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A. Jayasri and M. Yaseen

Zinc-rich paints

G. W. Kapse and Km. Bela Rani

A gas chromatography technique for the analysis of solvent mixtures based on hydrocarbons, esters, ethers etc., used in paints and lacquers

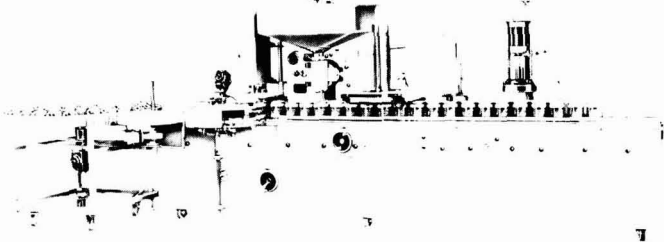
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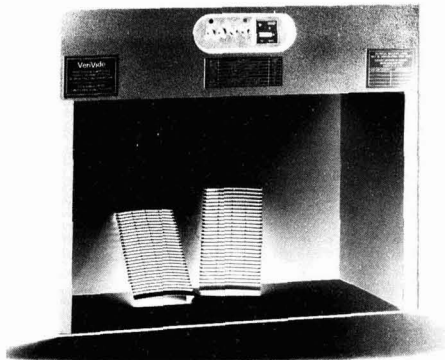
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OCCA Monograph No. 1 Marine finishes. Part I

By T. A. Banfield, PhD, DIC, ARCS, FICorrT, FTSC

Consultant, formerly with Berger Jenson and Nicholson Ltd

Foreword

With the exception of Part 7, *Works Practice*, the Association's series of Paint Technology Manuals are now out of print. Part 4, *The Application of Surface Coatings*, had been revised for a new edition, but it was found that the original publisher was willing only to issue a complete set of all the parts simultaneously. This could not be done because no other parts of the series were in the course of revision.

Part 7 had been produced by first publishing it in parts in *JOCCA* with additional pages being printed for subsequent binding into a separate volume. This method was also adopted successfully for the two Newcastle Section Symposia on UV curing.

The primary purpose of *JOCCA* is the publication of original papers, reports and notices relating to the Association's activities and news of interest to members. The space available in the *Journal* for review type articles

is strictly limited and the partwise publication of all six parts of the manuals could not be contemplated.

It was agreed to explore the possibility of publishing a series of *Monographs* covering mainly reviews of recent developments. Dr T. A. Banfield has kindly consented to write the first such publication on *Marine Finishes*, which would have become his chapter on this subject in a revised Part 4 of the Manuals.

It is hoped that it will become possible to produce a continuing series of *Monographs*, but this depends upon authors willing to write them being forthcoming. The Hon. Editor would be delighted to discuss the subject with anyone willing to contribute either a *Monograph* or *Student Review* on a suitable topic.

S. R. Finn
Hon. Editor

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 - 4.1.1. Conventional systems
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Part II*

- 4.2. Exterior surfaces below the waterline
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5. Application methods and hazards
 6. Acknowledgements

*It is expected that Part II of this Monograph will be published in the March issue of the *Journal*. It is intended that copies of Parts I and II will be run-on and bound together to form a separate booklet, which will be available later in the year.

1. Introduction

Ref. 1

Ships are built mainly of steel and the methods of preserving them are, essentially, a special aspect of the protection of steel. Other materials are used to some extent, e.g. light alloys are frequently used for the superstructures of large ships, whilst glass reinforced plastics or light alloys are widely used for small craft. Wood was the traditional material for yachts, but in recent years glass reinforced plastics have largely replaced it, and are now used for more than 80 per cent of new yachts. Nevertheless, steel is by far the most widely used material of construction for ships, and the present article will concentrate on steel ships and their protection. Painting is the principal means of protection, other methods, such as cathodic protection, being used only in conjunction with paint coatings. On the underwater areas of ships' hulls special paints are used to prevent attachment and growth of marine plants and animals; the formulation of these paints, called antifouling compositions, is a specialised aspect of marine paint technology. Ships are subject to more severely corrosive conditions of service than most land structures, whether the outer hull, the decks, the superstructure, the cargo holds or, in the case of tankers, the cargo and cargo/ballast tanks are considered. It is necessary to distinguish between these areas because conditions of service differ – thus the exteriors may be divided broadly into three parts: (a) the bottom, which is continuously immersed in seawater and requires protection against both corrosion and fouling, (b) the "boot-topping" or waterline area, immersed when the ship is loaded and exposed to the atmosphere when no cargo is being carried, and (c) the "topsides", deck and superstructure areas exposed to the atmosphere and to salt spray. In addition to these weather factors, the different areas suffer attack from their conditions of service, e.g. the boot-topping is subject to abrasion by rubbing against quays, wharves and barges, whilst the topsides, deck and superstructure may receive mechanical damage during cargo handling.

It may be noted here that the Committee on Corrosion and Protection¹ under the Chairmanship of the late Dr T. P. Hoar estimated in 1971 that the cost of corrosion and its prevention in the UK marine industries was £280 millions a year. The Committee also suggested that with better use of existing knowledge a saving of £55 millions could be made – a clear indication that the best corrosion preventive action is not always taken. Although improved methods of protection have been adopted in recent years it seems probable, bearing the rate of inflation in mind, that the possible saving nowadays could still be of the order of £50 millions.

The general principles relating to the painting of ships are the same as those for structural steel in general, as follows:

- (i) Proper surface preparation.
- (ii) Application of a paint system appropriate to the conditions of service, and of a sufficient film thickness.
- (iii) Good conditions of application.

In addition, there are other factors requiring attention in marine painting. In particular, speed of application and of drying or curing are generally more important on ships than on most land structures because of the loss of earnings when ships are taken out of service for maintenance.

Thus, in the case of the largest ships of 200,000 tonnes deadweight and over, such charges as interest, insurance and crew's wages amount to £20,000-£40,000 a day; these charges continue whether a ship is in service earning revenue or out of service undergoing repairs. Accordingly, it is of the utmost importance to provide long-term maintenance-free protection and to minimise the time out of service when maintenance is eventually required. The use of sophisticated protective coating systems is fully justified under these circumstances.

2. Theory

Refs. 2-4

2.1. Corrosion

The electrochemical mechanism of corrosion of steel in seawater² has a very great bearing on the properties required of a protective paint system for ships' hulls. The electrolytic resistance of seawater is low owing to its salt content and there is an ample supply of dissolved oxygen, except at great depths. Potential differences between different parts of a steel surface cause corrosion cells to be set up; the potential differences arise from the presence of millscale or from local variations in conditions, e.g. the oxygen content of the seawater, or the crystal structure, stress, heat treatment or composition of the steel.

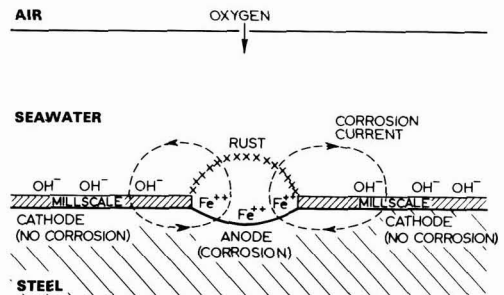
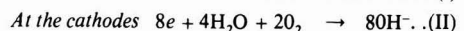


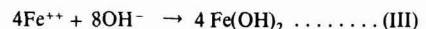
Figure 1. Corrosion cell at a break in millscale on steel immersed in sea water

Millscale is the film of oxide formed on steel when it is hot rolled and is one of the major causes of corrosion in seawater, there being a potential difference of about 0.3 volts between scale-free and scale-covered areas. The electrochemical cell set up at a break in millscale on steel immersed in seawater is illustrated in Fig. 1; the scale-free areas become anodic and iron goes into solution, i.e. corrosion occurs, whilst the scale-covered areas become cathodic and no corrosion occurs.

The reactions may be shown as:

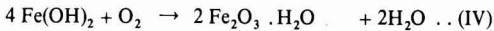


The products of these separate reactions diffuse from the surface and react with each other:



Note particularly that the reaction product, ferrous hydroxide, is not formed in immediate contact with the surface and hence does not stifle the reaction. The ferrous

hydroxide is subsequently oxidised to hydrated ferric oxide, rust:



Steel free from millscale corrodes by a similar mechanism, but the potential differences arising from crystal structure, stress, etc. are less than those due to millscale and generally localised so that bare steel exposed to seawater usually corrodes fairly uniformly. This is in contrast to the effects of millscale, where a high ratio of scale-covered cathodic areas to scale-free anodic areas (i.e. steel covered with nearly intact millscale) leads to rapid pitting attack on the bare areas – up to about 5 mm a year. Partial removal of millscale is, therefore, dangerous, and it is most important completely to remove millscale.

2.2. Cathodic protection

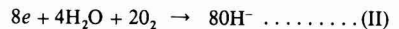
The electrochemical mechanism of corrosion can be suppressed by electrochemical means – usually called cathodic protection³. In this process steel is connected to a separate anode, so that the entire steel surface becomes cathodic and hence does not corrode – see Fig. 2. The anode may be either (a) a more active metal in the electrochemical series, e.g. pure zinc, a magnesium or aluminium alloy, or (b) an inert metal or alloy activated by an applied voltage. In the former case the anodes corrode and must be replaced at intervals (“sacrificial” or “galvanic” anodes) whilst the inert anodes used in impressed current systems are practically non-corroding and have a very long life. In theory, it should be possible to protect a bare steel hull from corrosion by cathodic protection alone, but this is not a practical proposition because the cost of renewing sacrificial anodes or of generating sufficient impressed current would be too high. However, the combination of cathodic protection with a suitable protective paint system is effective, the cathodic protection costs being very much reduced because essentially only the steel exposed at minor imperfections in the coating requires protection. Combined protective systems are widely used, most large vessels having an impressed current cathodic protection system in conjunction with a high performance coating. It is necessary to control the cathodic protection system so that the steel hull has a potential of about -0.80 to -0.85 volts with respect to a silver/silver chloride electrode, this being sufficient to prevent corrosion of the steel without affecting properly formulated and well applied paint coatings. An important point to note is that coatings used on cathodically protected ships must be especially resistant to alkaline attack because the entire hull is made a cathode from which electrons are released and there is an excess of hydroxyl ions in the vicinity – refer to Fig. 2.

2.3. Corrosion prevention by paints⁴

It follows from the above theory that corrosion of steel in seawater can be prevented by suppressing the electrochemical reactions and this is theoretically possible by, (a) suppressing the anodic reaction, (b) suppressing the cathodic reaction, or (c) interposing such a high electrical resistance between the metal and the seawater as to prevent the flow of corrosion currents. The anodic reaction may be suppressed by (i) paints supplying electrons – in practice this means applying zinc-rich primers, or (ii) passivating the surface, thus ensuring that the naturally occurring thin oxide film is kept in a good state of repair – this being achieved by using priming paints containing “inhibitive” pigments, namely either some basic pigments (e.g. basic lead compounds, zinc oxide) or oxidising pigments (soluble chromates). Suppression of the cathodic reaction, which requires both moisture and oxygen, by paints is not practicable because paint films of normal thickness are so easily permeable to these agents that the reaction proceeds almost unhindered. The most general mechanism of protection by paints, however, is inhibition by resistance, that is to prevent the flow of corrosion currents by impeding the movement of ions. This is achieved by applying a film of high electrical (ionic) resistance, so that ions cannot pass between anodic and cathodic areas. In general, highly crosslinked films have the highest ionic resistance; an obvious practical consideration is that the resistance of a paint film increases with its thickness.

2.4. Cathodic protection plus paint coatings

As mentioned under paragraph 2.2. above, cathodic protection causes conditions over the entire hull to become cathodic and alkaline, so paints used on the outer hulls of cathodically protected ships must have good alkali resistance. In close proximity to anodes the current density on a ship’s hull is higher than elsewhere on the hull and the rate of production of hydroxyl ions is correspondingly higher, i.e. conditions become highly alkaline. Anodes, in fact, are normally surrounded by synthetic rubber mats or glass reinforced plastics coatings to avoid subjecting the paint coating to these extremely alkaline conditions. Calcium and magnesium carbonates are precipitated from seawater at about pH 11 and deposited on the anode shields. Under highly cathodic conditions, instead of the normal cathodic reaction (paragraph 2.1 above) with an ample supply of dissolved oxygen:



the rate of release of electrons becomes sufficient to

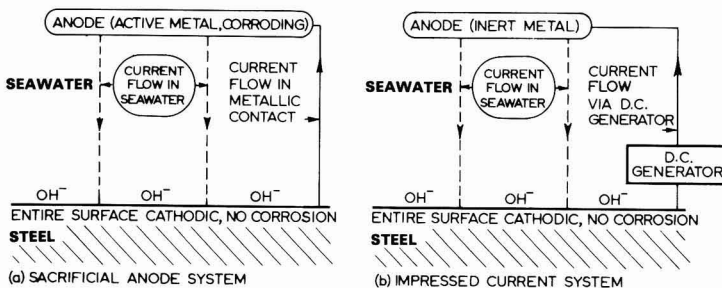
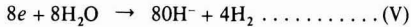


Figure 2. Cathodic protection of steel in sea water

exhaust the dissolved oxygen in pores in a coating and the reaction then becomes:



Thus, in addition to the usual hydroxyl ions, gaseous hydrogen is also produced. The precipitation of carbonates (or "cathodic chalk") and the evolution of hydrogen gas both tend to disrupt the coating so that these highly cathodic conditions must be avoided by controlling the potential of the hull at the value suggested in paragraph 2.2. above – this is done by electronic control of the cathodic protection installation.

2.5. Coating requirements

From the foregoing it follows that the essential requirements for protective paint coatings on ships' bottoms are that they should (a) provide a high electrical resistance between the metal and the seawater, and (b) withstand alkaline conditions. On cathodically protected ships this alkali resistance is specially important. In addition, of course, the physical properties of the coatings are important, good adhesion and tensile strength being necessary to achieve long term protection. Priming paints containing basic inhibitive pigments are effective in some systems, as are zinc-rich primers, but in general the main chemical property demanded is good alkali resistance. As regards electrical resistance, it is worth emphasising the importance of an adequate film thickness.

3. Surface preparation and pretreatment

Refs. 2, 5-18

3.1. Cleaning

The important role of millscale in the electrochemical corrosion of steel in seawater has been covered in section 2 above, and one of the primary requirements in preparing steel before painting is completely to remove millscale. This has been realised for many years⁵, but only in the last 25 or 30 years have the economics of the situation been fully appreciated by shipowners and shipbuilders. Until about 1960, the usual practice in shipbuilding was to allow steel to weather for the removal of millscale. Specifications spoke of "allowing the steel to weather for as long as possible, followed by scraping and wirebrushing to remove residual millscale and rust"⁷. In practice, this invariably left some millscale unless the weathering period was excessively long (2, 3 or 4 years), in which case the steel became pitted, and even the most careful manual or mechanical wirebrushing left some rust on the surface. Flame cleaning⁶ was sometimes used after weathering and undoubtedly gave some improvement because it, at least, provided a warm dry surface for application of the first coat of paint. It did not, however, remove all surface contaminants, and in addition it was costly both on account of the gases consumed and of the labour involved. Acid pickling was used in some shipyards, particularly for Royal Navy vessels, and this ensured complete removal of millscale. Full advantage of the process was not taken, however, the plates usually being allowed to rust after pickling and then wirebrushed at the time of painting. Pickling was not regarded favourably in shipyards because it is a messy wet process that could not be fitted into plate preparation shops: pickling tanks were generally relegated to a corner of the yard where problems of rinsing off acid residues and disposing of spent acid did not

interfere with the main steel fabrication processes. With the increasing speed of shipbuilding, the disadvantages and inefficiency of such methods of surface preparation became more and more obvious, until in the 1960's the procedures in shipyards were revolutionised by the introduction of airless blast cleaning machines and blast primers.

In airless blast cleaning, an abrasive is fed to a rotating impeller which directs it against the surface to be cleaned – in this respect it differs from open blast cleaning which uses compressed air to propel the abrasive. By using a number of impellers in the machine both sides of steel plates of any width or all surfaces of steel sections can be freed from millscale by one pass through the machine. The process is dry and the machines are totally enclosed so they may be set up in steel fabricating shops without interfering with the production flow – see Fig. 3. The choice of abrasive is important⁷ in determining the speed of cleaning and the surface finish obtained. Most shipyards use steel shot of 24 or 30 mesh and this is recycled after centrifugal separation from millscale and rust, thus in general use the abrasive consists of mixed round and broken shot. Cast steel grit, cast iron grit or chopped steel wire may also be used as the abrasive. In normal practice

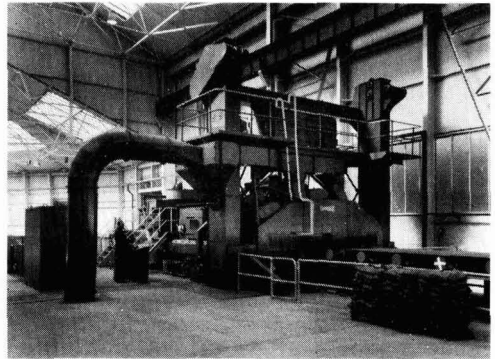


Figure 3. Blast cleaning machine in a shipyard
(Photograph: Spencer & Halsstead Ltd)

the plates are passed through the machine at 2-3 m/min., this producing a fairly smooth surface with a maximum surface roughness (trough to peak) not exceeding 100 microns and meeting the requirements of Second Quality of BS 4232:1967, Surface Finish of Blast-cleaned Steel for Painting, or the corresponding Sa 2½ "Very thorough blast cleaning" of Swedish Standard SIS. 05 59 00: 1967. This requires (i) the whole surface to show a blast-cleaning pattern, (ii) at least 95 per cent of the surface to consist of clean bare steel, and (iii) not more than 10 per cent of any single square of 25 mm side to show residues, consisting only of tightly-bonded millscale or rust. First Quality or Sa 3 is rarely obtained, and then only by conveying the plates through the machine at such low speeds as to be uneconomical. The cleanliness of the surface may be checked (a) visually using a hand lens, with which residual millscale can be seen, (b) chemically by a copper sulphate test⁸, or (c) by a reflectance method^{9,10}. The surface profile may be checked by (a) microscopic examination of a suitably mounted and polished section through the steel, (b) examination of the surface, or a plastic replica, with a Talysurf or other stylus type of surface profile instrument¹¹, (c) a simple probe type instrument¹², (d) a rough-

ness gauge^{9,10}, which depends on the rate of leakage of gas from a cup placed in contact with the surface, or (e) visual and tactile comparison with specially prepared samples¹³.

These processes have been reviewed more recently^{14,15} and the author suggests that some revision is required. In particular, it is pointed out that steel plates in shipyards are almost invariably rusted to some extent before blast cleaning; such surfaces are much more difficult to clean than unruined steel, and, in consequence, it is suggested that blast cleaning should be undertaken at the steel mills before any rusting occurs.

3.2. Initial protection/pre-treatment

The clean, dry, slightly rough steel surface obtained by blast cleaning is ideal for the application of paint, but it will rust quickly in the humid atmosphere of most shipyards. To prevent this, the steel is spray painted with a primer as it emerges from the blast cleaning machine. These rapid drying primers are described variously as "pre-treatment", "prefabrication", "blast" or "shop" primers – there being distinctions between these terms, although in shipyard usage the names are generally interchangeable; the term blast primer will be used here. The function of this primer^{2,16,17,18} is essentially to protect the surface of the steel for periods up to 6 or 9 months during fabrication and erection of the ship, and then to provide a suitable basis for the final protective painting scheme. In addition, it must meet other requirements to permit its use under practical conditions in shipyards, as follows:

- (i) It must dry rapidly to allow steel plates to be handled mechanically (e.g. by crane) within 2 or 3 minutes of application.
- (ii) The film must be mechanically strong and flexible to withstand damage during normal shipyard fabrication processes, e.g. bending.
- (iii) It must have good resistance to the high temperatures met when steel is welded or flame-cut, so as to minimise spread of damage to the paint film.
- (iv) It must not affect the speed of flame-cutting or welding, or the quality of welds.
- (v) It must not produce obnoxious or harmful fumes during welding or flame-cutting.
- (vi) It must provide a suitable basis for application of any type of paint system that may be used on the various parts of ships. All the steel used in a shipyard passes through the same blast cleaning and priming treatment and it is not possible to segregate the steel required for any particular part of the ship and apply a different blast primer.

These requirements vary in emphasis according to the fabrication processes used in different shipyards. Thus, at a yard where the complete protective paint system is applied under cover before the prefabricated sections are taken out of doors for final assembly, the weathering properties of the blast primer alone are comparatively unimportant. In some instances, too, preferences are expressed by shipyard workers on subjective grounds, e.g. the odour produced when blast primed steel is welded or flame cut.

