

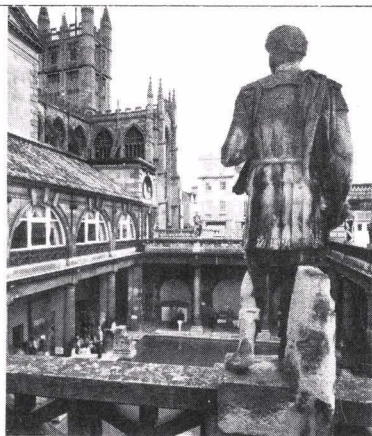


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Spectrophotometric studies on shellac. The relation between optical density and colour index

D. N. Goswami, N. Prasad and R. N. Das

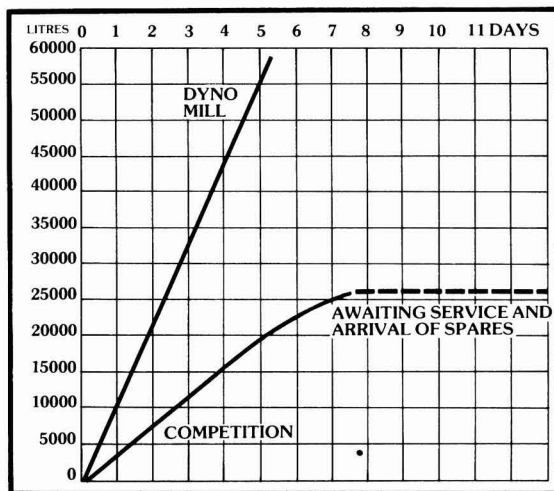
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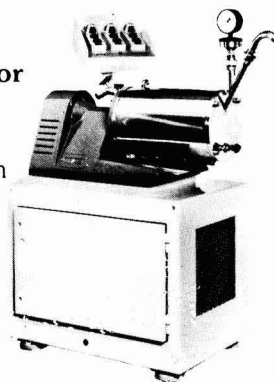
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Determination of metallic copper, cuprous oxide and cupric oxide during the manufacture and storage of antifouling paints

By C. A. Giudice, B. del Amo and J. C. Benitez

CIDEPINT, Research & Development Centre for Paint Technology, 52 - 121 y 122, 1900 La Plata, Argentina

Summary

The toxic efficiency of antifouling paints based on cuprous oxide, is influenced by the chemical composition of the toxicant (purity of cuprous oxide) and by the particle size distribution. These characteristics are determined by the conditions that exist during the electrolysis of cuprous oxide.

The presence of Cu^{2+} ions generated during cuprous oxide manufacture, during the preparation of the antifouling paint (milling and dispersing) or when the final product is stored, produces a reduction in the matrix solubility due to the formation of a substance which also affects the paint's bioactivity.

The pigment's composition is modified during storage under

the normal conditions employed in the paint industry and the Cu^0 (metallic Cu) and Cu^{2+} content is increased with a consequent reduction in the amount of cuprous oxide.

It was established that the generation of Cu^{2+} ions became significant when the milling and dispersing of cuprous oxide was carried out in water, in a solvent mixture or in an oleoresinous binder. The Cu^0 and Cu^{2+} content in the paint also increased as a function of storage time.

It has been demonstrated in this study that it is necessary to control the different stages of antifouling paint manufacture when cuprous oxide and rosin WW are used as raw materials.

Keywords

Types and classes of coatings and allied products

antifouling coating

Raw materials for coatings

prime pigments and dyes

copper oxide

surface active and rheological agents

dispersion agent

Processes and methods primarily associated with manufacturing or synthesis

dispersion
milling

service or utility

aging

La détermination de cuivre, de l'oxyde cuivreux et de l'oxyde cuivrique en peintures "antifouling", lors de leur préparation et stockage

Résumé

En peintures "antifouling" à base de l'oxyde cuivreux, la composition de l'agent toxique (la teneur en oxyde cuivreux), et la granulométrie exercent une influence sur leur efficacité toxique. Ces caractéristiques sont largement déterminées par les conditions qui régissent pendant la préparation de l'oxyde cuivreux à partir du cuivre électrolytique.

La présence des ions Cu^{2+} , produits soit lors de la fabrication de l'oxyde cuivreux ou de la préparation de la peinture "antifouling" (procédés de dispersion ou de broyage), soit où le produit fini est stocké, provoque une diminution de la solubilité dans la matrice à cause de la formation d'une substance qui, en même temps, est nuisible aux caractéristiques biocides de la peinture.

Sous les conditions normales à l'industrie de peintures, la com-

position du pigment se modifie lors du stockage, et la teneur en Cu^0 et en Cu^{2+} s'augmentent.

Il était possible d'établir que l'évolution des ions Cu^{2+} atteignait aux valeurs significantes où la dispersion et le broyage de l'oxyde cuivreux sont effectués soit à l'eau, soit dans un mélange de solvants, soit dans un vernis gras. La teneur en Cu^0 et en Cu^{2+} de la peinture s'augmentaient également en fonction de la durée de stockage.

Au cours de cette étude on a démontré, lorsque l'oxyde cuivreux et la colophane WW sont utilisés en tant que matières premières, qu'il est nécessaire de contrôler les diverses étapes de la fabrication de la peinture "antifouling".

Die Bestimmung von Kupfer, Kupfer(I)oxyd und Kupfer(II)oxyd in Antifoulingfarben, während ihrer Herstellung und Lagerung

Zusammenfassung

In auf Kupfer(I)oxyd gegründeten Antifoulingfarben wird die

Giftstoffsleistungsfähigkeit von der chemischen Zusammen-

setzung des Giftstoffs (der Gehalt an Kupfer(I)oxyd) und die Korngrösseverteilung beeinflusst. Diese Eigenschaften werden von den Bedingungen bestimmt, die bei der Herstellung von Kupfer(I)oxyd aus elektrolytischem Kupfer herrschen. Die Anwesenheit von Cu²⁺ Ionen, die während der Herstellung von Kupfer(I)oxyd oder von der Antifoulingfarbe (Dispergierungs- oder Mahlungverfahren), oder während der Lagerung des Fertigprodukts erzeugt werden, wirken eine Verminderung der Löslichkeit in der Grundsubstanz, wegen der Bildung einer Substanz, die die Giftwirksamkeit der Antifoulingfarben nachteilig beeinflusst.

Während der Lagerung unter den gewöhnlichen Bedingungen, die in der Farbenindustrie benutzt werden, wird die Zusammen-

setzung des Pigments modifiziert, und wird der Gehalt an Cu⁰ und Cu²⁺ vergrössert, so dass der Gehalt an Kupfer(I)oxyd vermindert wird.

Man konnte feststellen dass die Hervorbringung von Cu²⁺ Ionen erreichte bedeutsame Werte wenn die Dispergierung und die Mahlung von Kupfer(I)oxyd in Wasser, in einem Lösungsmittelgemisch, oder in einem Ölharzbindermittel ausgeführt werden. Der Gehalt an Cu⁰ und Cu²⁺ in der Antifoulingfarbe vergrösserte sich auch dem Lagerzeit gemäss. In dieser Arbeit hat man gezeigt dass es nötig ist die verschiedenen Stufen der Antifoulingfarbenherstellung zu kontrollieren, wenn Kupfer(I)oxyd und Kolophonium WW als Grundstoffe benutzt wird.

Introduction

Refs. 1-8

Substratums submerged in sea water are rapidly colonised by benthic organisms (fouling). In the case of ships' bottoms, the growth of fauna and flora increases the frictional resistance of vessels, producing displacement difficulties. These organisms furthermore, deteriorate the organic coating and facilitate the corrosion of the metallic surface. The use of efficient antifouling paints thus becomes crucial¹ and are then the most important layer in the paint system employed for hull protection, if they assure bioactivity over long periods.

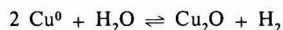
The antifouling paint film constantly changes its composition when in contact with sea water. Normally the matrix and toxicants become soluble, the latter having a lethal effect on fouling. The solubility of the oleoresinous antifouling paints used in the experiments below were based on the reaction between the abietic acid of rosin WW and sea water (pH 8.2). The solubility of the film was controlled by the addition of a plasticiser; a phenolic varnish was used in the formulations² below.

Cuprous oxide was used as the main toxicant and has toxic characteristics that have been proven in previous papers³⁻⁶, due to its wide spectrum it has a lethal action on most fouling organisms.

The dissolution mechanism of cuprous oxide is based on the formation of soluble complexes of the (Cl₂Cu)⁻ and (Cl₂Cu)²⁻ type⁷. The maximum toxic action takes place in the layer adjacent to the painted surface and away from this zone decreases rapidly.

The toxicant composition and the particle size distribution influence the toxic efficiency. These characteristics are affected by the conditions in the electrolytic manufacturing process.

The equation corresponding to cuprous oxide formation is:



The yield of the industrial operation depends, amongst other things, on the density of applied current, temperature, pH and the electrolyte concentration used.

Thus the bath temperature influences the purity, particle size and the colour of the final product. The current density affects the crystal size and, if it is not adequate, may be used to modify the purity by the formation of Cu²⁺ ions.

In the production of cuprous oxide the electrolytic processes may generate variable quantities of Cu⁰ and Cu²⁺ and it is therefore necessary to adjust the working conditions to avoid or reduce the quantity of these ions to a minimum. Furthermore, due to the dismutation or oxidation of cuprous oxide in contact with humid air, it is necessary to stabilise the pigment immediately after the electrolytic process.

To obtain an efficient antifouling paint it is necessary to use a correct formulation and the different stages of the manufacturing process must be controlled as these factors influence the final behaviour of the product.

The cupric ions generated during the electrolysis of cuprous oxide, in the preparation of the antifouling paint (grinding and dispersion) and in its subsequent storage decrease the binder solubility due to the formation of a substance of the type: (C₂₀H₂₉O₂)₂Cu.

As a consequence of the above considerations it was necessary to establish the content of metallic copper (Cu⁰), cuprous oxide (Cu⁺) and cupric oxide (Cu²⁺) at the different stages indicated previously. For this, analytical techniques of control were adapted⁸, they are indicated in the Appendix.

Experimental

Ref. 9

Pigment analysis

A freshly prepared and stabilised commercial sample of cuprous oxide was dipped first in toluene and then in neutral 96 per cent ethyl alcohol. It was dried at 105-110°C and weighed after cooling in a desiccator. The stabiliser material content was about 12 per cent in the different samples.

To establish the efficiency of the stabilisation process, a sample was stored in a container hermetically sealed using anhydrous calcium chloride as a dehydrating agent. Room temperature ranged between 20 and 25°C. The sample was analysed daily over a period of a month to determine the Cu⁰, Cu⁺, Cu²⁺ and total copper content. The latter was also determined electrolytically. The results obtained are shown in Table 1.

Grinding of pigment in different media; the influence of storage

The initial pigment composition is shown in Table 1 (the value corresponding to the first day).

Table 1
Modification of pigment composition during storage* (per cent, w/w)

Time (days)	Cu ⁰	Cu ₂ O	CuO	Total copper content	
				Chemical method	Electrochemical method
1	0.03	99.84	0.04	88.74	88.72
2	0.13	99.13	0.53	88.60	88.68
3	0.21	98.38	1.30	88.63	88.63
4	0.30	97.75	1.51	88.17	88.58
5	0.38	96.74	2.25	88.10	88.54
6	0.47	96.16	2.65	88.00	88.50
8	0.61	95.20	3.63	88.07	88.41
10	0.74	94.16	4.53	87.99	88.32
15	1.02	92.41	6.09	87.96	88.09
30	1.43	88.98	8.78	87.47	87.42

*Before paint preparation

The pigment was dispersed in a porcelain ball mill (capacity 3.3 litres) with a rotational speed of 59 rpm. The ball load occupied 50 per cent of the total volume of the container and consisted of balls of three different sizes (19.0, 22.5 and 25.0 mm in diameter, with a weight relationship of 1:1:1). The interstitial space generated was 41 per cent⁹.

The jar was filled in all cases with 810 g of cuprous oxide and 690 g of dispersing medium (distilled water, a mixture of toluene/white spirit or an oleoresinous binder).

Working temperatures ranged from 25 to 28°C and the grinding time was 150 hours.

The amount of Cu⁰, Cu⁺ and Cu²⁺ was determined on the basis of the pigment extracted from the paint sample by successive washings with solvents. The solvents were tested to determine the content of Cu⁺ and Cu²⁺.

As a consequence of the dispersion experiments in the three above mentioned media, the following considerations should be noted:

- Distilled water was used in order to obtain preliminary information on the emulsion type antifouling formulations (the stability of cuprous oxide in this media). In this case, the influence of grinding and storage times on the relative amounts of Cu⁰/Cu⁺/Cu²⁺ was established immediately after the preparation of the samples.
- The toluene/white spirit mixture (1:1 weight ratio) was employed as it is the usual solvent in antifouling paints of the oleoresinous type and in order to obtain information on the behaviour of cuprous oxide in this medium. Also in this case the influence of the grinding and storage times was determined with regard to the different states of copper oxidation.
- The oleoresinous binder used as a dispersing medium had the composition set out in Table 2 and

Table 2

Composition of the oleoresinous binder (per cent, w/w)

Rosin WW*	39.1
Plasticiser	13.1
Solvent mixture (toluene/white spirit 1:1)	47.8

*Abietic acid content: 85.0% w/w

has been shown to provide a matrix with adequate leaching rate both in raft and service trials. The same variables mentioned previously were assessed, the grinding time was 150 hours and the samples were stored for 48 months (the influence of ageing was studied using samples with three hours of grinding).

Results

Refs. 9-12

A major difficulty in the manufacture of efficient antifouling paints is the storage of stable cuprous oxide, this in spite of the stabilisation effected at the end of the electrolytic manufacturing process.

The analysis of the commercial pigment used, 24 hours after preparation, showed that the content of metallic copper and cupric oxide was small and of a similar magnitude (0.03 and 0.04 per cent, respectively). The purity of this product was 99.83 per cent.

The composition of the pigment during storage, under the conditions previously mentioned, altered with an increase in the amount of Cu⁰ and Cu²⁺. Within 10 days the metallic copper reached a concentration of 0.74 per cent; this amount has no significance in the composition of a paint. The decrease in the amount of cuprous oxide during this period exceeded 5 per cent compared to the original pigment; this loss would not modify the bioactivity of the antifouling paint, since a cuprous oxide level of 19 or 20 per cent in the paint showed equal toxic efficiency in previous trials.

The content of cupric oxide during this period (10 days) reached a significant value (4.53 per cent), increasing to 8.78 per cent after 30 days of storage. During manufacture this amount of cupric oxide will reduce the quantity of free abietic acid, considerably affecting the solubility of the matrix. During this latter period the quantity of Cu⁰ and Cu₂O was 1.43 and 88.98 per cent respectively.

The results obtained show that the formation of cupric ions is greater than that of metallic copper. These ions are produced by the simultaneous processes of dismutation and the oxidation of cuprous oxide, a phenomenon which acquires greater significance with time.

Analysing the results obtained in the grinding and

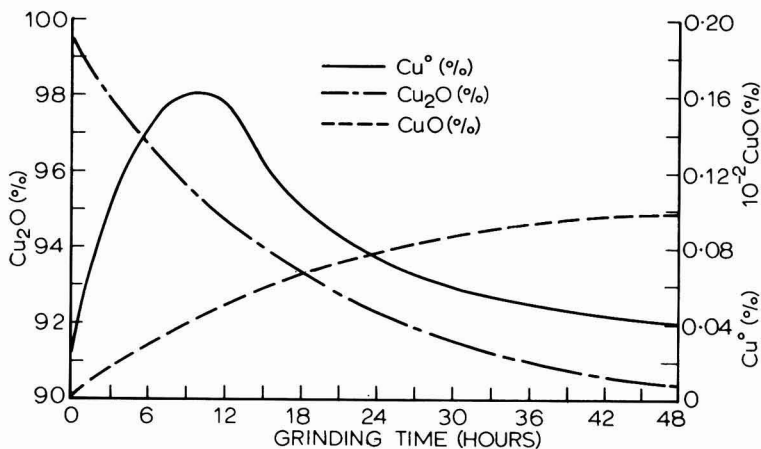


Figure 1. Pigment composition for different grinding times (dispersing medium, distilled water)

dispersion processes, carried out in water and in the solvent mixture, they demonstrate that the conversion of cuprous oxide to its other oxidation states takes place more rapidly in water for equal milling times. In both cases it can be seen that initially there is a rapid reaction with the production of cupric ions (Cu²⁺) taking place in direct proportion to the grinding time. The cupric oxide generated after 15 hours of grinding in distilled water was 10.9 per cent (Figure 1) and 5.7 per cent in the solvent mixture (Figure 2). After 48 hours of grinding the cupric oxide content was 15.2 per cent in water and 9.8 per cent in the solvent mixture. Measurements were taken immediately after the end of the dispersion process. The different behaviour represents a cupric oxide increase of 91.2 per cent taking into account the toluene-white spirit medium. The difference, although greater than in the previous case, is lower when considered as an overall percentage (55.1 per cent). This seems to be caused by the greater amount of oxygen dissolved in distilled water compared with that in the solvent mixture which after a rapid initial reaction in both cases reaches similar levels inside the mill.

Using the oleoresinous binder as a dispersing medium the grinding time again had an important effect on the generation of cupric ions.

In this case, the oxidation of cuprous ions to Cu²⁺ during grinding may have been caused by a reaction with the oxygen contained in the jar or by the presence of other binder components. However, the generation of cupric ions was less than that produced when distilled water or the solvent mixture was used, due to an organic film that surrounded the pigment particles.

After 15 and 48 hours of grinding, the amounts of cupric oxide produced, in relation to the pigment content, were 2.61 and 6.82 per cent respectively.

After an initial period of rapid reaction, the quantity of Cu²⁺ ions was directly proportional to the grinding time (Figure 3). During this stage the cupric oxide that had formed reacts with the acid components of the binder (especially with the abietic acid of the rosin WW) forming a substance of the (C₂₀H₂₉O₂)₂Cu type. The total formed

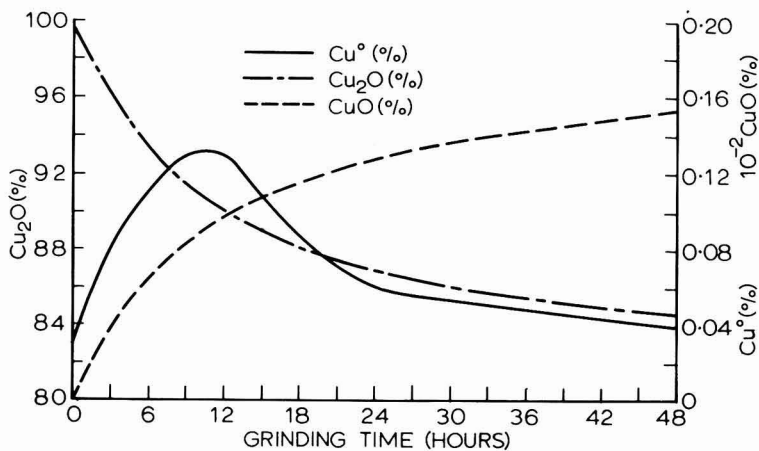


Figure 2. Pigment composition for different grinding times (dispersing medium, toluene-white spirit mixture)

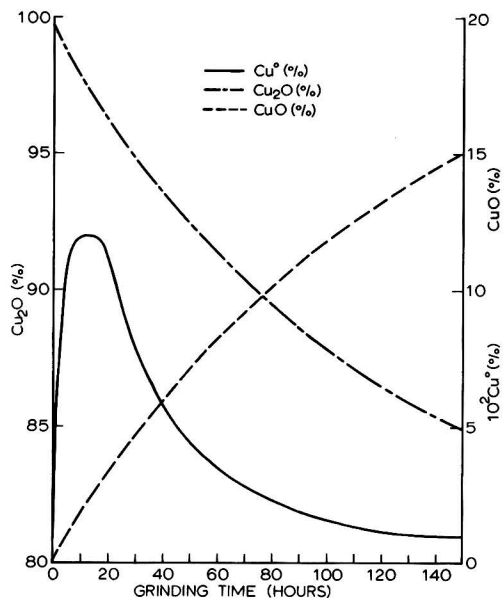


Figure 3. Pigment composition for different grinding times (dispersing medium, oleoresinous binder)

depended principally on the relative amounts of rosin WW and cuprous oxide, on the time and efficiency of the grinding process and on the temperature in the mill.

The reaction was assessed immediately after the end of the process by determining the cupric oxide formed and the remaining cuprous oxide.

The quantity of rosin WW that takes part in the above reaction can be calculated by presuming that the final compound is produced stoichiometrically and in a complete form.

The percentages of resin that reacted at different grinding times were calculated on the basis of this hypothesis, they correspond to a paint containing 54 per cent cuprous oxide and are shown in Table 3. It can be seen that the reaction has significantly reduced the quantity of free abietic acid, thus affecting the rosin WW/plasticiser ratio and the solubility of the binder in sea water. Consequently this reaction reduces the leaching rate of the paint. After three hours grinding the quantity of abietic acid consumed would amount to 21 per cent of the total quantity of rosin WW present in the formulation; after 24 hours it would be totally consumed. The analysis of the data obtained during the grinding process shows the necessity for adequate controls due to the chemical changes that take place.

The preparation of an antifouling paint in a pilot plant or on an industrial scale, starting from an optimised

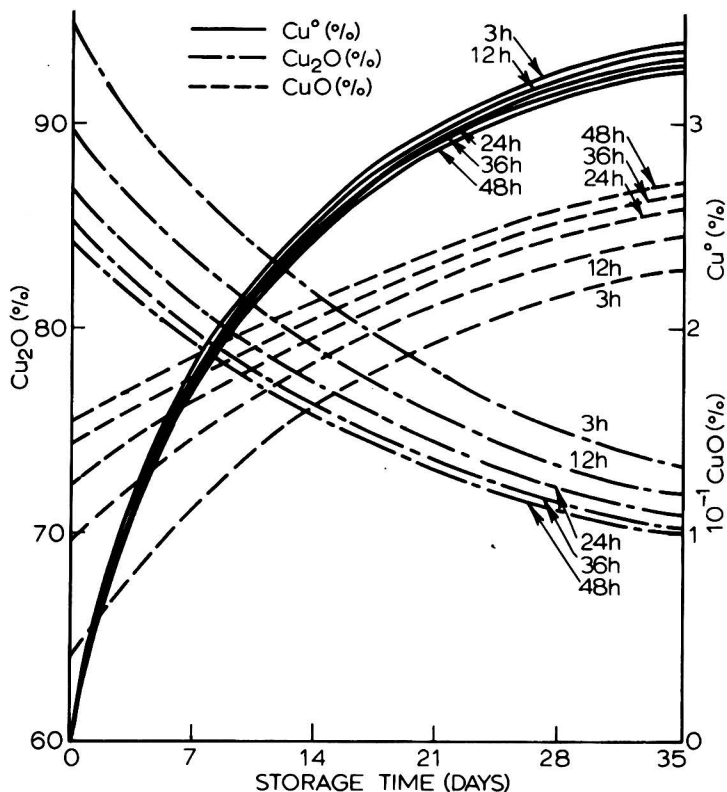


Figure 4. Pigment composition for different storage and grinding times (dispersing medium, distilled water)

Table 3
Calculation of free abietic acid for different grinding times in an antifouling paint*

Grinding time (hours)	Cupric oxide (per cent, in pigment)	Abietic acid consumed (per cent, in paint)	Abietic acid consumed (per cent, in original rosin WW)
3	0.79	3.2	21.0
6	1.23	5.0	32.8
9	1.75	7.2	47.1
12	2.22	9.1	59.5
15	2.60	10.6	69.4
18	3.00	12.3	80.6
21	3.45	14.1	92.3
24	3.80	15.6	101.7

*Cuprous oxide content in paint: 54%, w/w

laboratory formulation, can be done by carrying out a study of the variables relating to the change of scale or by following the reaction from the "chemical point of view", determining the cupric oxide formed and stopping the process when a predetermined quantity is reached. Thus, antifouling paints of equal bioactivity can be manufactured starting from the same formulation but using equipment of different sizes and operating characteristics^{9,12}.

