of the Association for not less than two years.

10 Shall have been engaged in practising the science or technology of coatings for not less than seven years and shall have attained a position of considerable standing in the industry.

11 Shall normally be required to satisfy the Professional Grade Committee in *viva voce* examination of his professional competence.

12 Shall normally be sponsored by three Ordinary Members of the Association in the professional grade (either Associate or Fellow) at least one of whom must be a Fellow.

13 Shall have paid the fee stipulated by the Council and have paid the current subscription payable by an Ordinary Member.

**D. Fellow**

*Note:* This is the senior award of the professional grade and signifies that the holder has made outstanding contributions to the science or technology of coatings or has reached a position of eminence in the industry through the practice thereof. The Professional Grade Committee will require substantial evidence of professional maturity in the science or technology of coatings although commercial experience will be taken into account in assessing the merits of candidates.

1. Shall be not less than 33 years of age.
2. Shall have been an Ordinary Member of the Association for not less than two years.
3. Shall be engaged in a position of superior responsibility in the coatings industry.
4. EITHER (a) shall have been an Associate of the professional grade for at least eight years;  
OR (b) shall have not less than fifteen years' experience of the science or technology of coatings in a position of superior responsibility.
5. Shall submit, with his application, an account of his experience, with due reference to scientific and technological interests, achievements and publications.
6. Shall normally be sponsored by three Ordinary Members of the Association in the professional grade, all of whom must be Fellows.
7. Shall have paid the fee stipulated by the Council and have paid the current subscription payable by an Ordinary Member.

*The fees payable with applications are as follows:*

Fellow—£10.00	Associate—£6.00
Licentiate—£3.00	
(Plus VAT at standard rate)	

**Application**

Completed application forms should be returned, together with the appropriate remittance, to the Director & Secretary at the Association's offices (except in the case of those Members attached to the Auckland,

South African and Wellington Sections who should address their forms to their Section Hon. Secretaries).

The Committee wishes it to be known that Members rejoining the Association after a period in other industries may include length of service as an Ordinary Member before their resignation as part of the qualifying periods for entry into the Grade.

Students wishing to apply for entry into the Professional Grade must first make application in writing for upgrading to Ordinary Membership, giving the reasons for their eligibility for such regrading. Applications, together with the appropriate remittance, should be addressed as for application for admission to the Professional Grade.

Potential applicants are recommended to give the fullest possible details of their appointments, including the number and type of staff under their control, and indicating to whom the applicant is responsible, as this aids the committee considerably in its deliberations.

It is felt that applicants for admission to the Licentiate grade might wish to have further information on the pattern which it is suggested should be followed for dissertations, the subjects of which have first to be approved by the Professional Grade Committee.

The dissertation should be preceded by a short summary and commence with a brief introduction and some account of the current state of knowledge. Where practicable it should follow the general format of a paper in *JOCCA*.

The dissertation may be a review of a subject, a theoretical treatment, descriptive of practical work or a combination of these. It must indicate that the candidate has a reasonably wide and up-to-date knowledge of his chosen subject and understands the basic scientific principles underlying it, and that he is able to think critically and constructively.

Where practical work is described, some attempts should be made to draw theoretical conclusions or to form some provisional hypothesis, together with an outline of what further work would be required to confirm the views put forward or further to advance the knowledge of the subject.

Where the dissertation is a review or a theoretical treatment, there should be an attempt to contrast and compare any opposing views expressed in earlier works, to examine the views critically, to suggest any compromise interpretation, to account for all the known facts and to outline any further work by which the opposing views could be tested.

Where applicable, references should be given to published work, graphs, diagrams etc. to be appended.

Length: Text should be approximately 5 000 words.

Applicants should refer to the paper by Moss which appeared in the January 1973 issue; the Professional Grade Committee feels that candidates for the Licentiate grade could with advantage use this paper as a model for their dissertations.