3.3. Formulation of blast primers

Several types of blast primer have been developed to meet the shipyard requirements described above. They include those pigmented with zinc dust, aluminium powder, red oxide, zinc chromate or zinc phosphate, dispersed in epoxy ester, cold cured epoxy, polyvinyl butyral, phenolic or silicate media. Factors requiring consideration include the following:

- (i) For rapid drying the solvents must evaporate from the film in a few minutes to leave an "apparently dry" film – final drying by oxidation or chemical curing following during the next few hours or days. In general, this requires solvents of low boiling point, and in most cases it also means low flash points so that the proper precautions must be taken in storage and use. Another factor in ensuring rapid drying is to restrict the amount of binder to the minimum consistent with satisfactory performance. Rapid drying is also assisted by application factors, such as: (a) applying the minimum film thickness capable of giving adequate protection – this aids rapid solvent release; (b) preheating the steel as it enters the blasting machine – this also serves to dry the steel if it has been stored out of doors; (c) heating the primed steel by a hot air blast or radiant heaters as it emerges from the spray-painting machine – this aids rapid solvent release and initiates the oxidation or curing reactions.
- (ii) Metallic zinc pigmented blast primers, in cold cured epoxy or in silicate media, provide good long term resistance to corrosion, but they do have some disadvantages including: (a) On exposure they become covered with water-sensitive zinc salts and special attention is necessary at the time of overcoating to remove them. This applies particularly to "zinc-rich" types containing at least 92 per cent zinc by weight in the dry film – primers with lower zinc contents, say 75-80 per cent, do not form zinc salts to the same extent and are more easily cleaned for overcoating; (b) Zinc based blast primers are not acceptable in cargo tanks for aviation fuel because of the risk of contaminating the cargo; (c) Welders in some shipyards object to the zinc oxide fumes evolved when zinc primed steel is heated during flame cutting or welding. The fumes may cause temporary discomfort, an effect long known in the galvanising industry as "zinc chills" or "zinc fever", but health authorities confirm that there are no long-term effects. For these reasons zinc pigmented blast primers are not accepted in all shipyards.
- (iii) Wash primers based on polyvinyl butyral resins were first developed during World War II for the pre-treatment of ship plate. They dry rapidly, the solvents being lower alcohols, and give low film thicknesses (12-15 microns) which do not interfere with welding or burning, but the original type did not give long-term protection without overcoating. By blending the polyvinyl butyral wash primers with phenolic resins, however, the weathering properties may be improved and satisfactory blast primers made. Typical formulations are pigmented with red oxide, sometimes with an inhibitive pigment such as zinc tetroxy chromate (basic zinc chromate or insoluble zinc chromate); they may be single or twin-pack types, the single-pack type being more commonly used in shipyards. This type of blast primer is widely used, although it is not recommended for the interiors of cargo tanks on solvent and chemical carriers because some cargoes,

e.g. benzene or methanol, may penetrate the subsequent epoxy system, soften the primer and cause adhesion failure of the complete system.

- (iv) Cold cured epoxies form the basis of some blast primers. They are generally pigmented with red oxide and an inhibitive pigment, e.g. zinc phosphate or a chromate. Solvent blends such as toluene/isopropanol and a high pigment/binder ratio ensure that the primers are hard enough after drying to permit handling in a few minutes, the curing reaction between the epoxy resin and the hardener (generally a polyamide) continuing for the next day or two. These primers give good protection and do not interfere with normal shipyard practice when applied at dry film thicknesses of 20-25 μm . Technically, this type is the most generally acceptable blast primer in shipbuilding – it gives adequate protection to the steel, may be overcoated after relatively simple cleaning with almost any type of marine paint system (including epoxy tank systems in solvent carriers) and has a higher solids content than the wash primer type, thus giving a greater spreading rate for a given dry film thickness.

Arising from the above technical points and the related cost considerations, the present position in the UK shipyards is that the following types of blast primer only are in commercial use: (a) phenolic reinforced polyvinyl butyral wash primers, pigmented with red oxide and sometimes with an inhibitive pigment; generally single-pack; (b) cold cured epoxies pigmented with red oxide and generally with an inhibitive pigment such as zinc phosphate, basic zinc chromate or calcium chromate; (c) cold cured epoxies pigmented with metallic zinc, the zinc content usually being less than in zinc-rich primers; and (d) zinc silicate blast primers, generally ethyl silicate types.

3.4. Application of blast primers

The general procedure is to spray the primer on the steel as it emerges from the blast-cleaning machine. Airless spray guns traverse each side of the plates, being triggered automatically so that they operate only when steel passes the guns. The speed of traverse and the fan width are adjusted in relation to the speed of the plate conveyor, so that the steel is completely coated with only a slight overlap between passes. The size of spray gun orifice then determines the amount of paint applied, i.e. the film thickness. The normal dry film thickness lies in the range of 15-25 μm – this gives adequate protection to the steel without appreciably affecting the fabrication properties. The thickness can be checked by magnetic gauges, but these do not give absolute values because the dry film thickness is usually less than the surface profile amplitude – relative values are obtained. A more accurate value for the average film thickness can be obtained by placing a piece of plate glass on the steel as it enters the spray-painting machine and measuring the primer thickness on the surface by micrometer or by microscope. The distribution of a blast primer over the peaks and troughs of a blast-cleaned surface may be checked by metallurgical sectioning techniques; the thickness over the peaks is normally less than in the troughs because some flow occurs before the film sets¹⁰. In practice there is appreciable wastage of blast primer due to overspray, allowances of 30 per cent being typical when calculating dry film thicknesses from overall spreading rates.

The methods of surface preparation by blast cleaning

and blast priming have been covered in some detail because this is the most important stage in the protective painting of ships, and the one that can be most closely controlled.

4. Marine paint systems

Refs. 19-27

4.1. Exterior surfaces above the waterline

As indicated earlier, these areas are subject to salt spray in addition to normal atmospheric exposure conditions. This does not call for any fundamental difference in the protective paint systems as compared with steel structures ashore.

4.1.1. Conventional systems

Inhibitive priming paints based on red lead, zinc phosphate or zinc chromate form the basis of conventional painting systems. The traditional structural steel primer, red lead in linseed oil – generally complying with British Standard BS. 2523: 1966, Type B – is still used although it has the disadvantage of requiring a long drying time before being overcoated, and oleoresinous media that dry more quickly are more usual. Zinc chromate primers based on alkyd, epoxy ester or modified phenolic/stand oil media dry more quickly than linseed oil primers and are suitable for use on light alloys as well as on steel. However, both lead and chromate pigments are subject to restrictions on the grounds of health hazards and their use is declining. Zinc phosphate primers have been developed in more recent years; they are non-toxic and may be formulated as nearly white colours, an advantage when they are to be overcoated with white or pale colours. Urethane oil is sometimes used to replace part of an alkyd medium to improve the speed of drying and the film hardness. Finishing paints, too, are similar to those used ashore, alkyls of medium-long oil length giving good service. White is used extensively on the superstructures of ships; it is necessary to make it “lead-free” to avoid sulphide staining due to hydrogen sulphide fumes evolved from the polluted waters of many estuaries and docks, or from some grades of crude oil. Marine white paints are normally “non-yellowing”, based on alkyls made from oils such as soya bean oil or tall oil with a high linoleic acid content, which do not turn yellow on exposure so readily as linseed oil alkyls which have a higher linolenic acid content. The grey paint¹⁹ specified for use on British Naval vessels consists of rutile-type titanium dioxide in such a non-yellowing alkyd. Black topsides paints, used on many merchant ships, are often alkyd types, although modified phenolic/stand oil media are also suitable since non-yellowing properties are not required.

4.1.2. High performance systems

In more recent years not only have much larger ships been built – the largest tankers in service, for instance, being ten times the largest of twenty-five years ago – but increasing automation of ship operation makes the number of the crew much less. In consequence, no maintenance painting can be undertaken by the crew whilst the vessel is in service and a need has arisen for long-term “maintenance-free” paint systems. High performance systems based on epoxy, polyurethane or vinyl resins and blends such as vinyl/acrylic are used, but a notable trend is towards

chlorinated rubber which has special advantages for marine use, particularly for maintenance work.

Epoxy types are chemically cured two-pack materials, a pigmented epoxy resin solution (base) being mixed with an amine-adduct or polyamide resin solution (hardener) at the time of use. The epoxy resins commonly used are solid diepoxide types²⁰ with WPE (equivalent weight per epoxide group) about 450-500. These may be cured at ambient temperatures by reaction with aliphatic polyamines (e.g. diethylene triamine), amine adducts or polyamide resins. The free polyamines are rarely used as cold curing agents because of their objectionable odour, their tendency to react with atmospheric carbon dioxide and form a bloom on the film during curing and also because they are skin sensitisers that may cause dermatitis. Instead, an excess of the amine is pre-reacted with epoxy resin to form an amine adduct, which contains residual amino hydrogens capable of curing epoxy resins. The use of these adducts, instead of the free amines, avoids the disadvantages just mentioned. The other common cold-curing agents for epoxy resins are polyamide resins - aminopolyamides produced by reacting dimerised and trimerised vegetable oil fatty acids with polyamines. These are complex mixtures containing amide groups, also primary and secondary amine groups, the latter being capable of reacting with epoxy resins. The amounts of epoxy resin and curing agent in the base and hardener are adjusted so that one epoxide group reacts with one active amino hydrogen; the ratio is not critical when polyamide curing agents are used because both reactants are resinous. The curing rate is dependent upon temperature, being very slow in North European winter conditions, the lowest recommended curing temperature being about 10°C; at low temperatures an addition of the tertiary amine, tris-2,4,6 dimethylaminomethyl phenol, is often made to the hardener - the phenolic hydroxyl group in this compound accelerates the curing reaction. The reaction between the epoxy resin and the curing agent commences in the can as soon as the components are mixed, and the paint must be applied before the reaction proceeds too far and gelation occurs, i.e. the mixed paint has a limited "pot-life". After application to the surface and evaporation of the solvents, the curing reaction proceeds to completion over the next few days, according to temperature. To ensure the best intercoat adhesion with cold cured epoxy resin paints, successive coats must be applied before the previous coat has fully cured so that, in practice, there are maximum as well as minimum recommended overcoating intervals, and both are dependent upon temperature. For application to the topsides of a ship a typical epoxy system would consist of two coats of high build epoxy intermediate coat, each applied by airless spray to give a dry film thickness of 100-125 µm, and one coat of epoxy enamel at about 50 µm thickness. This would be applied over a blast primed surface after making good any mechanical or other breakdown of the blast primer.

An epoxy system such as just described gives satisfactory service on the topsides of ships where the characteristic chalking and loss of gloss typical of epoxies is not of primary importance. On the superstructure, however, where decorative appearance is important, epoxy enamels generally would not be accepted. Instead, a finishing enamel based on polyurethane would be substituted for the epoxy enamel. Polyurethanes are chemically cured two-pack materials, polyester resins being cured by reaction with a polyisocyanate. For best gloss retention and non-yellowing properties an aliphatic polyisocyanate should be used. The curing reaction is not

so dependent upon temperature as is the epoxy curing reaction, but the films are sensitive to moisture at the time of application. Long intervals before overcoating must be avoided to secure the best intercoat adhesion, as with epoxies.

Vinyl resin paints were developed for the US Navy during World War II and are still used by the US and some other Navies, but hardly at all on merchant ships. They are based on vinyl chloride/vinyl acetate copolymers, often modified with hydroxyl or carboxyl groups. Strong solvent blends containing aromatic hydrocarbons, ketones and esters are required and, in general, the solids content is low, leading to a low film thickness per coat. In recent years, however, high build paints based on newer types of vinyl resin have been described²¹. These resins have a narrower range molecular size distribution than those previously available and, in particular, a low content of very high molecular weight species; this permits solutions with much higher solids contents to be made in the usual solvent blends, and hence paints with a greater film thickness per coat. Using the US Navy formulation, a total of 10-12 coats would be required to build up a total protective film thickness of about 200 µm; these could be applied at intervals of $\frac{1}{2}$ - 1 hr as the solvents evaporate quickly. The finishing coat was a vinyl/alkyd blend. With the newer resins high build coats capable of airless spray application at about 125 µm can be formulated, so the total protective thickness can be achieved in two coats. Blends of vinyl and acrylic resins have also been used for marine paints, it being possible to make solutions having a higher solids content than with the older types of vinyl resin. With the introduction of the newer vinyl resins, however, this is no longer necessary and the use of such blends is declining. Vinyl paints are single pack solution types drying by solvent evaporation, a process not greatly dependent upon temperature. The films remain soluble in the original solvents, so there are no critical overcoating intervals - the surface of the previous coat being softened by the solvents in the next coat and this ensuring good intercoat adhesion irrespective of the time interval between coats.

The high performance paints just described give good performance on the topsides and superstructures of ships, but have some practical disadvantages as indicated. Chlorinated rubber systems also give good performances and have certain practical advantages, thus: (a) they are single pack paints so that errors from incorrect mixing at the time of use are avoided; (b) they dry solely by solvent evaporation, a process not greatly affected by temperature so they may be applied successfully in practically any climate; and (c) overcoating intervals are not critical because the solvent in successive coats softens the surface of previous coats so that good adhesion is achieved even after long intervals - an important point when recoating after a period in service. Paints based on chlorinated rubber have been used on ships for 40 or more years, but only during the last 20 years have high build types suitable for application by airless spray been developed^{22,23}. The paints are based on solutions of chlorinated rubber in aromatic hydrocarbons; the raw material was formerly made by chlorinating natural rubber, but present day grades are usually made from synthetic polymers e.g. polyisoprene. It is necessary to include plasticisers, and non-saponifiable types such as chlorinated paraffins are used. Inert pigments and fillers are used, sometimes flake pigments, e.g. mica or aluminium, to increase the water impermeability of the films. Reactive or water soluble inhibitive pigments are not required in primers, although

zinc phosphate is sometimes used. A typical chlorinated rubber system for application to the topsides of a ship would consist of one coat aluminium pigmented primer to give a dry film thickness of about 50 μm , one coat high build intermediate coat, pigmented with red oxide and fillers, at about 125 μm , and one coat gloss finish pigmented with titanium dioxide plus carbon black at about 50 μm , thickness, all applied by airless spray. This system would be applied over a blast primer in good condition; it may be noted that chlorinated rubber paints do not always adhere well to polyvinyl butyral blast primers, so it is preferable to use an epoxy type. It will be realised that vinyls are also single pack solution type paints and, therefore, share some of the practical advantages of chlorinated rubber listed above, but they require stronger solvents and until the fairly recent introduction of newer resins gave poor film build per coat.

The conventional oleoresinous or bituminous systems described at the beginning of this section are generally more tolerant towards imperfect surface preparation than epoxies, vinyls and chlorinated rubbers, and may even give better results than high performance systems, if poor surface preparation must be accepted. First class surface preparation is essential if any of the high performance paint systems is to give its optimum performance. Normally, they would be applied over a blast-cleaned and blast-primed surface, after any mechanical or other breakdown of the blast primer had been made good by locally re-blasting and re-application of blast primer.

The high performance systems are sometimes applied over a zinc silicate primer^{24,25,26,27}, often called inorganic zinc silicate because the binder is a silicate instead of an organic material, as in most paints. This requires the use of a zinc silicate blast primer, overcoated as soon as possible after fabrication with 75-90 μm of a zinc silicate primer. The high performance paints described above are suitable for application over this type of primer, all being based on non-saponifiable media that resist the alkaline nature of some zinc silicates. One advantage of this procedure is that a zinc silicate primer has good abrasion resistance, so that even if the top coats are removed from the sides of a ship by rubbing against quays the primer will often remain intact and prevent rusting until the areas can be recoated. For this reason zinc silicates are sometimes known as "permanent primers". There are two types, water based and solvent based. In the former, the vehicle is an aqueous solution of alkali silicate - lithium, sodium, potassium or quaternary ammonium - in the latter an alcoholic solution of a partially hydrolysed ethyl silicate. In both types, the zinc dust pigment is packed separately and stirred into the vehicle at the time of use. When applied to a surface the water or solvent evaporates and the silicate hydrolyses; one of the products of hydrolysis is silicic acid which reacts with some of the metallic zinc to form zinc silicate, and the final dry film consists of the remaining metallic zinc in a complex zinc silicate/silica polycondensate. The setting or curing reactions are not fully understood. When aqueous silicates are used the other main product of hydrolysis is the corresponding alkali hydroxide which in turn reacts with atmospheric carbon dioxide to form the carbonate. The presence of hydroxide or carbonate in the fresh film makes it alkaline and gives rise to problems when overcoating; it is generally advised to leave the fresh film exposed to the weather for a few weeks or to hose it with fresh water to

remove the alkali. In the case of ethyl silicate, however, the other product of hydrolysis is ethyl alcohol which evaporates to leave a practically neutral film which is easier to overcoat. This easier overcoating is a useful practical advantage of the solvent based type of zinc silicate - another is that they may be applied successfully at low temperatures, down to -5°C or even -10°C , whereas the aqueous types do not give satisfactory films below about 0°C . For these reasons the solvent types of zinc silicate are gaining in favour over the aqueous types. They are applied either, as already stated, to a zinc silicate blast primer provided it has not been exposed to the weather for a long period, or to freshly blast cleaned steel. The normal dry film thickness is about 75-90 μm - thicker coats tend to show "mud cracking". Although zinc silicates are usually used as primers in a composite system, i.e. overcoated with a non-saponifiable high performance coating based on epoxies, vinyls or chlorinated rubbers, they are sometimes used alone at places where their matt grey colour is acceptable; for instance some shipowners use them on decks without overcoating.

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Solubility parameter values suggested using the reported and calculated values for organic compounds

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Summary

Solubility parameter values for a compound reported in the literature and calculated by different methods are found to vary from each other. These values are grouped together and single values for individual compounds are reported. They have also been illustrated graphically as a function of molar volume (molar volume inverse, molar volume and log. molar volume) for each individual series. The plots of δ versus molar volume inverse are linear and δ values of a compound in the series can

be determined by extrapolation of the plot, provided the molar volume of the compound is known. The slopes of the plots of δ versus molar volume inverse are found to be dependent on the polarity of compounds belonging to a series, as the slope is negative (-144) for aliphatic hydrocarbons, but for carbitol derivatives it is positive (601). The intercept and the δ value for the lowest member in the series indicate the range of solubility parameter values for compounds in a particular series.

Keywords

Raw materials for coatings
solvents

solvent

Properties, characteristics and conditions primarily associated with materials in general

solubility parameter
internal cohesive energy

Les valeurs des paramètres de solubilité proposées pour certains composés organiques en vue de celles mentionnées dans la littérature ou calculées

Résumé

On a trouvé que les valeurs des paramètres de solubilité pour un composé organique mentionnées dans la littérature et celles calculées par de différentes méthodes se varient les unes les autres. Ces valeurs ont été regroupées et les valeurs δ simples ont été mentionnées. Elles ont été indiquées graphiquement dans le cas de chaque série individuelle, en fonction du volume molaire (volume molaire invers, volume molaire, et volume molaire logarithmique). Les courbes du δ contre le volume molaire invers sont linéaires et les valeurs de δ relatives à un composé de la série peuvent être déterminées en faisant une extrapolation de

la courbe, pourvu que l'on connaisse déjà le volume molaire du composé. On a trouvé que les gradients des courbes de δ contre le volume molaire invers se dépendent de la polarité des composés faisant partie d'une telle série, puisque le gradient est négatif (-144) dans le cas des hydrocarbures aliphatiques, mais positif (600) pour les dérivés de carbitol. L'ordonnée à l'origine et la valeur δ du composé qui commence la série indiquent l'éventail des valeurs des paramètres de solubilité des composés d'une seule série.

Vorschläge für Löslichkeitsparameter-Werte unter Verwendung der für organische Verbindungen veröffentlichten und berechneten Werte

Zusammenfassung

Man findet, dass Löslichkeitsparameter-Werte für Verbindungen, wie in der Literatur veröffentlicht und nach verschiedenen Methoden berechnet, voneinander abweichen. Diese Werte werden zusammengruppiert, und die einzelnen Werte für individuelle Verbindungen berichtet. Sie wurden auch graphisch als eine Funktion des Molarvolumens (umgekehrtes Molarvolumen, Molarvolumen und log. Molarvolumen) für jede individuelle Reihe dargestellt. Die Darstellungen von gegen umgekehrte Molarvolumenwerte sind linear, und Werte einer Verbindung in der Reihe können durch Extrapolierung der

Kurve bestimmt werden, vorausgesetzt, dass das Molarvolumen der Verbindung bekannt ist. Die Kurven der Darstellungen von gegen umgekehrtes Molarvolumen findet man als abhängig von der Polarität von Verbindungen, die zu einer Reihe gehören, wenn die Kurve negativ (-144) für aliphatische Kohlenwasserstoffe ist, aber für Carbitolabkömmlinge ist sie positiv (601). Der "Intercept" und der Wert für das niedrigste Mitglied einer Reihe deutet den Bereich der Lösungsparameterwerte für zu einer speziellen Reihe gehörenden Verbindungen an.

Introduction

Refs. 1-8

Organic coating materials have selective solubility; the solvents or their blends used for thinning them have distinct effects on the properties of their coatings, such as

ease of dispersibility, application properties, durability, appearance etc. The practical and theoretical approaches for selecting the best solvents for film formers have promoted the more extensive application of solubility parameter data in the coatings industry during recent years. Usually, organic coating materials and solvents which have solubility parameter values in close ranges are

likely to be miscible with each other in all proportions, provided there is not a wide difference in their polarity, extent of hydrogen bonding and other properties.

The solubility parameter, δ , being a numerical expression of cohesive energy density can be found by using any of the mathematical derivations recommended for the calculation of molar internal energy ΔE . δ is expressed in terms of ΔE and molar volume V .

$$\delta = \left(\frac{\Delta E}{V} \right)^{\frac{1}{2}} \dots \dots \dots (1)$$

The simplicity of equation (1) and accuracy of results obtained from it depend on the method chosen for determining ΔE .

The most widely used Hildebrand's expression¹ for calculating ΔE at 25°C relates heat of vapourisation, ΔH , with the boiling point T_b :

$$\Delta H_{25^\circ} = -2950 + 23.7 T_b + 0.02 T_b^2 \dots \dots \dots (2)$$

The δ values obtained from this equation are found to be comparable with other reported values for poorly hydrogen bonded compounds. For alcohols and esters, Burrell² proposed to add 1.4 and 0.6 respectively to the δ values calculated using equation (2).

Hoy³ derived the following equation for δ using Haggemacher's equation⁴ and Antoine's⁵ constants B and C .

$$\delta = \left\{ \frac{RTP}{M} \sqrt{\frac{T_c^3 P}{P_c^3 T}} \left(\frac{2.303 BT}{(T+C - 273.16)^2} - 1 \right) \right\}^{\frac{1}{2}} \quad (3)$$

This equation is useful when δ is calculated within the temperature validity range of B and C . Several other equations which involve the use of critical temperature T_c and pressure P_c , Van der waal's constants etc., also have limited ranges of application.