Pigment composition varies with different storage and grinding times. This is also the case with dispersing media where significant amounts of Cu⁺ are transformed into other oxidation states (Cu⁰ and Cu²⁺). This process is accentuated when distilled water is employed (Figure 4) compared with the solvent mixture (Figure 5). This transformation is directly proportional to the ageing time.

Using a paint that had been milled for 3 hours, the

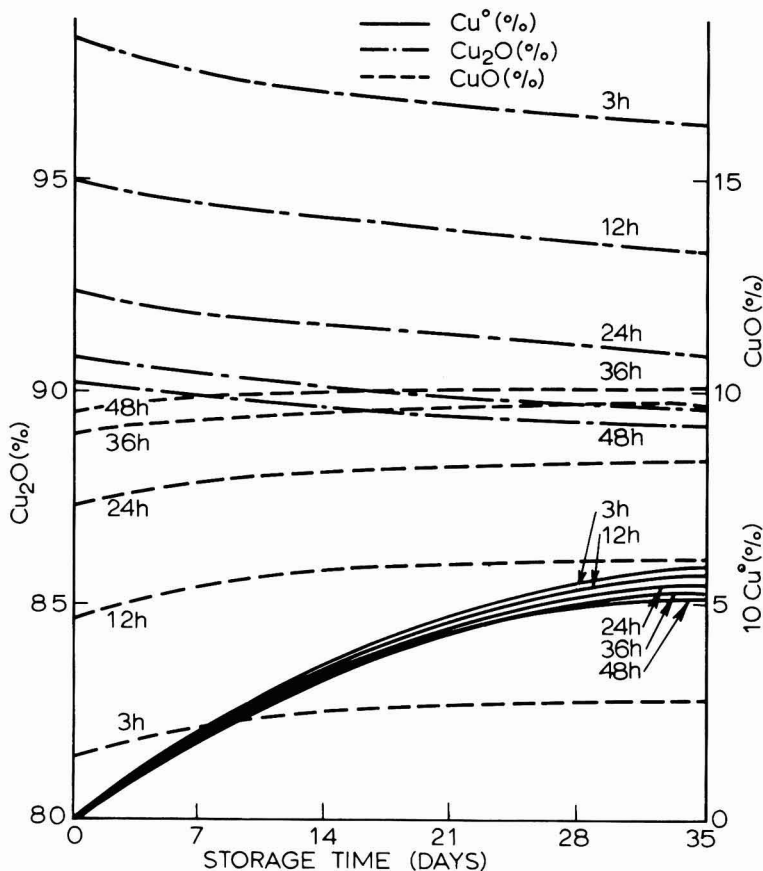


Figure 5. Pigment composition for different storage and grinding times (dispersing medium, toluene-white spirit mixture)

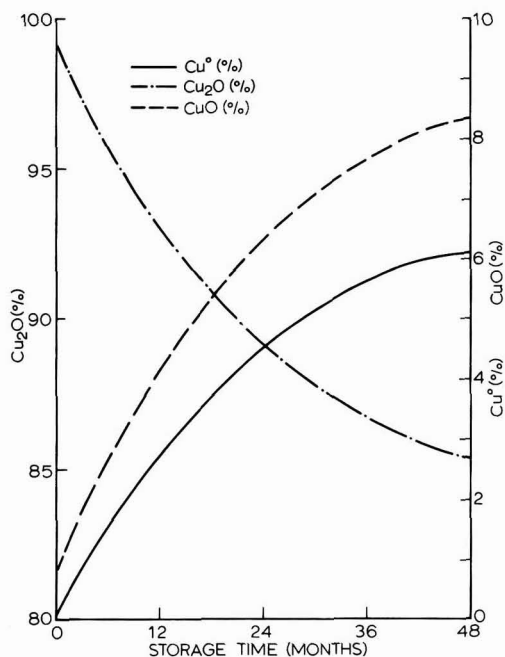


Figure 6. Pigment composition for different storage times in a paint produced after 3 hours of grinding (dispersing medium, oleoresinous binder)

influence of ageing was determined by chemical analysis of the pigment. The results obtained (Figure 6) show the increase in metallic copper and cupric oxide content. After 180 days of storage the values obtained were, respectively, 1.61 and 2.65 per cent, calculated in terms of dry pigment. The quantity of combined abietic acid (Table 4) was 70.6 per cent related to that contained in the resin. After 300 days of storage, the amount of metallic copper and cupric oxide in the pigment was 2.67 and 3.77 per cent, respectively, values corresponding to a theoretically complete reaction of the free abietic acid of the resin. In this form the solubility of the matrix changes and the bioactivity is affected.

The ageing process due to storage can be evaluated directly by determining the amount of metallic copper in

the pigment as cupric oxide is not generated at this stage. The copper produced during grinding remains adhered to the balls and to the walls of the jar, thus the content in the paint immediately after preparation is negligible.

Although it is necessary to control storage, the critical stage from the point of view of the appearance of Cu²⁺ is related to the manufacturing process.

Data obtained after 3 hours of grinding showed that 21 per cent of the abietic acid from the original content of resin had been consumed. After subsequent storage for 30 days the total consumption of abietic acid amounted to 31 per cent. The storage "contribution" over this period was 10 per cent.

If the toxicant content was less than that used in the samples, the generation of metallic copper and cupric oxide would decrease proportionally. In this case the influence of the grinding process and storage time would be reduced.

Conclusions

1. The electrolytic production of cuprous oxide gives a final product of high purity. However, stabilisation of the pigment is not adequate and the industrial product does not meet storage requirements.
2. The control of the cuprous oxide grinding process can be monitored by determining the quantity of Cu²⁺ ions generated. The ageing process during storage can be monitored directly by determining the metallic copper generated.
3. If the rosin WW/plasticiser ratio is high (very soluble matrices) and the content of cuprous oxide low, the influence of grinding and storage is not important, since the amount of cupric oxide generated at both stages is not significant. The consumption of abietic acid expressed in per cent (w/w) will then be low and the matrix solubility will not be affected. On the other hand, for the same amount of cuprous oxide in the formulation, if the rosin WW/plasticiser ratio is low, the percentage of the abietic acid consumed will be very significant and will reduce the leaching rate of the paint.
4. The results obtained show the importance of optimising the grinding process in order to prepare antifouling paints with the same bioactivity, though employing different equipment.

Table 4
Calculation of free abietic acid for different storage times in an antifouling paint*

Storage time (days)	Cupric oxide (per cent, in pigment)	Abietic acid consumed (per cent, in paint)	Abietic acid consumed (per cent, in original rosin WW)
30	1.15	4.7	31.0
60	1.50	6.1	39.7
90	1.81	7.4	48.3
120	2.12	8.5	55.8
150	2.40	9.8	63.8
180	2.65	10.8	70.6
210	2.90	11.8	76.9
240	3.20	13.1	85.6
270	3.45	14.1	92.4
300	3.77	15.4	101.0

*Cuprous oxide content in the paint: 54%, w/w

5. The analytical techniques employed to determine the metallic copper, cuprous oxide and cupric oxide content of the pigment of an antifouling paint seem to be acceptable for the objectives of this study. This was confirmed by the determination of total copper content by an electrolytic method.

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Appendix

Metallic copper determination

Weigh approximately 1 g of cuprous oxide, free of stabilising material, put it in an Erlenmeyer and remove the air with a current of carbon dioxide. Without interrupting the gaseous flow add 150 ml of extraction solution (solution I) avoiding violent agitation. The time required for the complete dissolution of the cuprous oxide ranges from 1 to 5 minutes. The liquid is filtered by suction and the precipitate washed 5 or 6 times with distilled water saturated with carbon dioxide to eliminate remnants of reducing agents.

Heat the solid, consisting of a mixture of cupric oxide and metallic copper, with 15 ml of ferric chloride (solution II) until its dissolution (below 40°C); add 10 ml of 85 per cent phosphoric acid and 3 g of indicator (solution III) and titrate with potassium dichromate (solution IV). The final point is indicated by a change of colour from green to dark violet.

Cuprous oxide determination

Weigh a sample of approximately 0.2 g and add 15 ml of ferric

chloride (solution II) for its dissolution. Bubble carbon dioxide to make the atmosphere inert and then titrate the Fe²⁺ ions with potassium dichromate solution, assessing metallic copper and cuprous oxide content. The cuprous oxide of the sample is calculated in the following manner:

$$\text{Cu}_2\text{O} \% = \left(V - \frac{\text{Cu} \% \times p_1}{N \times mE_1 \times 100} \right) \frac{N \times mE_2}{p_2} 100$$

where:

mE ₁	milliequivalent of metallic copper (0.03177)
mE ₂	milliequivalent of Cu ⁺ (0.06354)
p ₁	weight of the sample used to determine Cu ⁺
p ₂	weight of the sample analysed
N	normality of potassium dichromate solution

Cupric oxide determination

Weigh approximately 1 g of sample and place in an iodine flask, glass stoppered, adding 10 ml of acetic acid and 5 g of potassium iodide. Let it react for 5 minutes and begin titration with a solution of sodium thiosulfate (solution V) until it takes a pale yellow colour, adding 2 ml of starch solution at 2 per cent and continue titration until the blue colour disappears. Add 3 ml of potassium thiocyanate solution at 50 per cent and the titration ends when it takes a white colour.

Solutions used

Extraction solution (solution I)

Add 6 g of hydrazine sulfate to 1 litre of ammonium hydroxide.

Ferric chloride solution (solution II)

Weigh 150 g of ferric chloride, dissolve in 300 ml of concentrated hydrochloric acid and add 800 ml of distilled water that has been boiled and saturated with carbon dioxide. Keep in a closed container.

Indicator (solution III)

Weigh 2 g of dyphenil-barium-sulfonate and add 5 g of sodium sulfate. Add 50 ml of distilled water saturated with carbon dioxide. Shake until a uniform suspension is obtained and add 50 ml of distilled water, filter and keep in a covered dark bottle.

Potassium dichromate solution (solution IV)

Weigh approximately 4.9 g of potassium dichromate and add distilled water to complete 1 litre.

Sodium thiosulfate solution (solution V)

Weigh approximately 24.8 g of sodium thiosulfate, add distilled water recently boiled to complete 1 litre. Add a preserver (chloroform, borax, anhydrous sodium carbonate, etc.) and contrast it with a solution of potassium dichromate.

Spectrophotometric studies on shellac. The relation between optical density and colour index

By D. N. Goswami, N. Prasad and R. N. Das

Division of Chemistry, Indian Lac Research Institute, Ranchi 834 010, Bihar, India

Summary

The absorption spectra of different shellacs of various colour indices were investigated in the complete UV and visible region. Absorption peaks were obtained at 225, 425 and around 290

nm for all shellacs. At a particular concentration, the optical density at 425 nm was found to increase with an increase in the colour index of shellac.

Keywords

Properties, characteristics and conditions primarily associated with materials in general

translucency

Miscellaneous terms

colour index

Types and classes of coatings and allied products

shellac

Processes and methods primarily associated with analysis, measurement or testing

spectroscopy

Les études spectrophotométriques sur la gomme laque. Le rapport entre la densité optique et l'index de couleur

Résumé

Les spectres d'absorption de diverses variétés de gomme laque ayant de différents indices de couleur ont été étudiés à la région visible et à l'ultra-violet. On a obtenu, dans le cas de toutes les gommes laques, les pics d'absorption à 225, 425 et 290 nm à

peu près. On a trouvé, à une concentration particulière, que la densité optique à 425 nm augmente à mesure que l'index de couleur de la gomme laque augmente.

Spektrophotometrische Untersuchungen über Shellack. Die Beziehung zwischen optischer Dichte und Colour Index

Zusammenfassung

Die Absorptionsspektren verschiedener Shellacke, deren Colour Index unähnlich ist, wurden in dem UV und dem visuellen Gebiet untersucht. Absorptionsspitzen an 225, 425 und etwa

290 nm wurden in Falle aller Shellacke erhalten. An einer bestimmten Konzentration fand man dass die optische Dichte an 425 nm zunahm als der Colour Index des Shellacks zunahm.

Introduction

Refs. 1-9

All methods of spectroscopy have found extensive application in polymer characterisation. The main application of ultraviolet absorption spectroscopy is in the detection, identification and quantitative analysis of additives such as stabilisers, accelerators as well as aiding in structure determination¹. Although most of the physical and chemical characteristics of lac have been determined, so far no study has been made on the absorption spectra of whole lac (shellac) in the visible and ultraviolet region. Some studies have, however, been made on the absorption spectra of the individual constituent terpenic acids of shellac in the UV region^{2,5}. Besides the terpenic acids erythrolaccin⁶ (1,2,5,7-tetrahydroxy-4-methyl anthraquinone), the colouring material present in shellac was also expected to exhibit absorption maxima in the visible

region. In the present paper, the absorption spectra of shellac in the combined UV and visible region is reported.

Colour is an important aspect in the sale and purchase of shellac. The colour of shellac, which varies from a translucent pale orange to an almost opaque dark red, is of great importance to the consumers where the lighter grades are in greatest demand. In spite of the considerable importance attached to this physical property there are very few methods available for its assessment. The existing methods are generally based on matching colours of diluted alcoholic solutions of shellac with a standard iodine or other solution^{7,9}. In the present report, a relationship has been established between the optical density and the colour index of shellac.

Materials and methods

Different shellacs of various colour indices were obtained

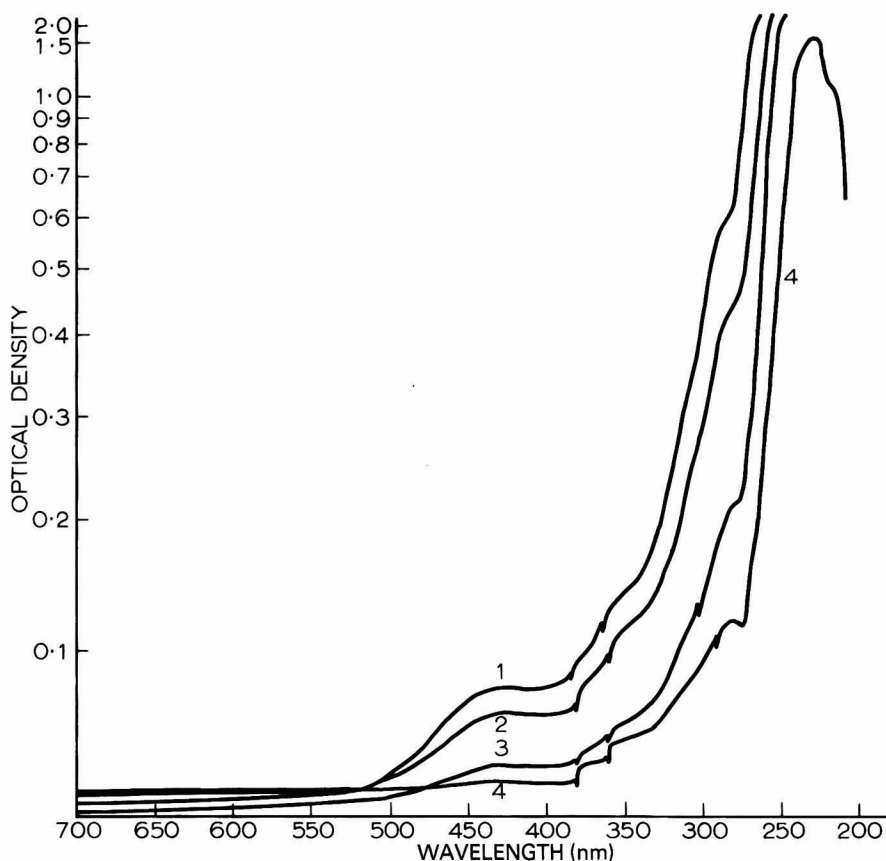


Figure 1. Absorption spectra of dewaxed lemon (DL) shellac at different concentrations. (1) 1.5×10^{-3} , (2) 10^{-3} , (3) 4.5×10^{-4} , (4) 10^{-4} g/ml

from M/s. Angelo Brothers, Calcutta. The colour indices of the shellacs obtained from the manufacturer were compared with values determined analytically in the conventional manner. Both sets of values were in good agreement. The average values of the colour indices are shown in Table 1 against the corresponding type of shellac. Bhatta shellac (a rural product) and bleached lac were obtained from the Technology Block of the Institute of Lac Research.

A Beckman DB-GT spectrophotometer together with a Beckman 1005 ten inch recorder were used for obtaining

Table 1

Colour indices of various commercially available shellacs

Shellac type	Colour index
Platina	0.6
Super Blonde	0.85
Blonde	1.7
Lunar	2.7
DL	6
DO	10
Deora	20
DG	35
Bhatta	16

the absorption spectra. The absorption spectra of all shellacs were taken in 95 per cent ethyl alcohol solution.

Results

The absorption spectra of dewaxed lemon (DL) shellac at different concentrations in the complete UV and visible region are shown in Figure 1. At higher concentrations a distinct absorption maximum and shoulder can be observed at 425 and 350 nm respectively. At a concentration of 10^{-4} g/ml, a few additional peaks at 225 and 285 nm were obtained together with a shoulder at 215 nm.

The absorption spectra of bleached lac at different concentrations in the UV and visible region are shown in Figure 2. It may be noticed that the absorption maximum and shoulder at 425 and 350 nm, as observed in the case of DL shellac, are absent. In the UV region absorption maxima at 225 and 290-300 nm were obtained together with two small peaks at 255 and 265 nm. The absorption peak at around 290 nm (at a concentration of 1.5×10^{-3} g/ml), was found to occur at a higher wavelength with the lowering of concentration. The shoulder obtained at 215 nm for DL shellac was found to be replaced by a sharp peak in the spectra of bleached lac (Figure 2).

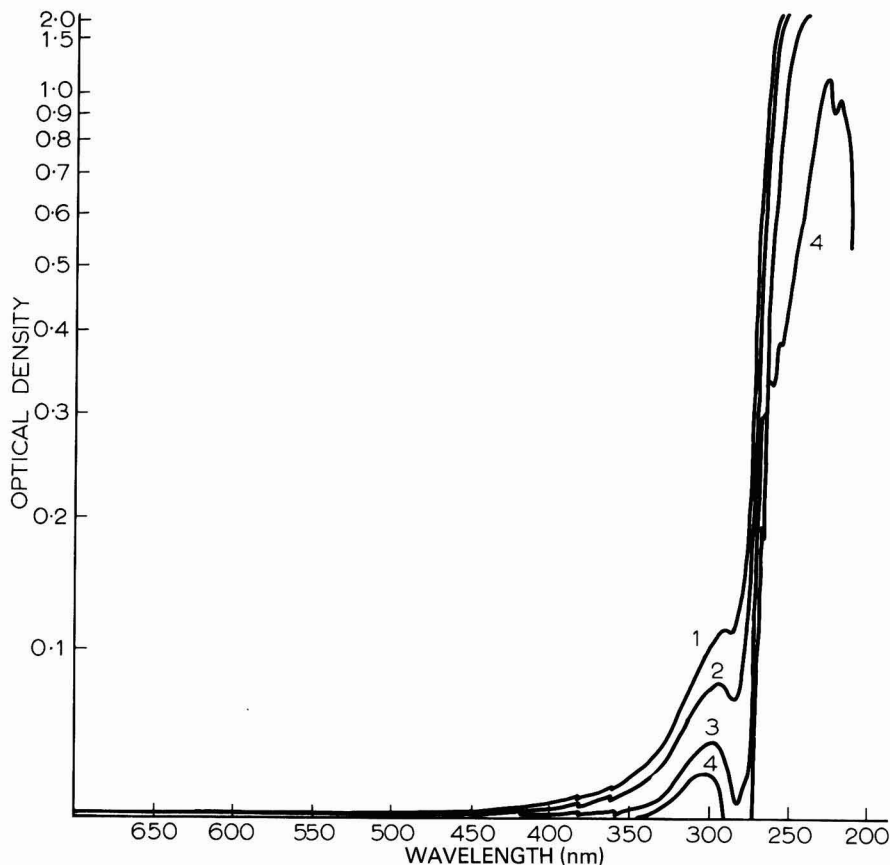


Figure 2. Absorption spectra of bleached lac at different concentrations. (1) 1.5×10^{-3} , (2) 10^{-3} , (3) 4.5×10^{-4} , (4) 10^{-4} g/ml

The absorption spectra of other shellacs of various colour indices were found to be identical to those of DL shellac. An increase in absorption at 425 nm was found for shellacs of greater colour indices. For comparison, the absorption spectra in the region 300-700 nm of different shellacs at the same concentration (10^{-3} g/ml) are shown in Figure 3. In Figure 4 the optical density observed at 425 nm was plotted against the corresponding value of colour index for the different shellacs. A straight line was obtained passing through the origin. The slope was found to be 0.0073. From the inverse of the slope the following relation between optical density and colour index was calculated:

$$\text{Colour index} = 136.9 \times \text{optical density} \dots \dots \dots (1)$$

The readings of absorption at 350 nm did not, however, exhibit a linear relationship with colour indices. The absorbance values observed at 225 nm for the different shellacs are shown in Table 2. The values differed for shellacs with different colour indices.

The plots of optical density at 425 nm with concentration for shellacs of various colour indices produced straight lines passing through the origin. Beer's law was thus found to be obeyed by all shellacs investigated over

the concentration range studied (10^{-4} - 1.5×10^{-3} g/ml). $E_{1\text{cm}}^{1\%}$ values for these shellacs were evaluated from the plots. $E_{1\text{cm}}^{1\%}$ also showed a linear relationship with colour

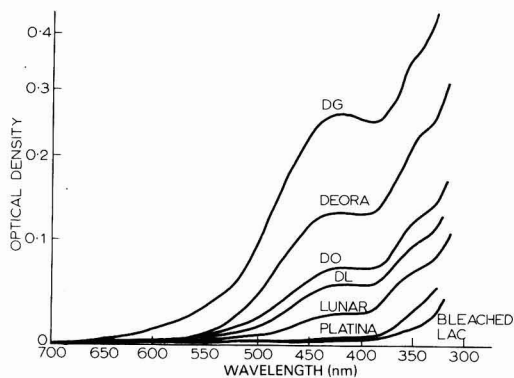


Figure 3. Absorption spectra of different shellacs of various colour indices. Concentration for all shellacs 10^{-3} g/ml

Table 2
Optical density of different shellacs measured at 225 nm
(concentration 10^{-4} g/ml)

Shellac type	Optical density at 225 nm
Platina	1.0
Super Blonde	0.95
Blonde	1.15
Lunar	1.1
DL	1.5
DO	1.1
Deora	1.3
DG	1.2
Bleached lac	1.1

index. The following relationship between extinction coefficient and colour index was obtained.

$$E_{1\text{cm}}^{1\%} = 0.073 \times \text{colour index} \dots\dots\dots (2)$$

Discussion

Refs. 2-17

An inspection of the absorption spectra of different shellacs reveals their complicated nature. Besides erythrolaccin, about nineteen different aliphatic and aromatic acids are present in shellac^{6,10-13}. It is not yet known how these constituents, which form the shellac molecule, are arranged. Sukh Dev and co-workers^{14,15} have, however, been able to suggest a tentative arrangement of the major constituents for soft and hard fractions of shellac. A molecular interpretation of the observed spectra is therefore difficult. The data in the present investigation have been analysed with a view to establishing a relationship between absorbance and colour index.