## Professional Grade

At a meeting of the Professional Grade Committee held on 5 July 1978, the following Ordinary Members were admitted to the categories shown. The Section to which each Member is attached is shown in brackets.

### Fellow

Albert Kenneth Rileigh (*General Overseas—Australia*)

Herman Rudolph Hamburg (*London*)

### Transfer from Associate to Fellow

Peter John McQuirk (*London*)

### Associate

Herbert Walter Maynard Armstrong (*London*)

Anthony Harold Hughes (*Manchester*)

Paul Francis Le Maistre (*Midlands*)

Brian James Smith (*London*)

### Courses for Licentiatehip

Several colleges of further education are willing to help Registered Students and Ordinary Members of the Association with courses and the preparation of dissertations in respect of Licentiatehip in the Technology of Surface Coatings (LTSC). Details of the courses including those within the TEC framework are available from:

**Watford College**, Hempstead Road, Watford, Herts WD1 3EZ.  
Mr L. Young, Head of Department of Printing and Packaging.

**London College of Printing**, Elephant and Castle, London SE16.  
Mr K. Bradshaw, Science and Printing Department.

**Polytechnic of the South Bank**, Borough Road, London SE1 0AA.  
Mr P. Barnes, Department of Chemistry and Polymer Technology.

**Manchester Polytechnic**, All Saints, Manchester M15 6BR.  
Mr G. Higginbotham, Department of Printing Technology.

**Manchester Polytechnic**, Chester Street, Manchester M1 5GD.  
Mr R. Stott, Department of Polymer Technology.

**College of Arts & Technology**, Maple Terrace, Newcastle upon Tyne NE4 7SA.  
Mr P. Maycock, Head of Department of Science.

**East Ham College of Technology**, High Road South, London E64ER.  
Mr G. Wood, Department of Sciences.

**The Polytechnic**, Wolverhampton WV1 1LY.  
Dr B. W. Rockett.

**Matthew Boulton Technical College**, Sherlock Street, Birmingham 5.  
Mr C. J. Thompson.

**Coventry Technical College**, Butts, Coventry CV1 3GD.  
Dr M. J. Hall, Head of Department of Science.

**Warley College of Technology**, Crocketts Lane, Smethwick, Warley B66 3BU.  
Dr R. A. W. Longden, Head of Department of Chemistry, Computing and Applied Sciences.

**Langley College of Further Education**, Station Road, Langley, Slough SL3 8BY.  
Mr L. H. Smith, Head of Applied Sciences Department.

**Stow College—Glasgow**, 43 Shamrock Street, Glasgow G4 9LD.  
Mr D. C. Dunn, Head of Department of Management Services.

## Section Programmes for the 1978-79 session

### Main Association Events

#### 1979

**Tuesday 3—Friday 6 April**, OCCA-31 Technical Exhibition, to be held at Alexandra Palace, London, N22.

**Wednesday 20—Saturday 23 June** OCCA Conference, to be held at the Stratford Hilton Hotel, Stratford-on-Avon.

**Friday 22 June** Annual General Meeting at the Stratford Hilton Hotel, Stratford-on-Avon, *time to be announced*.

### Auckland

#### 1978

**Thursday 27 July—Sunday 30 July** OCCA Convention at Rotorua—Hotel International (Organised by the Wellington Section).

**August** Lecture on Airless spray by speaker from Nordson, U.S.A. *Details to be announced*.

**September** Talk and factory inspection—N. Z. Starch Products Ltd, Te Papapa. *Details to be announced*.

**October** "Hot method adhesives and coatings" by Mr David Reid of Peterson's Chemicals. *Details to be announced*.

**November** Talk and inspection of the Water Treatment Plant, Auckland Regional Authority at Titirangi, by Mr D. Payne. *Details to be announced*.

#### 1979

**March** Annual General Meeting. *Details to be announced*.

### Bristol

Unless otherwise stated, all meetings will be held at the Royal Hotel, College Green, Bristol, at 7.15 p.m.