The introduction of group contribution technique has made it possible to determine the δ value for any type of compound. This technique, which is based on the principle of the additivity of contribution of chemical groups, atoms and bonds present in a molecule, was suggested first by Small⁶ for determination of molar internal energy. However, it does not give such accurate results for strongly hydrogen bonded compounds. Based on the homomorph concept introduced by Blank⁷, Hansen⁸ calculated δ values by using the relationship:

$$\Delta E = \Delta E_{\text{polar}} + \Delta E_{\text{non-polar}}$$

A glance at the δ values for compounds, such as alcohols, esters, ethers, halogenated solvents, hydrocarbons, ketones and nitrogen solvents listed in Tables 1-7 indicates that the δ values reported by individual workers for a given compound differ widely from each other. It is often found difficult to select one δ value for a compound from those reported in the literature or calculated by using any one of the equations. Therefore, it was considered worthwhile to develop some criterion for a single δ value of a compound from amongst the several reported and calculated δ values.

Each method for evaluation of solubility parameter is based on some physical properties of a substance. For

instance, Hoy's method, Hildebrand's equation and the group contribution method depend on critical constants (T_c , P_c), boiling point etc., whilst Hansen's three dimensional solubility parameter takes into account the internal forces, such as hydrogen bonding, polarity etc. Thus, a single value of δ worked out by considering most of the reported and calculated values would include the effect of all such properties on solubility parameter and might be the best choice.

Procedure

Refs. 1, 3, 6, 8, 9, 10

The δ values calculated by Hoy³ using equation (3) are listed in column (3) of the tables. In the case of a few compounds for which the δ values are not reported by Hoy, the values were calculated by substituting the reported values of Antoine's constants B and C , critical pressure and temperature, P_c and T_c , in equation (3). Column (4) gives the δ values reported by Hansen⁸ who calculated them on the basis of components of solubility parameter $\delta = \sqrt{\delta_d^2 + \delta_p^2}$. δ values for a number of compounds reported by Burrell are listed in column (5). The experimentally deduced δ values reported by Van Krevelan⁹ which he used for testing the validity of δ values obtained by using the atom and bond contribution method, are reported in column (6). The δ values calculated by using the values of the contribution of chemical groups reported by Hoy³, Small⁶, and Van Krevelan⁹ are in columns (7), (8) and (9) respectively. The values calculated by adding up the contributions to cohesive energy¹⁰ are in column (10) and those calculated by using Hildebrand's equation¹ are in column (11).

δ values calculated by using chemical group contributions suggested by Hoy are relatively low, in the case of all the compounds (column 7). The values for alcohol series calculated by using Small's group contribution and Hildebrand's equation (Table 1), δ values for hydrocarbon series and halogenated solvents (Tables 2 and 4) calculated using cohesive energy group contribution, and the values for esters and ketones calculated using Van Krevelan's atom and bond contributions are either high or low when compared with other values (Tables 1-7). Even the slopes and intercepts obtained from computerised data for each set of δ values for compounds in a series show that the values reported in the columns mentioned above are not closely comparable with δ values listed in rest of the columns. Therefore, all

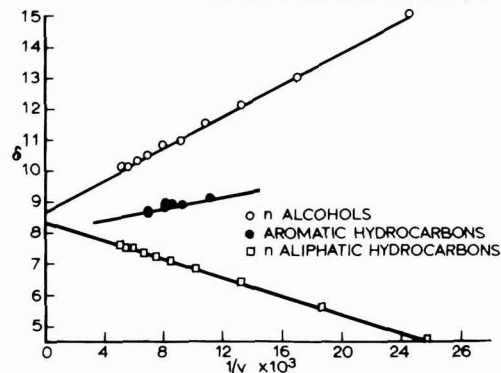


Figure 1A. δ versus molar volume inverse for alcohols and hydrocarbons

such values have not been considered when estimating single δ values.

After having excluded the δ values wherever found necessary as described above, the reported and calculated δ values for a compound have been processed by a linear least squares computer programme. In this case $1/v$ is taken as the independent variable and δ as the dependent variable. The values of δ so obtained are listed in column (12). Similarly, a single value of δ for each compound is worked out on a rational basis (column 13) from the reported and calculated δ values. For the purpose of testing the uniformity of correlation amongst the values listed in column (13), they have been plotted as a function of molar volume (Figures 1, 2 and 3). Wherever it was felt necessary for good graphical illustration of the results, the compounds in a series have been sub-divided, in order that the plots do not overlap each other.

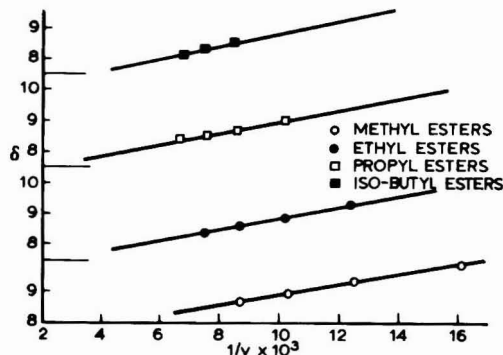


Figure 1B. δ versus molar volume inverse for esters

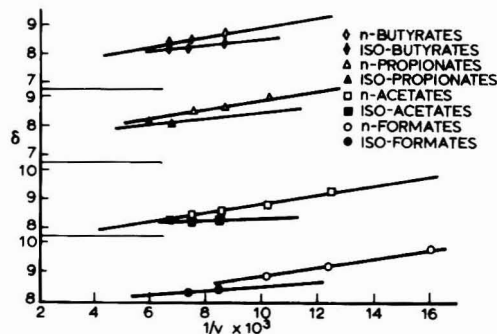


Figure 1C. δ versus molar volume inverse for esters

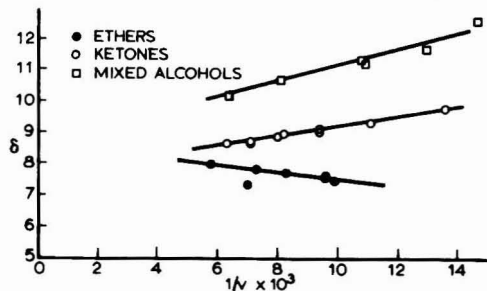


Figure 1D. δ versus molar volume inverse for ethers, ketones and mixed alcohols

Table 1 Alcohols

Compound	Molar volume $V_{25^\circ\text{C}}$	Values of δ reported by							Values of δ calculated using group contributions				Values of δ	
		Hoy	Burrell	Hansen	Krevelan	Hoy	Small	Krevelan	Cohesive energy	Hildebrand's equation	Computerised	Suggested		
1. Methanol	40.41	14.50	14.28	—	—	—	9.26	15.69	14.77	12.91	14.82	15.00		
2. Ethanol	58.37	12.70	12.92	—	—	8.66	8.86	13.20	13.12	11.15	12.93	12.95		
3. Propanol	74.70	11.90	11.97	11.40	11.90	8.52	8.70	12.10	12.29	10.33	11.99	12.09		
4. Butanol	91.73	11.60	11.30	10.70	11.40	8.40	8.55	11.40	11.69	9.41	11.39	11.50		
5. Pentanol	108.24	11.12	10.90	10.70	11.12	8.32	8.46	10.92	11.27	9.10	10.97	10.95		
6. Hexanol	124.81	10.77	10.70	10.70	10.70	8.27	8.40	10.60	10.95	8.88	10.67	10.78		
7. Heptanol	141.93	10.50	10.60	10.32	10.32	8.28	8.36	10.29	10.70	8.69	10.42	10.50		
8. Octanol	157.93	10.30	10.30	9.66	10.30	8.20	8.33	10.10	10.51	8.25	10.25	10.30		
9. Nonanol	174.34	10.13	—	—	10.13	8.18	8.31	9.90	10.35	8.54	10.10	10.13		
10. Decanol	190.88	10.03	—	—	10.03	8.16	8.28	9.07	10.21	8.39	9.98	10.12		
11. Isopropanol	60.09	11.44	—	—	11.50	7.95	8.18	11.30	11.87	9.84	11.60	11.60		
12. Isobutanol	74.12	11.24	—	—	10.80	8.06	8.20	11.29	11.39	9.53	—	11.26		
13. Sec. butanol	74.12	11.08	—	—	10.80	8.56	8.27	10.80	11.44	9.37	11.11	11.12		
14. 2 ethyl butanol	102.17	10.34	—	—	10.50	8.17	8.27	10.75	10.86	9.00	10.53	10.60		
15. 2 ethyl hexanol	130.23	10.15	—	—	—	8.10	8.35	10.20	10.41	8.57	10.20	10.14		
16. Allyl alcohol	58.28	12.55	—	—	—	8.39	7.67	12.53	12.76	10.83	—	12.48		

Table 2 Hydrocarbons

Compound	Molar volume $V_{25^{\circ}\text{C}}$	Values of δ reported by							Values of δ calculated using group contributions				Values of δ		
		Hoy	Burrell	Hansen	Krevelan	Hoy	Small	Krevelan	Cohesive energy	δ from Hildebrand's equation		Compu-terised	Suggested		
										9	10			11	12
<i>Aliphatic</i>															
1. Methane	38.65	—	—	4.70	—	—	—	5.17	—	—	—	—	—	—	
2. Ethane	53.60	5.77	—	5.65	—	6.20	4.30	5.96	8.17	5.18	—	4.68	5.70	4.65	
3. Propane	73.33	6.59	—	6.20	—	6.60	5.04	6.45	8.12	5.90	—	5.70	6.46	6.45	
4. Butane	96.87	7.02	7.0	6.62	—	7.16	5.78	7.07	8.25	6.74	—	6.89	6.89	6.88	
5. Pentane	119.26	7.24	—	7.24	—	7.36	6.00	7.13	8.12	7.03	—	7.12	7.10	7.10	
6. Hexane	130.50	7.50	—	7.42	—	7.50	6.30	7.35	8.12	7.05	—	7.26	7.26	7.25	
7. Heptane	146.53	7.60	—	7.55	—	7.55	6.69	7.48	8.09	7.38	—	7.38	7.38	7.38	
8. Octane	162.34	7.64	—	7.65	—	7.60	6.81	7.66	8.08	7.48	—	7.47	7.47	7.49	
9. Nonane	178.79	7.74	—	7.72	—	7.66	6.92	7.73	8.05	7.51	—	7.55	7.55	7.56	
10. Decane	194.88	8.10	—	7.72	—	7.72	7.27	7.98	8.04	7.51	—	7.62	7.62	7.63	
11. Cyclopentane	93.38	8.19	8.20	8.18	—	8.25	7.27	7.98	8.25	8.13	—	7.98	7.98	7.98	
12. Cyclohexane	108.02	—	—	—	—	8.27	8.02	8.10	—	8.30	—	—	—	8.20	
<i>Aromatic</i>															
13. Benzene	88.86	9.16	9.20	9.15	9.15	7.50	8.21	9.15	—	9.07	—	9.17	9.14	9.14	
14. Toluene	106.29	8.90	9.00	8.91	8.91	8.93	7.83	8.90	9.25	8.93	—	8.95	8.92	8.92	
15. Xylene (o)	120.62	8.88	8.80	8.80	8.80	8.84	8.15	8.80	9.29	9.03	—	8.83	8.84	8.84	
16. Xylene (m)	122.85	8.83	8.75	8.75	8.80	8.84	8.15	8.80	9.29	8.85	—	8.81	8.81	8.81	
17. Xylene (p)	123.30	8.84	8.80	8.80	8.80	8.84	8.15	8.80	9.08	8.82	—	8.80	8.80	8.79	
18. Ethyl benzene	122.47	—	—	8.65	—	8.25	—	8.94	—	8.81	—	8.81	8.81	8.82	
19. Propyl benzene	139.42	8.60	8.52	8.52	—	8.54	7.64	8.93	9.08	8.62	—	8.70	8.60	8.60	
20. Isopropyl benzene	139.48	9.35	9.30	9.30	—	8.50	8.12	9.17	—	8.53	—	8.70	8.70	8.73	
21. Styrene	114.77	—	—	—	—	—	—	—	—	9.25	—	—	—	8.94	

Table 3 Esters

Compound	Molar volume $V_{25^{\circ}\text{C}}$	Values of δ reported by							Values of δ calculated using group contributions				Values of δ		
		Hoy	Burrell	Hansen	Krevelan	Hoy	Small	Krevelan	Cohesive energy	δ from Hildebrand's equation		Compu-terised	Suggested		
										9	10			11	12
<i>Aliphatic</i>															
1. Methyl formate	62.10	9.93	10.20	10.05	—	8.95	10.05	8.44	—	9.48	—	10.08	9.84	9.84	
2. Ethyl formate	80.21	9.31	9.40	9.55	—	8.57	9.44	8.24	—	8.90	—	9.52	9.22	9.22	
3. Propyl formate	97.82	—	9.20	9.56	—	8.37	8.89	8.16	—	8.67	—	9.18	8.96	8.96	
4. Isobutyl formate	116.72	—	—	8.58	—	8.04	8.39	8.03	—	8.33	—	—	8.45	8.45	
5. Isoamyl formate	133.36	—	—	8.45	—	7.90	8.34	8.16	—	8.27	—	—	8.36	8.36	
6. Methyl acetate	79.88	9.46	9.60	9.49	—	7.80	9.24	8.27	9.88	9.03	—	9.40	9.32	9.32	

Table 3 Esters (continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13
7. Ethyl acetate		97.79	8.91	9.10	9.10	—	7.72	8.91	8.16	9.49	8.59	9.07	8.85
8. Propyl acetate		115.14	8.80	8.80	8.74	8.68	7.70	8.72	8.12	9.23	8.40	8.85	8.60
9. Butyl acetate		131.70	8.69	8.50	8.46	—	7.73	9.26	8.10	9.26	9.82	8.70	8.49
10. Isopropyl acetate		116.45	8.58	8.40	8.45	—	7.36	8.42	8.03	9.36	8.10	—	8.34
11. Isobutyl acetate		133.33	8.43	8.30	8.42	—	7.42	8.34	8.04	9.16	8.12	—	8.28
12. Isoamyl acetate		148.10	—	—	8.32	—	7.57	8.41	8.05	—	—	—	8.26
13. Methyl propionate		96.32	9.14	—	9.05	—	9.20	10.42	8.29	9.56	8.72	—	8.93
14. Ethyl propionate		114.02	8.77	—	8.74	—	7.73	8.81	8.20	9.27	8.40	—	8.60
15. Propyl propionate		131.55	—	8.50	8.25	—	7.34	8.64	8.15	—	8.27	—	8.46
16. Isobutyl propionate		146.67	—	—	8.05	—	7.64	8.50	8.24	—	7.57	—	8.04
17. Isoamyl propionate		165.76	—	—	8.14	—	7.55	8.32	8.12	—	7.95	—	8.14
18. Methyl butyrate		113.73	—	8.90	8.90	—	7.79	8.83	8.22	—	8.51	8.70	8.70
19. Ethyl butyrate		132.15	8.29	8.50	8.52	—	7.70	8.61	8.11	9.04	8.19	8.48	8.40
20. Propyl butyrate		148.10	—	—	8.28	—	7.76	8.58	8.17	—	7.43	8.33	8.37
21. Methyl isobutyrate		114.62	—	—	8.52	—	7.48	8.55	8.17	—	8.23	—	8.34
22. Ethyl isobutyrate		133.62	—	—	8.23	—	7.40	8.33	8.02	—	7.95	—	8.18
23. Propyl isobutyrate		147.26	—	—	7.95	—	7.61	8.45	8.29	—	8.02	—	8.15

Table 4 Ketones

Compound	Molar volume $V_{25^\circ\text{C}}$	Values of δ reported by			Values of δ calculated using group contributions			δ from Hildebrand's equation			Values of δ	
		Hoy	Burrell	Hansen	Krevelan	Hoy	Small	Krevelan	Cohesive energy	Computed	Suggested	
1. Acetone	73.33	9.62	10.00	9.77	9.90	7.63	9.59	10.07	—	9.36	9.59	9.68
2. Methyl ethyl ketone	89.57	9.45	—	9.27	9.10	7.72	9.33	9.86	—	9.03	9.22	9.24
3. Diethyl ketone	105.56	—	8.80	8.86	—	7.79	9.18	9.66	—	8.81	8.95	9.00
4. Methyl propyl ketone	106.07	—	8.70	8.92	—	7.75	9.14	9.62	—	8.76	8.96	8.92
5. Methyl butyl ketone	120.67	—	—	8.62	—	7.90	9.13	9.59	—	8.71	8.78	8.92
6. Methyl isobutyl ketone	124.93	—	8.40	8.57	—	7.41	8.63	9.26	—	8.40	8.73	8.83
7. Methyl amyl ketone	138.90	—	8.50	8.84	—	7.82	8.73	9.32	—	8.51	8.61	8.67
8. Ethyl butyl ketone	139.53	—	—	9.04	—	7.78	8.85	9.27	—	8.32	8.61	8.68
9. Dipropyl ketone	139.69	—	—	8.85	—	7.77	8.84	9.26	—	8.38	8.60	8.62
10. Methyl hexyl ketone	156.74	—	8.40	8.50	—	8.78	9.13	10.63	—	8.13	8.48	8.63
11. Cyclopentanone	88.73	10.53	10.40	10.54	—	9.13	10.28	10.63	—	9.54	—	10.05
12. Cyclohexanone	103.56	10.42	9.90	9.88	—	8.66	9.99	10.43	—	9.97	—	10.15
13. Acetophenone	117.10	10.58	—	9.68	10.40	8.71	10.45	11.16	—	10.20	—	10.33
14. Isophorone	150.50	9.36	9.10	9.71	—	—	—	9.13	—	9.22	—	9.40

Table 5 Esters

Compound	Molar volume $V_{25^\circ\text{C}}$	Values of δ reported by						Values of δ calculated using group contributions				Values of δ											
		Hoy		Burrell		Hansen		Krevelan		Hoy		Small		Krevelan		Cohesive energy		δ from Hildebrand's equation		Compu-terised		Suggested	
		3	4	5	6	7	8	9	10	11	12	13	11	12	13	11	12	13	11	12	13		
1. Methylisopropyl ether	100.88	—	—	7.52	—	6.40	7.34	8.03	—	—	—	—	—	—	—	—	—	7.43	7.52	7.68	7.43	7.52	7.68
2. Ethyl ether	103.88	7.53	—	7.62	—	6.49	7.35	7.80	—	—	—	—	—	—	—	—	—	7.37	7.53	7.44	7.37	7.53	7.44
3. Ethylpropyl ether	120.42	—	—	7.77	—	6.17	7.45	7.86	—	—	—	—	—	—	—	—	—	7.47	7.57	7.66	7.47	7.57	7.66
4. Ethylbutyl ether	136.60	7.68	—	8.04	—	6.90	7.58	7.97	—	—	—	—	—	—	—	—	—	7.55	7.60	7.79	7.55	7.60	7.79
5. Isopropyl ether	142.10	7.06	—	7.03	—	6.19	6.91	7.63	—	—	—	—	—	—	—	—	—	6.96	7.61	7.30	6.96	7.61	7.30
6. Butyl ether	170.20	7.76	—	7.77	—	7.05	7.61	7.98	—	—	—	—	—	—	—	—	—	8.28	7.65	7.95	8.28	7.65	7.95
<i>Carbitol derivatives</i>																							
7. Methyl carbitol	118.20	11.15	—	10.72	—	9.56	8.93	10.21	—	—	—	—	—	—	—	—	—	10.03	10.66	10.60	10.03	10.66	10.60
8. Carbitol	136.20	10.34	9.60	11.00	—	9.26	8.73	10.60	—	—	—	—	—	—	—	—	—	9.49	10.02	10.30	9.49	10.02	10.30
9. Butyl carbitol	170.50	9.79	8.90	8.96	—	8.94	8.53	10.08	—	—	—	—	—	—	—	—	—	8.89	9.17	9.48	8.89	9.17	9.48
10. Diethyl carbitol	182.00	8.67	—	8.98	—	7.86	7.89	8.84	—	—	—	—	—	—	—	—	—	6.49	8.95	8.38	6.49	8.95	8.38
11. Dibutyl carbitol	248.00	8.33	—	8.67	—	7.89	7.94	8.69	—	—	—	—	—	—	—	—	—	7.67	8.11	8.20	7.67	8.11	8.20
<i>Cellosolve derivatives</i>																							
12. Methyl cellosolve	79.10	11.68	10.80	12.06	—	9.51	9.10	13.06	—	—	—	—	—	—	—	—	—	10.69	11.88	11.38	10.69	11.88	11.38
13. Butyl cellosolve	131.60	9.87	8.90	10.24	—	8.71	8.50	10.97	—	—	—	—	—	—	—	—	—	9.11	9.49	9.57	9.11	9.49	9.57
14. Diethyl cellosolve	133.70	8.35	—	9.99	—	7.87	8.23	9.04	—	—	—	—	—	—	—	—	—	8.16	9.43	9.15	8.16	9.43	9.15
15. Dibutyl cellosolve	209.00	8.20	—	8.37	—	7.55	7.81	8.41	—	—	—	—	—	—	—	—	—	7.66	8.16	8.02	7.66	8.16	8.02

Table 6 Halogenated solvents

Compound	Molar volume $V_{25^\circ\text{C}}$	Values of δ reported by						Values of δ calculated using group contributions				Values of δ												
		Hoy		Burrell		Hansen		Krevelan		Hoy		Small		Krevelan		Cohesive energy		δ from Hildebrand's equation		Compu-terised		Suggested		
		3	4	5	6	7	8	9	10	11	12	13	11	12	13	11	12	13	11	12	13	11	12	13
1. Methyl chloride	57.5	—	—	—	—	6.15	8.42	7.57	—	—	—	—	—	—	—	—	—	8.22	8.07	8.00	8.22	8.07	8.00	
2. Ethyl chloride	73.60	—	—	—	—	6.59	8.38	7.78	—	—	—	—	—	—	—	—	—	8.30	8.18	8.10	8.30	8.18	8.10	
3. Propyl chloride	88.25	8.39	8.50	8.50	—	6.98	8.50	8.04	—	—	—	—	—	—	—	—	—	8.30	8.24	8.25	8.30	8.24	8.25	
4. Butyl chloride	104.71	8.37	—	8.46	—	7.14	8.43	8.08	—	—	—	—	—	—	—	—	—	8.32	—	8.28	8.32	—	—	8.28
5. Isopropyl chloride	90.00	8.07	—	8.07	—	6.87	8.07	7.88	—	—	—	—	—	—	—	—	—	8.05	—	8.00	8.05	—	—	8.00
6. 2-butyl chloride	106.10	8.12	8.10	8.12	—	6.80	8.10	7.98	—	—	—	—	—	—	—	—	—	8.13	—	8.10	8.13	—	—	8.10

