

November 1989 Vol. 72, No. 11





Wood Finishes



# IS YOUR Q.C. READY YET? — OURS IS!!!

Why wait until 1992 to get your Q.C. sewn up? We are one of the world's leaders in the design and manufacture of colour measuring instruments. We have models to check paint, powder coatings, anodising, plastics, packaging, ceramics and much more.

If Quality Control is important to you, so are our meters.





Statistical Process Control is becoming the universally accepted method of checking manufacturing procedures to ensure that tolerances are adhered to. For the first time, we can now offer a package that will allow SPC on colour by linking our Chroma Meters to the best selling Dataputer<sup>®</sup> 3000 SPC Analyser. X-Bar/Range and X-Bar/Sigma Charts can be produced, as well as Histograms and Capability Studies.

MINOITA



COLOUR METERS FOR INDUSTRY

Call me now for a free literature pack, or a 'no strings' demonstration, on 0908-211211, extension 216, or write to: The Industrial Department, Minolta (UK) Limited, 1-3 Tanners Drive, Blakelands North, Milton Keynes, Buckinghamshire MK14 5BU.

Tracey Walker

DATAPUTER IS THE REGISTERED TRADE MARK OF SELLERS DATA SYSTEMS LTD



JOURNAL OF THE OIL AND COLOUR CHEMISTS' ASSOCIATION

### Contents

News	428
Feature: Wood Finishes Jordan Award Paper: Wood finishes—field and laboratory tests by I. Melville and L. A. Simpson	434
Polymethacrylate dispersions for wood preservation: Their manufacture, application and characteristics by H. D. Christian	443
Cracking of furniture surfaces by T. Sparkes	447
The involvement of ETAFF in the development of wood finishes throughout Europe by A. H. Rieck	450
<b>Transactions and Communications</b> A versatile method of characterizing cure in filled reactive polymer systems by S. Affrossman, A. Collins, D. Hayward, E. Trottier and R. A. Pethrick	452
Chester Conference Paper Finishes and furniture research by M. Charity	454
Horizons Precis papers	458
From the General Secretary	462
OCCA Meetings	463
OCCA News	465
<b>Cover:</b> Wood finishes being tested at the Tioxide Weathering Station, Carlton England (Photo courtesy of Tioxide Group PLC)	, N.E.

Forthcoming Features: December – Waterborne Coatings, January – Corrosion, Process Operation: Dispersing and Mixing, February – Quality Assurance; PO, Computer Controls.

Contributions are welcomed at least five weeks prior to publication date.

JOCCA is published by the Oil and Colour Chemists' Association Priory House, 967 Harrow Road, Wembley HAO 2SF, England Tel: 01-908 1086 Fax: 01-908 1219 Telex: 922670 (OCCA G) Annual subscription rate for 1989: £80.00 (\$160), post free by surface mail. Single copies £8.00 (\$16), post free by surface mail. Editorial correspondence should be addressed to the Honorary Editor, and general correspondence addressed to the General Secretary, at the Association Headquarters. The Council and the Oil and Colour Chemists' Association do not accept responsibility for opinions and statements expressed by correspondents or contributors to this Journal. The

contents of the Journal are copyright and permission to reproduce Transactions and Communications, Features and Horizons, in full or in part, must be obtained from the Honorary Editor. Printed by The Herald Press, 17 Rother Street, Stratford-upon-Avon,

Honorary Editor and Chairman of the Publications Committee J. R. Taylor BSc, CChem, FRSC, FICorrST, FPRI, FTSC Publications Committee: A. G. North, BSc, FTSC B. F. Gilliam, FTSC L. J. Brooke, ATSC S. G. Lawrence, PhD, BSc, ATSC G. W. Fowkes D. Robinson, LRSC G. J. Steven, BSc M. Langdon, ATSC M. J. Round, MRSC, CChem J. Bravey, CChem, MRSC H. Jess J. Clarke D. Horne. ATSC S. Birkett, LTSC J. G. Pitt E. Puterman, BSc R. E. Cromarty, BSc, ATSC MSA Chem A. T. Hopgood, FTSC J. Hemmings, LRSC, ATSC

General Secretary C Pacey-Day

Assistant Editor P J Fyne, MA, DPhil

Advertisement Manager F Craik

ISSN 0030 - 1337

Copyright OCCA 1989



Circulation



An official Journal of the Paintmakers Association of Great Britain Ltd.

NOVEMBER 1989

Warwickshire CV37 6NB Tel: 0789 66261

427

### Union Carbide's breakthrough in VOC reduction technology

Union Carbide has developed a revolutionary technology that substitutes recycled supercritical CO<sub>2</sub> for much of the solvent normally required in spray coating formulations. The UNICARB<sup>TM</sup> system for spray coatings reduces volatile organic compounds (VOC) by 30-70%. The UNICARB<sup>TM</sup> system will allow coatings applicators to achieve the proposed amendments to the US Clean Air Act. The technology was developed by Ken Hoy, a Senior Corporate Fellow in Union Carbide's South Charleston R & D Laboratories, USA.

### VOCs - the facts

VOCs are chemicals that mix with nitrogen oxides  $(NO_x)$  in the presence of sunlight to form ozone. Heat speeds up this reaction, therefore ozone concentration is built up in summer leading to smog.

Ozone is a colorless, very reactive gas that will oxidize (produce deterioration in) almost every material that it comes into contact with. Ozone poses both short- and long-term health risks, i.e. shortness of breath and permanent lung damage, and also has effects on vegetation (soybeans, wheat, corn).