#### 1978

**Friday 29 September** "The development of horizontal milling, with particular reference to the Dyno Mill" by Mr D. I. R. Kerr of Glen Creston Machinery Ltd.

**Friday 27 October** "The refinishing of motor vehicles" by Mr D. E. Sellen of Berger Paints.

**Friday 24 November** *Ladies' evening*. "The colouring and decoration of pottery" by Mr A. J. Simkin of Blythe Colours Ltd.

#### 1979

**Friday 26 January** "Water reducible printing inks" by Mr R. C. Coates of Coates Brothers Inks Ltd.

**Friday 23 February** "Surface active agents

in surface coatings" by Dr A. Pryce of ABM Chemicals Ltd. Joint meeting with the Birmingham Paint, Varnish and Lacquer Club.

**Friday 23 March** Annual Dinner Dance at the Mayfair Suite, New Bristol Centre.

**Friday 30 March** "Prohesion, methods of test and prediction of performance" by Mr F. D. Timmins of British Rail, Derby.

**Friday 27 April** Annual General Meeting.

### Hull

Unless otherwise stated, the meetings will be held at the George Hotel, Land of Green Ginger, Hull at 6.30 p.m.

#### 1978

**Monday 2 October** "The practical problems of painting and maintaining large industrial plant" by D. A. Bayliss of B. I. E. Anti-Corrosion Ltd. Joint meeting to be held with the Institution of Chemical Engineers at the Humber Bridge Hotel, Barton, South Humber side at 6.45 p.m.

**Friday 6 October** Annual Dinner Dance to be held at the Willerby Manor Hotel, Willerby, Nr. Hull.

**Monday 6 November** "The safe use of solvents and the trend toward development of low aromatic grades" by G. Hicks of Esso Chemicals Ltd.

**Monday 4 December** "The manufacture of self adhesive labels" by R. Couch of Harlands of Hull Ltd, *details to be announced.*

#### 1979

**Monday 8 January** "Training" by T. A-Fillingham of the Marfleet Refining Co. Ltd.

**Monday 5 February** "Developments in milling and dispersing equipment" by a speaker from Herbert Smith & Co. Ltd, *details to be announced.*

**Monday 5 March Ladies' Evening** "Drug abuse", lecture and film to be given by a member of the Drug Squad of the Humber-side Police.

**Monday 2 April** Annual General Meeting.

## Irish

Unless otherwise stated, all meetings will be held at the Clarence Hotel, Dublin at 8.00 p.m.

#### 1978

**Friday 15 September** "The theory and practice of pigment dispersion" by Dr W. Carr, Ciba-Geigy.

**Friday 20 October** "Aqueous based printing inks" by Mr R. Millard, Harlow Chemical Co. Ltd.

**Friday 24 November** Annual Dinner Dance at the Clarence Hotel, 8.30 p.m.

**Friday 8 December** "Dispersion techniques" by Mr R. Ward, Torrance & Sons Ltd.

#### 1979

**Friday 19 January Ladies' Evening**—Wine/cheese at the Clarence Hotel.

**Friday 16 February** "Low odour solvents" by lecturer from Carless Chemicals Ltd.

**Friday 23 March** "Fire prevention in factory/home" by Dublin Fire Department.

**Friday 20 April** Annual General Meeting at the Clarence Hotel at 9 p.m.

**June** Annual Golf Outing—*details to be announced.*

## London

#### 1978

**Thursday 21 September** "Marketing with reference to the developing countries and the EEC" by Mr R. I. Farr, Cowan Colours Ltd, at the "Princess Alice", Romford Road, E7 commencing at 6.15 p.m.

**Tuesday 17 October** Afternoon visit to the Metropolitan Police Forensic Science Laboratory, Lambert Road, London SE1, commencing at 2.30 p.m.

**Wednesday 18 October** "Finishes and materials for window frames" by Mr P. Whiteley, Building Research Establishment at Rubens Hotel, Buckingham Palace Road, SW1, commencing at 7.00 p.m.