Table 6 Halogenated solvents (Continued)

1	2	3	4	5	6	7	8	9	10	11	12	13
7. 2-ethylhexyl chloride	169.10	8.12	—	8.43	—	7.36	8.23	8.25	8.70	8.08	—	8.25
8. Chlorobenzene	101.71	9.67	9.50	9.57	—	8.74	9.88	9.50	9.87	9.58	—	9.70
9. Bromobenzene	104.74	9.87	—	9.78	—	8.99	10.26	10.18	10.01	9.91	—	10.05
10. O-dichlorobenzene	112.67	10.04	10.00	9.98	—	9.90	10.62	10.23	10.41	9.99	—	10.30
11. Carbon tetrachloride	96.45	8.55	8.60	8.65	9.50	8.84	10.23	9.54	10.58	8.63	9.09	9.05
12. Chloroform	79.67	9.16	9.30	9.21	9.24	9.77	8.80	8.40	10.86	9.13	9.26	9.10
13. Ethylene dichloride	79.00	9.86	9.30	—	—	8.35	9.39	8.90	10.19	9.18	9.27	9.40
14. Trichloro ethylene	90.27	9.16	9.30	9.28	—	8.70	9.49	9.29	10.37	9.17	9.14	9.23
15. Propylene dichloride	97.46	9.06	9.00	9.43	—	7.08	9.10	8.94	9.88	9.03	9.08	9.20
16. 1-1 dichloro ethane	84.29	8.92	—	9.78	9.07	7.65	9.17	8.71	10.06	8.76	9.20	9.30

Table 7 Nitrogen solvents

Compound	Molar volume $V_{25^\circ\text{C}}$	Values of δ reported by						Values of δ calculated using group contributions			δ from Hildebrand's equation		Values of δ					
		Burrell		Hansen	Krevelan	Hoy	Small	Krevelan	Cohesive energy	Compu-terised	Suggested							
		Hoy	4	5	6	7	8	9	10			11	12	13				
Amines																		
1. Ethanol amine	60.00	15.52	—	15.48	—	11.93	—	9.80	—	13.48	—	—	—	—	—	—	—	—
2. Propyl amine	82.21	8.87	—	8.97	—	7.76	—	8.72	—	8.65	—	—	—	—	—	—	—	8.80
3. Butyl amine	98.83	8.66	—	—	—	—	—	8.64	—	7.79	—	—	—	—	—	—	—	8.60
4. Diethyl amine	102.90	8.04	—	7.96	—	7.19	—	8.68	—	7.89	—	—	—	—	—	—	—	8.30
5. Hexyl amine	132.66	8.45	—	—	—	8.38	—	—	—	7.78	—	—	—	—	—	—	—	8.47
6. Dipropyl amine	137.04	7.97	—	7.79	—	7.32	—	8.52	—	7.85	—	—	—	—	—	—	—	7.92
7. Dibutyl amine	168.51	8.15	—	8.15	—	8.88	—	8.15	—	7.51	—	—	—	—	—	—	—	8.02
Anilines																		
8. Aniline	91.12	10.70*	—	11.04	—	9.99	—	9.80	—	11.23	—	—	—	—	—	—	—	10.42
9. Methyl aniline	106.67	9.83*	—	10.47	—	9.31	—	10.21	—	10.49	—	—	—	—	—	—	—	9.90
10. Ethyl aniline	126.84	10.49	—	—	—	8.75	—	9.84	—	9.02	—	—	—	—	—	—	—	9.76
11. Dimethyl aniline	126.80	8.88*	—	9.54	—	8.21	—	—	—	9.54	—	—	—	—	—	—	—	8.88
12. Butyl aniline	161.43	9.95	—	—	—	9.28	—	9.43	—	8.71	—	—	—	—	—	—	—	9.62
Nitriles																		
13. Acetonitrile	52.44	12.71	11.90	11.75	—	9.59	11.90	13.07	—	11.85	—	—	—	—	—	—	—	11.98
14. Propionitrile	70.33	10.73	10.80	10.50	—	9.02	10.76	11.70	—	—	—	—	—	—	—	—	—	10.70
15. Butyronitrile	86.82	10.17	10.50	9.96	—	8.84	10.25	11.05	—	10.05	—	—	—	—	—	—	—	10.23
16. Benzoinitrile	102.08	9.78*	8.40	10.78	—	10.16	11.22	11.52	—	10.73	—	—	—	—	—	—	—	—
17. Capronitrile	120.10	—	9.40	9.03	—	9.39	—	10.27	—	8.57	—	—	—	—	—	—	—	9.65

*Values calculated.

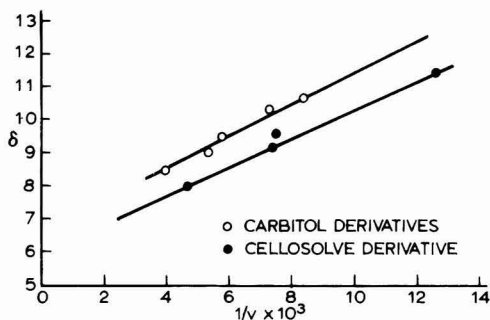


Figure 1E. δ versus molar volume inverse for carbitol and cellosolve derivatives

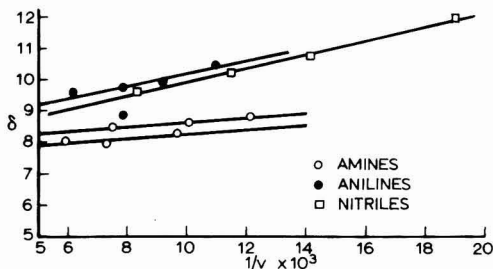


Figure 1F. δ versus molar volume inverse for amines, anilines and nitriles

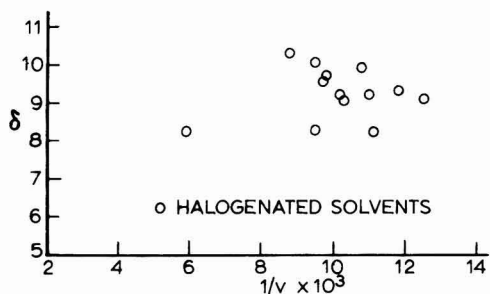


Figure 1G. δ versus molar volume inverse for halogenated solvents

Results and discussion

Ref. 11

Compounds having a common functional group in a series are grouped together and δ values are tabulated in the increasing order of the molar volumes. The δ values obtained by different methods for compounds in an individual series have certain features common with respect to molar volume (Tables 1-7). For example, δ values for compounds in most series decrease with increase in molar volume, except in the case of ethers and hydrocarbons where they increase with molar volume.

As the solubility parameter is proportional to the square root of inverse of molar volume,

$$\delta = \left(\frac{\Delta E}{V} \right)^{\frac{1}{2}}, \text{ it is likely}$$

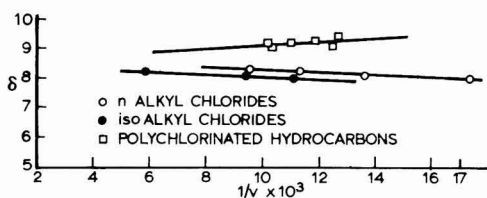


Figure 1H. δ versus molar volume inverse for halogenated solvents

to decrease with an increase in V , provided the increase in ΔE is not proportionately high. The relatively large increase in heat of vapourisation with the number of carbon atoms in the chain of aliphatic hydrocarbons¹¹ accounts for the increase in their δ values with molar volume. The same observation holds good for ethers.

δ values for lower aliphatic hydrocarbons obtained by extrapolation of the plots are in good agreement with the values reported by some workers. For example, the extrapolation δ values of 4.65 and 5.65 for methane and ethane respectively compare very well with the only values reported by Hansen (Table 2).

The δ values for alcohols calculated by using Hildebrand's equation can be brought closer to Burrell's values by adding 1.65, as shown by the intercept and slope values obtained for the two sets from the computerised data:

Burrell : Intercept = 8.91; Slope = 224
Hildebrand : Intercept = 7.25; Slope = 229

Burrell suggested the addition of 1.4 to such values.

An individual plot of δ as function of molar volume inverse for compounds in any series passes through most points under consideration showing a good correlation among the suggested δ values. The intercept of the straight line plot with the Y-axis represents the solubility parameter of a compound having an infinitely large molar volume in the homologous series. δ values for all the members belonging to a particular series fall on a line and the first datum point corresponds to the compound having the lowest molar volume. Therefore, the first datum point and the intercept of the plot with Y-axis give the possible range of δ values for compounds in the homologous series (Table 9). This information can be used in determining the miscibility of two solvents belonging to different series and

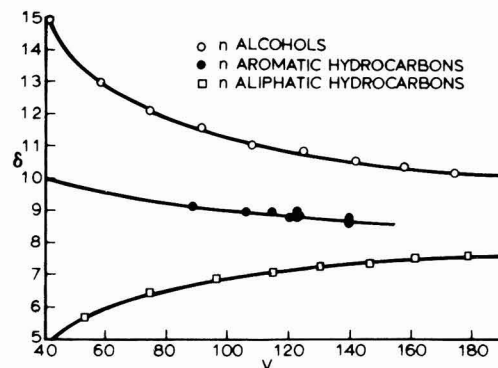


Figure 2. δ versus molar volume for alcohols and hydrocarbons

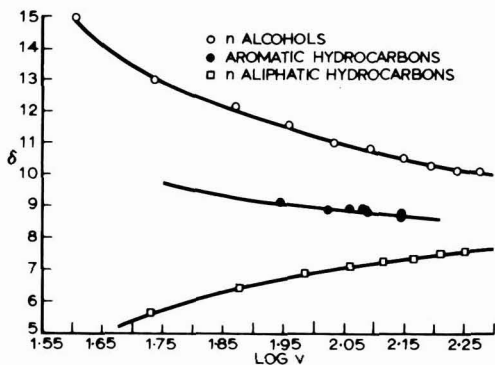


Figure 3. δ versus log. molar volume for alcohols and hydrocarbons

also the solvent/non-solvent mixture for a polymer solution.

Carbitol and cellosolve derivatives have δ values in a wide range of 5.5-11.5, and hence they are likely to be miscible with most of polar and non-polar solvents. The lower members of these series have greater miscibility with alcohols than with hydrocarbons, since, in these compounds, the effect of the OH group is greater than that of the ether group, which also results in high δ values. As the chain length increases (i.e. in higher members) the effect of the OH group decreases and the greater effect of the ether group results in their low δ values.

The differences in the slopes of plots (Table 8) of δ values for compounds belonging to different types of series can be attributed to the differences in their degrees of polarity. The plots for n-alcohols, aliphatic and aromatic hydrocarbons in Fig. 1A illustrate the diversity among δ values for compounds belonging to different types of series and also the nature of the slopes with respect to the polarity of these compounds. The replacement of a hydrogen atom with a hydroxyl group changes the negative correlation of δ values with inverse molar volume to a positive correlation in case of alcohols. Similarly, the substitution of halogen groups in hydrocarbons adds to the polarity of the compounds, because the halogenated solvents have greater polarity and also better solvency power for polar and non-polar substances than simple hydrocarbons.

In case of esters, compounds having almost the same molar volumes do not differ greatly in their δ values. These results are illustrated by plots for individual sets of esters, such as acetates, propionates etc. (Fig. 1B, 1C). The plots are linear and parallel to each other having almost the same slopes and intercepts. This shows that the δ values for different types of ester fall within one broad spectrum of plots.

Fig. 1G, the plot of δ versus molar volume inverse for halogenated solvents, exhibits a random distribution of points. When the δ values are rearranged in order of substituted halogen groups and plotted, a good correlation is observed within each group (Fig. 1H). The plots of aliphatic amines, anilines and nitriles (Fig. 1F) also exhibit a good agreement amongst δ values reported in column (13).

The plots of δ versus molar volume inverse are linear, whereas those of δ versus molar volume or log molar

Table 8 The slope and intercept values obtained from the plots of δ versus molar volume inverse

Compounds	Slope	Intercept
1. Hydrocarbons	-144.03	8.36
2. Ethers	-101.71	8.60
3. Halogenated solvents	-37.97	8.65
4. Polychlorinated solvents	58.08	8.55
5. Aromatic hydrocarbons	110.32	7.92
6. Ketones	148.65	7.62
7. Esters		
Formates	151.66	7.38
Acetates	171.61	7.15
Butyrates	168.30	7.19
8. Mixed alcohols	162.52	8.96
9. Anilines	200.00	9.20
10. Nitriles	243.18	7.32
11. n-aliphatic alcohols	251.86	8.73
12. Cellosolve derivatives	422.54	6.10
13. Carbitol derivatives	600.60	5.65

Table 9 The range of δ values for compounds in a series

Series	Solubility parameters
1. Hydrocarbons	4.65 to 8.36
2. Ethers	7.40 to 8.60
3. Halogenated solvents	8.00 to 9.40
4. Aromatic hydrocarbons	7.92 to 9.10
5. Ketones	7.62 to 9.68
6. Esters	7.15 to 9.84
7. Nitrogen solvents	7.32 to 11.90
8. Alcohols	8.73 to 14.85
9. Cellosolve and carbitol derivatives	5.65 to 11.38

volume (Figs. 2 and 3) are non-linear. The expression of results by a linear relationship is useful in determining the δ value of a compound of known molar volume. Moreover, the linear plots of the results could be compared with each other and used to derive definite conclusions. Thus, it can be concluded that the δ values are better illustrated as a function of molar volume inverse than other types of plots. The suggested δ values reported in column (13) of the tables well satisfy the plots. The difference between these values and δ values obtained from the computerised results (column 12) is not greater than 0.1 in most of the cases.

Acknowledgements

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Zinc-rich paints

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Summary

Zinc-rich corrosion inhibiting primers, in both organic and inorganic media, are now well established in the UK, USA, Europe and Australia. As far as the inorganic zinc-rich paints are concerned, a survey of the published works shows that only silicates (particularly sodium silicate) which have a silica to Na_2O ratio of 3.3:1 to 3.5:1 have been advocated for this purpose. Silicates having a silica:alkali ratio of 2.8:1 and 3:1 are generally available on the Indian market. In the present work the silicates with the lower range of silica:alkali ratios were employed. The efficacy of additives, such as another metal and/or metal oxides, in addition to the zinc component was also investigated. Different curing methods were studied.

The laboratory tests and outdoor exposure indicated that

zinc-rich paints can be formulated to give satisfactory performance in silicate media, even with a low silica:alkali ratio. The zinc content in such paints should not be less than 75-80 per cent. Amongst the curing methods used, good results were obtained when salts and acids were employed. Self-cured paints at a lower zinc content gave poor performance, but a zinc content of 80 per cent is currently showing a good performance.

Zinc-rich paints in chlorinated rubber media were also prepared. It was observed that here good performance is possible with a 75 per cent zinc content (only one concentration was studied) with chlorinated paraffin as plasticiser. A low level of plasticiser showed good performance. Another plasticiser did not give good results.

Keywords

Types and classes of coatings and allied products

zinc rich coating
anticorrosive coating
primer

Properties, characteristics and conditions primarily associated with

dried or cured films

humidity resistance
weather resistance

Types and classes of structures or surfaces to be coated

steel

Raw materials for coatings binders (resins, etc.)

sodium silicate
chlorinated rubber

chemically active pigments

zinc dust

Peintures riches en zinc

Résumé

Les primaires anticorrosifs riches en zinc et basées sur les liants organiques ou inorganiques sont maintenant fort bien établis au Royaume Uni, aux Etats Unis, en Europe et en Australie. Dans le cas des peintures inorganiques riches en zinc, une revue des études déjà publiées révèle que les silicates (surtout le silicate de soude (ayant un rapport SiO_2 ; Na_2O de 3,3 : 1 à 3,5 : 1 sont les seuls que l'on a proposés pour cet emploi. Les silicates ayant un rapport SiO_2 ; Na_2O de 2,8 : 1 à 3 : 1 sont largement disponibles sur le marché indien. Au cours de l'étude actuelle, on a utilisé les silicates ayant un éventail plus faible de rapports silice:alkali. L'efficacité des adjuvants tels qu'un autre métal et/ou des oxydes métalliques, aussi bien que le constituant zincique a été étudiée. De diverses méthodes de durcissement ont été étudiées également.

Les essais au laboratoire et de résistance aux intempéries ont indiqué que l'on peut formuler les peintures riches en zinc à base

d'un milieu silicate même à faible rapport silice:alkali, qui donnent un rendement satisfaisant. La teneur en zinc de telles peintures ne devrait pas être inférieure à 75-80 pour cent. Parmi les méthodes de durcissement utilisées, on a obtenu de bons résultats avec des sels et des acides. Peintures autodurcissables à une teneur en zinc plus faible donnaient un mauvais rendement, mais celles ayant une teneur en zinc de 80 pour cent donnent actuellement un bon rendement.

On a préparé en outre des peintures riches en zinc à base de caoutchouc chloré. On a noté qu'un bon rendement est possible à une teneur en zinc de 75 pour cent (la seule concentration étudiée) et en présence d'une paraffine chlorée en tant que plastifiant. Un bon rendement était obtenu avec une faible teneur en plastifiant. Un autre plastifiant ne rendait pas de bons résultats.

Zinkreiche Farben

Zusammenfassung

Zinkreiche Korrosion inhibierende Primer in sowohl organischen, als auch anorganischen Bindemitteln sind jetzt im UK, der USA, in Europa und Australien wohlbekannt. Eine sich nur auf anorganische zinkreiche Farben beziehende Übersicht von Veröffentlichungen zeigt, dass lediglich Silikate

(insbesondere Natriumsilikat) mit einem Siliziumdioxid zu Na_2O Verhältnis von 3,3:1 bis 3,5:1 für solche Verwendung befürwortet werden. Im indischen Markt sind im allgemeinen Silikate mit einem Siliziumdioxid:Alkali Verhältnis von 2,8:1 und 3:1 erhältlich. Die vorliegende Arbeit bezieht sich auf

Silikate, deren Silica:Alkali Proportionen niedrig sind. Auch die Effektivnes von Zusatzmitteln wie z.B. eines anderen Metalls und/oder Metalloxides zusätzlich zur Zink-Komponente wurde untersucht. Verschiedene Härtungsmethoden wurden geprüft.

Die Laboratoriums- und Bewitterungsversuche zeigten an, dass nützliche, zinkreiche Farben mit Silikatbindemitteln zusammengesetzt werden können, selbst wenn diese ein niedriges Silizium:Alkali-Verhältnis besitzen. Der Zinkgehalt solcher Farben sollte nicht unter 75-80% liegen. Unter den benutzten Härtungsmethoden wurden gute Resultate mit Salzen und

Säuren erzielt. Selbsthärtende Farben mit einem niedrigeren Zinkgehalt verhielten sich schlecht; ein Zinkgehalt von 80% zeigt z.Z. ein gutes Verhalten.

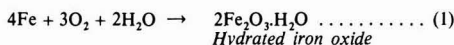
Zinkreiche Farben in Chlorkautschukbindemitteln wurden gleichfalls hergestellt. Es wurde beobachtet, dass bei einem Zinkgehalt von 75% (die einzige geprüfte Konzentration) und mit chloriniertem Paraffin als Weichmacher gute Ergebnisse erhalten werden. Das Verhalten war mit niedrigem Weichmachergehalt gut. Ein anderer Weichmacher bag keine guten Resultate.

Introduction

Refs. 1, 2

The wastage of metals due to corrosion has become an all-important problem. An accurate and direct estimate of corrosion losses is seldom possible and indirect methods have, therefore, to be used to assess them. In a recent publication Chaudhuri¹ has reviewed the cost due to corrosion in many countries. For India the estimated figure is Rs. 500 million per year. The corresponding figures for USA and UK are \$15 billion and £1365 million per annum. Such serious losses make the prevention of corrosion essential. Painting is one of the simplest and most widely used methods for the prevention of corrosion.

It is well known that iron, when exposed to moist air, soon becomes corroded and usually a film of hydrated iron oxide is formed on the surface. The overall chemical reaction is:



This reaction² can be broken down into two separate reactions which are taking place at the anodic and cathodic regions on the surface of the metal:



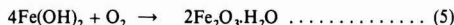
an anodic reaction where electrons are liberated, and



a cathodic reaction where electrons are consumed. Combining equations (2) and (3), gives:



Ferrous hydroxide in the presence of excess air (oxygen) becomes oxidised to hydrated ferric oxide, the common rust:



Iron can be protected by suppressing either the anodic reaction or the cathodic reaction, or by the insertion of a high electrolytic resistance in the path of the corrosion current, so that there will be no direct movement of electrons from anode to cathode.

The cathodic reaction

This reaction involves oxygen, electrons and water as indicated in reaction (3). The paint film could be effective only if it were impervious to electrons, but paint films are so permeable to water and oxygen that they can not inhibit corrosion by preventing water and oxygen from reaching the metal substrate. Therefore, a cathodic reaction can not be suppressed completely.

The anodic reaction

This reaction can be suppressed in two ways:

- (a) If the electrode potential of iron is made sufficiently negative, the positively charged iron ions are not able to leave the metallic lattice. This is called cathodic protection.
- (b) If the surface of the iron becomes covered with a film impervious to iron ions, their movement into the solution will be prevented. This is called anodic passivation. Zinc chromate, red lead etc. are generally used for this purpose.