The UV absorption spectra of different terpenic acids present in shellac have been studied by several investigators²⁻⁵. The positions of the absorption maxima of the different terpenic acids in ethyl alcohol obtained by Prasad⁵ are shown in Table 3. An examination of the absorption spectra of DL shellac, bleached lac and Table 3 reveals that the absorption maxima obtained in the UV region below 350 nm were due to the constituent terpenic acids of shellac. The data in Table 2 indicate that erythrolaccin does not contribute towards absorbance at 225 nm. The difference in the absorbance values observed at 225 nm for different shellacs could not be explained.

The absence of the absorption maximum and shoulder at 425 and 350 nm respectively in the spectra of bleached

Table 3

Values of Wavelengths corresponding to the absorption maxima of different constituent terpenic acids of shellac*

Name of the acids	λ_{max} in nm
Shellolic	229
Epishellolic	228
Jalaric	210, 230 and two small peaks at 260 and 275
Laccijalaric	222
Laksholic	228
Epilaksholic	225
Unidentified new acid	210, 225 and 274

*Prasad⁵

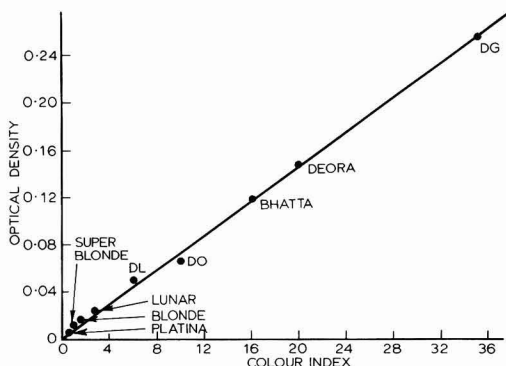


Figure 4. Variation of optical density with colour index, optical density values recorded at 425 nm. Concentration for all shellacs 10^{-3} g/ml

lac (Figure 2) and the increased absorbance at 425 nm with higher colour indices (Figure 3), indicates that the absorption maximum and shoulder at these wavelengths were due to the colouring material present in shellac. Early studies on the absorption spectra of erythrolaccin discovered absorption bands at 640-680, 540-560 and 500-525 nm (for erythrolaccin in sulphuric acid solution), at 480-510 nm (for erythrolaccin in ether-alcohol mixture) and around 475 nm (for erythrolaccin in ethanol⁶). The presence of other constituents caused a shift of the absorption maximum in the case of free erythrolaccin.

The gradual increase in absorbance observed at 425 nm (Figure 3) for platina shellac to DG shellac, was due to the presence of an increased quantity of erythrolaccin in shellac from low to higher colour indices. The study of the colour reaction between partially saponified poly (vinyl acetate) and iodine-iodide in the presence of amylose and boric acid, also showed a gradual increase in absorbance (in the visible region) with an increased concentration of amylose and boric acid in the complex^{16,17}. The straight line obtained from the optical density versus colour index plot (Figure 4), suggests that Equation 1 can be used for the determination of the colour index of shellac; in the existing method two different procedures are followed⁸, one for values in the range 0-5 and the other for values of 5 and above. Equation 1, however, can be employed for a quick and convenient determination of colour index. It eliminates the cumbersome processes of the existing methods⁷⁻⁹ such as matching the colours of diluted alcoholic solutions of shellac with those of standard iodine or other solutions.

Acknowledgements

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Influence of thixotropic agent concentration on the rheological properties of protective coatings based on oxidised bitumen

By A. Papo and F. Sturzi

Istituto di Chimica, Università degli Studi di Udine, Viale Ungheria, 43 - 33100 Udine, Italy

Summary

The rheological properties of a series of thixotropic protective paints based on oxidised bitumen were studied. These paints were formulated using different concentrations of Bentone, which was employed as a thixotropic agent. The rheological investigation was carried out at 25°C. A commercial coaxial cylinder viscometer, Rotovisko-Haake RV 11, was used. Experimental tests were performed within a wide range of shear rates.

The influence of the thixotropic agent concentration on both equilibrium-flow behaviour and time-dependence was studied. Satisfactory results were obtained by fitting the equilibrium data of τ (shear stress) and $\dot{\gamma}$ (shear rate) into an equation of the power law type. Time-dependence was investigated by applying the experimental procedures suggested by Camina-Howell and Trapeznikov-Fedotova.

Keywords

Types and classes of coatings and allied products

high build coating

Properties characteristics and conditions primarily associated with

materials in general

rheological property
thixotropy
viscosity

Raw materials for coatings

binders (resins etc)

bitumen

surface active and rheological agents

rheological agent
flow control agent

L'influence de la concentration de l'agent thixotropique sur les caractéristiques rhéologiques des peintures de protection à base de bitume oxydé

Résumé

On a étudié le comportement rhéologique de familles de peintures thixotropiques de protection à base de bitume oxydé. Les peintures ont été formulées avec plusieurs niveaux de Bentone, qui a été employé en qualité d'agent thixotropique. L'étude rhéologique a été conduite à 25°C. On a employé un viscosimètre à cylindres coaxiaux, Totovisko-Haake RV 11. Les expériences ont été conduites dans un large domaine de vitesse

de déformation. On a étudié l'influence de concentration de l'agent thixotropique sur les conditions d'équilibre et sur la dépendance du temps des peintures. Notamment on a obtenu des résultats satisfaisant correlant les données d'équilibre τ et $\dot{\gamma}$ par une équation de type loi de puissance. La dépendance du temps a été étudié en appliquant les procédures expérimentales suggérée par Camina-Howell et par Trapeznikov-Fedotova.

Der Einfluss von der Konzentration des Thixotropiermittels auf die rheologischen Eigenschaften der auf oxydisierten Bitumen gegründeten Schutzfarben

Zusammenfassung

Die rheologischen Eigenschaften einer Reihe der auf oxydisierten Bitumen gegründeten Schutzfarben wurden untersucht. Diese Farben wurden auf verschiedenen Konzentrationen von Bentone formuliert, der als Thixotropiermittel benutzt wurde. Die rheologische Untersuchung wurde bei einer Temperatur von 25°C durchgeführt. Ein Viskosimeter mit zwei koaxialen Walzen, das Rotovisko-Haake RV 11, wurde benutzt. Experimentalversuche wurden über einer breiten Reihe

von Scherungsgeschwindigkeiten durchgeführt. Der Einfluss der Konzentration des Thixotropiermittels auf das Gleichgewichts-Fliessverhalten und auf die Zeitabhängigkeit wurde untersucht. Mit Benutzung von einer Potenzgleichung für die Gleichgewichtsdaten von τ und $\dot{\gamma}$ wurden genuegende Resultate erhalten. Zeitabhängigkeit wurde durch die von Camina-Howell und Trapeznikov-Fedotova vorgeschlagenen Experimentalverfahren untersucht.

Introduction and objective

Refs. 1-6

Oxidised bitumen is at present employed in the formulation of high-build protective coatings both in the industrial and in the transportation field. These primers are designed

for the protection of metallic surfaces from corrosion caused by extended exposure to chemical and atmospheric agents.

In formulating these paints technological aspects such as application and film properties are to be considered as well as the performance requirements regarding resistance

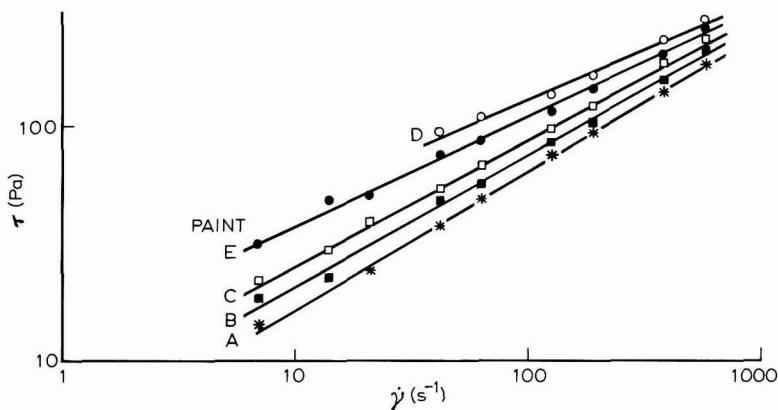


Figure 1. Equilibrium-flow curves τ versus $\dot{\gamma}$ for Paints A-E

to corrosive and destructive agents. These are materials which are commonly applied by means of airless spraying and allow dry films of high thicknesses to be laid down in a single coat on vertical surfaces without sagging. This fact gives rise to the problems in connection with the rheological properties of the paints. Papers on this subject are available¹⁻⁵.

As far as the rheological behaviour of high build paints based on oxidised bitumen is concerned, the first approach by the Authors was carried out in a previous work⁶.

The present paper refers to the results of a series of investigations carried out on the rheological behaviour of a family of paints containing oxidised bitumen, within which a compositive parameter was varied, namely the thixotropic agent concentration.

Experimental

Refs. 7-9

Materials

The materials examined were high build thixotropic paints containing oxidised bitumen (25-30 pen.) and white spirit. The thixotropic agent was Bentone Sedapol 44.

Five paints were formulated at different thixotropic agent concentrations ranging from 1 to 5 per cent by weight.

The designation and composition of the paints are shown in Table 1.

Apparatus

A commercial coaxial cylinder viscometer, Searle type, Rotovisko-Haake RV 11 and a measuring device, MVI,

Table 1
Paint designation and composition

Paint	Thixotropic agent concentration (% by weight)
A	1.00
B	1.75
C	2.50
D	3.75
E	5.00

were employed. Shear rates applied were within the range 7.05 - 571 s⁻¹. Tests were carried out at 25 ± 0.1 °C.

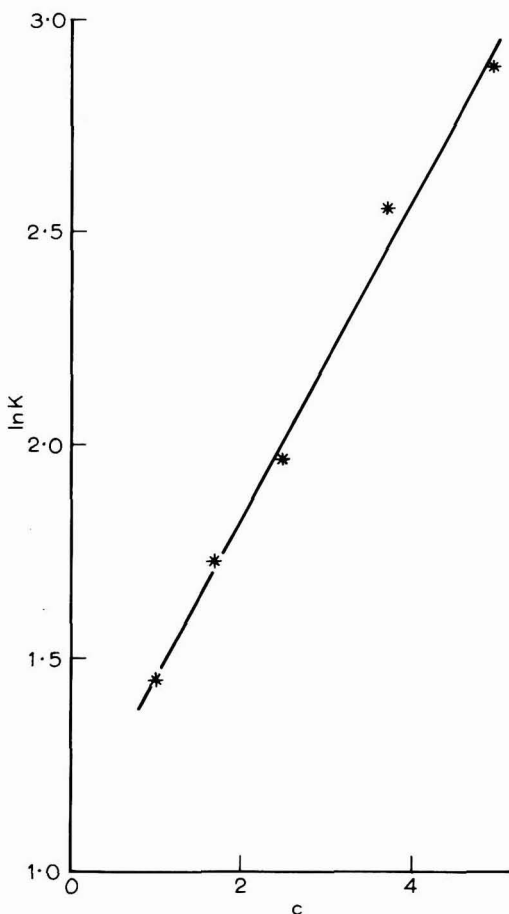


Figure 2. Natural logarithm of consistency versus Bentone concentration

Procedures

The study of the rheological properties of the paints was carried out by applying the experimental procedure by Camina and Howell⁷. This procedure consists of subjecting the material to be tested to a high shear rate until equilibrium conditions are attained and then recording, while applying a lower shear rate, the shear stress increase due to the re-building of the thixotropic structure inside the material. With this method it is possible to obtain both equilibrium-flow data and some information on the thixotropic build-up⁸ of the material tested. With regard to thixotropic build-up, it is possible to draw a map of flow curves characterised by the same re-building time t_r . This map allows the evaluation of both the amplitude of the thixotropic build-up (by examining the distance between the curve at $t_r=0$ and the curve at equilibrium) and the "type" of time-dependence (by examining the distances among the single curves), which could be related to the kinetics of the thixotropic build-up.

For a deeper understanding of the thixotropic behaviour the experimental procedure proposed by Trapeznikov and Fedotova⁹ was also taken into consideration. This procedure consists of subjecting the material to a given shear rate until equilibrium conditions are attained and then measuring the initial shear stress, τ_{max} , after the application of the same shear rate after a given period of rest, t_r . The procedure is repeated for various test times.

From the data obtained the thixotropic re-building can be evaluated.

Results and discussion

Refs. 6, 10-14

All the materials examined exhibited thixotropic flow behaviour.

With regard to the equilibrium-flow data, satisfactory results were obtained by fitting τ and $\dot{\gamma}$ data into an equation of the power law type⁶:

$$\tau = K\dot{\gamma}^n \dots \dots \dots (1)$$

where $n \leq 1$

Figure 1 shows the plot of τ versus $\dot{\gamma}$ for the paints studied.

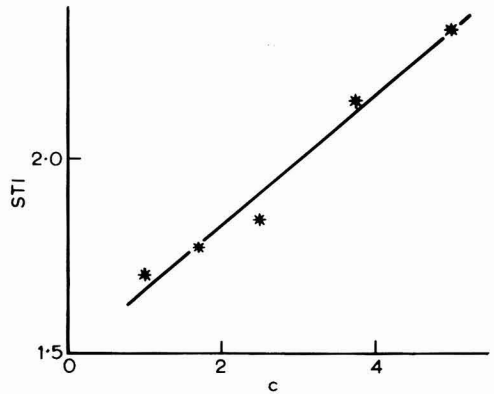


Figure 3. Shear-thinning index versus Bentone concentration

Linear correlations were found by fitting both the natural logarithm of the consistency versus the thixotropic agent concentration ($\ln K = 1.09 + 36.90c$), and the shear-thinning index $STI = 1/n$ versus the thixotropic agent concentration ($STI = 1.49 + 16.50c$) in the c range considered.

The plots $\ln K$ versus c and STI versus c are shown in figures 2 and 3 respectively.

It may be observed that both K and STI increase with increasing thixotropic agent concentration.

As for the time-dependent behaviour, the results showed the strong influence of Bentone concentration on time-dependence properties. As can be seen in Figure 4, which presents the build-up maps obtained for the paints A and E, the increase of Bentone concentration gives rise to both an increase in the amplitude of the thixotropic phenomenon and a different "type" of structural build-up. From a detailed examination of the curves in Figure 4 at the same t_r , it appears that in the first steps of the process the re-building kinetics increase with increasing Bentone concentration, whereas the re-building of the equilibrium structure requires a longer period, the higher the thixotropic agent concentration.

Data resulting from the application of the Trapeznikov-Fedotova procedure can be treated according to different approaches¹⁰⁻¹⁴. Among these the Werner approach¹⁴,

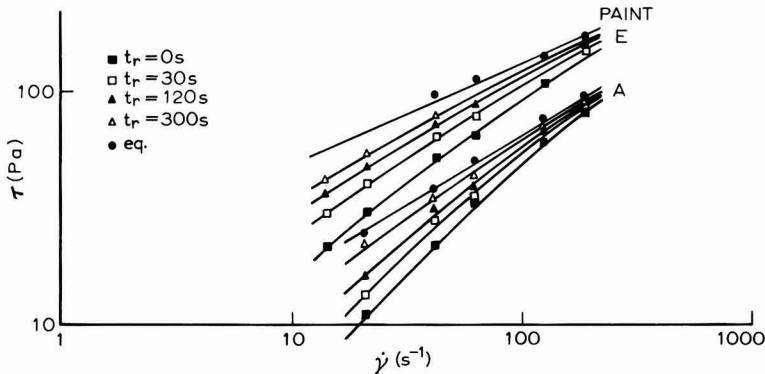


Figure 4. Build-up maps for paints A and E

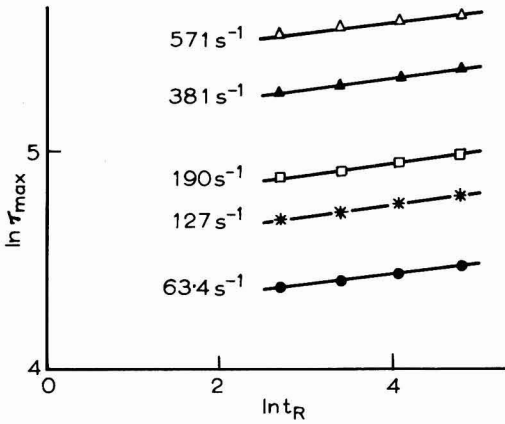


Figure 5. Influence of rest time on peak shear stress at various shear rates for Paint C

which suggests the slope of the curve τ_{max} versus t_R , at $t_R = 0$, is a re-building "characteristic", allows the determination of the properties of build-up at rest of the material immediately after shearing, which is important with regard to the technological aspects connected with sagging phenomena.

Since difficulties were encountered in determining the slope of the curve τ_{max} versus t_R , at $t_R = 0$, and it was noticed that at rest times higher than 15 s, τ_{max} varies with t_R according to an equation of the power law type (see figures 5 and 6):

$$\tau_{max} = A t_R^S \dots \dots \dots (2)$$

The slope S_{15} determined at $t_R = 15$ s was selected to characterise the build-up at rest.

S_{15} can be calculated by means of the following formula:

$$S_{15} = \left(\frac{d\tau_{max}}{dt_R} \right)_{t_R=15} = AS \left(t_R^{S-1} \right)_{t_R=15} \dots \dots \dots (3)$$

Figure 7 shows the plot S_{15} versus c at $\dot{\gamma} = 381 \text{ s}^{-1}$. It may be noted that S_{15} varies linearly with the thixotropic

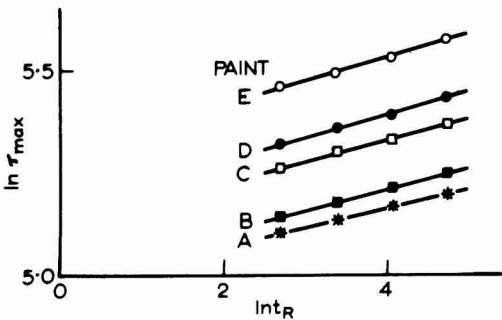


Figure 6. Influence of rest time on peak shear stress at $\dot{\gamma} = 381 \text{ s}^{-1}$ for Paints A-E

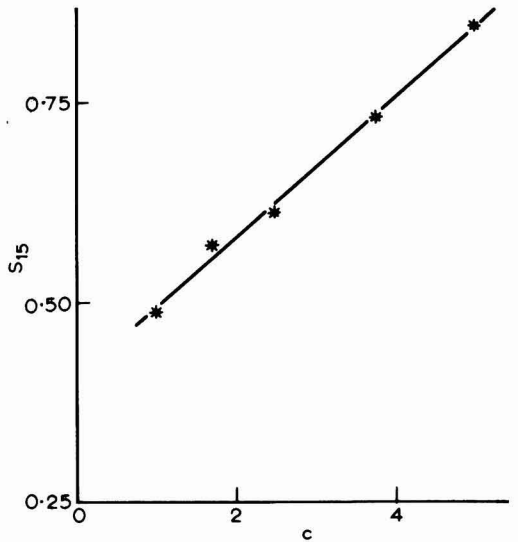


Figure 7. Influence of Bentone concentration on the build-up characteristic S_{15} at $\dot{\gamma} = 381 \text{ s}^{-1}$

agent concentration in the c range investigated ($S_{15} = 0.41 + 0.09c$).

Conclusion

Refs. 15-17

The application of the experimental procedures proposed by Camina-Howell and Trapeznikov-Fedotova produced a lot of significant information on the thixotropic behaviour of the materials examined.

In particular, it was noted that the influence of Bentone concentration was similar on both the build-up at shear (Camina-Howell) and the build-up at rest (Trapeznikov-Fedotova).

For a deeper insight into the thixotropic behaviour the model proposed by Cheng and Evans^{15,16} should be taken into consideration, which permits¹⁷ both a state equation of the type:

$$\tau = \eta(\lambda, \dot{\gamma}) \dot{\gamma} \dots \dots \dots (4)$$

and a kinetics equation of the type:

$$\frac{d\lambda}{dt} = f(\lambda, \dot{\gamma}) \dots \dots \dots (5)$$

where λ is the "structural parameter" which in the "Structural Theory of Thixotropy" by Cheng and Evans is related to the structure level inside the material tested.

Acknowledgement

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Notation

A	see Equation 2
c	thixotropic agent concentration (% by weight)
K	consistency (see Equation 1)
n	power index (see Equation 1)
S	see equation 2
S_{15}	build-up characteristic (see Formula 3)
STI	shear-thinning index
t_r	re-building time
t_R	rest time
$\dot{\gamma}$	shear rate (s^{-1})
η	viscosity (Pa.s)
λ	structural parameter
τ	shear stress (Pa)
τ_{max}	peak shear stress (Pa)

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The influence of pressure on blister growth

By L. A. van der Meer-Lerk*, and P. M. Heertjes†

*Paint Research Institute TNO, Delft, The Netherlands

†University of Technology, Laboratory for Chemical Engineering, Delft, The Netherlands

Summary

The relation between pressure in a blister and the resulting blister growth has been studied. To this end a piece of apparatus was developed with which blister growth could be simulated by forcing water between a varnish film and a substrate via a bore-hole in the substrate. The pressure, that was adjusted by means of a piston, deformed the free part of the film above the bore-hole whilst the attached part of the film was peeled-off from the substrate. The blister growth was followed photographically and the decreasing pressure recorded. The experiments were performed with different varnish film-substrate combinations to

show the difference in the ways peeling-off and deformation take place.

The criterion for peeling-off was described by means of an equation showing the relationship between the pressure, the adhesion strength and the deformation. With this criterion a homogeneous distribution of the tensions in the film at the rim of the blister is assumed. For zero peeling-off velocity, from this equation, the minimum value of adhesion strength of each varnish film-substrate combination was estimated.

Keywords

Types and classes of coatings and allied products

varnish

Types and classes of structures or surfaces to be coated

steel
PVC

Properties, characteristics and conditions primarily associated with

dried or cured films

adhesive strength
blistering
peeling

L'influence de la pression à l'intérieur de la cloque sur sa croissance

Résumé

On a étudié la relation entre la pression à l'intérieur de la cloque et la croissance des cloques qui en résultent. A cet égard on a mis au point un appareil à l'aide duquel on a simulé la croissance d'une cloque en faisant introduire de l'eau entre le film et le support par un petit trou percé dans celui-ci. La pression, que l'on règle au moyens d'un piston, provoque la déformation de l'aire du film juste au-dessus du trou, tandis qu le restant du film se détache du support. On a noté le croissance de cloques par photographie et la décroissance de pression a été constatée. On a effectué les expériences avec de diverses combinaisons de vernis et de supports afin de démontrer les différents types de détachement et de déformation.

On pourrait décrire le critère de détachement au moyens d'une équation entre la pression, la force d'adhérence et la déformation. On a supposé dans le critère qu'existe une distribution homogène des forces dans le film à la périphérie de la cloque. A partir de cette équation on a fait une appréciation de la valeur minimale de la force d'adhérence pour chaque combinaison de film et de support, afin d'assurer la vitesse de détachement de zéro.

Der Einfluss von dem Innendruck auf den Blasenwachstum

Zusammenfassung

Die Beziehung zwischen dem in der Blase vorherrschenden Druck und dem folgenden Blasenwachstum wurde untersucht. Zu diesem Zweck wurde ein Gerät geschaffen, womit das Blasenwachstum, in dem man durch ein in dem Substrat gebohrten Löchelchen, Wasser zwischen den Klarlackfilm und das Substrat zwingt. Der Druck, der mittels eines Kolbens reguliert wird, verunstaltet das freie Stück des über dem Löchelchen stehenden Films, während der feste Film von dem Substrat gesondert wurde. Das Blasenwachstum wurde photographisch beobachtet und der abnehmende Druck wurde eingetragen. Die Untersuchungen wurden mit verschiedenen Zusammensetzungen von Klarlackfilmen und Substraten

ausgeführt, um die verschiedenen Formen von Absonderung und Verunstaltung zu zeigen.