**Friday 27 October Ladies' Night** to be held at Selsdon Park Hotel, Sanderstead, Surrey, commencing at 7.00 p.m. for 7.30 p.m.

**Friday 17 November** "Colour instrumentation". Day meeting in association with the Society of Dyers and Colourists, London Region, at Thames Polytechnic, Woolwich, commencing at 10.00 a.m.

#### 1979

**Thursday 18 January** Lecture on permeability (*full title to be announced later*) by Mr A. Roberts, C.E.G.B., Scientific Services Dept, at the "Princess Alice", Romford Road, E7, commencing at 7.00 p.m.

**Wednesday 21 February** "Novel ink systems" by Mr P. G. Richardson, Fishburn Printing Ink Co. Ltd, at Rubens Hotel, Buckingham Palace Road, SW1, commencing at 7.00 p.m.

**Friday 16 March** "Maintenance painting of structural steel". Day meeting in association with the Institute of Corrosion Science and Technology at Thames Polytechnic, Woolwich, commencing at 10.00 a.m.

**Thursday 19 April** Annual General Meeting at Rubens Hotel, Buckingham Palace Road, SW1, commencing at 6.30 p.m.

**Wednesday 20 June** Afternoon visit to Exposure Trials Station, Central Dockyard Laboratory, Ferry Road, Eastney, Portsmouth, commencing at 2.30 p.m.

## Manchester

#### 1978

**Wednesday 13 September** Golf Tournament at the Stockport Golf Club, *details to be announced.*

**Friday 15 September** Student Seminar "Emulsion paints" at the Woodcourt Hotel, Sale, Cheshire, *details to be announced.*

**Friday 13 October** "Theory versus practice of dispersion" by Dr W. Carr of Leeds University at the Manchester Literary & Philosophical Society, George Street, Manchester commencing 6.30 p.m.

**Friday 20 October** Annual Dinner at the Piccadilly Hotel, Manchester, *details to be announced.*

**Monday 6 November** "Quality control" by Mr Murray of Crown Decorative Products Ltd, at the Woodcourt Hotel, Sale, commencing at 6.30 p.m.

**Wednesday 15 November Student Lecture** "Additives improve emulsion paints" by Mr B. L. Hinds of Allied Colloids at Manchester Literary & Philosophical Society, George Street, Manchester, commencing at 4.30 p.m.

**Friday 8 December** "Long-life paint systems—sensible methods of test at last" by Mr Timmins of British Rail Ltd at Manchester Literary & Philosophical Society, George Street, Manchester, commencing at 6.30 p.m.

#### 1979

**Monday 8 January** "Titanium dioxide in coloured stoving enamels" by Dr R. Schwindt of Kronos Titanium Pigments Ltd, at the Woodcourt Hotel, Sale, commencing at 6.30 p.m.

**Wednesday 24 January Student Lecture** "Paints for electrodeposition" by W. G.

Topham of Goodlass Wall Ltd at Manchester Literary & Philosophical Society, George Street, Manchester, commencing at 4.30 p.m.

**Monday 5 February** "Inks for packaging" by Mr Duffin of Irlam Inks. Joint lecture with Institute of Printing Inks at Woodcourt Hotel, Sale, commencing at 6.30 p.m.

**Wednesday 21 February Student Lecture** "Powder versus water based paints, a comparison of properties" by K. H. Dodd of Carrs Paints at Manchester Literary & Philosophical Society, George Street, Manchester, commencing at 4.30 p.m.

**Friday 9 March** Informal Buffet Dance at the RAFA Club, Sale, *details to be announced.*

**Wednesday 14 March** Student works visit, *details to be arranged.*

**Friday 16 March** "North Sea oil" by lecturer from Esso Ltd at Manchester Literary & Philosophical Society, George Street, Manchester, commencing at 6.30 p.m.