The present study deals with zinc-rich paints which protect the metallic surface by cathodic protection.

Cathodic protection

The electrode potential of iron is made sufficiently negative that positively charged metal ions are unable to leave the metallic lattice. To make the potential of the iron more negative, it must receive a continuous supply of electrons. Only the metallic pigments are known to contain free electrons; pigments which can be used for protection must satisfy the following conditions:

- (a) The pigment must be a metal less noble than iron, otherwise the flow of electrons will be in the wrong direction.
- (b) The pigment particles must be in direct contact with each other and with the substrate (iron).

Zinc dust is the only commercially available pigment which fulfils both these conditions and, therefore, is used for the protection of iron.

Approach to the present study

Ref. 3

The zinc-rich paints in both organic and inorganic media are well established in UK and USA, but these, particularly when based upon silicates, are seldom available in India. Therefore, there is a need to develop this type of paint. Their performance depends very largely on the percentage of zinc in the composition and also on the type of the binders. Various³ materials may be used as binders, but silicates were used in this work. So far silicates of three alkali/silica ratios have been used, thus determining whether or not silicates of low alkali/silica ratio could be used. Bearing these points in mind, various formulations were developed to compare the efficiency of the paints formulated with those of the inorganic or organic coatings available on the market.

Experimental procedure

Refs. 4, 5

The following materials were used in the experiments:

Materials	Specification
Sodium silicate	Alkali-silica ratio, 1:2.3 and 1:3
Potassium silicate	Alkali-silica ratio, 1:2.8
Chlorinated rubber	Commercial
Zinc dust powder	Commercial
Zinc oxide	Chemically pure
Red lead	Commercial pigment
Lead metal powder	Commercial
Chlorinated paraffin (A)	Commercial
Di-octyl phthalate (B)	Commercial

Preparation of steel panels

Eighteen gauge galvanised iron panels, sizes 15 × 6.25 cm, 15 × 10 cm and 15 × 15 cm, were first pickled in 10 per cent dilute sulfuric acid to remove the zinc coating then thoroughly washed with water. The panels were allowed to dry in the laboratory and superficial rust was removed with fine emery paper. The panels were then cleaned with benzene or xylene and the experimental paints were applied. The coating thickness was about 75 microns (3.0 mil).

Preparation of protective coatings

Zinc dust was the main pigment, and various amounts of other substances were also added to adjust other properties of the paints. Two types of coatings were developed using two different binders.

(i) Silicate based coatings

Sodium silicate of sodium oxide-silica ratio 1:2.3 and 1:3 and potassium silicate of potassium oxide-silica ratio 1:2.8 were used. The zinc content^{4,5} was kept at 60, 70, 75 and 80 per cent by weight of the total paint and the consistency was adjusted with water for application by brush.

Curing: All the silicate based paints were subjected to two types of curing: self-curing, as well as post curing. The latter was carried out in two ways:

- (a) By heating at 110°C for 24 hours
- (b) By adding chemical compounds

(ii) Rubber based coatings

Two types of rubber based coatings were developed using two different plasticisers at different levels. In both types of formulation, chlorinated rubber was used as binder and the zinc content was kept at 75 per cent. The paints were diluted with solvents, such as xylene, benzene etc.

Methods of assessment

All the formulations, silicate based as well as rubber based, were designed to study the effect of various parameters.

(i) **Laboratory test:** The performance of a coating was first evaluated in the humidity cabinet for a period of 100 hours at a relative humidity of 100 per cent and at temperatures from 42°C to 48°C, as required by IS No 101-1961. At the end of the 100 hours no corrosion was observed. The panels were then tested for longer intervals. The results are given in Tables 1 and 2. Those formulations which satisfied the above requirements were then exposed in a twin arc weatherometer.

(ii) **Natural weathering:** Panels were also exposed on the terrace of the Institute in racks facing South at an angle of 45°. The panels were examined every month for rusting, cracking, chalking and general appearance.

The performance of the coatings during these tests are given in Tables 1-6.

Table 1
Results of Humidity test for silicate based paints

Zinc content	Type of curing	Performance after 100 hrs	Performance after 200 hrs	Performance after 300 hrs	Performance after 500 hrs
60% with metal	Self-cured	G	-	-	-
60%					
(a) with metal	Chemically cured	E	-	-	-
(b) with oxide	Chemically cured	E	-	-	-
(c) with oxide	Heat cured	P	-	-	-
70% with metal	Cured (self)	P	-	-	-
70%					
(a) with metal	Chemically cured	G	-	-	-
(b) with oxide	Chemically cured	G	G	G	G
75% with metal	Self-cured	F	-	-	-
75% with metal	Chemically cured	G	G	G	G
75% with metal	Chemically cured	E	E	E	E
75% with oxide	Chemically cured	E	P	-	-
75% with oxide	Chemically cured	P	-	-	-
81% with metal	Self-cured	E	E	E	E
81%					
(a) with metal	Chemically cured	E	E	E	G
(b) with oxide	Chemically cured	E	G	G	G
(c) with metal + oxide	Chemically cured	E	G	G	G
81% with oxide	Chemically cured	E	E	E	-
81% with oxide	Chemically cured	E	G	G	-
81% with oxide	Chemically cured	P	-	-	-

E Excellent

G Good

F Fair

P Poor

Table 2
Results of humidity test for chlorinated rubber based paints

Zinc content	Plasticiser content	Performance after 200 hrs	Performance after 400 hrs
75%	25% Plasticiser A		
	(a) control	E	E
75%	(b) with metal	E	E
75%	(c) with oxide	E	G
	35% Plasticiser A		
75%	(a) control	E	G
75%	(b) with metal	E	E
75%	(c) with oxide	E	G
	44% Plasticiser A		
75%	(a) control	G	F
75%	(b) with metal	G	F
75%	(c) with oxide	G	F
	25% Plasticiser B		
75%	(a) control	E	G
75%	(b) with metal	E	G
75%	(c) with oxide	E	G

E Excellent G Good F Fair P Poor

Discussion

Humidity cabinet test

(a) *Self-cured silicate paints*: From Table 1 it is observed that the paints containing 75 per cent and 80 per cent zinc content pass the requirements of IS No 101-1961.

(b) *Post-cured silicate paints*: According to Table 1 all the formulations containing 60 to 80 per cent zinc content pass the requirements of IS No 101-1961, i.e. they do not show any rusting, cracking, and chalking etc.

(c) *Rubber based paints*: Paints based on chlorinated rubber with both the plasticisers pass the test according to IS No 101-1961. The performance was found to be good, even when tested for longer periods, such as 400 hours.

Accelerated weathering tests

(a) *Self-cured silicate paints*: Table 3 indicates that the formulations containing 60 and 70 per cent zinc content show rusting after 300 hours.

(b) *Post-cured silicate paints*: None of the formulations show any rusting up to 300 hours, as shown in Table 3. Exposure for longer periods is being carried out.

Table 4
Results of accelerated weathering of chlorinated rubber based paints

Zinc content	Plasticiser content	Performance after 100 hrs
75%	25% Plasticiser A	
	(a) Control	E
75%	(b) with metal	E
75%	(c) with oxide	E
	35% Plasticiser A	
75%	(a) control	E
75%	(b) with metal	E
75%	(c) with oxide	E
	44% Plasticiser A	
75%	(a) control	E
75%	(b) with metal	E
75%	(c) with oxide	E
	25% Plasticiser B	
75%	(a) control	E
75%	(b) with metal	E
75%	(c) with oxide	E

E Excellent F Fair
G Good P Poor

Table 3
Results of accelerated weathering of silicate based paints

Zinc content	Type of curing	100 hrs performance	200 hrs performance	300 hrs performance
60% with metal	Self-cured	F	F	F
60% with oxide	Heat cured	E	F	F
60% with metal	Chemically cured	E	E	E
60% with oxide	Chemically cured	E	E	E
70% with metal	Self-cured	G	F	P
70% with metal	Chemically cured	E	E	E

E Excellent G Good F Fair P Poor

(c) *Rubber based paints*: From Table 4 it can be seen that all the formulations have performed well up to 100 hours, i.e. no rusting, cracking, chalking etc. is observed. Tests are being carried out for longer intervals.

Natural weathering tests

(a) *Self-cured silicate paints*: Compositions containing sodium and potassium silicates with zinc contents of 60 and 70 per cent showed slight rusting after 1½ months (Table 5). The extent of rusting increased with time. The

compositions containing higher percentages of pigment do not show any rusting, as shown in Fig. 1. The ratings given are in accordance with ASTM Designation: D 610-43.

(b) *Post-cured silicate paints*: Compositions containing 60 and 70 per cent zinc content showed rusting after two months. Some of these panels were removed after four months. The formulations containing 75 and 80 per cent zinc content were in good condition at the end of 20 months (Table 5 and Figs. 2 and 3). Ratings given are according to ASTM Designation: D 610-43.

Table 5
Results of natural weathering of silicate based paints

60% zinc content	Type of curing	After 1 month	After 2 months	After 4 months	After 6 months	After 10 months	After 24 months
Potassium silicate with metal	Self-cured	F 7-6	P 4	withdrawn	—	—	—
Potassium silicate with oxide	Self-cured	F 7-6	P 4	withdrawn	—	—	—
Potassium silicate with metal	Chemically cured (1)	G 9	G 9	F 7-6	F 7-6	F 7-6	P 4
Potassium silicate with oxide	Chemically cured (1)	G 9	P 4	withdrawn	—	—	—
Sodium silicate with metal	Heat cured	F 7-6	P 4	withdrawn	—	—	—
Sodium silicate with oxide	Heat cured	F 7-6	P 4	withdrawn	—	—	—
Sodium silicate with metal	Chemically cured (1)	G 9	F 7-6	F 7-6	F 7-6	F 7-6	F 7-6
Sodium silicate with oxide	Chemically cured (1)	E 10	E 10	E 10	E 10	F 7-6	F 7-6
70% zinc content	Type of curing	After 1 month	After 2 months	After 4 months	After 6 months	After 10 months	After 24 months
Potassium silicate with metal	Self-cured	P 4	withdrawn	—	—	—	—
Potassium silicate with oxide	Self-cured	F 7-6	P 4	withdrawn	—	—	—
Potassium silicate with metal	Chemically cured (1)	F 7-6	P 4	withdrawn	—	—	—
Potassium silicate with oxide	Chemically cured (1)	E 10	E 10	E 10	E 10	E 10	G 9
Sodium silicate with metal	Heat cured	F 7-6	P 4	withdrawn	—	—	—
Sodium silicate with oxide	Heat cured	E 10	E 10	E 10	E 10	E 10	G 9
Sodium silicate with metal	Chemically cured (1)	E 10	E 10	E 10	E 10	G 10	E 10
Sodium silicate with oxide	Chemically cured (1)	E 10	E 10	E 10	E 10	G 9	F 9
75% zinc content	Type of curing	After 1 month	After 2 months	After 4 months	After 8 months	After 20 months	
Potassium silicate with metal	Self-cured	G 9	F 7-6	F 7-6	F 7-6	F 7-6	
Potassium silicate with metal	Chemically cured (2)	E 10	E 10	E 10	E 10	E 10	
Sodium silicate with metal	Self-cured	E 10	E 10	E 10	E 10	G 10	
Sodium silicate with metal	Chemically cured (1)	E 10	E 10	E 10	E 10	G 10	
Sodium silicate with oxide	Chemically cured (3)	G 9	F 7-6	F 7-6	F 7-6	F 7-6	
Sodium silicate with oxide	Chemically cured (4)	F 7-6	F 7-6	F 7-6	F 7-6	F 7-6	
80% zinc content	Type of curing	After 1 month	After 2 months	After 4 months	After 8 months	After 20 months	
Potassium silicate with metal	Self-cured	E 10	E 10	E 10	E 10	G 9	
Potassium silicate with metal	Chemically cured (1)	E 10	E 10	E 10	E 10	E 10	
Sodium silicate with metal	Self-cured	E 10	E 10	E 10	E 10	E 10	
Sodium silicate with oxide	Self-cured	E 10	E 10	E 10	E 10	E 10	
Sodium silicate with metal	Chemically cured (1)	E 10	E 10	E 10	E 10	E 10	
Sodium silicate with oxide	Chemically cured (1)	E 10	E 10	E 10	E 10	E 10	
Sodium silicate with metal + oxide	Chemically cured (1)	E 10	E 10	E 10	E 10	E 10	
Sodium silicate with oxide	Chemically cured (2)	E 10	E 10	E 10	E 10	E 10	
Sodium silicate with oxide	Chemically cured (3)	G 8	F 7-6	F 7-6	F 7-6	F 7-6	
Sodium silicate with oxide	Chemically cured (4)	F 4	F 4	F 4	F 4	F 4	

E = Excellent, G = Good, F = Fair, P = Poor

Ratings are according to ASTM Designation D 610-43 where 10 = no rusting and 4 = maximum rusting (Type 1)



Figure 1. The performance of sodium and potassium silicate based paints and the effect of variation of the pigment content. All paints self-cured.



Figure 2. The efficacy of the three salts used for post-curing (20 months).

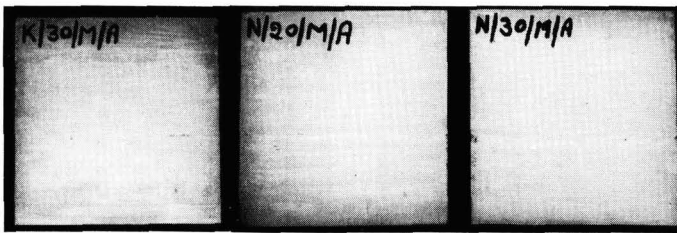


Figure 3. Sodium and potassium silicate based coatings post-cured chemically at two levels of pigmentation.

Table 6
Results of natural weathering of rubber based paints

Zinc content	Plasticiser content	After 2 months	After 4 months	After 6 months	After 12 months	After 24 months
75%	25% Plasticiser A					
	(a) control	E 10	G 9-8	G 9-8	G 9-8	G 9-8
75%	(b) with metal	E 10	G 9-8	G 9-8	G 9-8	G 9-8
75%	(c) with oxide	E 10	G 9-8	G 9-8	G 9-8	G 9-8
	35% Plasticiser A					
75%	(a) control	E 10	E 10	E 10	G 9-8	G 9-8
75%	(b) with metal	E 10	G 9-8	G 9-8	G 9-8	G 9-8
75%	(c) with oxide	E 10	G 9-8	G 9-8	F 7-6	F 7-6
	44% Plasticiser A					
75%	(a) control	E 10	G 9-8	G 9-8	F 7-6	F 7-6
75%	(b) with metal	E 10	P 4	-	-	-
75%	(c) with oxide	E 10	E 10	G 9-8	G 9-8	G 9-8
	25% Plasticiser B					
75%	(a) control	E 10	G 9-8	G 9-8	F 7-6	F 7-6
75%	(b) with metal	E 10	G 9-8	G 9-8	F 7-6	F 7-6
75%	(c) with oxide	E 10	E 10	E 10	G 9-8	F 7-6

E = Excellent, G = Good, F = Fair, P = Poor

Ratings are according to ASTM Designation: D 610-43 where 10 = no rusting, 4 = maximum rusting (Type 1)

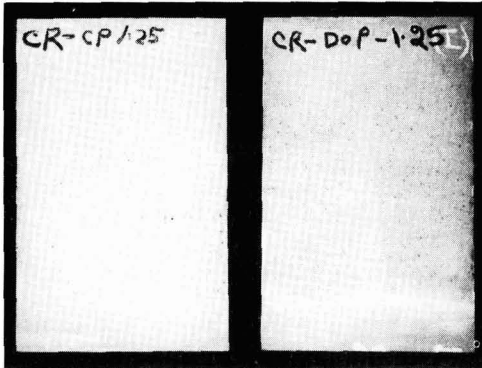


Figure 4. The performance of two plasticisers at the lowest level (24 months).

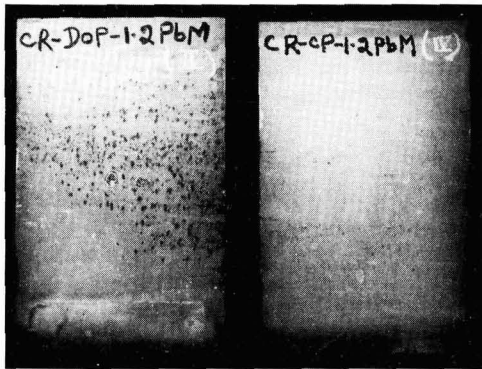


Figure 5. The performance when additional metallic pigment is added to the paint (24 months).

(c) *Rubber based paints*: It is clear from Table 6 that all rubber based paints containing 25 and 35 per cent plasticiser *A* were in good condition at the end of 24 months, but after 6 months some rusting was observed in the rubber based paints containing 44 per cent of plasticiser *A* content. The rubber based paints containing plasticiser *B* showed rusting after 12 months and the extent of rusting remained unchanged at the end of 24 months.

Conclusions

On the basis of the laboratory tests (Tables 1-4) and the limited exposure tests (Table 5 and 6), it can be inferred that the approach followed is on right lines. As far as post-

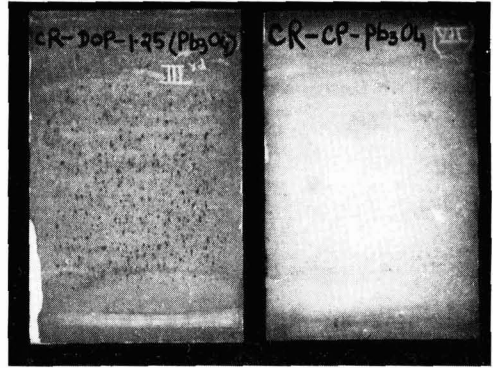


Figure 6. The performance when additional metallic oxide pigment is added to the paint (24 months).

cured types of zinc-rich silicate paints are concerned, the results have been very encouraging.

1. A survey of literature shows that only silicates with high alkali/silica ratios (1:3.2 and 1:3.5) have been employed in the preparation of silicate based paints. The present study clearly shows that silicates with lower alkali/silica ratios could also be employed by using suitable additives in the formulations.

2. With the "self-cured" type of paints, encouraging results have been obtained with sodium silicate binders. Those based on potassium silicate were found not to be so good.

3. Panels cured at elevated temperatures have shown a markedly improved performance, as compared to those self-cured at room temperature.

4. Zinc-rich chlorinated rubber paints with suitable plasticiser (and a suitable level of plasticiser) can be formulated to give good performance, even at 75 per cent zinc content.

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A gas chromatography technique for the analysis of solvent mixtures based on hydrocarbons, esters, ethers etc. used in paints and lacquers

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Summary

The gas chromatographic technique enables the solvents or thinners of paints and lacquers to be analysed by a sample injection method by choosing appropriate working conditions and columns. In this work a sample of thinners, as mainly used in

Iran for the dilution of paints and lacquers, based on nitro-cellulose is investigated. The hydrocarbon constituents of the thinner are studied by a capillary column method. The chromatographic conditions and data are also given.

Keywords

*Raw materials for coatings
solvents
solvent*

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

Une Méthode de chromatographie en phase gazeuse pour l'analyse des solvants mixtes à base des hydrocarbures, esters, éthers, etc utilisés en peintures et en vernis clairs

Résumé

La technique de la chromatographie en phase gazeuse permet l'analyse des solvants et des diluants en peintures et en vernis clairs, au moyen d'une méthode utilisant un procédé de simple injection et des colonnes appropriés sous les conditions opératrices convenables. Au cours de cette étude on a examiné un échantillon du diluant utilisé généralement en Iran pour

allonger les peintures et les vernis clairs à base de cellulose nitrate. Les constituants hydrocarbures du diluant ont été étudiés par une méthode faisant appel à une colonne capillaire. En outre on donne les conditions et les données chromatographiques.

Eine gaschromatografische Technik für die Analyse von auf Kohlenwasserstoffen, Estern, Äthern etc. basierenden Lösungsmittelgemischen, wie in der Lackfabrikation gebräuchlich

Zusammenfassung

Die gaschromatografische Technik ermöglicht Analyse von Lösungsmitteln und Verdünnungsmitteln von Lacken aller Art durch eine einfache Injektionsmethode, vorausgesetzt, dass geeignete Arbeitsbedingungen und Kolonnen angewandt werden. In dieser Arbeit wird ein Muster von Verdünnungs-

mitteln für die hauptsächlich in Iran verwendeten Nitrozelluloselacke untersucht. Die Kohlenwasserstoffbestandteile des Verdünnungsmittels werden mittels einer Kapillarkolonnen-Methode untersucht. Die chromatografischen Bedingungen und Merkmale werden ebenfalls erwähnt.

Introduction

Refs. 1-4

Because of the continuing usage of paints and lacquers based on cellulose ester derivatives (e.g. nitrate, acetate, acetatebutyrate), acrylic esters, vinyl resins, epoxy resins, etc., it is important to study such solvents or thinners to determine the percentages of the components. This type of thinner or solvent is made by mixing aromatic and aliphatic hydrocarbons (as diluents or non-solvents) and esters, ketones and ethers (as solvents)¹.

The difficulty which arose in the old classical methods for identification of the component fractions, was due to fractional distillation² where each fraction is studied separately. Therefore, the classical methods³ were very time consuming and involved much labour. A gas

chromatographic method^{2,4}, allows the separation and identification of the quantities of the fraction components by a sample injection method. The problem which is involved in this method is how to overcome the presence of the mixture of aromatic and aliphatic hydrocarbons, which interferes with the measurement and determination of the other component fractions.

Experimental

Ref. 5

Materials

Sample – a paint or lacquer thinner based on acetate ester, glycol ether and AW 409⁵.

AW 409 – a petroleum fraction solvent with a boiling

range 106-125°C. During distillation, 50 per cent by volume of the solvent was recovered at 109°C, 90 per cent by volume of the solvent at 111°C, odour acceptable, sulfur content 0.05 per cent max., aromatic content 75 per cent vol. min., consisting mainly of toluene; produced by National Iranian Oil Company, Abadan Refinery.