Das Absonderungskriterium würde mittels einer Gleichung für die Beziehung zwischen dem Druck, der Adhäsionskraft und der Verunstaltung beschrieben. Für das Kriterium wird eine homogene Verteilung der Spannung in dem am Blasenrand liegenden Film vorausgesetzt. Aus dieser Gleichung hat man die minimalen Werte von der Adhäsionskraft jeder Kombination von Klarlackfilm und Substrat geschätzt, um eine Nullabsonderungsgeschwindigkeit zu bekommen.

Introduction

Refs. 1-3

In two preceding papers^{1,2} blister growth caused by a difference in water activity over a film was studied. In

blistering of this sort water transport is governed by the changing water activity in the blisters and a pressure above atmospheric pressure is built up. The pressure in the blisters is so low compared with the osmotic pressure, that it does not influence (inhibit) water transport. The pressure however causes deformation and peeling-off of the film,

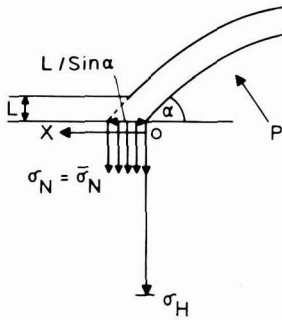


Figure 1a. Uniform tensile distribution

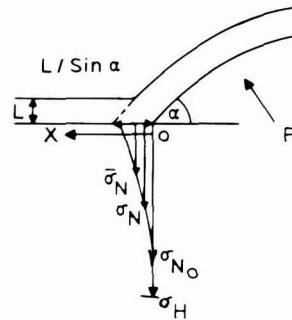


Figure 1b. Tensile concentration at the rim of the blister

influencing blister size and geometry. To complete the model of blister growth, this relationship also has to be studied. Generally, the pressure that is built up in blisters by the local accumulation of water cannot be measured, so that the relation between pressure and blister growth cannot be examined in a simple way. This necessitated the development of an experiment in which blister growth was simulated by adjusting the pressure and that was based on the "blister test" of Dannenberg³. In Dannenberg's test glycerol was forced between a film and substrate until a blister with a fixed magnitude was formed. The energy needed for this operation was measured. After subtracting the energy needed for a blank test, in which a free film lying on a substrate was inflated, the adhesion energy was obtained. The objective of this study was the measurement of the adhesion strength in the presence of water, Dannenberg's method was therefore slightly modified. Water was forced between the film and substrate by a stepwise increase in pressure, resulting in deformation of the film. This was continued until visible peeling-off was observed and the experiment was then started. From that moment on the pressure was not increased any further. The blister growth was followed photographically while the decreasing pressure was recorded. In this way the relation could be studied between the pressure and the combined deformation and peeling-off. From this relationship the adhesion strength could be estimated if the distribution of tensile stresses in the film, created by the visco-elastic deformation, was known. With the values of adhesion strength it is possible to estimate the pressure in any blister in the corresponding system, e.g. for blisters from the preceding papers, where the pressure could not be measured.

Physical description of blister growth

The pressure in a blister causes bending and stretching of the film, resulting in a distribution of tensile stresses and momenta of bending. This distribution is, in general, not easily quantifiable because it is influenced in a complex way by the pressure, the geometry of the blister, the film thickness, the adhesion strength and the visco-elastic properties including the visco-elastic history of the film. In a few extreme cases however, the tensile distribution can be predicted. If the film is thin and the modulus of elasticity is low, the normal components of stress will be the most important factors. In this case the stresses are practically uniformly distributed in the film (Figure 1a) and consequently almost equal to the mean stress $\bar{\sigma}_N$. If the film is rigid, the momenta of bending are of greater importance and the stresses are concentrated at the rim of the blister (Figure 1b). The maximum stress, called peak stress (σ_{N0}) is then the most important parameter because

detachment occurs as soon as it exceeds the adhesion strength σ_H . Unfortunately this parameter cannot be calculated. Instead of σ_{N0} , the mean stress $\bar{\sigma}_N$ was used in the present description which can be calculated. The use of $\bar{\sigma}_N$ as a substitute for σ_{N0} , is acceptable because $\bar{\sigma}_N$ is always lower than σ_{N0} , and approximates to it if the concentration of stress at the rim of the blister is reduced by relaxation in the film. At slow blister growth this may be assumed to occur. If a uniform tensile distribution is present, the criterion for detachment can be expressed as:

$$\sigma_{N0} = \bar{\sigma}_N > \sigma_H \dots\dots\dots (1)$$

The parameter $\bar{\sigma}_N$ can be calculated from the pressure and the geometry of the blister:

$$P \pi r^2 = \frac{\bar{\sigma}_N 2 \pi r L}{\sin \alpha} \dots\dots\dots (2)$$

If the blister takes the form of a segment of a sphere:

$$\sin \alpha = \frac{2rh}{r^2 + h^2} \dots\dots\dots (3)$$

Equation 2 can then be written as:

$$\bar{\sigma}_N = \frac{Pr^2h}{L(r^2 + h^2)} \dots\dots\dots (4)$$

or

$$P \pi r^2 = \bar{\sigma}_N 2 \pi r L \frac{r^2 + h^2}{2rh} \dots\dots\dots (4)$$

During the experiment the pressure in the blister was recorded and the dimensions of the blister were followed photographically. In this way the velocity of peeling-off (dO/dt) could be derived, as well as the parameter $\bar{\sigma}_N$ from Equation 4. At the moment of zero peeling-off velocity (when peeling-off stops), $\bar{\sigma}_N$ must be equal to σ_H , so that by extrapolation of the curve $\sigma_N (= \bar{\sigma}_N) = f(dO/dt)$ to $dO/dt = 0$, the adhesion strength can be obtained. In the case of a peak in the tensile distribution at the rim of the blister, the calculated value of σ_H will be lower than the real adhesion strength. From the above it follows that the experiment can be a useful means to study blister growth in relation to pressure and to estimate the minimum adhesion strength of a film.

Experimental

Ref. 1

Preparation of the systems

In order to study the influence of the visco-elasticity and adhesion on blister growth, different varnish-substrate combinations were used: a polyurethane, an epoxy, a chlorinated rubber and an alkyd-varnish. These were applied onto a circular plate (diameter 5 cm, thickness 8 mm) of stainless steel or hard PVC, with a bore-hole ($\phi=2$ and 3 mm) in its centre. The PVC plates were supported by a steel plate to prevent deformation. To attain the most uniform adhesion on these substrates, the plates of stainless steel were polished and afterwards cleaned with perchloro-ethylene at 120°C; the PVC plates were cleaned with ethanol. To obtain flat films over the bore-holes, the holes were temporarily filled, during application of the varnish, with a material that does not adhere to the applied varnish but is wetted well by the liquid varnish. For polyurethane or epoxy varnishes a filling of silicone-rubber was used, for alkyds and chlorinated rubber, acetamide, obtained by crystallisation, was used. The film thicknesses obtained (in the range 60-150 μm) were quite uniform over the bore-hole and equal to those on the plates.

The "fillings" in the bore-holes were easily removed, the chlorinated rubber was simply picked out of the hole, the acetamide was dissolved in water.

Determination of the blister dimensions

The blisters formed in the experiments were too large to be measured with a "Lichtschnitt" microscope¹, therefore a special measurement technique was developed (Figures 2a and 2b). To measure the height and diameter of a large blister, a lattice of light beams was created, this lattice work met the flat film surface at an angle of 45°. The distance between the beams was 1 mm, which established the scale. The varnish film was covered with a white water paint, while the film was kept wet. Therefore a number of contours of the blister were lit up by the reflection. Only the two contours that went through the top, i.e. through the largest width of the blister, were of

importance. Photographs were taken perpendicularly above the blister so that projections of the diagonal sections on the base of the blister were obtained. From these pictures, the lengths of AB and CD were determined. Since the beams entered at an angle of 45°, the blister height h ($=AT$) was equal to the length of AB. (It should be noted that point A was situated on the line CD, since the diagonal section through T was going through the top of the blister.)

Experimental set-up

A cylindrical vessel of stainless steel with a screw-thread on top was covered with a test plate (Figure 3). The vessel was equipped with:

- a piston, to build up a pressure under the varnish film,
- a piezo-electric crystal, to measure the pressure,
- an overflow, so that surplus water could flow away when the test plate was screwed down on the vessel.

The piezo-electric crystal was a closed silicium cell the operation of which is based on its semi-conductivity properties. The cell changes its electric resistance when subjected to a mechanical strain, producing a change in the voltage applied. Because the pressure had to be used for the deformation and peeling-off of the film, inclusion of air while filling the vessel was avoided. The system was therefore evacuated while a plate without a bore-hole was used. The apparatus used for this operation is shown in Figure 3. By closing tap A and opening tap B, water flowed into the vessel. Tap C was closed and the plate replaced by a test plate with a varnish film applied over the bore-hole. To avoid the inclusion of air in the bore-hole, it was filled with water and covered with a small piece of aluminium foil; the plate was then placed on the vessel. The surplus water flowed out via tap D and the foil sank to the bottom of the vessel. Finally tap D was closed and the system was ready for use.

Experimental procedure

The pressure under the film was increased by displacement of the piston until visible peeling-off of the film was observed. The blister growth was then followed photographically and the pressure recorded.

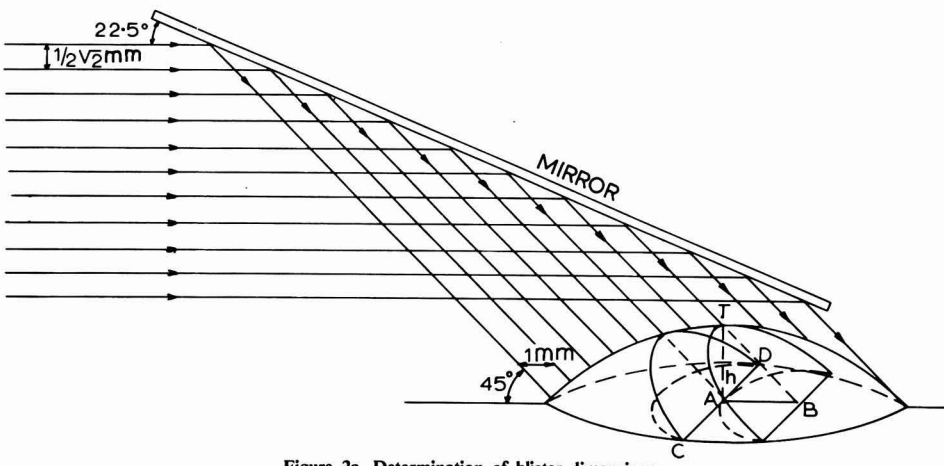


Figure 2a. Determination of blister dimensions

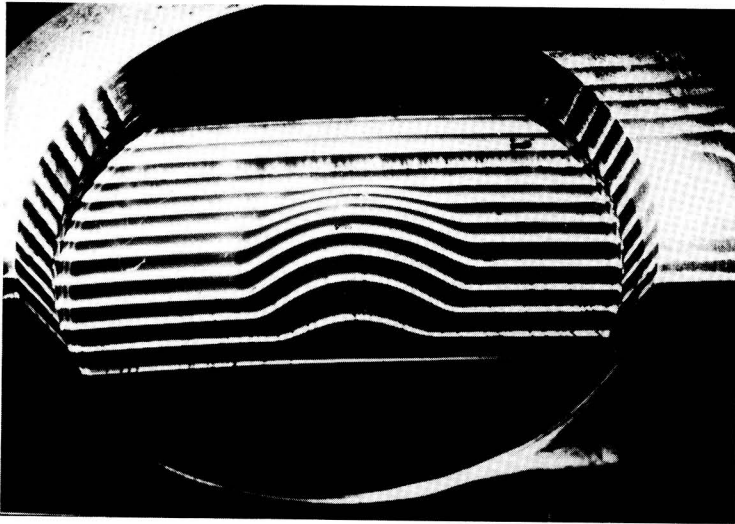


Figure 2b.

From the data the mean stress was calculated using Equation 4. The values were plotted against the velocity of peeling-off (the increase of peeled area in a given time). Extrapolation of this curve to a zero peeling-off velocity, gave the adhesion strength σ_H , if the tensile distribution was uniform (when $\sigma_{N_0} = \bar{\sigma}_N$). If there was a tensile concentration at the rim of the blister, the value found would be below the value of the real adhesion strength.

If the growth of the blister was symmetrical, the test could be repeated. Each test from the start until the end of the peeling-off process was called a "cycle of detachment". From these cycles different values of σ_H could be found due to local differences in adhesion. The result of one test is presented in detail for each combination of varnish film-

substrate, to show the mechanisms of the peeling-off processes, for the other tests only the values of σ_H found are given.

Results

Refs. 4-7

The peeling-off of polyurethane films from stainless steel

The results of one experiment are presented in detail in Table 1, including the pressures recorded, the parameters concerning the dimensions of the blister at the corresponding moments and the calculated values for the mean stress $\bar{\sigma}_N$. From the results the following was noted:

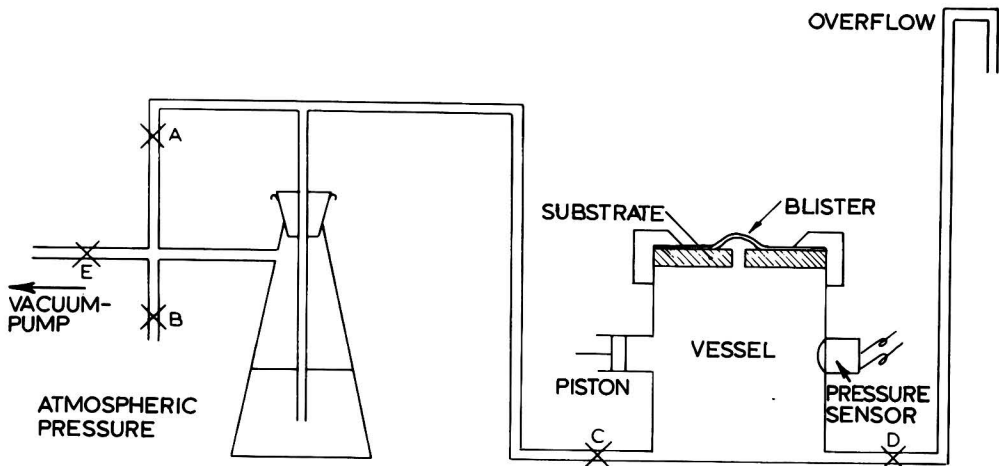


Figure 3. Apparatus used for the experiments

Table 1
The peeling-off of a polyurethane film (93 μm) from stainless steel

Photo no.	P (atm)	t (min)	r (mm)	h (mm)	α ($^\circ$)	ΔO (mm 2)	dO/dt (mm 2 /min)	$\bar{\sigma}_N$ (10^5 N/m 2)	σ_H
First cycle									
1	0.70		1.75	0.75	46	0	0	4.9	
2	1.00		1.75	0.75	46	0	0	6.9	
3	1.20		1.75	1.00	59	0	0	9.8	
4	1.40	0	1.87	1.00	56	1	2	11.7	
5	1.30	4	2.50	1.30	61	10	1.33	13.4	
6	1.20	9	3.00	1.60	56	19	1.00	16.3	
7	1.10	14	3.00	2.00	67	19	0.90	16.6	
8	1.00	19	3.25	2.10	65	23	0.80	16.1	
9	0.90	24	3.50	2.50	71	29	0.70	16.2	
10	0.68	39	4.00	3.00	73	41	0.50	14.2	
11	0.60	48	4.00	3.00	73	41	0.40	12.45	
12	0.50	68	4.25	3.00	70	47	0.16	10.9	
13	0.44	83	4.50	3.25	71	54	0.14	10.2	
14	0.39	104	4.37	3.25	73	50	0.11	8.9	
15	0.34	134	4.50	3.25	71	54	0.04	7.9	8
16	0.24	226	4.50	3.25	71	54	0	5.6	
Second cycle									
17	1.00	0	4.50	3.25	71	0	2.42	23.2	
18	0.80	3	4.75	3.50	72	7	2.42	19.7	
19	0.70	6	5.00	4.00	77	15	2.00	18.6	
20	0.60	11	5.25	4.00	74	23	1.33	16.5	
21	0.48	21	5.25	4.00	74	23	1.33	13.2	
22	0.38	41	5.75	4.50	76	40	0.17	11.5	10
23	0.30	77	5.75	4.50	76	40	0	9.1	
Third cycle									
24	1.20	0	5.75	4.50	76	0	16	36.4	
25	1.00	0.25	5.87	5.00	80	4	16	31.4	
26	0.80	0.75	6.00	5.00	79	9	10	25.7	
27	0.60	2	6.25	5.00	77	19	2.66	19.9	
28	0.40	13	6.50	5.00	75	29	0.20	13.7	
29	0.27	53	6.62	5.00	79	34	0.125	9.3	8.5
30	0.24	79	6.62	5.00	74	34	0	8.3	

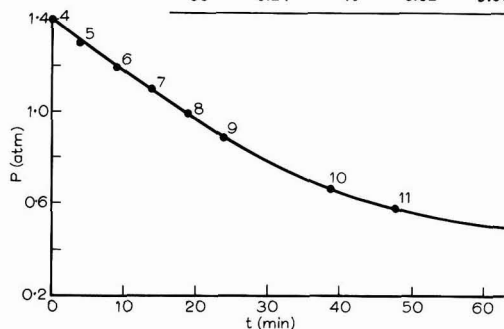


Figure 4a. First cycle

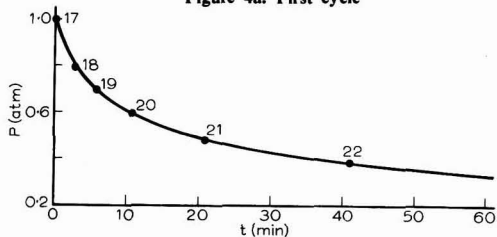


Figure 4b. Second cycle

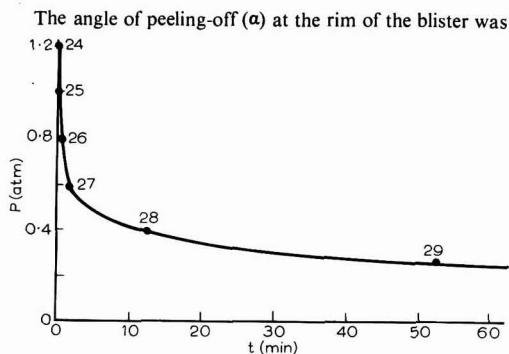


Figure 4c. Third cycle

Figures 4a,b,c. The pressure in a blister in a polyurethane film (93 μm) on stainless steel

A pressure of 1.0-1.4 atmospheres was sufficient to create peeling-off and peeling-off was faster the larger the blister was (see Figures 4a,b,c in which the pressure in the blister is presented as a function of time). The numbers in the figures correspond to the number of the photographs shown in the table. The continuing decrease in pressure after the moment peeling-off had stopped, which was observed photographically, must have been caused by leakage or by elasticity in the apparatus, for instance in the packing.

Table 2
The peeling-off of polyurethane films from stainless steel

Panel no.	Number of cycles	Thickness of film (μm)	Age of film (days)	Immersion time of film (days)	Angle of peeling ($^\circ$)	σ_H (10^5 N/m^2)
1	3	93 \pm 5	28	7	75 \pm 3	9.1 \pm 0.9
2	4	93 \pm 5	35	16	73 \pm 3.5	7.3 \pm 1.8
3	4	93 \pm 5	91	70	69 \pm 2	16.3 \pm 2.6
4	1	93 \pm 5	112	91	70	14.2
5	4	93 \pm 7	119	98	74 \pm 5	12.9 \pm 1.5
6	2	112 \pm 8	91	70	57 \pm 7.5	13.4 \pm 0.7
7	3	152 \pm 40	21	6	65 \pm 5.5	7.4 \pm 1.9
8	1	162 \pm 50	14	2	76	11.1

dependent on the pressure, the film thickness, the area of the blister base, the visco-elasticity and the adhesion. This angle appeared to be larger the longer the amount of time the film was kept under pressure, so apparently the history of the visco-elastic deformation has an influence. During peeling-off the angle was practically constant, except at the beginning of the procedure.

The peeling-off velocity appeared to depend linearly on the mean stress⁴. Therefore linear extrapolation to $dO/dt=0$ in the $\bar{\sigma}_N - dO/dt$ diagram produced the adhesion strength, under the assumption that mean and peak stresses are equal (Figures 5a,b,c).

For large blisters, the peeling-off velocity could not be determined accurately because of the rapid enlargement of the blister base. After the third cycle peeling-off had become asymmetrical.

The values for σ_H found from the various cycles, agreed satisfactorily.

For the other tests the results are shown in Table 2. From this table the following conclusions can be drawn: The angle of the paint film before peeling off took place was, in most cases, about 70°. The values of σ_H were between 7 and 16 $\times 10^5 \text{ N/m}^2$. The variation found may have been caused by inaccuracies in the extrapolations or may have been real local differences in adhesion^{5,6}. Further, the results indicated that the adhesion is stronger for older films.

The peeling-off of epoxy films from stainless steel

The results of one experiment are presented in detail in Table 3. Only the first cycle could be used for evaluation, because by the second cycle the process had become too fast. With respect to the pressure, angle and peeling-off velocity, the following were noted. The decrease in pressure at the beginning was very steep (Figure 6) compared to the polyurethane experiments. After this sharp decrease the curve (Figure 6) shows that the peeling-off had virtually stopped. This difference in behaviour of the two types of varnishes may have been due to their different visco-elastic properties. The rigid epoxy varnish film needed a high pressure to attain a peak stress which exceeded the adhesion strength. The distance over which the stresses were distributed is probably equal to $L/\sin \alpha$, and because of the smaller angle of deformation (α), greater than that for polyurethane. Therefore, during one cycle a large base area was peeled-off which was accompanied by a sharp decrease in pressure so the peeling-off stopped abruptly.

For the other tests the results are shown in Table 4. The

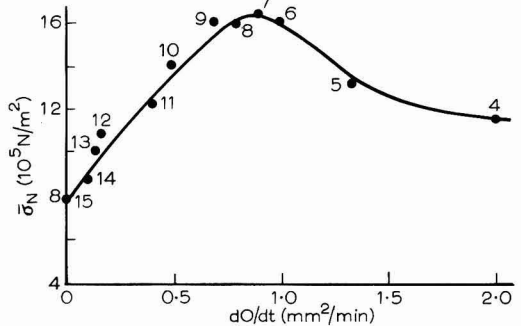


Figure 5a. First cycle

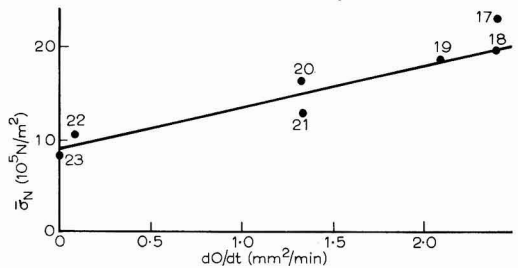


Figure 5b. Second cycle

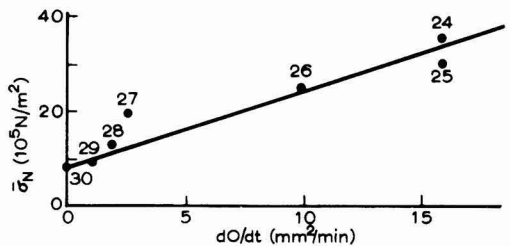


Figure 5c. Third cycle

Figures 5a,b,c. The mean stress $\bar{\sigma}_N$ versus the velocity of peeling-off, dO/dt , of polyurethane film (93 μm) on stainless steel

results obtained exhibit a variation in the angle of peeling-off between 19° and 50°. The values for the adhesion strength often lay between 10×10^5 and $20 \times 10^5 \text{ N/m}^2$ were of the same order of magnitude as those for polyurethane on stainless steel. No influence due to film age could be distinguished.