**Friday 20 April** Annual General Meeting at the Pavilion Room, Old Trafford, *details to be announced.*

## Midlands

Unless otherwise stated, all meetings will be held at the Calthorpe Suite, County Ground, Birmingham, commencing at 6.30 p.m.

#### 1978

**Friday 22 September Ladies' Night.** Dinner and Dance at the Botanical Gardens, Birmingham, *details to be announced.*

**Thursday 28 September** "Foaming in aqueous media" by T. G. Palmer of Bevaloid Ltd.

**Thursday 19 October** "Coil coating" by Mr E. Sharpe of Merritts Ltd.

**Thursday 16 November Student Lecture.** "Mineral pigments through the ages" by Mr E. Hare.

#### 1979

**Friday 19 January** Dinner Lecture in conjunction with Trent Valley Branch "Protection of structures involved in North Sea oil operations" by Mr J. R. Bourne of Mebon Ltd and Mr F. H. Palmer of BP Ltd, to be held at Chamber of Commerce & Industry Ltd, Harborne Road, Birmingham, *details to be announced.*

**Thursday 15 February** "Case for chromes" by F. Chapman and A. Cowley from ICI Ltd.

**Wednesday 23 March J. Newton Friend Lecture. Ladies Invitation and Buffet.** "Mountain rescue" by Dr D. Bunting to be held at Chamber of Commerce & Industry Ltd., Harborne Road, Birmingham, *details to be announced.*

**April** Annual General Meeting, *details to be announced.*

### Trent Valley Branch

Unless otherwise stated, all meetings will be held at the Crest Hotel, Pastures Hill,

Littleover, Derby, commencing at 7.00 p.m.

#### 1978

**Thursday 14 September** "Cathodic protection" by D. E. Marlborough of Metal & Pipeline Endurance Ltd.

**Thursday 12 October** "Coil coatings" by Dr Gilmore of Conway Coatings Ltd.

**Friday 27 November** Halloween dance at the Cross Keys Inn, Turnditch, *details to be announced.*

**Thursday 9 November** "Effect of coatings on the quality of drinking water" by Dr N. P. Burman.

#### 1979

**Thursday 8 February** "Printing of food packaging materials" by a speaker from Bemrose Packaging.

**Thursday 8 March** "Latest developments in driers" by Mr J. H. W. Turner of Manchem Ltd.

**Friday 6 April** Annual General Meeting followed by a Buffet Dance at the Cross Keys Inn, Turnditch, *details to be announced.*

## Newcastle

Unless otherwise stated, all meetings will be held at St. Mary's College, Elvet Hill Road, Durham, commencing at 6.30 p.m.

#### 1978

**Thursday 5 October** "Solvent recovery for the surface coatings industry" by Mr I. Smallwood, of Fraser McNaughton Ltd.

**Thursday 2 November** "Recent advances in pigment dispersion and dispersion equipment" by Mr R. W. English and Mr J. Perkins of Mastermix Engineering Ltd.

**Thursday 7 December** "Paint Research Association and the surface coatings industry" by Mr J. H. Arendt of the Paint Research Association.

#### 1979

**Thursday 4 January** Management paper—*title to be announced.*

**Thursday 1 February** Joint meeting with the Plastics and Rubber Institute. "Glass fibre reinforced polyester as a substrate for painting" by Mr F. E. Bassford of Cray Valley Products Ltd.

**Friday 16 February Ladies' Night** to be held at Five Bridges Hotel, Gateshead, *details to be announced.*

**Thursday 8 March** "Water borne paints in industrial coating" by Dr H. Rauch-Puntigam, of Vianova Kunstharz AG.

**Thursday 5 April** Annual General Meeting.

## Scottish

Unless otherwise stated, all meetings will take place at the Albany Hotel, Glasgow, commencing at 6.00 p.m.

#### 1978

**Thursday 12 October** "The practical problems of painting and maintaining large industrial plants" by D. Bayliss, BIE Anti-Corrosion Ltd.