Standard mixture for sample analysis – The chemicals were purchased from Merck, GFR, Darmstadt, pure analytical grade and were added to 0.5 ml toluene in a 3 ml septum vial as follows:

Ethyl acetate (150 μ l), butyl acetate (150 μ l), ethyl glycol ether (200 μ l).

Standard mixture of hydrocarbons for AW 409 analysis – Hydrocarbons were purchased from Merck-Schuchardt, GFR, Darmstadt (Lab. grade) and prepared as follows:

Ethylbenzene (20 μ l), p-xylene (100 μ l), m-xylene (100 μ l), o-xylene (50 μ l), n-propyl benzene (5 μ l), p-ethyl toluene (5 μ l), m-ethyl toluene (5 μ l), o-ethyl toluene (5 μ l), mesitylene (5 μ l), 1,2,4-trimethyl benzene (5 μ l), m-diethyl benzene (5 μ l) and 1,2,3-trimethyl benzene (5 μ l), were injected into a 5 ml septum vial containing 4.5 ml toluene.

Apparatus

A Varian Aerograph model 2800 gas chromatograph equipped with a flame ionisation detector was used.

Operating Conditions

1/8" FFAP column: carrier gas, helium (10 ml/min.); air flow (300 ml/min.); electrometer setting ($10^{-9} \times 64$ A/mv.). A coiled copper column (24 ft \times $\frac{1}{8}$ in) was packed with 15 per cent FFAP on Chromosorb P, AW, 60/80 mesh and stabilised at 250°C with nitrogen flow at a rate of 10 ml/min for 24 hours; column temperature 100°C for 32 min., was then programmed to increase at a rate of 20°C/min. up to 200°C; injector temperature 240°C; detector temperature 245°C; injection volume 0.5 μ l.

Capillary column: carrier gas, helium (1.35 ml/min.); air flow (300 ml/min.); hydrogen flow (25 ml/min.); electrometer setting ($10^{-11} \times 2$, $10^{-12} \times 4$ A/mv.). A stainless steel capillary column (200 ft \times 0.01 in) was packed with poly-m-phenylether (6 ring) and stabilised at 150°C with nitrogen flow at a rate of 1 ml/min. for 48 hours; column temperature 50°C for 15 min., was then programmed to increase at a rate 1°C/min. up to 125°C; injector temperature 240°C; detector temperature 240°C. 0.8 μ l of the sample was injected and split into the ratio (1:50).

Procedure

The chromatogram of a sample (Fig. 1), AW 409 and the standard mixture are obtained separately, using the FFAP column. The chemical components of the sample are identified and determined quantitatively.

AW 409 is also analysed on the capillary column and the related chromatogram is obtained (Fig. 2).

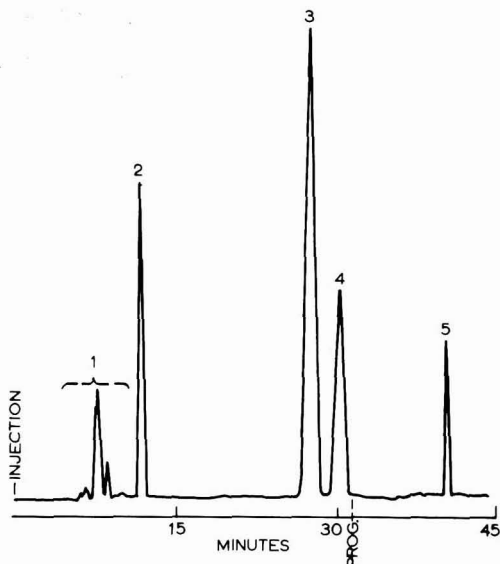


Figure 1. Chromatogram of a sample of thinner analysed on FFAP column.

Results and discussions

Referring to Fig. 1, it can be concluded that AW 409 is divided in two groups of peaks in the chromatogram (e.g. aliphatic and toluene groups, peak numbers 1 and 3 respectively) and there is no appreciable interference with other constituents of the thinner sample (e.g. peak nos. 2,4,5). Therefore, FFAP column is suitable for fast and accurate analysis of the nitrocellulose lacquer thinner. The results obtained from measurements of a sample using the standard mixture as reference are given in Table 1.

AW 409 was also studied on the capillary column (Fig. 2) and the results for the aromatics are summarised in Table 1. From these data it can be concluded that about 76.1 per cent of the solvent is toluene and the total amount of the other aromatic hydrocarbons (except benzene) is less than 0.25 per cent. The aliphatic hydrocarbons (group of peaks before toluene peak) were not investigated and the amount of benzene was not determined, due to the interference by the aliphatic hydrocarbons peaks.

[Received 13 July 1979]

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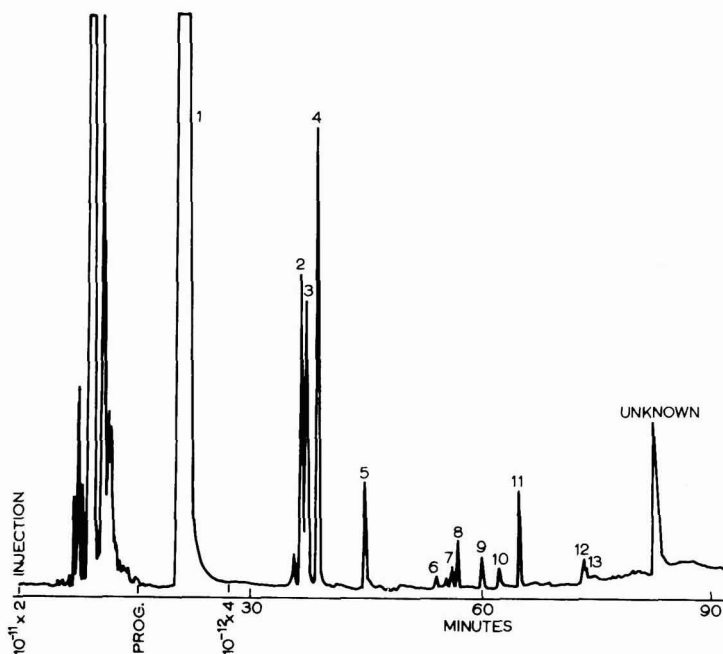


Figure 2. Chromatogram of a sample of AW 409 analysed on a capillary column.

Table 1
Chemical composition

Sample of nitrocellulose lacquer thinner analysed on FFAP column			Sample of AW 409 analysed on capillary column		
Chemical Name	Percentage	Peak No.	Chemical Name	Percentage	Peak No.
Aliphatic Section (AW 409)	10.0	1	Toluene	76.1	1
Ethyl acetate	25.5	2	Ethylbenzene	0.051	2
Toluene Section (AW 409)	32.0	3	p-Xylene	0.045	3
Butyl acetate	24.5	4	m-Xylene	0.075	4
Ethyl glycol ether	8.0	5	o-Xylene	0.018	5
			n-Propylbenzene	0.002	6
			p-Ethyltoluene	0.004	7
			m-Ethyltoluene	0.007	8
			Mesitylene	0.005	9
			o-Ethyltoluene	0.003	10
			1,2,4-Trimethyl-benzene	0.014	11
			m-Diethylbenzene	0.003	12
			1,2,3-Trimethyl-benzene	0.001	13

Next month's issue

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

OCCA Monograph No. 1 – Marine finishes. Part II by *T. A. Banfield*

Evaporation and water-dilutable coatings by *L. O. Kornum*

The relationship between glass transition and melting temperatures of natural resins by *D. N. Goswami*



**OCCA
meetings**

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 Section concerned or may be forwarded to the lecturer.

Hull

Instrumental control in the paint industry

The second ordinary meeting of the Hull Section was held on 5 November 1979, at the George Hotel, Land of Green Ginger, Hull. The guest speaker was Miss S. Williams, a Director of Instrumental Colour Systems, who spoke on "Instrumental control in the paint industry".

Miss Williams introduced her talk by describing the stages in the manufacture of paint where a colour measurement could be made, demonstrating, with examples, the types of colour measuring instruments that are available.

This was followed by a comprehensive presentation of colour measurement, covering the basic theory of colour, the types of colour measuring instruments that are available, and the colour difference formulae that can be used in the calculation of a single unit tolerance figure to express the colour difference.

Miss Williams stated that the talk was based upon the lectures given by her Company during training sessions, and it was clear that great care had been taken to select the appropriate material to illustrate each point made in the lecture.

Mr H. Lythgoe proposed the vote of thanks after a lively question period, on behalf of the 20 members and guests who were present.

Reader Enquiry Service No. 21

F.D.R.

Auckland

Marine anticorrosive systems

Thirty-two members of the Auckland Section heard a lecture by Mr G. Apperley, Construction Manager of HMNZ Dockyard, at a meeting held on 29 November 1979 at the Auckland Leagues Club. A film issued by the Electrolytic Zinc Company of Australia Limited demonstrated the very large usage of galvanised steel and zinc rich

primer in the construction of the MV Zincmaster, which is now in service for the company, carrying zinc ore and zinc metal from and to Tasmania and the mainland of Australia.

Mr Apperley then spoke about the preparation and priming of steelwork on HMNZ ships which total four frigates, a hydrographic ship, an oceanographic ship, four patrol boats, a diving tender, a tug, and fifty small boats. Over 1000 people are employed at the dockyard, including 25 painters.

The frigates are given a refit every three years, with a long refit (of a year or more) every nine. These vessels are quite lightly built compared with merchant ships and corrosion was, at one time, very severe, particularly at the water line. High duty coatings have reduced this, but it is essential to ensure good surface preparation. An impressed current anticorrosive system is also fitted. Coal tar pitch-epoxy resin paints give a five to six year life and where plates had previously to be replaced regularly, they have not needed replacement for the last ten years.

Internal corrosion where bilge water is retained is still a problem and plates are still regularly replaced. In such areas it is not practicable to use grit blasting because of the dust which would affect other components.

Sand blasting has been carried out for several years, but recently a change to a 3 mm blue metal chip was made, as this creates much less dust and is very efficient. High pressure water blasting at 8000 lb/sq in is now carried out and this effectively cleans the surface to a high standard.

Zinc/silicate is the commonly used primer, and zinc metal spraying is also carried out. Many questions were answered by Mr Apperley, before the meeting was drawn to a close by the Chairman, Mr R. White, and a vote of thanks to the speaker was proposed by Mr A. Macdonald.

Reader Enquiry Service No. 22

A.M.

Thames Valley

Visit to Brent Chemical Co. (Pyrene)

The first technical meeting of the 1979-80 session took the form of a works visit to the Brent Chemical Co. on 11 October 1979 at 6.30 p.m.

The management very kindly arranged to keep certain sections of the plant running and many members of the

technical staff remained after hours to conduct the visitors on what proved to be a most entertaining and informative tour.

The party was welcomed in the comfortable cine theatre by Mr Brian Freeman, Technical Director, who introduced a film as the first item on the programme.

The film covered the principles and applications of phosphate coatings as pre-treatments for subsequent painting systems and also showed applications for lubrication of the work in sheet metal pressing and wire drawing, and as insulation coatings for transformer laminations.

The visitors were then split into two parties and conducted around the works and laboratories.

A highlight of the tour was the Gold Seal Panel Plant, which is a complete production unit for converting coiled strip from the mill by blanking, polishing, degreasing and phosphating into the familiar standard substrate which the paint industry now relies upon for its testing purposes.

At the conclusion of the visit the party was entertained to a beer and sandwich supper which was much appreciated by all.

The Chairman, Gil Hill, spoke a few words of thanks to the management and to Messrs Ron Ashdown, Bob Lilley and Chris Saunders and their staff who had so kindly given their time to make a successful evening for their OCCA visitors.

Reader Enquiry Service No. 23

A.W.F.

West Riding

Quality assurance of batch liquid products

A meeting of the West Riding Section, was held on Tuesday 4 December, at the Mansion Hotel, Leeds.

The speaker, Mr D. J. Murray of the Hay Management Consultants, gave a talk entitled, "Quality assurance of batch liquid products with particular reference to paints".

Mr Murray defined quality as being the totality of the features and characteristics of a product that bear on its ability to satisfy a given need. Quality control was said to be the machinery in operation throughout an organisation, for the maintenance and improvement of quality.

It was suggested, that throughout British industries, some £10,000 million were lost annually due to inadequate quality assurance.

Mr Murray went on to discuss quality determinants. These were divided into areas of designing and product manufacture. Designing involved product, plant and process design. During product manufacture, quality determinants ensured that the product met the users' requirements.

The quality assurance factors which influenced product, process and plant design were highlighted.

Mr Murray emphasised the importance of a well organised quality control scheme for testing raw materials. Such a scheme should include standard testing methods,



sampling procedures, and adequate communication of results to the appropriate people.

Mr Murray finished with the point that for quality assurance to be effective, it must have the commitment of management. One idea suggested was for the company's chief executive to sign a quality assurance policy.

The vote of thanks was given by Mr D. V. Maltman on behalf of the 28 members and guests who were present.

Reader Enquiry Service No. 24

D.V.M.

Manchester

Weatherability of surface coatings

Thirty-two members and visitors were present at the New Administration Building, Manchester Polytechnic, All Saints, on 21 November 1979, to hear Mr E. Oakley of BTP Tioxide Ltd deliver a student lecture entitled "Weatherability of surface coatings".

Many OCCA Members will have previously met Ernie Oakley, who is based at the Carlton Weathering Station, Teesside, and also lives on the site! This background information, coupled with his length of service at BTP was an accurate indicator of the in-depth knowledge that he was to contribute to the lecture.

The basic aims at Carlton were expressed thus:

- (1) Performance of pigments in various binders, e.g. paints and plastics.
- (2) The quality control of pigments – improvements.
- (3) Pigments development work.
- (4) Finished paints – BTP and customers.

The various temperate climates used were described as UK, North America and Central and Northern Europe. The Carlton Site used 32 exposure racks 100 ft long and incorporated both 45° south facing aspect and vertical fences with North and South Exposure facilities. The 45° angle gave an increase in relation to incident light and moisture retention, both important factors in the potential embrittlement and photochemical degradation of surface coatings.

The various substrates used included bonderised steel, asbestos cement, concrete and wood. Regular examinations of exposed panels were performed in relation to gloss, chalking and film defects that include cracking, checking, flaking etc.

The role of Carlton as an Official Meteorological Station was described fully; the data collected included rainfall, sunlight, temperature, relative humidity and "wetness" – a measure of the degree of surface moisture in

occa meetings

relation to time, which has been found to have greater degradation effects than direct rainfall.

Mr Oakley then discussed methods used to accelerate the natural weathering processes, including overseas exposure sites with particular emphasis on the facilities available at Phoenix, Arizona, USA. This site enjoys an available 11 hours per day sunshine average, it is classified as sub-tropical desert climate and the natural conditions are accelerated by the use of mirrors, water sprays, air cooling and automatic panel orientation.

The final subject discussed was the controversial one of accelerated weathering. BTP use several types of apparatus including the well established Marr Weatherometer, modified to operate with two 1000 W carbon arc lamps. Other types discussed were the Atlas Dew Point and Xenon arc machines. The established cautionary approach in the interpretation of results obtained from accelerated weathering exposure was emphasised.

Included in the colour slides shown by the lecturer were the visual results of four years natural weathering of various white masonry paints applied by BTP to adjoining cottages in a Teesside village.

The meeting was concluded by the answering of several questions from the audience which included the method of storing control panels, air pollution levels on Teesside and the relative merits of sand incorporation into masonry paints.

Mr G. T. Flood proposed the vote of thanks which was enthusiastically received, as was the distribution of an excellent BTP publication entitled "Measuring Durability".

In similar vein, BTP are to be congratulated in not only providing the obvious technical service facilities in relation to weathering for their customers, but in addition the Carlton Weathering Station and its associated test programmes are quoted by many persons in the Surface Coating Industry as an example of a dedicated approach to the complex subject of "The weatherability of surface coatings".

Reader Enquiry Service No. 25

Natal

The uses of methylcellulose in surface coating formulations

A meeting of Natal Section was held on Monday 29 October 1979 at the University of Natal, Durban, when 36 members and guests were present to hear a lecture by Dr H. Ludwig of Hoechst AG, Frankfurt on "The uses of methylcellulose in surface coating formulations".

Dr Ludwig described the chemistry of cellulose ethers in considerable detail, describing how cellulose via acyl cellulose can be reacted with methyl chloride to give

methyl cellulose; with methyl chloride and ethylene oxide to give MHEC; with ethylene oxide to give hydroxyethyl cellulose; and with sodium chloroacetate or chloroacetic acid to give carboxymethyl cellulose.

The uses of these in building paints were discussed, together with the advantages conferred on various types of water based paint. Low percentage additions are usually needed, and they give an exact viscosity combined with stabilisation of consistency. They improve water retention, and bind distempers, improving adhesion, giving non-drip properties and low sedimentation. They improve the structure, giving high viscosity on standing and low viscosity during brushing. Water-retention is needed to improve brushing on partly porous substrates, and Dr Ludwig described the Venema water retention meter, used to measure retention during the first 30 seconds after application.

A broad comparison between four types of water based paint was made, i.e. distemper, high-scrub distemper, interior PVAc, and exterior PVAc, with the cellulose content falling from 3 per cent to 0.35 per cent over the four types.

Comparisons were also made between the three main cellulose ethers, MC, HEC and CMC, in respect of effect on flow and splashing during rolling (MC best), and biodegradability (also MC best). Solubility is dependent on temperature, that of MC becoming lower at higher temperatures, to the point of precipitation at high temperature. Highly substituted ethers are more resistant to biodegradation, and this property is less affected by an increased concentration of medium viscosity cellulose than by a low concentration of high viscosity cellulose.

Reader Enquiry Service No. 26

Water reducible industrial coatings

A joint meeting of the Natal Section with the SACI was held at the University of Natal, Durban, on Tuesday 6 November 1979 when 48 members and guests were present to hear a lecture entitled "Water reducible industrial coatings based on isophthalic acid and trimellitic anhydride" presented by Dr A. F. Allavena of Amoco Chemicals Europe.

Dr Allavena related the historical development of TMA and IPA based water soluble coatings, which were first made some 20 years ago. Initially air-drying water-soluble coatings were a curiosity, with no obvious practical advantages, due to the relatively high polymer cost. However, interest has grown rapidly in recent years, since the time of the 1973 oil crisis, to the current situation where solvent thinned industrial coatings for virtually any end use, from primers to finishes, can be matched both economically and in performance by water thinned products, commonly based on Amoco trimellitic anhydride and isophthalic acid.

Dr Allavena stressed with the aid of a large number of tables and graphs how all the properties of solvent thinned paints such as viscosity, drying time, cure time, hardness, flexibility, etc. could be matched or improved by water thinned products.

To conclude his lecture, he showed a series of slides of typical articles ranging from agricultural machinery to domestic appliances which had been finished in water thinned TMA/IPA systems.

The vote of thanks was proposed by Mr R. A. Eglinton.

Reader Enquiry Service No. 27

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.

news

Sachtleben expansion

Sachtleben have recently opened a northern sales office in Whitefield, Manchester, as part of an expansion of their coverage to the UK surface coatings industries. Sachtleben products include Hombitan Titanium Dioxide, Lithopone, Blanc Fixe and Barytes which are extensively used in the paint, paper, printing ink, plastics and rubber industries.

Reader Enquiry Service No. 31

Matting agents

W. R. Grace Limited has announced that sales of *Syloid* to the coatings industry will be made directly in the UK and Ireland by Grace's own UK based sales and sales support personnel.

Syloid, a range of synthetic amorphous silicas, has been used world-wide as a high efficiency matting agent for more than twenty years and it has been decided that the Grace UK sales, warehousing and distribution facilities should be placed directly at the disposal of customers in the coatings industry

Reader Enquiry Service No. 32

ICI nitrocellulose plant

ICI is to spend £3 million on new solvent-damping facilities for the industrial nitrocellulose plant of Organics Division at Stevenston, Ayrshire. The new facilities will replace old units for solvent-damping at Stevenston and Stowmarket, and are due to be completed in 1981.

Reader Enquiry Service No. 33

Nomenclature panel

The Chemical Society has recently announced the formation of a joint Royal Society-Chemical Society Nomenclature Panel for chemicals. The terms of reference of the Panel are to consider proposals including all those from IUPAC, for chemical nomenclature and associated terminology and conventions including their implications in general and in the United Kingdom in particular; to consider the application of the International Union of Pure and Applied Chemistry (IUPAC) recommendations in the UK, including problems arising from different interpretations of such recommendations.

Reader Enquiry Service No. 34

Energy savings

The Marchon Works of Albright and Wilson at Whitehaven will soon be saving energy equivalent to two million gallons of oil a year using a new combined heat and power scheme.

About 100 tons of steam an hour are

generated on-site, mostly as a by-product of burning sulphur. The sulphur burners operate at 250 psi. In the new system, about half the steam will be passed through a turbine to reduce its pressure to 40 psi. This new low pressure system will provide enough steam for many process plants including the £20 million phosphoric acid purification and concentration plants commissioned recently.

About one and a half miles of distribution pipework is being installed. When the system is operating at full capacity and the pressure in the network has been optimised, the company hopes to be able to boost output to 5MW an hour, saving about 40,000 MW a year.

Reader Enquiry Service No. 35

Change of name

Keegan Brico Tetley Chemicals Limited have recently changed their name and will be trading as Durham Chemicals Distributors Limited.

Reader Enquiry Service No. 36

Interox UK expansion

Europe's only caprolactone plant, built at Warrington by Interox Chemicals Limited (jointly owned by Laporte Industries and Solvay et Cie) is to be expanded to meet the growing worldwide demand for caprolactone and polycaprolactones.

By the end of 1980, the expansion will almost double the present production capacity for all products of 5000 tonnes per annum.