Table 3
The peeling-off of an epoxy film (89 μm) from stainless steel

Photo no.	P (atm)	t (min)	r (mm)	h (mm)	α ($^\circ$)	ΔO (mm 2)	dO/dt (mm 2 /min)	$\bar{\sigma}_N$ (10^5 N/m 2)	σ_H
First cycle									
1	3.5		1.00	0.25	28	0		9.4	
2	3.5		1.37	0.50	39	2.76		17.5	
3	3.5		1.37	0.50	39	2.76		17.5	
4	3.5		1.37	0.50	39	2.76		17.5	
5	3.5	0	1.75	0.75	46	6.47		25.2	
6	3.5	5	1.75	1.00	59	6.47	0	30.0	
7	1.45	9	4.87	1.50	34	71.34	4.6	22.6	
8	1.30	20.5	4.87	1.50	34	71.34*		20.2	
9	1.10	34.5	5.00	1.75	38	75.36*	0	19.5	20
10	0.95	61	4.87	1.75	39	71.34*		16.7	
11	0.80		5.00	1.75	38	75.36*		14.2	

*These variations are caused by errors in the measurements

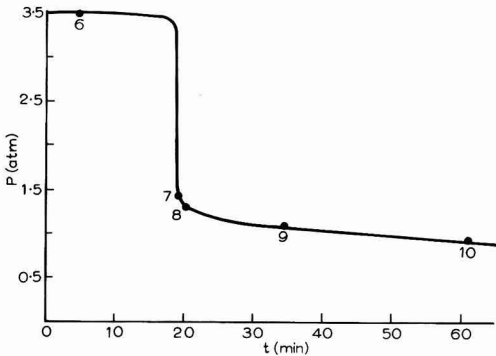


Figure 6. The pressure in a blister in an epoxy film (89 μm) on stainless steel

The peeling-off of alkyd films from stainless steel

In Table 5 the results of one experiment are presented. From the curve of pressure as a function of time (Figure 7), it is apparent that the behaviour was similar to that of polyurethane. The angle of peeling-off varied between 50 $^\circ$ and 60 $^\circ$, and these values lie between those for the epoxy and polyurethane films. Furthermore, it is obvious that the

pressure needed for peeling-off was lower for larger blisters.

The results of the other tests are summarised in Table 6. The angle of peeling-off was, in most cases, about 50 $^\circ$, except in one case (73 $^\circ$). The value of σ_H was low (2.3-7.9 $\times 10^5$ N/m 2) compared with the values of other varnish films studied. The "wet" adhesion of alkyd on stainless steel was poor. The influence of film age on the adhesion strength could not be examined from this series because all the films used were about the same age.

The peeling-off of chlorinated rubber films from stainless steel

The efforts to obtain peeling-off in this case were not successful. At a pressure of one atmosphere, the angle of deformation was almost 90 $^\circ$. Calculation of the peak stress for this situation produced a value of 20 $\times 10^5$ N/m 2 . At increased pressure the film tore. The highest pressure reached was 2 atmospheres. Based on these results it was concluded that the adhesion strength was at least 20 $\times 10^5$ N/m 2 and larger than the tear strength.

The peeling-off of different varnish films from hard PVC

Peeling-off experiments with epoxy and polyurethane films were unsuccessful because of asymmetrical detachment,

Table 4
The peeling-off of epoxy films from stainless steel

Panel no.	Number of cycles	Thickness of film (μm)	Age of film (days)	Immersion time of film (days)	Angle of peeling ($^\circ$)	σ_H (10^5 N/m 2)
1		80 \pm 6	96	27	30	18
2		81 \pm 7	68	6	25	18
3		81 \pm 9	69	7	31	27
					50	19
4		83 \pm 7	96	27	22	13
					37	16
5		85 \pm 5	75	6	32	16
6		89 \pm 9	75	6	34	20
					46	11
7		125 \pm 15	69	1	19	9
8		126 \pm 10	69	1	26	13
9		127 \pm 21	95	26	21	8
10		130 \pm 8	70	1	31	18
11		133 \pm 9	71	2	44	17
12		133 \pm 11	95	26	23	10

Table 5
The peeling-off of an alkyd film (47 μm) from stainless steel

Photo no.	P (atm)	t (min)	r (mm)	h (mm)	α ($^\circ$)	ΔO (mm^2)	dO/dt (mm^2/min)	$\bar{\sigma}_N$ (10^5 N/m^2)	σ_H (10^5 N/m^2)
First cycle									
1	1	0	1.75	0.75	46	0		13.7	
2	1.06	7	3.0	1.25	45	18.65	2	18.1	
3	0.9	8	3.125	1.25	43	21.07	2	20.8	
4	0.8	8	3.125	1.5	51	21.07	1.3	21.0	
5	0.7	10	3.5	1.5	46	28.86	1.3	19.1	
6	0.6	12	3.5	1.75	53	28.86	0.8	18.1	
7	0.5	14	3.5	1.75	53	28.86	0.72	15.1	
8	0.4	18	3.625	1.75	51	31.65	0.24	12.2	
9	0.34	24	3.625	1.75	51	31.65	0	10.4	10.4
10	0.25	39	3.625	1.75	51	31.65	0	7.2	
11	0.18	62	3.75	1.75	50	34.54		5.2	
Second cycle									
12	0.60	64	4.0	2.5	64	6.09		23.2	
13	0.40	65	4.125	2.5	62	9.29	3.20	15.7	
14	0.30	67	4.25	2.5	60	12.56	1.63	11.9	
15	0.19	85	4.5	2.5	58	19.44	0.38	7.8	7.8
Third cycle									
16	0.24	89	5.0	3.0	61	14.91		11.4	
17	0.14	115	5.125	3.0	60	18.90	0.15	6.7	6.7
Fourth cycle									
18	0.16	116	6.375	3.5	57	45.12		9.2	
19	0.12	132	6.5	3.5	56	50.18	0.32	7.0	
20	0.12	155	6.5	3.5	56	50.18	0	7.0	7.0

possibly because adhesion on the PVC surface was not uniform. The pressure at which peeling-off occurred, varied from 1.5 to 5 atmospheres. With these experiments, determination of the adhesion strength was not possible. Chlorinated rubber showed tearing of the films in all experiments. Peeling-off experiments with alkyd films were also unsuccessful but were nevertheless of some value. The experiments showed good adhesion of alkyd films on PVC. At a pressure of about one atmosphere, the films were strongly deformed into blisters with an angle of 80 to 90°. At higher pressures, the films tore at the rim of the blister. The calculated peak stresses (assuming that they were equal to the mean stresses) at those moments are shown in Table 7. It may be concluded that the adhesion strength was larger than these values, but in any case the adhesion of an alkyd film on PVC is much stronger than on stainless steel⁷.

Discussion and conclusions

Refs. 1,2

The apparatus developed was a useful tool for simulating

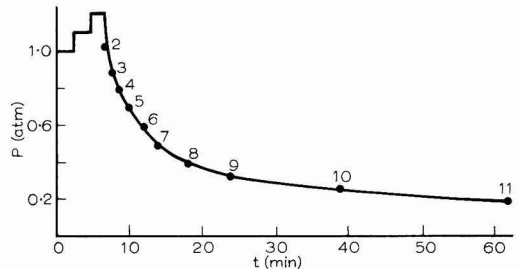


Figure 7. The pressure in a blister in an alkyd film (47 μm) on stainless steel

blister growth in such a way that the relation between the pressure in a blister and blister growth could be studied. The polyurethane, epoxy and alkyd films peeled-off from their substrate of steel or hard PVC at pressures lower than 5 atmospheres. The chlorinated rubber films tore before peeling-off could be observed. Furthermore, the apparatus clearly demonstrated the different ways of

Table 6
The peeling-off of alkyd films from stainless steel

Panel no.	Number of cycles	Thickness of film (μm)	Age of film (days)	Immersion time of film (days)	Angle of peeling ($^\circ$)	σ_H (10^5 N/m^2)
1	3	41 \pm 7	50	1	50.6 \pm 4.0	6.9 \pm 1.7
2	4	47 \pm 6	50	1	56.2 \pm 3.8	7.9 \pm 1.5
3	3	79 \pm 5	49	8	73.3 \pm 1.5	7.5 \pm 0.6
4	3	80 \pm 5	50	1	47.0 \pm 9.0	5.5 \pm 1.4
5	1	85 \pm 4	46	5	53.0	5.7
6	1	85 \pm 7	49	8	48.0	5.6
7	3	89 \pm 8	49	8	52.0 \pm 6.5	2.3 \pm 0.5

Table 7
The peeling-off of alkyd films from hard PVC

Panel no.	Thickness of film (μm)	Pressure at tear (atm)	Angle of blister (°)	$\bar{\sigma}_N$ at tear (10 ⁵ N/m ²)
1	38±8	2.5	90	58
2	50±2	3.0	90	45
3	48±2	2.2	90	38
4	84±2	5.0	90	60
5	59±13	5.0	90	65

Table 8
 σ_H (10⁵ N/m²) for various varnish film-substrate combinations*

Substrate	Varnish			
	Polyurethane	Epoxy	Alkyd	Chlorinated rubber
Stainless steel	11.4±4.4	15.7±5.6	5.9±2.0	> 20
Hard PVC			> 60	

*These values are lower than the real adhesion strengths because in the calculations a uniform tensile distribution was assumed, in spite of the fact that in the systems used tensile concentration might have occurred.

peeling-off of the various varnish film-substrate combinations.

The criterion for peeling-off is formulated as follows:

$$\sigma_{N_0} = \bar{\sigma}_N = \frac{Pr^2h}{L(r^2+h^2)} > \sigma_H \dots\dots\dots (4)$$

in which a homogeneous distribution of the tensions at the rim of the blister is assumed.

According to this equation, a high pressure is necessary to achieve peeling-off if:

- σ_H is large (strong adhesion),
- r is small (small blister),
- L is large (thick film) or
- α is small (rigid film).

These predictions were confirmed by the experimental results.

By means of the criterion above, the minimum value of adhesion strength of the systems studied was determined. The values found are summarised in Table 8 and show that the adhesion of chlorinated rubber on stainless steel was better than that of epoxy and polyurethane films. These in turn had a better adhesion than alkyd films on this substrate. The adhesion of an alkyd film on hard PVC was much better than on stainless steel.

With values for adhesion strength it is now possible to estimate the pressure in any blister in the corresponding system, e.g. for blisters as studied in the preceding papers^{1,2} which were initiated by amounts of dosed salt and in which the pressure could not be measured. The calculations led to the conclusion that the pressure in the

first days of blistering could have been 5-12 atmospheres, whereas the osmotic pressure was some hundred atmospheres; it was confirmed that the pressure in these blisters was so low, compared with the osmotic pressure, that it would not inhibit water transport.

[Received 30 September 1980

List of symbols

- h height of a blister (mm)
- L thickness of film (μm)
- O area of blister base (mm²)
- ΔO change in area of blister base (mm²)
- P pressure in a blister (atmospheres)
- r radius of the blister base (mm)
- t time (min)
- α angle at the rim of a blister (°)
- σ_H adhesion strength (N/m²)
- σ_N normal component of stress (N/m²)
- $\bar{\sigma}_N$ mean value of the normal components of stress (N/m²)
- σ_{N_0} peak stress (N/m²)

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3. Dannenberg, H., *J. Appl. Pol. Sc.* Vol. V, 1961, issue no. **14**, 125.
4. Heertjes, P. M. and de Jong, J., *JOCCA*, 1970, **53**, 427.
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6. de Bruyne, N. A. and Houwink, R., "Adhesion and Adhesives", *Elsevier*, A'dam, 1965.
7. van der Meer-Lerk, L. A., *Thesis*, Delft University of Technology, 1976.

Next month's issue

The Honorary Editor has accepted the following papers for publication. They are expected to appear in the February issue of the *Journal*:

Micaceous iron oxide pigments by *D. M. Bishop*

The formulation of textured coatings for plywood by *J. Boxall and W. Worley*

Electrical impedance on coated metal electrodes. Part 1: Polarization effects by *L. M. Callow and J. D. Scantlebury*

Triple Roll Milling

Sir – May I echo the authors of “Effect of pigmentation level on the efficiency of triple roll milling” (*JOCCA* November 1980 p 438) to the effect that it would be unwise to be dogmatic on the basis of limited evidence. There is however unlimited evidence to indicate that the performance of mills requiring the premixing of a pigment paste is directly dependent upon the efficiency of premixing. The latter is dismissed in one small paragraph “The premixing was done by hand until the pigment *appeared* to be wetted out etc”. This is horrifying! Was no action taken to ensure that the pigment was really wetted out? It is here that the major tests could be undertaken!

The preparation of premixes by hand is quite wrong; it is necessary to use the shear intensive mixers – so peremptorily dismissed – with adjusted initial composition of the pigment paste to ensure adequate kneading.

Without satisfactory premixing there is no question that the results could be surprising. On the other hand the authors should not be surprised that their results are questioned.

Yours faithfully,
I. Berg

22 Gladstone Court,
Anson Road,
London
NW2 4LA

17 November 1980

Dr Carr comments

Sir – Over the years I have had many a friendly discussion/argument with Mr Berg on dispersing efficiency, and I am well aware of his long and varied practical experience in the field of milling and milling machinery. I know his views are given without malice and intended to be helpful.

I have not had time to contact the co-authors of the paper in question but the following represents my comments on his letter.

- (i) The object of the work was not to study the factors affecting the efficiency of triple roll milling but was to prepare ranges of inks of the same composition but differing in dispersion levels so that the effect of dispersion levels on the properties of the inks could be determined. This is why the effect of pre-mixing was not studied in depth.
- (ii) It was in the preparation of these inks that the minimal effect of pigmentation levels on TRM

letters

efficiency was discovered. This was quite unexpected and the results were published because it was thought that they would be of interest.

- (iii) Although the pre-mixing was done by hand, the dispersion levels reached in the pre-mixing stage are given in the paper and they make interesting reading. With the calcium 4B metal salt, the hand premixing gave very poor dispersions at all pigmentation levels, but one very light pass on the TRM (at 2Kg/cm²) brought a dramatic increase in dispersion level to the same extent at each pigmentation level. With the yellow, the premixing gave appreciable and similar levels of dispersion at each pigmentation level. Similarly for the blue pigment and the carbon black.
- (iv) In each of the four types of ink, the dispersion levels of the inks after hand premixing and one very light pass, were sufficiently good to convince me at least that all the pigments were well wetted out and therefore the subsequent findings are valid, i.e. the effect of pigmentation level on the efficiency of the TRM is very small.
- (v) Mr Berg appears to place great store on ensuring that the pigment was “really wetted out”. Could he enlighten us on what he means by this phrase and how one can be sure that this has really taken place.
- (vi) I would welcome Mr Berg's views on this question of “wetting out” which has always seemed to me to be a red herring and would like to know whether he really agrees or disagrees with our findings and is or is not surprised by them.

Finally, I would like to thank him for putting his views on paper and providing me with an excuse for a good, honest, enjoyable argument.

Yours faithfully,
W. Carr

31 Lindow Fold Drive,
Wilmslow,
Cheshire,
SK9 6DT

28 November 1980

reviews

High Solids Coatings (Bibliographies in Paint Technology No. 35)

R. H. Chandler

R. H. Chandler Ltd, September 1980

A4 pp 86

This bibliography is divided into four parts:

1. Literature review.
2. Literature references.
3. Patent abstracts.
4. Author and patent indexes.

The literature review is a well written and very readable presentation of the literature from 1975 to August 1980 including, where required, graphs and tables to illustrate the text more clearly.

The references (277) included in the review are tabulated in sections 2 and 3. Section 4 consists of an alphabetical list of authors, a list of patents by country of origin and number, and finally a list of companies, all of which make this a very useful publication for those in this field.

Reader Enquiry Service No. 21

D. S. Newton

Surface Contamination: Genesis, Detection and Control

K. L. Mittal, Ed

Vol. 1 Part 1: General Papers
Part 2: Cleaning of Surfaces

Vol. 2 Part 3: Surface Contamination Detection, Identification, Characterisation and Control

Part 4: Implications of Surface Contamination

Plenum Press, New York. 1979
Vol. 1 XXX + 523. Vol. 2 XVI + 523
Price \$65 two volume set

The books comprise reprints of papers given at a symposium on Surface Contamination in Washington DC, 10-13 September 1978. The subject itself is undoubtedly of great importance to paint technologists and for users who almost invariably are presented with surfaces to paint which are contaminated and poorly receptive of paint. Contamination can be greasy, hydrophilic or particulate and either reduces paint adhesion or gives the painted surface a poor appearance. Information on the detection and elimination of contaminants is

Further information on any of the publications reviewed may be obtained by circling the appropriate *Reader Enquiry Service* number on the form at the back of the *Journal*. Enquiries will be forwarded to the publisher.

therefore always welcome. The present work has a certain interest for the paint technologist, but is not particularly directed towards this field. A great deal of emphasis is placed on ambient contamination such as dust and organic matter which must be removed from electronic equipment during manufacture if it is to operate successfully. Tenacious contaminants like rolling lubricant on metals do not really come into consideration. Some papers are certainly worth consulting however. The Editor, K. L. Mittal gives a useful introductory review. T. Matsunaga explains the significance of wetting angle in relation to contamination. F. Galembreck and others discuss contamination of plastics. W. J. Whitfield describes the effect of moisture on particle adhesion. Dr J. A. Cross discusses powder coating particle adhesion. G. B. Munier and others have a chapter on ambient contamination of zinc and aluminium. Special topics in Volume 1 receiving a mention are radioactive contamination of concrete, cleaning of microelectronics and of water and mineral surfaces. Volume 2 deals principally with removal of contaminants (by solvent for example, where solvent is matched to contaminant) and most interestingly with detection and identification of contaminants.

From the individual papers useful information on the application of modern analytical techniques can be garnered, but the criticism must be made that the chapters are highly repetitious and information on any one subject must be quarried out of a number of papers. However, the effort is worth the reader's time if he or she wishes to be brought up to date. Topics discussed include wetting angle, ellipsometry, surface potential, evaporation rate analysis, microscopy, ESCA, Auger spectroscopy, ion scattering and ion mass spectrometry, photoelectron emission, remission photometry, microfluorescence, plasma chromatography, and mass spectroscopy. Certainly a work of reference for anyone concerned with the chemistry of commercial surfaces.

Reader Enquiry Service No. 23

J. L. Prosser

Photochemistry of dyed and pigmented polymers

N. S. Allen and J. F. McKellar, Eds

Applied Science Publishers, London

pp XI + 284 Price £20

Photo oxidative degradation of paint films is of great importance in paint technology and the present book is, by nature of the treatment of the subject, of considerable interest in the paint field. The five chapters deal mainly with the fading and tendering mechanisms of dyes on natural and synthetic fibres and textiles, with incursion into polymer films and the photocatalytic activity of pigments in paint films (principally in the last chapter by N. S. Allen and J. F. McKellar on Photosensitised degradation of polymers by dyes and pigments). Because of the emphasis on theory and mechanisms (the first chapter by E. D. Owen on Basic photochemistry is an excellent concise and readable treatment of the subject) the book should be read by paint technologists, as much for the ideas it may stimulate as for the information it contains.

Reader Enquiry Service No. 22

J. L. Prosser

OCCA meetings

Hull

Handling and process control in a paint factory

The first ordinary meeting of the 1980-81 session was an annual joint meeting with the South Humberside Group of the Institution of Chemical Engineers and was held at the Humber Bridge Hotel, Barton. Ing. H. F. J. Houben, the Managing Director of TBMA Holland, was the guest speaker. The title of his paper was: "Handling and Process Control in a Paint Factory". This was a particularly relevant and exciting topic of great interest to the membership of both societies, given by a speaker with practical experience of developing new systems here in the UK and in Europe.

Mr Houben stated that it was necessary to have complete collaboration for each project between the customer and his company's design team, so that all the known parameters, such as the products physical data, batch sizes, mixing sizes, throughput schedules etc. would be available. This would ensure that the correct units could be recommended to meet the agreed criteria.

The lecturer continued by enumerating the items of plant used in the bulk handling of raw materials for the paint, plastics, food and fertiliser industries. On the design of silos, the lecture developed from the simple silo to partitioned silos with multicompartments, which could be used with a single, or a mixture of raw materials. Specific spiral partitions gave equal wall pressures over the full depth of the silo, reducing compaction leading to easier discharge.

Where discharge units were required, these could be of the single or double discharge screw type. In special cases with materials that are difficult to discharge, a vibrating plate discharge unit could be used. A development from this was the multiple vibrating plate type which continually broke the micro-bridges which form to give an even discharge. Frequencies in the range 800 to 1800 cycles/minute are the most efficient. This type can be used as a dosing system.

A further development was the vibrating frame, augmented by a specially designed fluidisation system. The fluidisation is used to prevent material packing between the screens and the silo wall. With this latter system, 5 metre diameter silos holding 300 tons of titanium dioxide have been constructed. Mr Houben's experience has shown that mechanical vibration plus fluidisation is the best combination.

When raw materials are delivered in bags the use of a bag slitter of the semi or fully automatic type is recommended. In the latter case, 400 to 600 bags/hour can be processed. Depending upon the material, the order of product retained on the bags can be as low as 0.01 per cent, but losses of up to 0.5 per cent may be registered.

On conveying systems those of gravity feeding, dilute and dense phase pneumatic conveying methods of both blowing and suction types and mechanical screw feeding were briefly described. These were ably illustrated by slides and diagrams. Mr Houben favoured the dilute phase

conveying system as the most satisfactory, but indicated that it was limited to specific raw materials.

Ing. Houben continued with a brief outline of the special rotary and diverter valves used in bulk handling systems, along with receiving vessels, mixers and mixer/weight feeders. Special designs of lower energy mixers were available of up to 50 cubic metre capacity with a mixing accuracy of 1 in 1,000 after a 10-15 minute mix.

Since the running time of the lecture was at a premium the chairman reminded the audience of the time of the last Hull ferry for the OCCA members from the North Bank. A very brief conclusion to this excellent lecture covered bag filters, load cells and paint dispersers. The question time which followed was lively with in-depth questions on most of the items covered in the lecture.

The Hull OCCA chairman Mr Peter Munn gave the vote of thanks which was enthusiastically endorsed by the 54 members present from both societies. The chairman also welcomed the OCCA members present from the West Riding Section.

F. D. Robinson

Irish

Safe transport and handling of chemicals

At a meeting of the Irish Section on 19 September 1980, held at the Clarence Hotel, Dublin, Mr D. Fitzgerald of the FICI (Federation of Irish Chemical Industries) gave a talk entitled "Safe Transport and Handling of Chemicals".

To start, Mr Fitzgerald gave some details of the involvement of FICI in the area. The Federation is the sole representative body of 122 companies engaged in high technology science based industries. Before introduction of the new Irish regulations, FICI were involved in such measures as promoting the use of European System of Transport Emergency Cards (Tremcards) and publishing an Industry Code of Practice to improve safety in chemical transport.

Mr Fitzgerald then spoke on the new Irish regulations concerning the road transport of dangerous substances.

The Declaration Order (S.I.236:1980) designates 25 named chemicals as being "dangerous substances" in the context of the regulations. The Minister for Labour, when appropriate, can designate additional chemicals as dangerous substances.