**Thursday 9 November** "The academic-industrial interface" Joint meeting with ASDC, commencing at 7.30 p.m.

**Friday 8 December** "Biodeterioration in surface coatings" by Dr D. Allsop of University of Aston.

#### 1979

**Friday 12 January Ladies' annual evening.**

**Thursday 18 January** "New developments in azo pigments" by A. G. Abel of Hoechst UK Ltd.

**Saturday 10 February** "Fundamentals of modern emulsion paint formulation" by J. Clark of BTP Ltd. *Student invitation lecture.*

**Thursday 8 March** "Calcium and zinc ferrites—Two new anti-corrosive pigments" by a lecturer from Bayer Ltd.

**Thursday 12 April** Annual General Meeting followed by *Ladies' Evening*. Evening of light music, *venue to be arranged.*

## Eastern Branch

#### 1978

**Friday 20 October** Skittles match, *details to be announced.*

**Wednesday 22 November** "Hydrocarbon resins" by A. Malatesta, a speaker from Esso Chemicals Ltd, *venue to be announced.*

**Thursday 14 December** "Scientific aspects of carton printing" by D. Lawson, a speaker from Wm. Thyne Ltd, *venue to be announced.*

#### 1979

**Wednesday 24 January** "Dispersion techniques" by J. Davidson, *venue to be announced.*

**Wednesday 28 February** "Acrylic emulsions in and on paper" by J. B. Tait of Rohn & Haas Ltd, *venue to be announced.*

**Wednesday 21 March** Annual General Meeting, *details to be announced.*

## Thames Valley

Unless otherwise stated, all meetings will be held at the Beaconsfield Crest Motel (White Hart), Aylesbury End, Beaconsfield, Bucks, commencing at 6.30 p.m. for 7.00 p.m.

#### 1978

**Friday 8 September** Medieval evening at Great Fosters, Egham, *details to be announced.*

**Thursday 12 October** One day meeting at Building Research Establishment, Princes Risborough. "Coatings for wood", *details to be announced.*

**Thursday 9 November** "N.A.D.s. A progress

report" by Mr M. Waghorn of ICI Paints Ltd.

**Thursday 7 December** "Accelerated weathering tests—objectives and choice of methods" by Dr M. L. Ellinger of Ault & Wiborg Paints Ltd.

#### 1979

**Thursday 25 January** "Quinacridone pigments" by Dr R. Zabel of E. I. du Pont de Nemours & Co. Inc.

**Friday 9 February** Buffet dance at Great Fosters, Egham, *details to be announced.*

**Thursday 22 February** "Screen printing and its application to textiles and carpets" by H. H. Lavell of Sericol Ltd.

**Thursday 15 March** "Recent advances in photoinitiators for UV curing" by M. A. Parrish of Ward Blenkinsop & Co. Ltd.

**Thursday 19 April** Annual General Meeting followed by the talk on "Local history" by G. Berry.

## West Riding

Unless otherwise stated, all Meetings will be held at the Mansion Hotel, Roundhay Park, Leeds, 8, commencing at 7.30 p.m. Would members please note that meetings will take place on the 1st Tuesday in every month.

#### 1978

**September** West Riding Chairmans' Golf Trophy at the Knaresborough Golf Course. *Date to be arranged.*

**Tuesday 5 September** "Defoaming agents: the theory and application with regard to the paint industry" by Mr R. W. Harrison of Diamond Shamrock Chemicals (UK) Ltd.

**Tuesday 3 October** "Instrumental colour control in the paint industry" by Mr R. P. Best of Instrumental Colour Systems Ltd.

**Tuesday 7 November** "The testing of hazardous chemicals with particular reference to the requirements of the Health and Safety at Work Act" by Mr D. H. Pullinger, Assistant Scientific Director of the Bazelton Laboratory Europe Ltd.