Polycaprolactones are now widely used in high-performance polyurethane elastomers where their stability, consistent quality and flexibility, even at low temperatures, are important.

Reader Enquiry Service No. 37

Solvents distribution

Tennants Consolidated Limited have been appointed by Hythe Chemicals Limited to supply their range of glycol ether and glycol ether ester solvents.

Reader Enquiry Service No. 38

new products

Fraction collector

Baird and Tatlock Limited are now able to supply the Buchler Fraction Collector 'Alpha 200' which is designed with safety and reliability in mind.

Fraction collection is usually the last stage of a long process before analysis begins and prevention of loss of elute

through any error in the system is desirable. Should an overflow occur, a liquid detection fuse will shut down the collector and any ancillary equipment connected to the outlet on the back of the unit. A mechanical jam also shuts off power.

The passage of elute from the column to the collecting tube proceeds through the Drop Stop Safety Solenoid which prevents loss of sample during rack movements or power shutdown.

Reader Enquiry Service No. 39

New pigments and extender

Sachtleben has introduced two new zinc sulphide pigments, Lithopone DS and Sachtolith HDS, and a superior extender, Blanc Fixe. These products have been developed to give smaller particle sizes and even better properties of dispersibility and ease of wetting.

A special high-energy grinding process (micronisation) has been used in the manufacture of these new products and any remaining sediment is now extracted by a special screening process to refine the products.

The two new Lithopone grades are Lithopone DS Red Seal, which contains 30 per cent zinc sulphide and Silver Seal which contains 60 per cent zinc sulphide.

Reader Enquiry Service No. 40

Self-adhesive banded tapes

A new range of colour printed self-adhesive tapes for pipeline and services identification has been introduced by Vi-Seal Tapes Limited.

The new tapes are protected by a polypropylene laminant which gives improved colour clarity in adverse conditions. Bands in recommended safety colours conforming to the new British Standard Specification No. 4800 in respect to main services, together with secondary service identification in accordance with BS.1710 (Identification of Pipelines) are produced as stock items.

Reader Enquiry Service No. 41

High-purity elastomeric granules

High-purity, custom-made, elastomeric compounds for critical industrial applications are now produced in a new plant set up by the Swiss Dolder AG company of Basle. This type of granule, based on Du Pont's specialised elastomers such as "Hypalon" synthetic rubber or "Nordel"

news

hydrocarbon rubber, is principally used in the electrical and packaging industries, and also has application in the production of packaging film, where polyolefin modification with "Nordel" gives improved weld-strength, tear-resistance etc., and in concentrate thermoplastic masterbatches (colour, UV, flame retardant slip and/or "antiblock").

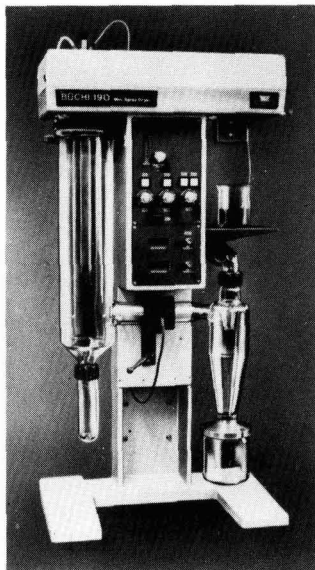
The new plant, which is entirely automated, enables Dolder AG to supply granules of any size and weight with a precision lower than 0.5 per cent and a degree of purity close to 99 per cent.

Reader Enquiry Service No. 42

Mini spray dryer

New bench-top equipment for spray drying solutions, emulsions and dispersions has been introduced in the UK by Orme Scientific of Manchester. The new bench-top machine called Buchi 190 Mini Spray Dryer enables small samples of substance to be spray dried on an experimental scale. The majority of components are glass, allowing the process to be visually monitored during the cycle. Digital displays of inlet and outlet temperatures and input connections for a pen recorder facilitate accurate control and allow a permanent record to be kept.

Reader Enquiry Service No. 43



The new bench top Mini spray dryer from Orme Scientific



Permoglaze Thermarend being applied to a wall by a normal plastering technique

Insulating render system

Blundell-Permoglaze Building Chemicals Division has launched an insulating render system which, it claims, can reduce heat loss from solid wall buildings by at least 20 per cent. The new product, Permoglaze Thermarend, is applied to the exterior of buildings using normal plastering techniques. It consists of expanded polystyrene beads in a cementitious matrix. Built-in permeability allows water vapour to escape from the render allowing the structure to "breathe". At the same time, the material together with its decorative coating, Renovo Scratch Plaster, resists the entry of moisture.

Reader Enquiry Service No. 44

Standard ion solutions

The Stan-ioN range, comprising ready-for-use standard solutions of anions and cations is now available from Hopkin & Williams, for use in trace analysis.

The Stan-ioN range of cations largely replaces the present range of standard solutions of metals for atomic absorption spectrophotometry and other trace analytical techniques. Both the solutions of cations and anions are supplied at a concentration of 1000 ppm of the ion in question. The strength of each solution is guaranteed to be within ± 0.5 per cent of the nominal value.

Reader Enquiry Service No. 45

"Intrinsically safe" thermometer

Thermographics Measurements Limited have introduced a hand held portable digital thermometer with a West German "intrinsically safe" certificate, the Model 9600. The instrument allows measurements to be made in explosive atmospheres containing combustion or explosion classes 1 and 2 in zone G1 to G5.

Reader Enquiry Service No. 46

Solvent recovery equipment

Newgate Simms Limited have introduced a new series of batch machines into their range of Solvent Recovery equipment, the SC50, SC100 and SC200. The machines are simple and safe to operate and have distillation capacities up to 20, 30, and 60 litres an hour respectively, dependent upon the type of solvent and the degree of contamination.

The machines consist of a double wall tank, capable of holding 50, 100 and 200 litres of dirty solvent, which is evaporated by electrically heated transfer oil. A float switch warns of any loss of heat-transfer fluid. The distillate is formed in a water cooled condenser and a low water safety valve constantly monitors the flow of water for cooling. After the distillation process is complete the system is automatically switched off by the safety thermostat.

Reader Enquiry Service No. 47



The Model 9600 "Intrinsically safe" digital thermometer

High solids pigment dispersions

CIL-Gould Limited has launched a new range of twelve water-based high solids pigment dispersions developed for the paper coating industry, but also useful in the manufacture of decorative paints and water-based printing inks. These dispersions, designated Cilsperse HSD Pastes are produced using non-ionic and anionic wetting agents and will withstand the high processing temperatures encountered in the paper coating process.

Reader Enquiry Service No. 48

literature

General catalogue

The latest edition of the Perkin-Elmer General Catalogue "Analytical Instruments" is now available. This annual publication covers the wide range of analytical instruments produced by Perkin-Elmer, giving brief details of the specifications and applications of each.

Perkin-Elmer have also available a new book entitled "Differential Scanning Calorimetry" by J. L. McNaughton and C. T. Mortimer. This book details the operation of the differential scanning calorimetry thermal analysis instrument and explores many applications including specific heats, purity determinations, phase diagrams and heats of chemical reactions etc.

Reader Enquiry Service No. 49

CHAL brochure

The Wellman Engineering Corporation Limited has just published a new leaflet covering CHAL complete drum finishing plants available from Wellman Incandescent. The leaflet shows examples of continuous ovens, coolers, booths and

application equipment, together with mechanical handling systems including automatic transfer lines.

The brochure also includes the latest addition to the CHAL range, namely the Blu-Surf Dynamic Flow high velocity ovens.

Reader Enquiry Service No. 50

meetings, etc.

Environmental quality

Harwell Laboratory is organising a seminar entitled "Environmental Quality - The Industrial Dimension" to be held on 4 and 5 June 1980 at the Lorch Foundation, High Wycombe. The seminar is intended to bring together interested parties to examine the impact that industry has on the environment.

Reader Enquiry Service No. 51

Protecting steel

Derby Lonsdale College of Higher Education has announced that it will organise a symposium concerned with the protection of structural steelwork against corrosion. The symposium will be held at the college on 1 April 1980 and is entitled "Protecting steel in a big way".

Reader Enquiry Service No. 52

appointments

Mr W. Bass Watkins has been named to succeed Mr R. W. Grimble as chairman of Du Pont de Nemours International S.A. in Geneva. Mr Watkins will be responsible for Du Pont's activities in Europe, Africa and the Middle East. Mr

news

Grimble retires from the company after more than 33 years' service.

Mr Charles N. Taylor, Marketing Director of Tioxide Group Limited since 1969, has been made Managing Director (Operations) of the company.

Mr Peter A. Duncan has been appointed as Marketing Manager - Paper by Engelhard's Minerals & Chemicals Division. In his new position, Mr Duncan will continue development of long-term strategies for the worldwide marketing of the Division's products for the paper industry.



Peter A. Duncan

Further information on any items below may be obtained by circling the appropriate Reader Enquiry Service number on the form at the back of the Journal.

OCCA Conference 1981 - Call for Papers

The Association's Technical Committee has now drawn up preliminary plans for the Association's Biennial Conference which will take place in June 1981. Details of the venue chosen will be published in due course but, in the meantime, the following information is published for the benefit of authors wishing to submit summaries of a proposed paper for consideration by the Technical Committee.

"Alternative Technologies in Coating"

The future holds both opportunity and challenge for alternative technologies and topics covered by the conference should include, EEC regulations covering

introduction of new chemicals, alternative means of obtaining opacity, impact of micro processors and computers on processing and application methods, high solids coatings, aqueous systems, radiation curing and powder coatings.

A departure from the usual conference format will be the inclusion of a 'Discourse' session with the sub-title "Alternatives to Coatings" where the use of techniques such as cathodic protection and substitution of coated items by plastics could be discussed.

Offers of papers with a short summary of 200 words are now invited for con-

OCCA news

sideration. These should be sent to the Director and Secretary of the Association at the address on the Contents page.

Annual General Meeting

The Eighteenth Annual General Meeting of the Incorporated Association is to be held in London on 26 June 1980 at the Piccadilly Hotel, London W1, following a Luncheon and Lecture. The Speaker will be Professor, Sir Herman Bondi, KCB, FRS, Chief Scientist of the Department of Energy.

OCCA news

OCCA-32 Exhibition

13-15 May 1980

Cunard International Hotel
Hammersmith, London W6



The international focal point

Allocation of Space

The first allocation of space for the OCCA 32 Exhibition took place in December and a list of exhibitors was published in the January 1980 issue of the *Journal*.

The list of companies participating at the Exhibition included several organisations returning to the exhibition after an absence of several years as well as more regular exhibitors and those completely new to the Exhibition.

Since the list was published in the January issue, several other companies have booked space and are listed below (marked with asterisks) together with the names of organisations whose products will be shown on the stands of other exhibitors.

Amalgamated Oxides (1939) Ltd
American Gilsonite Co.
BTR Ltd
Billington/Shell Group of Companies
Bradhurst Ltd
Daltrade Ltd
Deanshanger Oxide Works Ltd
*Dow Chemicals

*Elcometer Instruments Ltd
Haake
Honeywell & Stein Ltd
Industrial Newspapers Ltd
Interox Chemicals Ltd
*Jenag Equipment Ltd
Joyce-Loebl Ltd
*Kirklees Chemicals Ltd
Kronos Titanium Pigments Ltd
Mebon Ltd
Mettler Instruments
*Microfine
Micromeritics Corp.
Neville-Cindu Chemie
*Paint Manufacture
*Roban Engineering Ltd
S.A. Des Talc de Luzenac
*Sartorius Instruments
Solvay & Cie
*Swada Ltd
Talkumwerke Naintsch
Tokheim
Urachem International
Unilever Group
*Vickers Instruments Ltd
Wheatland Journals Ltd

Organisations intending to participate at the Exhibition who have not yet submitted their applications are reminded that space at the Cunard International

Hotel is strictly limited. Applications received will now be allocated any space remaining around those stands already allocated on a strictly first-come, first-served basis. Details of the space remaining may be obtained by contacting the Director and Secretary at the address on the Contents page.

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 50 countries, who travel to London each year to view the latest developments affecting the industry and to contact leading companies for their needs.

Theme for the Exhibition

Motif: The motif, designed by Robert Hamblin, uses the compass to symbolize the unique attraction of the OCCA exhibitions which annually draw exhibitors and visitors from numerous countries.

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.

Dates and times

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

Tuesday 13 May 1980..... 09.30 to 17.30
Wednesday 14 May 1980 . 09.30 to 17.30
Thursday 15 May 1980..... 09.30 to 17.30

The Cunard International Hotel

The new venue for the 1980 Exhibition will be the Cunard International Hotel, Hammersmith, London W6, and the main part of the Exhibition will be in two sections: on



The Cunard International Hotel



A view of part of the New Exhibition Hall at the Cunard

the ground floor, forming the entrance to the Exhibition, traditional style stands will be accommodated in the New Exhibition Hall where exhibitors of heavy machinery, plant and equipment will be located; on the first floor of the hotel, in the Queen Mary Suite, the stands will be of a simplified nature with the objective of allowing exhibitors to use modular display systems. These stands will have no platform, being erected directly on to the carpeted Suite floor, and so it will not be possible for heavy equipment to be displayed in this section.

Access between these two areas will be through the intermediate Mezzanine floor, where there are a number of rooms in the Armada Suite for companies to display free standing exhibits together with an Exhibitors' lounge.

In addition there will be several suites and syndicate rooms on the third floor of the hotel, either for companies who wish to use this type of facility to exhibit, or for those who wish to have somewhere convenient to entertain their visitors in addition to their main stands elsewhere in the Exhibition. Already, several organisations have taken advantage of this opportunity to have a main stand for general enquiries, and the more private room for detailed discussions.

Travel arrangements

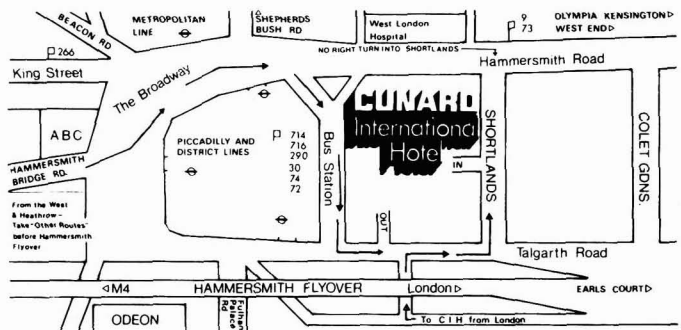
The Exhibition Committee has decided to move the venue of the 1980 Exhibition to the Cunard International Hotel, as it is felt that the more central site and greater range of types of exhibiting facilities it offers will be welcomed both by exhibitors and visitors to the Exhibition.

The Hotel has a selection of restaurants, shopping facilities and bars. There is a coffee shop close to the Queen Mary

Suite (which itself contains a bar), an Exhibitors' Lounge on the Mezzanine floor, and there are plans for a coffee bar to be erected in the New Exhibition Hall for the Exhibition.

The Hotel is situated near Hammersmith Station on the Piccadilly Underground Line between Heathrow Airport and the centre of London. Visitors from overseas may board the Piccadilly Line in the Airport complex, which will take them direct to Hammersmith Station or to central London where they may be staying. 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). The Hotel is adjacent to the Hammersmith flyover on the M4 Motorway which links Heathrow Airport by road. 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 from the Association with copies of the



OCCA news

Official Guide in advance. 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.

"Anyone visiting this exhibition (*OCCA 31*) could not have failed to be impressed by the spacious and comfortable layout and the ease with which one could identify individual stands. For those whose range of interests includes all of the varied displays, to be able to see at a glance individual stands and the personnel available for discussion and yet at the same time, while promenading, enjoy the many re-unions is recognised as another of the unique characteristics of this annual event. The atmosphere in this exhibition has never been bettered... the deserved claim to be the international forum for the surface coatings industries."

"The exhibition was well attended and seemed to need all of the vast space..."
The British Ink Maker, May 1979

Official Guide

It is intended, as in previous years, to publish the *Official Guide* to the Exhibition several weeks in advance so that it may be sent to visitors to enable them to plan the itinerary for their visits. The *Official Guide* will contain descriptions of all the exhibits together with much other useful information for visitors, such as maps of the exhibition areas, details of facilities, travel information and an analysis of the exhibits.

Many thousand copies of the *Official Guide* will be printed and distributed on a world-wide basis. Advertising space will be available in this publication, and details of availability, rates, special positions etc., may be obtained from the Assistant Editor at the address on the Contents page.

OCCA news

Stand 220

Ciba-Geigy Plastics and Additives Co

The Plastics Division of Ciba-Geigy are featuring their latest developments for surface coatings to meet the increasing demand for energy efficient and low pollution technologies. These include:

Powder Coatings

A range of epoxy resins, hardeners and polyester products is now available to satisfy the most sophisticated needs. This follows a comprehensive development programme which has led to an understanding of the powder formulator's problem.

Aqueous Powder Suspensions

A new concept in pollution free coatings. Versatile application techniques are coupled with excellent final properties.

White Interior Can Lining

A video presentation demonstrates this new development.

Solvent Free Coatings

A new low-hazard hardener is shown for cold cure, which will give colour-stable, blush-free coatings.

Discussion on recent developments with water based and UV curable industrial coatings will also be welcomed.

Stand 216 and Room 3119/21

NL Chemicals Europe, Inc.

United Kingdom:

Kronos Titanium Pigments Ltd

NL Chemicals produce *Titanox* and *Kronos* TiO₂ pigments, *Bentone* gellants and a wide range of other speciality chemicals. Backed by pigments plants in Belgium, France, Germany and Norway, *Bentone* and other additive manufacturing units in Germany, UK and the USA and a worldwide sales and technical service organisation, NL Chemicals is a major supplier to the coatings and many other industries.

NL Chemicals' exhibit will feature:

News of Exhibitors at OCCA-32

- *Several high quality *Kronos* TiO₂ pigments
- *New rheological additives offering significant performance advantages
- *The latest information on *Nalzin SC 1* anticorrosive pigment.

Among the products manufactured in NL Chemicals' new major chloride TiO₂ pigment plant are the coatings grades, *Kronos CL 300*, *Kronos CL 310*, and *Kronos 2160*, whose outstanding hiding power, tone, brightness, durability and dispersibility will be displayed.

Kronos CL 220, another chloride grade, is strongly established in powder coatings, where its ease of incorporation, contribution to flow and levelling and excellent optical properties are highly valued.

Other important titanium pigments displayed include *Kronos RN 59*, *Kronos RN 43* and *Kronos 2190*, whose properties are particularly suited to applications requiring maximum hiding power in emulsion paints and maximum gloss development in water-thinned systems.

Polytrope 1131 is a new NL Chemicals rheological additive for unsaturated polyester resins, offering several important advantages over traditional materials. *Bentone 128*, the latest addition to the NL Chemicals range of *Bentone* gellants, has been specially designed for ease of incorporation and effectiveness in printing inks.

Rheolate 1, a new rheological additive for acrylics and styrene-acrylic emulsion paints, and *Nalzin SC 1*, NL Chemicals' chromate- and lead-free anticorrosive pigment, have now been extensively tested in European formulations and latest test results will be available.

Stand 210

Macbeth Division of Kollmorgen (UK) Ltd

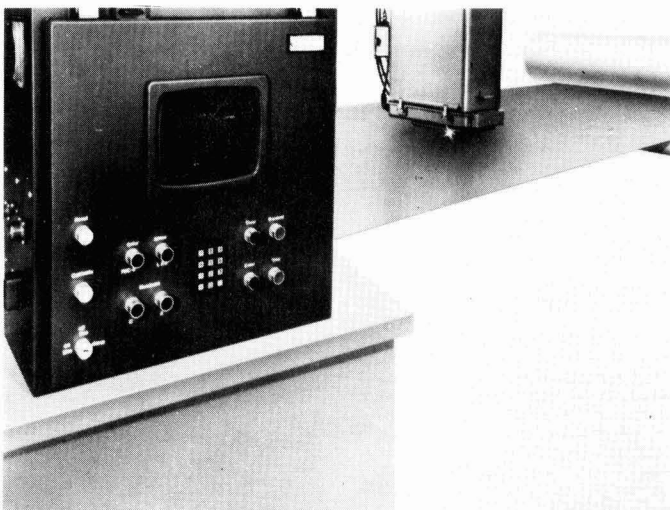
Macbeth, in following a policy of continuous development of systems for appearance control, are introducing several new concepts.

A computerised on-line colour monitor for continuous checking of colour on coil and web-fed machines will be demonstrated. The *MS4045 Colour Measuring System* displays deviations from previously set quality standards and permits operators to make on the run adjustments without the delays of current off-line quality inspection techniques.

Using technology developed for the successful off-line instruments introduced at OCCA-29, the *MS4045* utilises a pulsed xenon flashtube for illumination and a grating spectrophotometer. These techniques make possible instantaneous, non-contact measurement of moving samples. Stability of the spectrophotometer ensures consistent measurements in time and from one instrument to another.

The environmental conditions in production require practical instrumentation to be unaffected by temperature, humidity, polluted atmospheres, and equipment vibrations. The incorporation of cooling, sealing, and mechanical strength, has provided a design for continuous operation under production conditions.

The *MS2000* spectrophotometer and *MC1010* colorimeter are simple to use and provide fast accurate answers in



Macbeth's MS4045 on-line colour measurement system



A view of part of the Queen Mary Suite at the Cunard International Hotel

operator understandable language. They utilise a common spectrophotometric measuring head with individual consoles. Additional units have been introduced to expand the capacity of a modular system.

The 45/0° measuring head is particularly suited to paint and plastics applications and can be incorporated in both spectrophotometers and colorimeters. Additional consoles offer increased speed together with the flexibility to meet customer programming requirements. All systems are equipped with video display and the facility to interface with printers, plotters and computers, the latter to provide full computer match prediction systems.

Classification from physical samples and environments for visual control maintain an important role in the total programme.

Macbeth *Daylight* and *Examolite* units are used for critical colour matching and inspection.

Colour vision tests, educational materials and physical standards including tolerance sets are provided by Munsell.