The Road Transport Regulations (S.I.235:1980) came in for some criticism in that the departmental draughtsmen had tried to combine in a single document, the function of general "framework" legislation and the function of a detailed code of operating practice. The FICI feels that the framework regulations and the various codes of practice should have been kept separate but interlinked.

occa meetings

An interesting question time and discussion followed before the meeting was closed with P. McCrudden proposing the vote of thanks on behalf of an appreciative audience.

P. McCrudden

Scottish

Searching for oil in Alaska

The first meeting of the 1980-81 session was held at the Albany Hotel, Glasgow, on Thursday 9 October 1980.

The theme for this meeting was a talk given by J. R. Taylor, BSc, FRIC, FTSC, entitled "Searching for Oil in Alaska". Mr Taylor, who was formerly a consultant with BP Oil, spoke about his experiences in Alaska during the period when the oil pipeline was under construction.

The evening began with a most interesting film illustrating quite vividly the conditions under which both men and machinery had to work. It also clearly indicated the type of conditions that paints and other protective coatings had to withstand. The immense technical and physical problems which were experienced in both building and operating the pipeline were discussed at length and provoked a wealth of questions from the floor. The various methods used for coping with the permafrost and the resulting extremely low temperatures were discussed at length and many types of coatings were examined in the process.

At the end of the evening a vote of thanks was given by Mr Ron Barrett who asked for the Section to show their appreciation in the usual way.

W. L. MacDonald

Thames Valley

Modern coatings – a curse or a blessing

Report of the first technical meeting of the Thames Valley Section held on Thursday 2 October at the Beaconsfield Crest Motel, Beaconsfield.

"Modern Coatings – A Curse or a Blessing", a lecture given by Mr D. A. Bayliss of BIE (Anti-Corrosion) Ltd, Watford.

Mr Bayliss is a renowned, but not notorious member of the British coatings industry. Although he now works for BIE, he has spent many years working for the CEGB on paint coatings and corrosion control. Modern sophisticated coatings are generally classified as high performance materials, and prices are usually significantly higher than more conventional coatings. Since the user is paying these higher prices, he should therefore be entitled

to expect better performance. This is normally true, providing the manufacturers' data sheet requirements are adhered to and providing surface preparation has been carried out satisfactorily. The common standard for surface preparation these days is the Swedish Standard. Mr Bayliss indicated by means of graphs and slides, the problems that can occur with blast cleaned steel, showing that steel which apparently was clean may in fact still contain sufficient soluble salts to cause corrosion. Slides also indicated that steel which was in fact free from soluble salts when blasted could be kept for weeks in a high humidity, but non-condensing atmosphere, without corrosion occurring. Also shown was a classic example of a bridge, which is now 30 years old, with different paint systems on different panels all of which were behaving perfectly. The surface preparation had been minimal, the point being that the steel had been caught before any soluble salts had formed on its surface. The case presented clearly indicated that soluble salts left on a steel surface are a cause for concern and that adequate methods of testing have still to be achieved for proper site control. As a final example of surface contamination Mr Bayliss produced a matchbox which had been coated as part of a steel substrate.

The lecturer produced many questions, which brought out the following points:

1. It is always better to blast to the highest standard, particularly with corroded metals, to try and remove as much as possible of any salts which might be present in the pits which have formed. However, a further disadvantage which occurs now is that reactive primers, such as red lead, are being used less, but are of equal performance.
2. It was agreed that re-using grit tends to spread salt contaminants throughout the surface and may well impact them into the surface, and it was felt that a good washing down, or low pressure water blasting with sand, gave better results by removing surface contaminants. High pressure water blasting did not seem to give such a good surface.
3. There was a lot of value in defining surface preparation in words rather than just by photographs, and it was said that the British Standards approach of using descriptions is better understood by using operatives and inspectors, who have to ensure that the standards required are achieved.

It was an extremely constructive and entertaining evening, and the appreciation of Mr Bayliss by the audience for this was confirmed by Mr W. Tratton, who proposed the vote of thanks.

A. W. Fell

West Riding

Treatment and disposal of emulsion paint washings

The 1980/81 session of the West Riding Section started off on a bright note on Thursday 2 September, at the Mansion House, Leeds.

In a freshly decorated meeting room, the Chairman, Mr M. G. Bentley, of the Silvers Paint & Lacquer Company (SPL), gave an enlightening talk on the treatment and disposal of emulsion paint washings.

The paper consisted of an exposition of the problems and difficulties experienced by Mr Bentley's company, how they were solved and the costs involved.

The need to treat the effluent arose due to pressure from the local water authority. They used their legal powers to control the content, temperature, total amount and flow of the discharge into the sewer. Limits for the above were set and a charge made for the reception, conveyance, treatment and disposal of the effluent according to relating statutory provisions.

Mr Bentley went on to detail the problems that needed to be overcome.

Treatment of the effluent: the most technically difficult problem was said to be the reduction of the mercury content to less than 0.001mg/litre. After much work it was decided to change to non-mercurial preservatives.

The other problem was to drastically reduce the suspended solids. Three methods were considered; centrifuging, electro-flotation, and batch flocculation and elutriation. In view of its lower cost/efficiency, the latter process was the one adopted.

Mr Bentley illustrated and discussed the batch flocculation and elutriation process where the sludge would be disposed of by a sludge disposal contractor and the supernatant liquor via the sewer.

SPL was said to treat 0.5 million gallons of effluent per

occa meetings

year which cost an estimated £7,000. Mr Bentley advised that if non-treatment was allowed by the water authority their charges would then amount to £7,550 p.a.

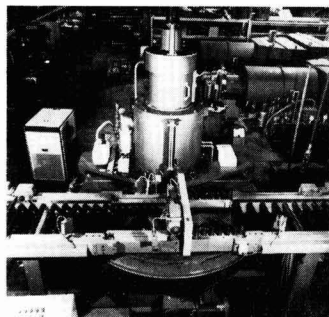
Cost of sludge removal was said to be £17,500 p.a. as tips approved to accept this were becoming fewer and more expensive. Dewatering of the sludge could reduce this cost dramatically.

Mr Bentley concluded his talk by stating that effluent treatment wasn't cheap, however satisfaction could be gained from the knowledge that a contribution to the environment was being made by helping to reduce pollution in streams and rivers.

After a prolonged and enthusiastic discussion period Mr Hugh Young gave the vote of thanks.

D. V. Maltman

Further information on any items mentioned below may be obtained by circling the appropriate Reader Enquiry Service number on the form at the back of the *Journal*. Enquiries will be forwarded to the organisation concerned.



Electron beam curing on shaped parts

The final breakthrough in the field of electron beam curing (EBC) of coatings on metallic and plastic shaped parts has been realised with the development of the first production unit, system ESH 150. Hitherto, EBC technology was suitable only for flat sections and sheeting. The new systems can be used with almost all materials.

An outstanding feature of the system, manufactured by Otto Dürr under licence from Polymer Physik Tübingen, is the use of only one high intensity beam which needs to be screened only with lead sheeting so that substantial space savings can be effected.

Reader Enquiry Service No. 31

CIL form new engineering equipment supply company

Compounding Ingredients Limited, the Manchester based manufacturer has set up a new company to supply chemical and general engineering equipment.

Compounding Ingredients (Technology) Limited will trade as CILTECH. General engineering products available from CILTECH will include pressure vessels, electric curing/drying ovens, blenders, heat exchangers, rotary filters and pumps.

Also available will be pneumatically controlled weighing systems and a range of pigment processing equipment including ovens, vats, mullers and mixers.

Reader Enquiry Service No. 32

European olefins and aromatics

Continued over-capacity in most petrochemical derivatives is forecast for the EEC and Western Europe in the latest study by CEFIC, the European Chemical Federation.

For example, the study forecasts total ethylene production capacity in Western Europe in 1983 will be 17.6 million tonnes, whereas its forecast of consumption is only 13.9 million tonnes. A similar pattern applies to propylene and butadiene.0

Reader Enquiry Service No. 33

news

Donald Macpherson acquisition

The Board of Donald Macpherson Group Limited have announced that they have acquired the whole of the issued share capital of Newcote Paints Limited on the basis of net asset value at a price of approximately £80,000. The company based in Mallusk, County Antrim, manufactures industrial coatings specialising in stove enamelling and finishes for agricultural vehicles, and has a turnover in excess of £500,000.

Reader Enquiry Service No. 34

Ellis & Everard to distribute copper sulphate

McKechie Chemicals Ltd, who claim to be Europe's biggest producer of copper sulphate, has appointed Ellis & Everard Chemicals as UK stockist and distributor for loads of up to one tonne.

Bulk supplies of over a tonne will continue to be delivered direct to customers by McKechie's from its manufacturing plants at Widnes and Bordeaux.

Reader Enquiry Service No. 35

news

Swale acquisition

Swale Chemicals Limited have announced the acquisition of International Paints Flexible Packaging Division, following a decision made by IP to rationalise their product range.

The products concerned comprise specialised coatings for metallised paper, high gloss overlacquers principally used for sachets, low temperature heat seals, cold seals and aluminium foil container coatings.

Reader Enquiry Service No. 36

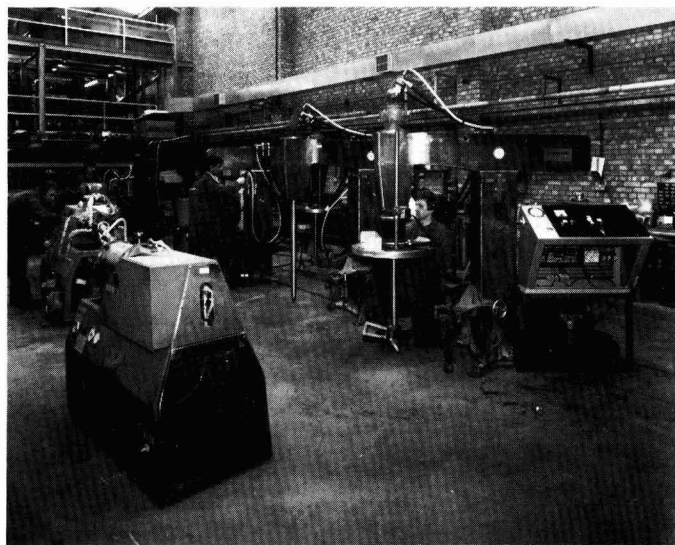
New location for Mastermix

At the beginning of February 1980, Mastermix Engineering Company Limited, took occupation at their new factory and offices in Vigo Place, Aldridge, Staffordshire.

Sustained expansion over the years had strained resources at both the Redditch and Bloxwich factories, therefore the present site was acquired with development commencing in January 1979.

The buildings were purpose built to the company's design, with special attention being given to stores and handling facilities in production and fabrication bays.

Reader Enquiry Service No. 37



New location for Mastermix

New lamps for old

A recent competition entitled "New Lamps for Old" was held to locate the oldest working stirrer manufactured by Voss Instruments Ltd.

The Magnetic Stirrer submitted by the Essex Water Company, still in good working order was found to be eighteen years old. This being the oldest out of the mechanical and magnetic stirrers submitted, it qualified them for an exchange.

Reader Enquiry Service No. 38

Price cut Volumair

A very large reduction in price of the Turbospray T2 portable surface coating unit has been announced by Volumair (UK) Ltd. The price has been reduced from £260 plus VAT to £170 plus VAT, making the T2 the most competitive of its type available in the UK.

The price cut follows increased production of these popular shoulder-portable units which has resulted in large economies of scale. Of almost equal importance however is the adoption of an improved motor design which, while giving greater performance reliability and ease of maintenance, is of a less complicated design so reducing component costs.

The fields of application for the Turbospray T2 range from automotive acrylics and vinyls, right through the middle range of enamels, glosses, emulsions etc. up to viscous textured coatings.

Volumair Turbospray units are also being used in industry for the manual and automatic application of such materials as release agents, adhesives - even foodstuffs such as sugar.

Reader Enquiry Service No. 39

Fluorescent pigments

By mutual agreement with Cornelius Chemical Co. Ltd, the agency for the Flare range of Daylight Fluorescent colours, is being handled by Capricorn Chemicals Ltd as from 1 December 1980.

Reader Enquiry Service No. 40

Solvent recovery

Process Water Systems are now offering "packaged" solvent recovery plants imported from West Germany, where more than 500 have been installed since they were introduced some four years ago. It is planned to manufacture them in the UK in 1981. A range of models to suit virtually all applications is available, mostly with delivery ex-stock, with optional full automation.

Reader Enquiry Service No. 41

International tie-up for Sonneborn & Rieck

Sonneborn & Rieck Ltd have concluded an agreement to produce and distribute the full range of wood finishing materials previously manufactured by International Paint Co. Ltd. This follows a decision by International Paint to cease manufacture of all wood finish products in the UK.

Reader Enquiry Service No. 42

new products

New-type Duran borosilicate glass safety valves

Schott of Mainz have developed and are introducing a new type of Duran borosilicate glass safety valve, to be used in particular for pressure vessels, apparatus and plants fittings, the nominal bores are DN 25, 50 and 100.

The new valve presents some marked advantages, it exhibits full valve passage in accordance with the nominal bores used for connection, i.e. the inlet pipe connection reaches onto the valve seat without any cross-section construction. As compared with the valve types so far in use, the blow-off capacity through the large-dimension outlet has been stepped up which ensures problem-free discharge of the media being issued.

The regulating excess pressure of this spring-loaded proportional safety valve can be chosen, depending on design, between 0.2 bar and 1.4 bar.

The valve is German Engineering Supervisory Association-tested and has been accorded a component test mark. Optimum inside and outside chemical resistance has been a prime feature in the design.

Duran borosilicate glass and PTFE are the only materials the medium comes in contact with.

Reader Enquiry Service No. 43



The pneumatically operated closing tool from Crosshall Engineering

Closing tool

A robust but lightweight range of pneumatically activated container closing tools which minimises operator fatigue has been developed by Crosshall Engineering.

Designed for closing tin-plate and other lids up to 22swg (0.5mm) and 12in (305mm) mean diameter the tool weighs only 28lb (13kg) and is therefore easily positioned over palletised or conveyor containers by twin handles incorporating a two-hand safety circuit.

Constructed of aluminium with stainless steel claws, the spiders are machined to suit particular lids and the claws machined after assembly to ensure an accurate closure. Standard models are available in imperial and metric sizes for 10, 11.25 and 12in and 220, 280, 285, 296 and 305mm mean diameter lids and incorporate 14 to 16 claws.

Reader Enquiry Service No. 44

Stannicide, fungi- and bactericidal

The use of organo-tin compounds to protect paint and adhesive films from fungal attack has been practised for many years. Their efficacy in this respect is well attested.

However, until now such products have had only limited bactericidal activity and when used in emulsion paint or adhesive systems the addition of an effective bactericide to provide protection during manufacture and storage has usually been required.

Stannicide FB, the latest addition to the Stannicide range, overcomes this disadvantage as it possesses both bactericidal and fungicidal properties. It provides in one product, protection for emulsion based paints and adhesives during manufacture, in-can storage and in the final dry-film state.

Reader Enquiry Service No. 45

Portable pH and mV meter

To supplement their portable pH meter range, Petracourt have added the PHM3. With separate outputs for pH and mV, the PHM3 has a resolution of 0.01pH and 1mV with an accuracy of ± 0.02 pH and ± 1 mV.

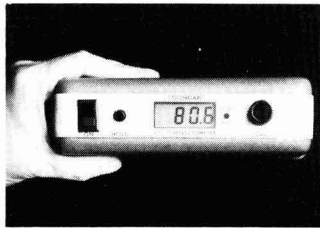
Reader Enquiry Service No. 46

Pocket size reflectometer

Elcometer have announced the availability of the Gardner Reflectometer II. It measures luminous (green) reflectance by utilising 45°/0° geometry, that is, light is incident at 45° and the sensor views the specimen perpendicularly.

Previous reflectometers were often large and cumbersome and required mains power for operation. For this reason, tests were usually carried out in the laboratory. The new digital Reflectometer II, introduced by Gardner Laboratory, is fully portable. It can easily be taken to a site, used for checks on the factory floor or on outdoor test sites. A hold button is provided to retain a reading when measurements are taken in difficult situations.

Reader Enquiry Service No. 47



The pocket size Gardner Reflectometer II from Elcometer Instruments

New fluorescent tubes

Starna Limited, stockists of specialist Philips Lighting products, are now able to offer the GraphicA 47 Fluorescent Colour Matching Tube. This tube has high specification and is designed to meet the needs of very demanding applications in the colour printing, photography and paint/pigment industries.

The GraphicA 47 has a correlated colour temperature of 5000K and a CRI of 98 per cent for the eight standard test colours (CIE Ra8), and better than 90 per cent for all test colours. This gives a very high fidelity of colour rendering and the lamp complies with BS 950 Part 2. Lamps are not required to be mixed or filtered in order to give the correct colour temperature.

Longevity is a major feature of the lamp's performance. Normally replacement is required only once per year, or after 4000 hours running time, thus helping to reduce both operating and maintenance costs.

Reader Enquiry Service No. 48

news

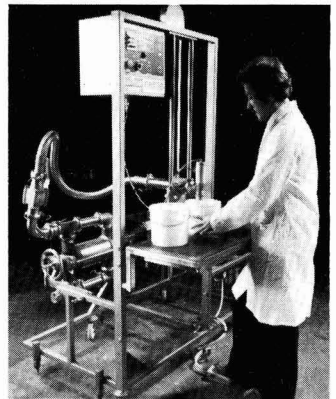
Filling machine for paints and chemicals

A semi-automatic filling machine for handling liquid paint, chemical and food products and capable of operating fully automatically is available from the Neumo Division of Neumo-Alite.

The air-operated machine will fill containers from 250ml to 25 litres semi-automatically or 250ml to 10 litres automatically. Volume of product dispensed can be changed instantly while accuracy of filling is guaranteed within ± 0.25 per cent by volume. Typical rates of filling are 40-250ml, 30-1 litres and 15-5 litres containers a minute fully or semi-automatically, automatic operation ensures consistent output and released operator for other duties.

The machine is equipped with a counterbalanced, variable height filling head for rapid positioning over various height containers or an interchangeable automatic rise-and-fall bottom filling head. A foot pedal control activates the semi-automatic operation through to completion of fill and an automatic counter gives multiple pump cycling for containers over 5 litres capacity. Adaptation to automatic operation requires only the replacement of a variable height filling platform with a continuous running conveyor equipped with a container sensor and gate mechanism which plug into the machine's pneumatic controls. All contact parts are stainless steel or PTFE and can be stripped quickly by hand when required or flushed through. The machine is flame and hose proof.

Reader Enquiry Service No. 49



Neumo's filling machine

Microprocessor controls new thermometer

The KM 10,000 series announced by Kane-May Limited provides numerous facilities not previously available with hand-held units.

Developed for industrial and scientific applications, the 10,000 series provides high accuracy throughout the range: minus 213°C to plus 1820°C ($\pm 0.2^\circ\text{C}$ ± 0.1 per cent reading between 25° to 300°C and $\pm 1.5^\circ\text{C} \pm 0.1$ per cent reading between 1370°C to 1820°C). Resolution is 0.1°C between -200°C and +200°C and 1°C outside this range.

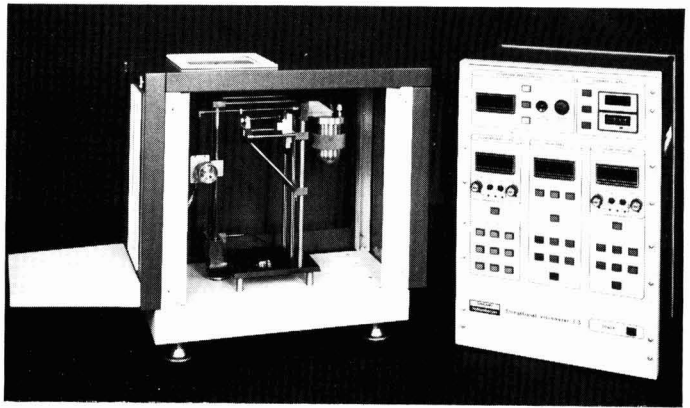
Conversion of displayed values from Centigrade to Fahrenheit, or from Fahrenheit to Centigrade, can be instantly effected at the touch of a button. In the Fahrenheit mode, resolution is 1°F at all times.

Other functions touch selectable from the calculator-style keyboard include constant monitoring and storage of maximum and minimum probe temperature, memory storage of any displayed temperature, memory recall of this value, and display of the value of probe temperature minus the temperature stored in the memory.

Reader Enquiry Service No. 50



New thermometer



Sangamo Schlumberger's Elongational Viscometer

Elongational viscometer

The Rheology Division of Sangamo Schlumberger has announced the introduction of a new Elongational Viscometer.

Essentially the instrument uses the principle of extruding fluid from a spinneret nozzle and extending it on a rotating drum. The force generated is measured by the deflection of the thin walled tube through which the fluid passes. This is achieved by a combination of mechanical amplification (through a pivot) and sophisticated electronics using an lvd transducer measuring system.

Load output is displayed digitally and/or recorded. Measurements are made for elongational stress and the rates of elongation along the extending fluid filament are determined. The drum speed is accurately controlled over a wide range from 0 to 2000rpm. Position of the drum, and hence fluid filament length can be varied from 25mm to 250mm. This is achieved electronically by push button control. The instrument is housed in an environmental chamber capable of controlled operation up to 100°C.

Reader Enquiry Service No. 51

Flameproof Bin-Dex level controls

A certified flameproof version of the Bin-Dex continuous level control, for solids and liquids, has been introduced by the 30-98 Company Ltd.

Among the important items of plant that are frequently required in hazardous areas are level indicators and controls for materials in bulk storage bins and tanks. For continuous level checking and indication, the Bin-Dex servo-operated level control is now available in versions certified for operation in areas with flammable gases and vapours.

For solid materials from powder to rock, the Bin-Dex consists basically of a bob suspended over a weight-sensitive pulley which checks whether the bob is clear of the material or in contact with its

surface. For liquids, from spirit to tar, the bob is replaced by a float. Sensing is carried out automatically at frequent pre-selected intervals, and between checks the readings are retained in a memory so that data logging can be carried out at any time.

For operation in normal atmospheres the principal components of the Bin-Dex are housed in a single weatherproof fibreglass head unit. In the new flameproof version the same items are accommodated in two enclosures. One enclosure, of cast iron and certified as flameproof, houses all electrical and electronic components, the second enclosure, of sheet steel, is open to the atmosphere and contains the load sending devices.

Reader Enquiry Service No. 52

Digital humidity and temperature meter

New to the range of Channel Electronics products is the series 5500 portable RH and temperature meter.

With the use of a powerful sealed fan, air is drawn across two precision matched temperature sensors, one of which measures the dry air temperature ("dry bulb") and the other, which is fitted with a moistened wick, measures the wet temperature ("wet bulb"). The two signals are then processed to automatically give a direct readout of relative humidity to a resolution of 0.1 per cent.

By determining relative humidity with this well proven technique, the errors normally associated with solid state sensors, such as contamination by smoke, oil, sulphur and water laden atmospheres are avoided and furthermore, due to the fundamental principles behind the aspirating psychrometric method, the sensor does not need the constant recalibration which is the fault most commonly associated with solid state RH sensors.

Reader Enquiry Service No. 53

Loctite applicator and Tak Pak

Loctite have made available their new air-actuated adhesive applicator. Known as the Loctite Nu-matic 800 series, it will dispense both Loctite cyanoacrylate and anaerobic adhesives direct from standard bottles in which these products are supplied.

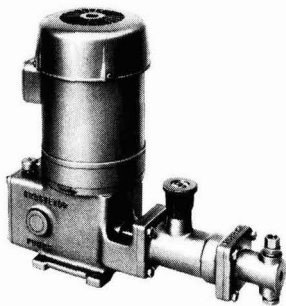
Adhesive is fed under air pressure to the application nozzle, to which is attached either a Vari-drop or Gluematic applicator. These manually-operated applicators can handle viscosities of up to 20,000cps and 50,000cps respectively, and the amount metered can be regulated by adjusting air pressure and valve open time.