**Friday 24 November** Dinner Dance at the Crown Hotel, Harrogate, *details to be announced.*

**Tuesday 5 December** "Pencil manufacturer" by Mr D. W. Tee of The Cumberland Pencil Company Ltd.

#### 1979

**Tuesday 2 January** West Riding Chairman's Lecture—*subject to be announced.*

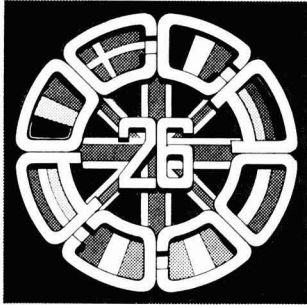
**Tuesday 6 February** "Some aspects of corrosion in C.E.G.B. installations" by Mr R. Umpleby of C.E.G.B. Scientific Services Department.

**Tuesday 6 March** "Water borne paints as industrial coatings" by Dr H. Rauch-Puntigam of Vianova Kunstharz, Aktiengesellschaft.

**Tuesday 3 April** Annual General Meeting.

# “The OCCA”

The annual technical exhibition of the Oil and Colour Chemists' Association (known to many simply as “The OCCA”) has become the world's most important event for all those connected with the paint, printing ink, polymer, adhesive, colour and allied manufacturing industries. The OCCA exhibition is held every year in London, England. The symbols for the 1974-79 exhibitions were specially designed by Robert Hamblin, Director and Secretary of the Association, to emphasise the very wide coverage which all the Association's activities attract:



The motif for OCCA-26 used the flags of the enlarged EEC converging on the British flag to symbolise the welcome extended to visitors from overseas to the Exhibitions for more than 25 years. (1974)

## The INTERNATIONAL Focal Point for the Surface Coatings Industries



The motif for OCCA-31 emphasises the unique aspect of the OCCA Exhibitions, which annually provide an international focal point for the surface coatings industries.



The 1974 theme continued at OCCA-27 by showing the world-wide interest aroused by the Association's annual Exhibitions in London which attract visitors from all parts of the globe.

The OCCA Exhibitions provide a unique annual focal point for the surface coatings industries, and bring together technical personnel to meet in an informal atmosphere allowing a free interchange of ideas and the rapid dissemination of knowledge of new products and new developments of existing products.

In recent years, visitors to the OCCA Exhibitions have regularly come from over fifty overseas countries and at the 1978 Exhibition, admissions by season ticket of over 10,000 were recorded at the turnstiles in the hall.



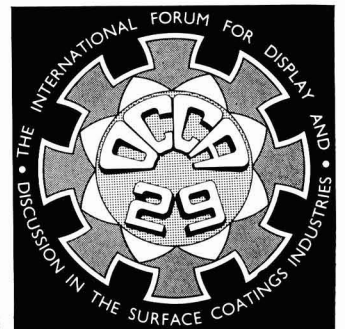
The motif for OCCA-30 used the symbol of a moving indicator on a calendar to emphasise the importance of the continuous dialogue year by year between suppliers and manufacturers.

The Exhibition provides an ideal opportunity for organisations to display and discuss their products and services to a wide spectrum of visitors from all over the world.


Organisations wishing to receive further details should contact the Director & Secretary, Mr R. H. Hamblin, Oil & Colour Chemists' Association, Priory House, 967 Harrow Road, Wembley, Middlesex HA0 2SF, England (Tel: 01-908 1086, Telex: 922670 OCCA G).



The motif for OCCA-28 emphasised that the target for 1976 was London where all the Exhibitions have been held, and continued the theme of its international aspect.



In 1977 the motif for OCCA-29 used inward pointing arrows to show the many places from which people came to the Exhibition, and these arrows formed outward pointing arrows to show the subsequent spreading of knowledge.