Stand 222 and Room 3124

Croda

Various Croda Divisions will be participating at OCCA to illustrate the full scope of their activities as major suppliers to the paint, printing ink and allied industries, including:

Croda Resins

Suppliers of a well established range of alkyd resins, vinyl modified alkyds, urethane modified resins and hard resins.

Croda Resins have recognised the likely impact of the proposals to restrict

solvent emissions and the constraints which could develop from increasingly stringent safety requirements. Their laboratories have continued to work on high solids systems which offer the advantages of reduced solvent emissions and, of importance, application is by conventional techniques. Water thinnable resins have also featured in development programmes and the newer products in these resin types will be illustrated.

Croda Resins, a leading manufacturer of silicone co-polymers, have further investigated the technical advantages and potential outlets for such systems and product information will be fully displayed.

Croda Processed Oils

Suppliers of oxidised, refined and polymerised vegetable oils, water soluble and water dispersible oils and oleoresinous varnishes to customers specifications.

Croda Chemicals

Suppliers of a comprehensive range of fatty acids, fatty amides, esters and related products.

Stand 229

Coulter Electronics Ltd

Coulter Electronics Limited will be exhibiting a number of instruments from their extensive range of equipment for the measurements of particle size and surface area which are being used widely in the paint and pigment industry throughout the world.

Nano Sizer

The Coulter *Nano Sizer* has been developed for the measurement of the average particle size in the overall range

OCCA news

of 40-3000 nanometers of colloidal particle suspensions and emulsions. No calibration is required since instrument response is absolute and the particle size, together with an indication of the size distribution width, is presented typically within four minutes.

TAII/PCA

The Coulter Counter Model *PAII* and Population Count Accessory is an extremely rapid particle size analyser, capable of producing a 16-point size distribution of almost any type of particle, typically within 90 seconds. Instrument response is largely independent of electrolyte concentration and temperature and covers the overall size range of 0.6-800 microns.

Micromeritics Sedigraph 5000 D

The *Sedigraph 5000 D* Particle Size Analyser is capable of analysing particles within the size range 0.1-50 microns, expressing the result as a direct plot of weight per cent against diameter on a built-in chart recorder. Analysis time for each sample is typically 45 minutes.

2200/2205

The Micromeritics High Speed Area Analysers measure the surface area of particles by gas absorption within the range of 0.1-500 m²/g. Three or more samples per hour may be analysed and the method used is a modified single point BET technique.

Stand 105

Mastermix Engineering Co. Ltd

Since 1964 Mastermix has supplied high quality dispersion and milling equipment to the surface coating industry. Now a major international supplier, the product range is as follows:

Mastermill

The application of this highly successful range of horizontal bead mills has been further increased by the introduction of the *Mastermill 5*. This machine of throughput 20-100 litres/hour solves the problem of short production runs where a laboratory size machine is unsuitable. The existing range of 1, 5, 30, 60 and 150 litres chamber capacities continues as before with minor improvements derived from operational experience.

PMD Range

This well-known series of high efficiency bulk dispersers is available in capacities from 1350-15000 litre. Fitted with both

OCCA news

high speed mixing head and a low speed cage, the *PMD* range offers very high quality dispersion with low power consumption. Most machines are now specified with the *Mastermix Autoraise system* which permits fully automatic control of the high speed disperser position.

Deaerator

This recently introduced machine is capable of very rapid deaeration of all paste and liquid materials. Capable of a throughput from 1000 to 3000 kg per hour, the *Deaerator* is straightforward to operate and easy to clean.

Change Can Dispersers

Mastermix manufacture a range of heavy duty change can dispersers from 11 kW

upwards. Available in high speed, high torque and twin shaft configurations, this range offers a very flexible high performance dispersion capability for most applications.

Mastermix is now specialising in the design and manufacture of complete systems for the production of surface coatings, with the emphasis on automatic control of all processes. A Design and Systems Division has been formed to design and control such contracts and presently several installations are in progress.

Technical experts will be available to discuss all aspects of Mastermix Service.

Proposed Nigerian Branch

A meeting of the new proposed Nigerian Branch of the Association was held in the Berger Paints training centre, Ikeja, Nigeria on Tuesday 4 December 1979 when Mr Francis B. Adefarati, Chief Technical Executive, Berger Paints Nigeria Limited spoke on the subject of "Paints and painting problems in the tropics".

The paper, based on the lecturer's experience in West Africa, dealt with local conditions that affect paint performance and formulations.

The relatively high humidity conditions, the suitable climatic conditions for floral growth (mould/algae), industrial pollution and high corrosion rate, especially in the coastal areas, account for no less than 85 per cent of common problems encountered in Nigeria. These problems include cracking, flaking, mould/algae growth, chemical staining, bacteriological degradation and corrosion of steel and vehicles.

The lecturer emphasised that all these have to be taken into consideration in formulating paint systems which will perform adequately in the tropics.

News of Members

Mr H. K. Raaschou Nielsen, a Fellow in the Professional Grade and currently a Vice-President of the Association, has been awarded a special testimonial in connection with the Scandinavian SLF's Silver Jubilee. The testimonial recognises Mr Nielsen's position as probably the best known Scandinavian Paint and Varnish Chemist.

new members

Ordinary Members

BALDWIN, RICHARD ALLAN, BSc, LRIC, W Canning Materials Ltd, Great Hampton Street, Birmingham B18 6AS. (Midlands)

BENNETT, CLIFFORD, BSc, Harmer Simpson (UK) Ltd, 709 Tudor Estate, Abbey Road, Park Royal, London NW10. (London)

BERRY, GEOFFREY LAURENCE, 12 Brook Close, Shirley, Solihull, West Midlands B90 1AB. (Midlands)

DEKKER, THOMAS THEOPHILE, Boterdijk 211, 1424 Ng de Kwakel, Holland. (General Overseas)

ELLEN, CHRISTOPHER MAURICE, MSc, 22 Mysore Street, Ngaio, Wellington 4, New Zealand. (Wellington)

FULTON, WALTER, 3619 Autumn Harvest Drive, Mississauga, Ontario, Canada. (Ontario)

GURUGE, RANJITH THALPE, BSc, Ceylon Paint Industries Ltd, Lady Catherine's Drive, Ratmalana, Sri Lanka. (General Overseas)

HOLLIDAY, MARTIN LOUIS, BSc, 54 Fox Hollies Road, Acocks Green, Birmingham B27. (Midlands)

HOLMES, BRIAN ANDREW, BSc, 10 Henshaw Road, Small Heath, Birmingham B10 0TB. (Midlands)

HUMPHREY, MAURICE JOHN, BTEch, PhD, 62 Presthope Road,

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

Selly Oak, Birmingham 29. (Midlands)

IMORU, KOKU AHMED, Berger Paints Nigeria Ltd, PMB 21052, Ikeja, Nigeria. (General Overseas)

IRVING, JOHN KENNETH, 2 Dell Avenue, Swinton, Manchester M27 2TT. (Manchester)

JANSEN, MURRAY LYLE, MSc, PhD, Building Research Association of NZ, Private Bag, Porirua, New Zealand. (Wellington)

KEMP, GRAHAM, BSc, PhD, MRIC, CChem, Ciba-Geigy Plastics and Additives Co., Duxford, Cambridge CB2 4QA. (London)

KENT, BRIAN, BSc, 3/51 Kia-ora Road, Birkdale, New Zealand. (Auckland)

MCINTOSH, DAVID JOHN, PO Box 12044, Jacobs 4026, South Africa. (Natal)

MCKAY, JOHN, MRIC, 92 Crediton Drive, Platt Bridge, Wigan, Lancs. (Manchester)

MARPLES, PETER, PO Box 737, Edenvale 1610, South Africa. (Transvaal)

MIDWOOD, JOHN, LRIC, Blundell Permoglaze Ltd, James Road, Tyseley, Birmingham. (Midlands)

MOTTRAM, GRAHAM FRANCIS, 34 Wymundsley, Astley Park, Chorley, Lancs. (Manchester)

NICHOLSON, PAUL, BTEch, 236 Bolton Road, Radcliffe, Manchester. (Manchester)

NUNN, ANTHONY STEPHEN, BSc, 49 Water Mill Way, South Darenth, Dartford DA4 9BE, Kent. (London)

PAYNE, KENNETH, 46 Haglane Copse, Pennington, Lymington, Hants SO4 8DQ. (Bristol)

RAMCHARAN, NOELLE PATRICIA, BSc, Berger Paints Trinidad Ltd, 11 Concessions Road, Sea Lots, Port of Spain, Trinidad, West Indies. (General Overseas)

SHARPLES, IAN, Dominion Colour Co., 445 Finlay Avenue, Ajax, Ontario, Canada. (Ontario)

VARMA, JYOTSNA, LRIC, 46 Penywern Road, London SW5. (London)

WARING, DAVID, 50 Elizabeth Street, Atherton, Manchester M29 9JN. (Manchester)

WOLFE, STUART STEPHEN, PO Box 12040, Jacobs 4026, Natal, South Africa. (Natal)

Associate Members

BRIGHT, WILLIAM, PO Box 37058, Overport 4067, South Africa. (Natal)

COOKE, MICHAEL RUSSELL, 20 Power Street, Corlett Gardens, Johannesburg 2192, South Africa. (Transvaal)

DICKINSON, ANTHONY GEOFFREY, Hoechst (NZ) Ltd, PO Box 38169, Petone, New Zealand. (Wellington)

FALVEY, STEPHEN JAMES, 6 Corlett Road, Plimmerton, New Zealand. (Wellington)

MACCARTHY, HILAIRE, 36 Gilbert Scott Road, Buckingham, Bucks. (Thames Valley)

new members

O'CONNOR, KIERN MARK, 28 Bradstocks Way, Sutton Courtenay, Oxon. (Thames Valley)

PITT, JOHN GEORGE, Dominion Colour Co. Ltd, 199 New Toronto Street, Toronto, Ontario M8V 2E9, Canada. (Ontario)

RAMSAY, DAVID, Thor Chemicals, 484 Main Reef Road, Denvor, Johannesburg, South Africa. (Transvaal)

ROWE, ALLAN FRANCIS, Silicate & Chemical Industries (Pty) Ltd, Box 14016, Wadeville 1432, South Africa. (Transvaal)

VAN DER WALT, AUBREY RAYMOND, Bevaloid SA (Pty) Ltd, PO Box 27076, Benrose 2611, South Africa. (Transvaal)

WALKER, RONALD TREVOR, 121 The Ridgeway, Stoke, Nelson, New Zealand. (Wellington)

Registered Student

TALBOT, PETER DAVID, 173 Waveney, Grovehill, Hemel Hempstead, Herts. (London)

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

occa diary

February

Monday 4 February

Hull Section: "China clays as opacifying extenders in paint" by R. McGuffog, Research & Development Department, ECC International, at the George Hotel, Land of Green Ginger, Hull, commencing at 6.30 p.m.

Tuesday 5 February

West Riding Section: "An integrated approach to dispersion applications using new technology" by R. W. English and J. Perkins of Mastermix Engineering Co., at the Mansion Hotel, Roundhay Park, Leeds 8, commencing at 7.30 p.m.

Thursday 7 February

Newcastle Section: "Packaging" by a speaker from Metal Box Ltd, at the Students Common Room, St. Mary's College, Elvet Hill Road, Durham, commencing at 6.30 p.m.

Friday 8 February

Manchester Section: "Transportation and labelling of hazardous materials" by a speaker from Esso Chemical Co.

Ltd, at the Manchester Polytechnic, New Administration Building, All Saints, commencing at 6.30 p.m.

Thames Valley Section: Buffet Dance at Great Fosters, Egham. *Details to be announced.*

Thursday 14 February

Midlands Section - Trent Valley Branch: "Pipeline protection" by D. Polkinhorne of Delpic Engineering Services Ltd, at the Derby Crest Motel, Pastures Hill, Littleover, Derby, commencing at 7.15 p.m.

Friday 15 February

Irish Section: "Waste is money - What are we doing about it?" by Irene Daly, Industrial Chemist, Irish Dunlop Ltd, at the Clarence Hotel, Dublin, commencing at 8.00 p.m.

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

Wednesday 20 February

London Section: "Pollution analysis" by N. A. R. Falla, Paint Research Association, to be held at the Rubens Hotel, Buckingham Palace Road, SW1, commencing at 7.00 p.m.

Thursday 21 February

Midlands Section: Lecture to be presented on behalf of the Paint Research Association, at the Calthorpe Suite County Cricket Ground, Edgbaston, Birmingham, commencing at 6.30 p.m. *Details to be announced.*

Scottish Section: "Chemistry of crime" by W. J. Rodger, Strathclyde Police Department, at the Albany Hotel, Glasgow, commencing at 6.15 p.m.

Thames Valley Section: "The restoration of paintings" by a speaker from the National Maritime Museum, at the Beaconsfield Crest Motel (White Hart), Aylesbury End, Beaconsfield, Bucks, commencing at 6.30 p.m. for 7.00 p.m.

Friday 22 February

Scottish Section - Eastern Branch: "Burns Supper" at the Commodore Hotel, Marine Drive, Edinburgh at 7.30 p.m. for 8.00 p.m. *Details to be announced.*

occa diary

Wednesday 27 February

Scottish Section - Eastern Branch: "The thermoluminescence dating technique applied to the authentication or otherwise of Chinese ceramics" by J. Tate of the National Museum of Antiquities of Scotland, at the Murrayfield Hotel, 18 Corstorphine Road, Edinburgh, commencing at 7.30 p.m.

Friday 29 February

Bristol Section: "The manufacture and uses of pigment chips" by F. J. Morpeth of Foscolor Ltd, at the Royal Hotel, Bristol, commencing at 7.15 p.m.

March

March

Manchester Section: Student Works visit, details to be announced.

Manchester Section: Informal Buffet Dance, details to be announced.

Monday 3 March

Hull Section: Ladies' Evening, details to be announced.

Tuesday 4 March

West Riding Section: "Industrial nitrocellulose - Manufacture and use" by A. W. E. Staddon of ICI Ltd, Organics Division, at the Mansion Hotel, Roundhay Park, Leeds 8 commencing at 7.30 p.m.

Thursday 6 March

Newcastle Section: "The manufacture and uses of pigment chips for the printing ink and paint industry" by F. Morpeth of Foscolor Ltd, at the Students Common Room, St. Mary's College, Elvet Hill Road, Durham commencing at 6.30 p.m.

Monday 10 March

Manchester Section: "Electrodeposition - Anodic versus cathodic" by H. V. Schenk of BASF Ludwigshafen, at the Woodcourt Hotel, Sale commencing at 6.30 p.m.

Thursday 13 March

Midlands Section - Trent Valley

Branch: "Fire precautions" by an officer of the Derbyshire Fire Service, at the Derby Crest Motel, Pastures Hill, Littleover, Derby commencing at 7.15 p.m.

Scottish Section: Student Invitation Lectures: "The practical aspects of colour in surface coatings" by T. Grieve of Isaac Spencer Ltd, and "The practical aspects of colour in printing inks" by G. Hutchinson of Croda Inks Ltd, at the Albany Hotel, Glasgow commencing at 6.15 p.m.

Wednesday 19 March

London Section: "Resins", Day meeting at Thames Polytechnic, Woolwich SE18, commencing at 10.00 a.m.

Thursday 20 March

Thames Valley Section: "Cathodic electrodeposition" by R. L. Bayliss of ICI (Paints) Ltd, at the Beaconsfield Crest Motel (White Hart), Aylesbury End, Beaconsfield, Bucks commencing at 6.30 p.m. for 7.00 p.m.

Friday 21 March

Bristol Section: Dinner Dance, to be held in the Mayfair Suite, New Bristol Centre, at 7.30 p.m. for 8.00 p.m.

Irish Section: "Paint lecture", at the Clarence Hotel, Dublin commencing at 8.00 p.m. Details to be announced.

Midlands Section: Newton Friend Ladies' Invitation Lecture: "Greeting cards through the ages" by A. Genmes of Webb Ivory Ltd, at the Birmingham Chamber of Commerce and Industry.

Wednesday 26 March

Scottish Section - Eastern Branch: Works visit to Lorimers Brewery, St. Leonards Street, Edinburgh at 7.15 p.m. for 7.30 p.m.

Friday 28 March

Bristol Section: "Low odour solvents" by A. Cumbers of Carless Solvents Ltd, at the Royal Hotel, Bristol commencing at 7.15 p.m.

Monday 31 March

Hull Section: Annual General Meeting, details to be announced.

April

Midlands Section - Trent Valley Branch: Annual General Meeting, to be followed by a Buffet Dance at the Cross Keys Inn, Turnditch. Details to be announced.

Tuesday 1 April

West Riding Section: Annual General

Meeting, at the Mansion Hotel, Roundhay Park, Leeds 8, commencing at 7.30 p.m. Details to be announced.

Thursday 10 April

Newcastle Section: Annual General Meeting, at the Students Common Room, St. Mary's College, Elvet Hill Road, Durham, commencing at 6.30 p.m. Details to be announced.

Friday 11 April

Association Dinner Dance, at the Savoy Hotel, London WC2.

Thursday 17 April

Thames Valley Section: Annual General Meeting. "Unusual experiences of a paint supplier" by R. Peacop of Technical Paint Services, at the Beaconsfield Crest Motel (White Hart), Aylesbury End, Beaconsfield, Bucks commencing at 6.30 p.m. for 7.00 p.m.

Friday 18 April

Irish Section: Annual General Meeting, at the Clarence Hotel, Dublin, commencing at 8.00 p.m. Details to be announced.

Manchester Section: Annual General Meeting, at the Lancashire Cricket Club, Old Trafford, Manchester. Details to be announced.

Wednesday 23 April

Scottish Section - Eastern Branch: Annual General Meeting, followed by "Pencil manufacture" by D. W. Tee of the Cumberland Pencil Co., at the Murrayfield Hotel, 18 Corstorphine Road, Edinburgh commencing at 7.30 p.m.

Thursday 24 April

London Section: Annual General Meeting, at the Rubens Hotel, Buckingham Palace Road, SW1 commencing at 6.30 p.m., followed by a lecture of general interest (speaker and subject to be announced). Ladies' Evening.

Friday 25 April

Midlands Section: Annual General Meeting, at the Belfry Hotel, Lichfield Road, Wishaw, commencing at 7.30 p.m. There will be a golf tournament in the afternoon at the adjoining golf course.

Bristol Section: Annual General Meeting at the Royal Hotel, College Green, Bristol, commencing at 7.15 p.m. A film will be shown at the end of the proceedings.

CLASSIFIED ADVERTISEMENTS

Classified Advertisements are charged at the rate of £4.00 per cm. Advertisements for Situations Wanted are charged at £1.00 per line. A box number is charged at 50p. They should be sent to D. M. Sanders, Assistant Editor, Oil & Colour Chemists' Association, Priory House, 967 Harrow Road, Wembley, Middlesex HA0 2SF. JOCCA is published EVERY month and Classified Advertisements can be accepted up to at least the 12th, and in exceptional circumstances the 20th of the month preceding publication. Advertisers who wish to arrange for an extension of the copy deadline should contact the Assistant Editor, D. M. Sanders, at the address given above (telephone 01-908 1086, telex 922670 OCCA G).

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Birmingham Paint, Varnish and Lacquer Club

50th Anniversary Year Symposium

The Birmingham Paint, Varnish and Lacquer Club will be holding a symposium on the effect of current legislation on the coatings industry.

The symposium will be held at the Birmingham Metropole Hotel on 15 May 1980.

Members of the Association wishing to register for the symposium may do so at a preferential reduced rate by applying to the Symposium Secretary, Mr D. M. Heath, Arthur Holden & Sons Limited, Bordesley Green Road, Birmingham B9 4TQ.

JOCCA

The largest circulation of UK publications to the surface coatings industries - sent each month to over 80 countries!



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London, 13-15 May 1980

CLASSIFIED ADVERTISEMENTS

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The post offered covers a varied and interesting field including drawing up specifications for all types of coatings, sealants and paint systems, investigating field complaints, and developing test methods.

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Written applications giving full particulars regarding qualifications, previous experience, present employment and salary, age and telephone number should reach the Personnel Manager, SABS, Private Bag X191, Pretoria, 0001, South Africa, as soon as possible. Please quote Ref No 9/80.

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OCCA-32 Exhibition



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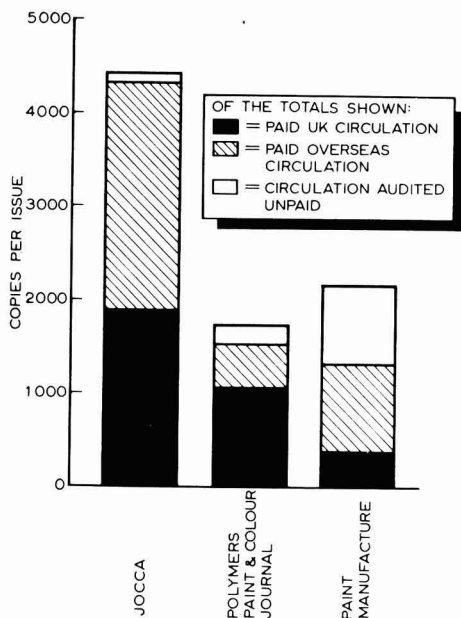
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Journal of the Oil and Colour Chemists' Association

Priory House, 967 Harrow Road, Wembley, Middx., HA0 2SF, England
 Telephone: 01-908 1086 Telex: 922670 (OCCA G)



(Reference Audit Bureau of Circulations Reviews. Jan-Dec 1978)

Comparison of circulations of U.K. publications to the paint, printing ink and allied industries

For full details of advertising in this, and other Association publications, contact D. M. Sanders, Assistant Editor.

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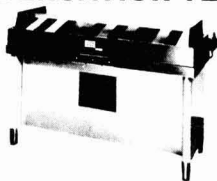
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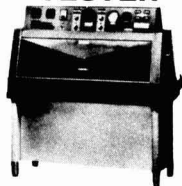
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