Also available is the new Loctite Tak Pak adhesive kit specially formulated for the electronics industry for wire tacking and coil terminating.

The TakPak kit is a self-contained adhesive work station comprising a container of adhesive, a bottle of accelerator, brush, dropper, cutting blade and a special applicator tip to prevent clogging of the container nozzle.

For wire tacking applications it is simply a matter of positioning the wire in place. The accelerator is then brushed on both board and wire at the bond line. It takes between 5 and 30 seconds for the accelerator to dry to the required level, depending on prevailing conditions. A bead of adhesive is then dropped at the bond line.

Reader Enquiry Service No. 54



Variable output pump

Variable output for Grosvenor Pumps

Grosvenor Pumps, known for many years for their fixed output "Pygme" dosing pumps, have now introduced a manually variable output version of this pump in three sizes giving outputs up to 40 litres/hr and maximum pressure of 100 Bar depending on output.

Based on the successful and reliable "Pygme" pump gearbox and pump head, the new model again uses uncomplicated design for maximum reliability and easy maintenance.

Reader Enquiry Service 55

SPL extend range

Another new line has been introduced by Silver Paint & Lacquer Co. Ltd to complement its existing range of popular Home Charm matt and silk vinyl emulsions.

New Home Charm interior/exterior matt vinyl emulsion, it is claimed, equals the quality of any brand leader and is a durable, washable paint with an excellent smooth finish, it is suitable for all heavy duty areas such as kitchens and bathrooms and can be applied easily by brush or roller.

Reader Enquiry Service No. 56

Flowmeters

A range of inexpensive flowmeters, designed specifically to protect capital equipment by monitoring lubrication flow has been launched by the Ranger Instrument Company. Consisting of three basic instruments, they provide complete monitoring, and are available with a number of accessories and design options, including automatic alarm devices and shut-down controls in the event of a sudden loss of lubricant.

Reader Enquiry Service No. 57

Super - V vacuum pumps

Testbourne announce the introduction of a new range of high speed Super - V compressed air driven vacuum pumps, having pumping speeds ranging from 5ft³/minute to in excess of 8000ft³/minute.

The Lavenco Super - V pumps have no electric or mechanical driven motors, in fact they have no moving parts whatsoever. They contain no oil or other sealing fluid and can be manufactured from almost any elemental metal or alloy to suit specific applications. They produce a vacuum to better than 27 inches or 76mmHg in seconds.

Reader Enquiry Service No. 58

literature

Kronos leaflets

Kronos Titanium Pigments Ltd have made available information leaflets on "A new method to characterise the durability of Titanium Dioxide Pigmented Coatings" and "Chloride Process Titanium Dioxide Pigments".

Reader Enquiry Service No. 59

Small tonnage chemicals

BP Chemicals markets a range of speciality chemicals, all of which are detailed in the new edition of its booklet, "Speciality Chemicals".

Preservatives and plasticisers, and products for cosmetics and surface coatings are among the many chemicals produced by Small Tonnage Chemicals.

Reader Enquiry Service No. 60

news

meetings, etc.

Rheology seminar

The Department of Industry's Warren Spring Laboratory is to hold a seminar on Suspension Rheology at the Institute of Marine Engineers Conference Centre, London EC3 on 19 February 1981. Further information is available from Mr K. W. Payne, Warren Spring Laboratory, PO Box 20, Gunnels Wood Road, Stevenage, Herts SG1 2BX.

Preparation of steel before painting

The Institution of Corrosion Science and Technology will be holding a one day seminar entitled "Preparation of steel substrates before application of paint and related products" at the Imperial Hotel, London on 30 January 1981. Further information is available from Mr D. Bayliss, B I E Anti-Corrosion Limited, 30 The Avenue, Watford, Herts WD1 3NS.

appointments

Barry Canterford ATSC has recently been appointed as Southern Area Technical Sales Representative by Capricorn Chemicals.

Dr Ken Geddes has been appointed Chairman of the Board of Hythe Chemicals Limited, succeeding Mr Alex McIntosh.

Dr Geddes is a director of BP Chemicals Limited. Hythe Chemicals manufactures ethylene oxide and derivatives at Hythe, Southampton.

Edward M. Irving has been elected president and chief executive officer of Inmont Corporation, effective 1 January 1981.

Mr Eric Holdsworth has been appointed Director and General Manager of the Wallington based company of Honeywill & Stein Limited. He succeeds the late Mr Dennis H. G. Beckman.

Honeywill & Stein, established chemicals merchants for more than 100 years, is wholly owned by BP Chemicals.

Mr G. M. Boyce, MA, who was formerly Sales Director of Binks-Bullows Limited, has been appointed Deputy Managing Director of Volstatic Coatings Limited.

OCCA news

IMF Commemorative Dinner

The picture (right) was taken on the occasion of the celebration of fifty years service to the Institute of Metal Finishing by Dr S. Wernick, OBE (left) on 31 October and shows him talking to the Director and Secretary of this Association (Mr R. H. Hamblin) who paid tribute to Dr Wernick's work. See *JOCCA* page 503 December 1980.

For information on membership of OCCA, enquiries should be sent to the Association's offices, see front cover for address



OCCA-33 ANNUAL EXHIBITION

28-30 April 1981



The Exhibition Committee announces that the first allocation of space for the OCCA-33 Exhibition has now taken place.

It is particularly pleasing to note the return to the Exhibition of many companies who have not been able to participate for a number of years, as well as companies new to this Exhibition.

The OCCA Exhibition, which is known as the international focal point for the surface coatings industries, is the most important annual event of its kind in the industries, and it offers an unparalleled opportunity for personnel in the manufacturing industries to meet and discuss their requirements with their counterparts in the supplying industries.

In recent years, the OCCA Exhibition has regularly attracted thousands of visitors from between 40 and 50 countries who travel to London each year to view the latest developments affecting the industry and to contact companies for their needs.

The aim of the Exhibition is the presentation of technical and commercial information relating to raw materials, plant and equipment used in the paint, polymer, printing ink, colour, adhesive and allied industries, both in manufacture, processing and application.

The thirty-third annual OCCA Exhibition, a three day event, will be open as follows:

Tuesday 28 April	09.30 - 17.30
Wednesday 29 April	09.30 - 17.30
Thursday 30 April	09.30 - 17.30

The venue for the 1981 Exhibition will be the same as for OCCA-32, i.e. the Cunard International Hotel, Hammersmith, London, W6 and the Exhibition will be in two sections: on the ground floor, forming the entrance to the Exhibition, and in the rooms on the third floor of the hotel. A fully licensed bar and seating area will be installed in the New Hall.

The hotel has a selection of restaurants, shopping facilities and bars. The hotel is situated near Hammersmith Station on the Piccadilly Underground Line between Heathrow Airport and the centre of London. Hammersmith Station is also served by the Metropolitan and

District Underground Lines (the latter of which connects to Victoria Station for those arriving at Gatwick Airport). Car parking at the hotel is limited, but there is a large NCP car park close by in King's Mall off King Street.

Admission to the Exhibition will be free, and visitors will be asked to complete registration cards which will be available in advance from the Association's offices with copies of the Official Guide. Copies of the official Guide will be charged at £1.50 each, and both registration cards and copies of the Official Guide will also be available at the entrance to the Exhibition.



The Cunard International Hotel, Hammersmith, London, where this years OCCA Exhibition is being held



OCCA CONFERENCE 1981

The Beaufort Hotel,
Bath, England
17-20 June 1981

Alternative technologies in coatings

As already announced in the *Journal*, the next Biennial Conference of the Association will take place at Bath from Wednesday 17 to Saturday 20 June 1981. The headquarters will be the Beaufort Hotel, with overflow accommodation at the Francis Hotel and the Royal York Hotel. The title for the Conference will be "Alternative technologies in coatings". Summaries of most of the papers and biographies of the lecturers are given below. The programme for the technical sessions is as follows:

Session I

Thursday 18 June 9.15 a.m.–12 noon

Chairman: Mr C. N. Finlay, ATSC (Hon. Research & Development Officer)

Alternative technologies in coatings – The challenge and the response (Keynote address) By Dr L. Valentine

(Director of Research & Development, Berger Jenson Nicholson Ltd)

Pigmented UV dual clear coatings (Paper presented on behalf of FATIPEC) By Mr A. Noomen (Sikkens BV, Netherlands)

Developments in aqueous powder systems By Mr A. G. North (Managing Director, Cray Valley Products Ltd)

Modern practices in formulating powder coatings By Mr S. T. Harris (Consultant)

Session II

2.00 p.m.–4.30 p.m.

Chairman: Dr G. de W. Anderson (Managing Director, Paint RA)

Caprolactone in surface coatings By Dr B. E. Bailey and Mr J. Lister (Laporte Industries Ltd)

Obtaining opacity with organic pigments in paints By Dr H. Schäfer (Hoechst AG)

Alternative means of controlling paint viscosity/temperature phenomena By Dr N. Reeves (NL Chemicals Europe Inc., Belgium)

Precision spectral ultraviolet measurements and accelerated weathering (Paper presented on behalf of FSCT)

By Dr M. L. Ellinger and Mr G. A. Zerlaut (DSET Laboratories, USA)

Session III "Alternatives to coatings"

Friday 19 June 9.15 a.m.–12 noon

Chairman: Mr F. D. Timmins (Mebon Paints Ltd)

How not to paint bridges By Dr R. R. Bishop and Mr M. A. Winnett (Transport and Road Research Laboratory)

Short presentations—To be followed by discussion period

(i) Don't paint—use wood stains

By Dr F. W. Brooks (Hickson Timber Products)

(ii) Don't paint—galvanize

By Dr J. Wilcock (The Galvanizers Association)

(iii) Don't paint—use plastics

By Dr D. Gardiner (Building Research Establishment)

(iv) If you must paint—coil coat

By Mr N. S. Makins (European Coil Coating Association)

Session IV

2.15 p.m.–4.15 p.m.

Chairman: Mr A. C. Jolly (Synthetic Resins Ltd)

Plastic pigments: A novel approach to microvoid hiding. Part IV: Effect of composition on latex paint performance

By Dr A. Ramig (Gliden Coatings and Resins, USA)

Flow in coatings and orientation in metallics (Paper presented on behalf of SLF)

By Mr P. Fink-Jensen (Consultant)

Prospects for automation in the paint industry

By Mr M. Camina (Paint RA)

Conference preprints

Preprints of the papers are now being prepared and it is expected that these together with details of accommodation, badges, programmes etc, will be sent to those who have registered early in June 1981. It is a feature of the Association's Conferences that preprints are sent well in advance of the function, in order to enable delegates to read them before the Conference, at which the lecturers illustrate their topics, but do not read the papers in their entirety. This allows for a much longer discussion period than at many other conferences, and has proved of immense value to those attending previous Association Conferences.

Registration fees

Forms of registration will be despatched shortly to all Members of the Association attached to the Sections in the UK, Ireland and General Overseas Section, and for the benefit of non-members registration forms can be obtained by filling in the form on page v.

Council has fixed the registration fees for the Bath Conference at £80.00 (plus Value Added Tax at the standard rate) for Members, £105.00 (plus VAT) for non-members, and £25.00 (plus VAT) for wives. A daily registration fee for Members of the Association of £45.00

(plus VAT) and of £25.00 (plus VAT) for Registered Students of the Association has been set.

Non-members wishing to avail themselves of the preferential Conference fee for Members should request application forms from the Association's offices and these should accompany registration forms.

Further information may be obtained from the Director & Secretary at the address on the Contents page of this issue (Tel: 01-908 1086; Telex 922670 OCCA G).

The 1981 Biennial Conference of the Association will take place at Bath from Wednesday 17 to Saturday 20 June. The headquarters will be the Beaufort Hotel, with overflow accommodation at the Francis and Royal York Hotels. The title of the Conference is "Alternative Technologies in Coatings". Summaries of the papers, which in keeping with earlier conferences, are of a very high standard and biographies of the lecturers are set out on the following pages.

Bath, with its eighteenth century and Ancient Roman history, together with the unrivalled surroundings of some of the most picturesque countryside in England, is expected to prove to be one of the most popular venues the Association has arranged for one of its Conferences. The varied social programme will afford delegates and their ladies an opportunity to visit places of historical interest including the Roman Baths, the Pump Room, the Abbey and Royal Crescent in addition to the coach tours across some beautiful countryside to Chepstow Castle, Tintern Abbey, Wells Cathedral and Glastonbury; a tour has also been arranged to Longleat House, seat of the Marquess of Bath, where tea will be taken and which is set in a beautiful park created by Capability Brown.

As an innovation, on the Wednesday afternoon a Works Visit has been arranged to Torrance & Sons Ltd, Bitton, where delegates will have an opportunity of inspecting the manufacturing equipment for the surface coatings industries produced by this long established West Country firm.

Following the success of the river trip during the last Conference at Stratford, delegates will this time have an opportunity to travel on the Kennet and Avon Canal on board the "Jane Austen", during which coffee and biscuits will be served.

In addition to theatre parties on the Wednesday and Thursday evenings, arrangements have been made for delegates to tour the John Harvey Wine Museum on Thursday evening where they will be given a lecture, shown a film and have an opportunity of tasting the various types of sherry - transport has been arranged for this function.

For those wishing to play in the golf tournament (for the OCCA Conference Trophy donated by Mr S. Sharp) facilities will be available at the Lansdown Golf Club.



The papers to be presented at the Conference together with summaries and biographies of the authors appear below

Alternative technologies in coatings - the challenge and the response

By L. Valentine

Various economic, sociological and legislative factors are influencing the paint business and coatings technology to greater and greater extents. The challenges that these trends present, and the responses which the coatings industry is developing in terms of alternative technologies in both decorative and industrial paints, are analysed. The critical role of innovation is stressed.



L. Valentine

Dr Leslie Valentine graduated from the University of Aberdeen in 1946 with a First-Class Honours Degree in chemistry, and then obtained a PhD in 1949 for research on the mechanism of copolymerization in the research school of Professor (now Sir Harry) Melville.

Further post-graduate research on polymerization kinetics at the University of Birmingham was followed by five years as lecturer in the chemistry of high polymers in the Textile Department of the University of Leeds.

In 1957 he was appointed Research Manager of Tootal Broadhurst Lee in Manchester, working mainly on resin treatments of cellulose fibres.

From 1960-67 he was Director of the Paint Research Association in Teddington, and since 1968 he has been Director of Research and Development for Berger, Jenson & Nicholson Limited, where in addition to R & D, he has responsibility for Health and Safety and the Far East, both areas of high technical content nowadays.

Pigmented UV dual cure coatings

By A. Noomen

One of the most important disadvantages of current UV curable systems is the difficult and often insufficient curing of pigmented coatings, caused by the high absorption of UV light by most of the pigments. Use of a UV dual cure binder combination, i.e. a combination of UV curing and a second independent curing mechanism might help to solve this problem. Suitable UV dual cure binders can be prepared, e.g. by the reaction of a polyisocyanate with a less than stoichiometric amount of a hydroxy acrylate ester.

The unsaturated bonds are used in the

UV curing process and the rest of the isocyanate groups can be cured subsequently with atmospheric moisture or binders containing active hydrogen atoms.

In a paper presented at the Fatipecc Congress 1980 at Amsterdam the properties of clear coatings based on this binder type were already described.

A number of these isocyanate based binders are pigmented with white and colour pigments and tested on cure speed. The influence of the UV initiator and the spectrum of the UV radiation source on cure speed will be described. Special attention will be paid to the results with white, blue and yellow UV dual cure coatings.



A. Noomen

Mr A. Noomen entered the paint industry in 1958, when he joined the Sikkens Paint Company at Sassenheim, Holland.

He was involved in the research and development of aircraft, furniture, marine and maintenance finishes and solventless materials for the building industry (plastic mortars, flooring etc.).

He is presently working as the leader of an innovative research project on room temperature curing high solids coatings.

Developments in aqueous powder systems

By A. G. North

Powder coatings dispersed in water allow the use of normal spraying equipment and can produce finishes of lower film weight if required. Conditions for optimum dispersion are established and performance is compared with electrostatically applied powder coatings.

By combining these powder dispersions with water soluble resins, coatings can be produced which can combine the advantages of both types of coatings and which can also be anodically or cathodically electrodeposited. Major economic advantages can be obtained if the previous systems can be equalled with combinations of pigmented water soluble resins and powdered resins. One can then develop this concept into the improvement of water based coating application solids by minor additions of aqueous dispersions of powdered resins.

These various concepts are studied and the advantages and disadvantages are discussed in terms of practical results using polyester powders and a variety of water soluble resins. Economics, theoretical considerations and long term stability are also studied.



A. G. North

Graham North was educated at London University where he gained a BSc with Honours in chemistry, and subsequently graduated from a Business School Programme at Harvard. He has spent his entire business career at Cray Valley Products in a variety of posts and is currently Managing Director. He is also a Director of the parent company, Coates Bros. & Co. Ltd. He is a past Chairman of the British Resin Manufacturers Association and until this year, has been Honorary Treasurer of the Paint Research Association. He is the author of

a number of technical papers on thixotropic resins, electrodeposition, radiation curing and ecological studies, having given lectures to many branches of OCCA in this country and overseas.

Modern practices in formulating powder coatings

By S. T. Harris

In the infancy of thermoset powder coatings development the formulating techniques of the plastics compounding industry were adopted by the coatings technologist without prior knowledge of the rheological behaviour of solvent-free, hot melt compounded systems. A decade of investigative development with resins, curing agents, pigments and an appreciation of the role of additives has produced standard practices for formulating sophisticated powder coatings. The modern procedures are reviewed and areas of future development are considered.



S. T. Harris

A graduate of London University Mr Harris was, for many years, involved in all aspects of synthetic resin research and development with Arthur Holden and was actively concerned from the mid-sixties with the new concept of powder coatings. Now serving as an independent coatings consultant his prime interests are the new developments in powder coatings technology. He is the author of the only authoritative textbook on powder coatings, has lectured widely and contributed many articles on formulating and manufacturing procedures.

Caprolactone in surface coatings

By B. E. Bailey and J. W. Lister

The incorporation of polycaprolactone into solvent based and water based surface coating resin media offers advantages which include higher solids, improved flexibility and adhesion and in some instances considerable cost saving.

The polymerization of caprolactone by a ring opening mechanism in the presence of active hydrogen containing "initiators" is described. Molecular weight and functionality are controlled by the

amount and type of "initiator" used. These properties enable caprolactone to be employed in the following surface coatings applications.

1. Graft copolymers

Hydroxyl containing resins such as acrylics, alkyds and oil free polyesters are suitable as initiators for the polymerization of caprolactone.

Methods are described to produce polycaprolactone modified acrylic resins which, when used with conventional cross-linking agents, produce flexible high solids coatings.

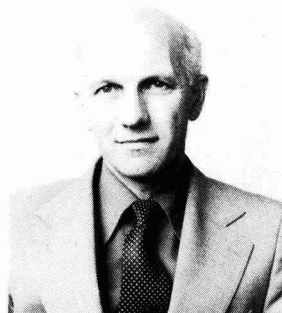
2. Polyesters

Low molecular weight polycaprolactone polyester diols and triols are low viscosity liquids which function as reactive plasticizers in a wide range of solvent and water based stoving coatings.

Improvements resulting from the addition of a polycaprolactone diol to epoxy amino primers and finishes are demonstrated.

Low molecular weight polycaprolactones can also be used as major components of high solids two pack polyurethane coatings or as intermediates for urethane acrylate UV curing media.

Brian E. Bailey graduated in chemistry in 1957 at Southampton University and in 1961 received a PhD with Professor



B. E. Bailey



J. W. Lister

Bamford at Courtauld for work on acrylonitrile polymerization. This was followed by a seven year period of research on rubbers and plastics at ISR. In 1967 he headed research at British Oxygen Chemicals covering emulsion paints and adhesives and tall oil products. For the last nine years he has controlled the applications research on caprolactone at Laporte.

Joe Lister graduated in colour chemistry at Bradford University in 1976. He worked in the can and coil coating division of Berger Paints before joining caprolactone applications research at Laporte in 1979.

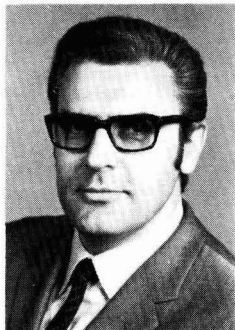
Obtaining opacity with organic pigments in paints

By H. Schäfer

For several reasons organic pigments are gaining importance in formulating lead-free deep yellow, orange and red shades.

Obtaining adequate opacity by using organic pigments only is, in most cases, not feasible. Two different ways which could lead to satisfactory results can be taken into consideration: Firstly high opacity organic pigments or secondly high strength organic pigments in each case in combination with appropriate inorganic pigments. The efficiency of these two principles is demonstrated. As the pigmentation level is one decisive factor in the resulting opacity, all comparisons were carried out with paints of identical flow properties. In addition it is logical that only chemically identical high strength and high opacity pigments can be considered for such a study.

Further, the characteristics and potentialities of high opacity organic pigments are discussed in more detail.



H. Schäfer

Dr H. Schäfer graduated from Frankfurt University in physical chemistry in 1966. After some years research work at the Institute of Physical Chemistry of the same university he joined the Technical Service Department, Pigments, of Farbwerke Hoechst AG in 1968. He was appointed group leader in 1974. His responsibilities include pigment

development and technical service activities for the paint industry.

Alternative means of controlling paint viscosity/temperature phenomena

By N. Reeves

The behaviour of a paint varies quite markedly with change in temperature. The degree of change in behaviour is related to the formulation, and can be influenced strongly by the presence, or absence, of quantitatively minor ingredients. The assumption that this behaviour can be easily predicted from limited information is on occasion quite erroneous.



N. Reeves

The lecturer studied at Teesside Polytechnic where he obtained his Grad. RIC. He then went on to carry out post-graduate research at Durham University where he obtained his PhD in 1970 for work on structure-property relationships of polyesters. After completing one year post-doctoral fellowship in the same subject, he joined the Technical Service Department of BTP Tioxide Limited. After a total of eight years with this company, he joined his present company, Nalterra Limited, a wholly owned subsidiary of NL Chemicals Europe Inc., as the Technical Service Manager, based at Livingston, Scotland.

Precision spectral ultraviolet measurements and accelerated weathering

By G. A. Zerlaut and M. L. Ellinger

The objective of accelerated testing is the prediction of long-term behaviour in short-term tests. Accelerated weathering has as its specific objective the prediction of environmental effects. It is becoming increasingly evident that the timing of exposure tests, on the basis of elapsed time only, is largely responsible for failures to achieve correlation between exposures at the same site, exposures between sites, and especially exposures between accelerated and real-time tests. Although the prevalence of moisture as dew, rain, condensation and humidity is acknowledged as critical to the weathering process, the quantitative and qualitative relationships between ultraviolet

deposited under various conditions are components of the weathering environment having a first-order effect. First to be affected by different sky conditions, as well as aging effects in simulated sun sources, are the shorter wavelengths that are most critical to the duration of materials, especially the more stable materials having spectral responsivity only at the shorter wavelengths.

It is these considerations that have lead DSET to begin reporting exposures in terms not of elapsed time, or even total langley's, but in terms of total ultraviolet in a given waveband: all UV below 400nm, total UV between 298 and 310, 310-320, 320-340, etc. This is being accomplished using the DSET solar spectroradiometer, currently one of only two such devices in regular use in the US.

The spectroradiometer is briefly described, and pertinent spectra are presented as they relate to fundamental exposure considerations employed at DSET. In this respect, the EMMA(QUA)[®] test method is discussed with attention devoted to the subject of completely different ultraviolet characteristics as a function of time of year (e.g. air mass).