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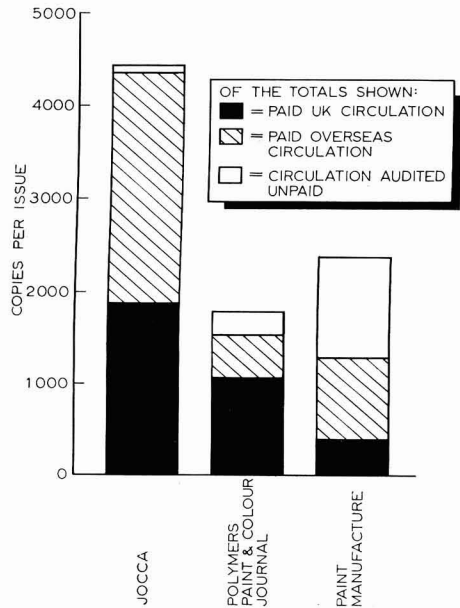
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(Reference Audit Bureau of Circulations Reviews.  
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For full details of advertising in this, and other Association publications, contact D. M. Sanders, Assistant Editor

## Journal of the Oil and Colour Chemists' Association (JOCCA)

Priory House, 967 Harrow Road, Wembley, Middx.  
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# OIL & COLOUR CHEMISTS' ASSOCIATION

Newcastle Section Symposium



# ULTRAVIOLET POLYMERISATION AND THE SURFACE COATING INDUSTRIES

# UV2 UV2

The eleven papers in this volume were originally published in the *Journal* earlier in 1978. They are based on lectures given at the Second International Symposium of the Newcastle Section of the Association held at Durham University on 14 and 15 September 1977. Titles and authors are listed below :

Exciplex interactions in photoinitiation of polymerisation by fluorenone amine systems *by A. Ledwith, J. A. Bosley and M. D. Purbrick*

Recent developments in photoinitiators *by G. Berner, R. Kirchmayr and G. Rist*

Present status of ultraviolet curable coatings technology in the United States *by J. Pelgrims*

The design and construction of ultraviolet lamp systems for the curing of coatings and inks *by R. E. Knight*

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The use of differential scanning calorimetry in photocuring studies *by A. C. Evans, C. Armstrong and R. J. Tolman*

The UV curing behaviour of some photoinitiators and photo-activators *by M. J. Davis, J. Doherty, A. A. Godfrey, P. N. Green, J. R. A. Young and M. A. Parrish*

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**2-5 November 1978**

**Lectures:**

Regulatory legislation - effect on pre-  
servative choice by *Mr A. J. Hinton  
ICI Ltd*

Epoxy-polyester coatings by *Mr W. L.  
Whitfield and Mr J. Greeves, B.I.P. Ltd*

Environmental legislation, new coatings  
are here by *Mr K. Piggott, Prolux*

Electron beam curing of coatings by  
*Dr G. D'Ollain, Atomic Energy Board*

Powder coatings - a need for definition  
by *Mr B. J. Stephens, Plascon-  
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Consultation before painting avoids  
litigation after by *Mr E. Duligal SABS*

Paint extenders based on naturally  
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Some diverse applications of pre-  
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**INDEX TO ADVERTISERS**

<b>D</b>		<b>N</b>	
Desert Sunshine Exposure Tests Inc. . . . .	ii	Neuman & Nydahl AB . . . . .	Cover
<b>F</b>		<b>Q</b>	
Federation of Societies for Coatings Tech- nology . . . . .	Cover	Q-Panel Co. . . . .	i
<b>M</b>		<b>S</b>	
Madley, Richard (Printers) Ltd . . . . .	Cover	Sanyo-Kokusaku Pulp Co Inc. . . . .	i
Mastermix Engineering Co. Ltd. . . . .	iii	Servo BV . . . . .	vi
		Shell International Chemicals . . . . .	viii, ix
		Sub-Tropical Testing Service Inc. . . . .	iii

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OIL & COLOUR



CHEMISTS'

ASSOCIATION



TECHNICAL EXHIBITION

3-6 APRIL 1979

The motif for OCCA-31, designed by Robert Hamblin, emphasises the unique aspect of the OCCA Exhibitions, which annually provide an international focal point for the surface coatings industries. In 1978, exhibitors were drawn from sixteen countries and visitors from over fifty countries.

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