G. A. Zerlaut

Mr Zerlaut, a graduate of the University of Michigan, is a co-owner of DSET Laboratories, Inc. where he is engaged in solar device testing, solar materials testing, accelerated weathering, and solar radiation measurements. Prior to joining DSET in 1973, he was employed by NASA's Marshall Space Flight Centre and later by IIT Research Institute for 11 years, where he was Manager of Polymer Chemistry Research. His memberships include: ISES, AIC, ACS, AIAA, SPE, SAE and ASTM. He is an ASTM representative for the US to the International Standards Organization's ISO/TC 61 Plastics Committee, and was recently elected Chairman of ASTM Committee E-44 on Solar Energy Conversion. He is a member of the board of directors of the Solar Energy Industries Association, is a member of the board of the Solar Energy Research and Education Foundation, and is a past Director of the American Institute of Chemists (for whom he developed a national accreditation/certification programme for Chemists and Chemical Engineers in 1967-75). He is credited with more than 50 publications.



M. L. Ellinger

Dr Marianne L. Ellinger graduated and received her PhD in chemistry in 1936 from the University of Sciences, Budapest. Following a decade in development work and later as Chief Chemist in the paint industry, she joined the Hungarian Paint Research Institute where she held the post of Head of Technical Service until her departure from Hungary in 1956. Dr Ellinger then joined General & Industrial Paints Ltd, later Ault & Wiborg Paints Ltd, Perivale, in 1957 as a research chemist working on motor finishing systems. Following her appointment as Senior Scientist in 1963, she was mainly involved in the research and technology of electrocoat paints. A long standing interest in durability studies of surface coatings led to close co-operation with DSET from 1967 on joint projects aimed at correlating the results of accelerated outdoor weathering with those of exposure in practice. On her retirement from A & W Paints Ltd in 1976, she was appointed European Representative of DSET Labs. Inc. She also works as a consultant on surface coatings and is a Fellow of the RSC and OCCA and author of several papers, one of the presented on behalf of OCCA at FSCT.

How not to paint highway bridges

By R. R. Bishop and M. A. Winnett

A novel approach is proposed for the protection of the structural steelwork of composite bridges by physically changing the environment to which the steelwork is exposed. Clean steel does not corrode at relative humidities up to 99 per cent if environmental contaminants are absent. It is apparent that the most critical factor affecting corrosion rates in enclosed spaces is pollution by chlorides and sulphur dioxide and not high relative humidity. A small scale experiment has shown that it is possible simply to enclose the already sheltered steelwork of a composite bridge to produce an environment which is contaminant-free and in which corrosion does not take place. It is very reasonable to assume that blast cleaned painted steel will have a very long maintenance free life in such environments free from contaminants. There is also interesting preliminary experimental work which indicates that the corrosion rate of pre-corroded specimens reduces

rapidly when introduced into a contaminant-free enclosure. This concept of steelwork enclosure will be regarded as novel but if the observations and experiments carried out to date are proved correct then potential savings in maintenance painting could be considerable.



R. R. Bishop

Dr R. R. Bishop graduated from London University with a BSc (1947) and PhD (1950) in chemistry. He has worked in the synthetic resin, paint and oil industries. Since 1963 he has headed a section engaged in corrosion prevention research at the Transport and Road Research Laboratory. He is a Fellow of the Institution of Corrosion Science and Technology and was for several years Chairman of the Technical Committee.



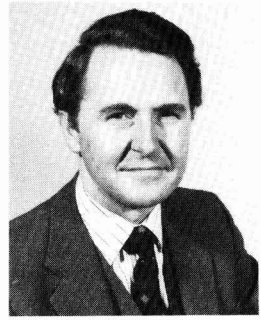
M. A. Winnett

Mr M. A. Winnett entered the Royal Navy Scientific Service in 1964 working at the Admiralty Underwater Weapons Establishment, Portland, where he also qualified as a shallow water diver. He moved, on promotion, to the Transport and Road Research Laboratory in 1971 joining a team developing a high speed laser profilometer. In 1975 he transferred to Dr Bishop's section studying the effect of microclimate on the maintenance painting season.

Don't paint—use wood stains

By F. W. Brooks

Dr F. W. Brooks was educated at Leeds University and left in 1966 to join the British Leather Manufacturers' Research Association as a Research Officer. In 1970 he joined the Timber Research and



F. W. Brooks

Development Laboratories of Hickson's Timber Products Ltd as a Development Chemist working initially on the formulation of wood preservatives. He is now the Technical Manager of Hickson's Timber Products Ltd and as such is involved with the development of both waterborne and organic solvent based wood preservatives for use around the world, taking into account the biological hazard conditions and also the environmental restrictions in force in different countries. The laboratory where he works also gives support to the sale of a range of translucent wood stains, formulated to be compatible with the wood preservatives which they manufacture.



N. S. Makins

If you must paint—coil coat

By N. S. Makins

In 1954 Mr N. S. Makins joined Richard Thomas Baldwins as a Sales Development Engineer, and since then has been involved in all aspects of the application of thin steel sheet products in both home and export markets. He joined Constrado in 1976 with responsibility for developing the use of thin steel sheet products in construction.

He was Chairman of the BSI Committee responsible for the preparation of DD24 "Methods of Protection against Corrosion on Light Section Steel Used in Building", the BSI Committee responsible for the preparation of coated steel sheet products standards and the ECSC Committee responsible for the preparation of Euronorms on zinc coated products. He is also Vice-President of the European Coil Coating Association.

Plastic pigment: A novel approach to microvoid hiding. Part IV: Effect of composition on latex paint performance

By A. Ramig

Latex paint films containing plastic pigment demonstrate an advantageous property balance. This property balance allows the design of higher hiding products at a given TiO_2 concentration while retaining other properties. The net result a reduction of up to 30 per cent in the amount of TiO_2 required to achieve the same opacity as a more conventionally formulated paint. The effects and interactions of plastic pigment concentration, TiO_2 concentration, extender concentration and coalescing solvent concentration on performance are described for one set of materials. Experiments are designed to allow analysis of results by regression methods, and mathematical models are developed. Also included is a discussion of performance optimization. Comments on the usefulness of this design and analysis methodology are offered.



A. Ramig

In 1964, Dr Ramig received his Bachelor of Science degree in chemistry from the University of Nebraska located in Lincoln, Nebraska. He received his PhD in physical chemistry from the University of Louisville in Louisville, Kentucky in 1970 with a thesis on polymers prepared from radiation polymerization.

He began his coatings career with the Celanese Coatings Company where he was employed for four years as a product development chemist specialising in latex interior and exterior trade sales paints. He joined the Glidden Coatings and Resins Division of SCM Corporation in 1970. At Glidden, he has conducted research on latex paints and has managed a coatings research department where he supervised new product research for both trade and

industrial market areas. He currently holds the position of Associate Director, Chemical Coatings R&D, where he administers new product development activities on waterborne, high solids, electrocoat and powder coatings.

He is a member of the American Chemical Society, the Federation of Societies for Paint Technology, Phi Lambda Upsilon Chemistry Honorary, and the Roon Foundation Committee.

Flow in coatings and orientation in metallics

By P. Fink-Jensen

A wet paint film is subject to various movements not only during application, but also in the subsequent, much longer, quiescent period until solidification. The flow processes are connected with the creation as well as the disappearance of surface imperfections, but may also have a profound influence due to the orientation of constituents of the bulk film.

The flow phenomena are usually attributed to gravity (sagging), surface tension (levelling) and its variations during evaporation (edge effects, Benard cells), however an additional mechanism will be presented and related to the effect of the surface profile of the substrate.

Orientation phenomena are especially pronounced with metallics, the resulting appearance being very sensitive to spray conditions. Theoretical explanations are proposed of some decisive flow factors connected with the spray process and the phenomenon of orientation of the flakes according to their shapes. The deductions seem to agree with practical experience. The practical possibilities of characterising orientation and appearance by colour measurements will be touched upon.



P. Fink-Jensen

P. Fink-Jensen graduated 1941 in chemical engineering from the Royal Technical University in Copenhagen. After six years of metallurgy he joined the paint industry and was the Research Director of Sadolin & Holmblad until 1978, when he became a consultant.

He has written many technical-scientific papers, notably involving physical phenomena, rheology and colour in Scandinavian and international journals. He has lectured to FSPT, FATIPEC, OCCA and SLF and also to national paint and printing ink associations of East and West Germany, Holland, Belgium, Sweden and Denmark.

He was a co-founder of the POC journal and has been a consulting editor since its start. For twelve years he was the chairman of the Supported Polymer Films group of IUPAC until he recently resigned. He further edited its booklet: "Hardness Testing of Organic Coatings", and has been a member of OCCA since 1953.

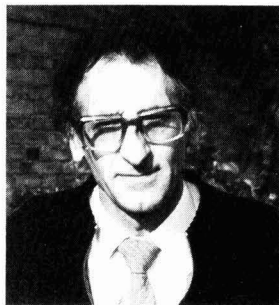
Prospects for automation in the paint industry

By M. Camina

The repercussions of the introduction of microprocessors into manufacturing industry has necessitated a closer look into ways of automating more difficult processes such as resin and paint making.

The steps involved in paint making, delivery of resin and solvent, addition of pigments and extenders and other materials, premixing, dispersion, colour corrections, viscosity control, and filling are discussed with the potential for automatic and microprocessor control.

Automatic control of resin making is a reality although various levels of microprocessor control can be used. The benefits and simple design criteria of an additional polymerization reaction are reviewed.



M. Camina

Mr M. Camina began work in the paint industry with Pinchin Johnson and Associates, now part of the International Paint Co. He moved to Australia to join the paint group at the Defence Standards Laboratories where he developed an interest in paint testing methods. Since 1967 he has been employed at the Paint Research Association. He recently served on the Working Groups, set up by the Paint RA, to evaluate the application of microprocessor control to paint and resin manufacture.

News of members

On 9 December 1980, Derek Bayliss was installed as President of the Institution of Corrosion Science and Technology.

Derek Bayliss started his corrosion working life as a Power Station chemist and, because of his interest in paints and coatings in corrosion prevention, helped to set up and form the CEGB Protective Coatings Laboratory in 1961. He was head of this section until 1977 when he

left to take up an appointment as Technical Director of a well-known independent painting and coating inspection company which operates throughout the world.

Derek Bayliss is widely known on the lecture circuit in this country and more recently overseas in the Middle East, USA, Far East and Australia. He has held a number of positions within the Oil and Colour Chemists' Association where he is currently a vice-president and also within the Institution of Corrosion

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Science and Technology where he is a past chairman.

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

MUNTENER, KURT, BSc, 18c Bycullah Road, Enfield, Middlesex EN2 8EJ (*London*)

SULLIVAN, JOHN PATRICK, 16 Osprey Avenue, Templeogue, Dublin (*Irish*)

JONES, JOHN STANLEY, 4 Norwood Crescent, Formby, Liverpool L37 4DB (*Manchester*)

MAYER, DAVID JOHN, BSc, PhD, Ceramics, Matthey Printed Products, William Clowes St, Burslem, Stoke on Trent ST6 3AT (*Midlands*)

ROWE, KEITH LESLIE HAMILTON, 21 Ombersley Road, Hasbury Halesowen, West Midlands B63 4PJ (*Midlands*)

JEFFERIES, ANTHONY DAVID, Fergussons Paints 12050, Jacobs 4026, South Africa (*Natal*)

MACKENZIE, ALAN BRUCE, Associated Lead Manufacturers, PO Box 12043, Jacobs 4026, South Africa (*Natal*)

CROZIER, PETER HUGH, BSc, 51 Rutland Road, Mt. Wellington, Auckland 6, New Zealand (*Auckland*)

CAMPBELL, GLENN RICHARD, BSc, Heating Industries Ltd, Private Bag, Rosebank, Auckland, New Zealand (*Auckland*)

BOLT, CLIVE JOHN, BSc, 20 Camwell Close, Backlands Beach, Auckland, New Zealand (*Auckland*)

Details are given of Association meetings in the United Kingdom and Ireland up to the end of the third month following publication.

January 1981

Manchester Section: January, Joint Lecture with the Institute of Printing. Details to be announced.

Monday 5 January

Hull Section: "The Paint Tin" by J. B. Welbury and Mr Holmes of Metal Box Ltd, at the Queens Hotel, George Street, Hull, commencing at 6.45 p.m.

Thursday 8 January

Newcastle Section: "Stability of Pigment Dispersions" by Dr M. Jaycock, Loughborough University, at the Students Common Room, St Mary's College, Elvet Hill Road, Durham, commencing at 6.30 p.m.

Thursday 15 January

"Advances in Development of Water-Borne Printing Inks for the Major Printing Processes" by Dr C. Armstrong of Coates Bros Ltd. This meeting will be held in the Royal Scot Hotel, Edinburgh and is a joint *Scottish Section/Eastern Branch Meeting*.

London Section: "Hydrocarbon Solvents" by A. M. Cumbers of Carless Solvents Ltd, at the "Princess Alice", Romford Road, Forest Gate, E7, commencing at 6.15 p.m. To be followed by a buffet supper.

Friday 16 January

"Automotive Paints - Views of a user

new members

BAILEY, PETER CHARLES, MSc, PhD, 11 Woodford Road, Mt. Eden, Auckland, New Zealand (*Auckland*)

STASSEN, LOU, Hunter Douglas, 960 Great South Road, PO Box 12046, Penrose, Auckland, New Zealand (*Auckland*)

POHIO, BARRY EDWARD, c/o Shell Chemicals, PO Box 1084, Auckland, New Zealand (*Auckland*)

Associate Members

HAZEN, MICHAEL WILLIAM JOHN, 32 Colbeck Crescent, Alliston, Ontario, Canada (*Ontario*)

DENT, HENRY, PO Box 11-091, Christchurch, New Zealand (*Wellington*)

TULLIS, DONALD CHARLES, Fergusson's Paints (Pty) Ltd, PO Box 12050, Jacobs 4026, South Africa (*Natal*)

Student Member

EDWARDS, JOHN RICHARD, BJN Holdings (NZ) Ltd, Box 19-020 Avondale, 507 Rosebank Road, Auckland, New Zealand (*Auckland*)

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and a manufacturer" by M. Kelly of BL Ltd and R. Tennant of Carrs Paints. This will be held at the Chamber of Commerce and Industry, Birmingham and is a joint *Midlands Section/Trent Valley Branch Dinner Lecture*.

Wednesday 21 January

Manchester Section: Student Lecture "Pigments for Printing Inks" by Dr J. D. Sanders of Ciba-Geigy Plastics &

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Additives Co., at the Manchester Polytechnic, New Administration Building, All Saints, commencing at 4.30 p.m.

Thursday 22 January

Thames Valley Section: Works Visit. *Details to be announced.*

Friday 23 January

Irish Section: Open Forum – Panel from Paint/Printing Ink Industries and IIRS, at the Clarence Hotel, Dublin, commencing at 8.00 p.m.

Friday 30 January

Bristol Section: "Paint Specifications – Acceptance procedures as they affect the Paint Industry" by R. L. J. Morris, QAD Woolwich, at the Royal Hotel, Bristol, commencing at 7.15 p.m.

February

Monday 2 February

Hull Section: "The Maintenance and protection of North Sea Structures" by F. M. Small of Berger (UK) Ltd, at the Queens Hotel, George Street, Hull, commencing at 6.45 p.m.

Tuesday 3 February

West Riding Section: Lecture on "Some Aspects of Micro Processors". *Details to be announced.*

Thursday 12 February

Midland Section – Trent Valley Branch: "Dispersants-Theory and Practice" by Dr R. D. Harding of Bevaloid Ltd, at the Derby Crest Motel, Pasture Hill, Littleover, Derby, commencing at 7.15 p.m.

Scottish Section: "Water-Borne Systems" (a) Industrial Finishes by Toxide International, (b) Wood Finishes by Hill Son & Wallace, at the Albany Hotel, Glasgow, commencing at 6.00 p.m.

Friday 13 February

Manchester Section: Lecture "Computer Match Prediction" by Dr I. Bridgman of Ciba-Geigy Ltd, at the Manchester Polytechnic, New Administration Building, All Saints, commencing at 6.30 p.m.

Scottish Section – Eastern Branch: Annual "Burns Supper" at the Commodore Hotel, Marine Drive, Edinburgh. *Details to be announced.*

Tuesday 17 February

London Section: "Surface Character & Performance of Organic Pigments" by Dr R. R. Mather of Ciba-Geigy Pigments & Additives Co. Joint meeting with the Society of Chemical Industry at the S.C.I. 14 Belgrave Square, London SW1 commencing at 6.00 p.m.

Midlands Section: "Pretreatment for Paint" by M. Danks of W. Cannings Materials Ltd, at the Calthorpe Suite, County Cricket Ground, Edgbaston, Birmingham, commencing at 6.30 p.m.

Thames Valley Section: "Truflex coatings for tennis court surfacing" by B. R. Wynne of R. J. Hamer & Sons Ltd, at the Beaconsfield Crest Motel (White Hart), Aylesbury End, Beaconsfield, Bucks, commencing at 6.30 p.m. for 7.00 p.m.

Wednesday 18 February

Manchester Section: Student Lecture "Woodpriming Paints" by Messrs F. Redman and W. Phillips of Crown Paints Ltd, at the Manchester Polytechnic, New Administration Building, All Saints, commencing at 4.30 p.m.

Friday 20 February

Irish Section: Ladies' Evening. *Details to be announced.*

Newcastle Section: Ladies' Night at the Five Bridges Hotel, Gateshead. *Details to be announced.*

March

Manchester Section: Student Works Visit. *Details to be announced.* Informal Buffet Dance. *Details to be announced.*

Monday 2 March

Hull Section: Ladies' Evening. *Details to be announced.*

Tuesday 3 March

West Riding Section: "Colour Systems" by G. Pakvis and L. Wehrens of Tenneco Colotrend BV, at the Mansion Hotel, Roundhay Park Leeds 8, commencing at 7.30 p.m.

Thursday 5 March

Newcastle Section: "A Hundred Years of Colour Chemistry" by Prof. Rattee, Colour Chemistry Dept, University of Leeds, at the Students Common Room, St. Mary's College, Elvet Hill Road, Durham, commencing at 6.30 p.m.

Monday 9 March

Manchester Section: Lecture "Medials" by Manchem Ltd at the Crest Motel, Bolton, commencing at 6.30 p.m.

Wednesday 11 March

Scottish Section – Eastern Branch: "Line Measurement of Colour" by Dr Ferguson of Instrumental Colour Systems. This is organised by BP and BIF Scottish District, and will be held in the King Malcolms Hotel, Dunfermline, at 7.30 p.m. to which all interested persons are invited.

Thursday 12 March

Scottish Section: "Pigments" Film and Lecture – Lecturer from BASF Ltd, at the Albany Hotel, Glasgow, commencing at 6.00 p.m.

Trent Valley Branch: "British Rail Specifications – What, Why and How" by Dr F. G. R. Zobel, Head of Surface Coatings Laboratories British Rail, at the Derby Crest Motel, Pasture Hill, Littleover, Derby, commencing at 7.15 p.m.

Wednesday 18 March

London Section: "Applications of Colour". Joint one-day symposium with the Society of Dyers and Colourists, London Region at the Thames Polytechnic, Woolwich, SE18, commencing at 10.00 a.m.

Ontario Section: Meeting at the York Suite of the Cambridge Motor Hotel, Ontario, commencing at 6.00 p.m.

Thursday 19 March

Midlands Section: Newton Friend Ladies' Invitation at Chamber of Commerce and Industry, Birmingham. "National Trust" by Mr Harrison of the National Trust.

Thames Valley Section: "Developments in building chemicals and compositions" by Dr Maurice Wilkinson of Blundell Permoglaze Ltd, at the Beaconsfield Crest Motel (White Hart), Aylesbury End, Beaconsfield, Bucks, commencing at 6.30 p.m. for 7.00 p.m.

Friday 20 March

Bristol Section: "Evaporation and Solvent Power" by Mr Barry Hudson, BP Chemicals Ltd, at the Post House, Cardiff.

Irish Section: "Timber Preservation" by E. A. Hilditch, Technical Director, Cuprinol Ltd, at the Clarence Hotel, Dublin, commencing at 8.00 p.m.

Friday 27 March

Bristol Section: Ladies' Night. *Details to be announced.*

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Formula 81 is organized by RAI Gebouw B.V., in close cooperation with an exhibition committee, composed of representatives of the relevant trade and industry.

All correspondence to:
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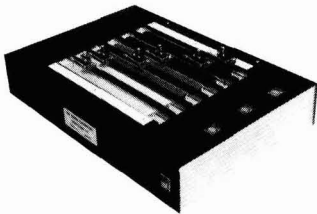
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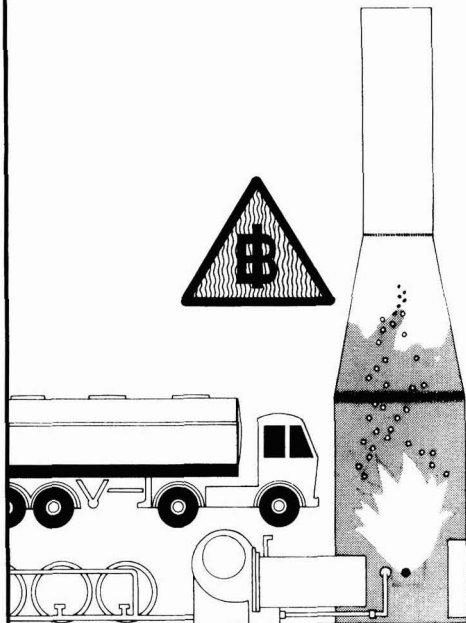
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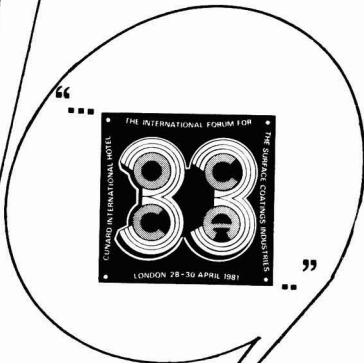
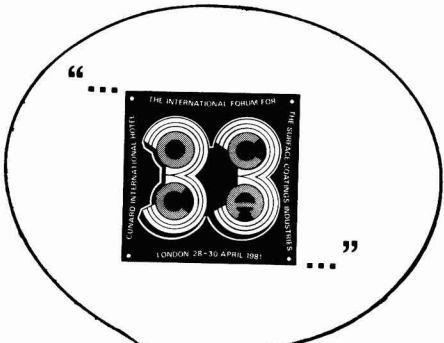
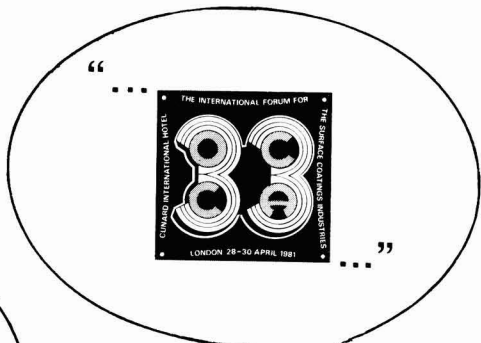
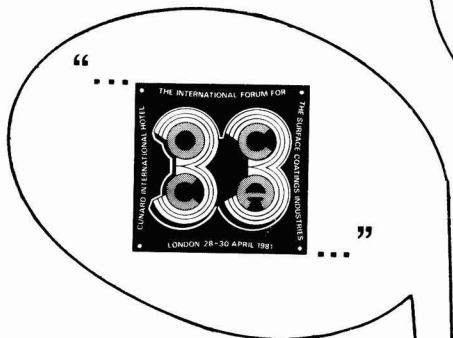


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