The major US sources of VOCs are motor vehicles (40%); small "area sources", e.g. paint spray applications, dry cleaners, and consumer solvents (40%); large point sources, e.g. petroleum refineries (15%); and gasoline refuelling (5%). President Bush has said that he will make the 1990s the era for clean air and with this in mind the UNICARB<sup>TM</sup> System has been developed to allow paint applicators to comply with the VOC standards of the proposed Clean Air Act Amendment.

### The supercritical technology

When a gas above its critical temperature is compressed until its density approaches that of liquid materials, the dense fluid behaves with solvent-like properties (see phase diagram). Such a



Solvent emission of one production day



CO2 pressure-temperature phase diagram

supercritical fluid can be used as a diluent solvent for thinning viscous coatings concentrates to a viscosity at which they can be readily atomized and applied as coatings. Supercritical fluid solvents mix, solvate and equilibrate much faster than conventional solvents because they have higher diffusivity and lower viscosity.

While many dense, gaseous fluids might be used in a supercritical fluid coating process, the physical properties of carbon dioxide (critical temperature of 31°C and critical pressure of 1,070 psi) make it ideally suited to coatings applications. These conditions are well within the temperature and pressure ranges of today's airless spray equipment. In addition, recycled carbon dioxide is non-toxic, non-flammable, readily available and inexpensive. The technology will not generate additional CO<sub>2</sub>

(which contributes to the Greenhouse Effect) but will utilise by-product  $CO_2$  of ammonia plants and refineries.

The UNICARB<sup>TM</sup> System can result in replacement of up to two-thirds of the organic solvents in coatings formulations. Coatings systems produced specifically for use with this new process are formulated at a much higher viscosity and lower organic solvent concentration than conventional systems. Using supercritical carbon dioxide as a diluent reduces the viscosity just prior to application to a level that facilitates atmomization through a spray gun. Applied at conditions typical of airless spray, the resulting coatings are equal or superior to those obtained by similar coatings formulated for and applied by an air gun. Both the particle size and distribution and the feathered or tapered edge of the spray fan



UNICARB<sup>TM</sup> spray coating system schematic

closely duplicates air-atomization coating sprays.

### The system process and equipment

Union Carbide has developed the process and equipment necessary for the preparation of coatings diluted to spray viscosity with carbon dioxide (see schematic). This delivery equipment prepares mixtures of coating concentrate and carbon dioxide accurately metered at the desired ratio. As the coating is sprayed, additional mixture is automatically mixed and available for spraying. The system can operate continuously or intermittently and may be controlled manually or automatically.

Typical pressures are in the airless spray operating range of 1,200 to 2,200 psig. Operating pressure can be easily adjusted over this range and is selected to optimize spray properties and carbon dioxide content. Operating temperature may vary from 38 to 65°C. The process temperature may vary from 38 to 65°C. The process equipment typically requires a 240-volt, single-phase electrical source and an 80-psi pneumatic air supply.

The UNICARB<sup>TM</sup> System can be designed to satisfy a broad range of production requirements—from small, simple end-uses to large, complex applications, such as automotive OEM. The system pictured above is suitable for small, commercial applications or pilot plant evaluations. It is capable of supplying coating to multiple spray guns which have been specially designed for the UNICARB<sup>TM</sup> System. The unit measures  $80^{\prime\prime}$ L x  $30^{\prime\prime}$ W x  $60^{\prime\prime}$ H and is easy to install. It can be operated using either cylinder or bulk carbon dioxide. UNICARB<sup>TM</sup> delivery equipment is designed as a retrofit or for grass-root installation.

The UNICARB<sup>TM</sup> System has been developed as a utility technology for spray-applied coatings applications. Expected end uses include automotive topcoats and component finishing, automotive refinishing, wood and metal furniture, appliances, pails and drums, aerospace, machinery and equipment, trucks and buses, and structural steel.

### The system coatings

The coatings utilized in the UNICARB<sup>TM</sup> System are viscous, paint concentrates which are specially formulated by coatings manufacturers to remove up to 70 per cent of the solvents. To bring the coating concentrate to spray viscosity, the UNICARB<sup>TM</sup> System delivery equipment blend  $CO_2$  into the coating at the applicator's facility. In most cases, no change in the resin system is required and only the solvent portion of the coating needs reformulation.

Union Carbide has filed for patents worldwide on the UNICARB<sup>TM</sup> System for Spray Coatings and ancillary technology. This new technology will be licensed to spray coatings applicators.



### Beckers opens up in the Far East

The Stockholm-based European Industrial Paint Manufacturer AB Wilh. Becker has signed an agreement signifying the formation of a company to manufacture coil coating in Kaohsiung, Taiwan. Beckers will hold a controlling interest in the new company, which will operate under the name China Becker Coatings. The production start-up is scheduled for the second half of 1990.

### **BP** invests in Barry

**B**P Chemicals is to make a substantial investment in its polymer specialities site at Barry in South Wales. The planned investment will be in the region of £25m and will centre on its Cellobond Phenolic Polymers Business. The project is scheduled for completion in 1991

### Exxon phthalic anhydride plant

E xxon Chemical has announced plans to build a grass roots phthalic anhydride plant at its Rotterdam site in Holland. The multi-million dollar plant will have an initial annual capacity of 50,000 tonnes and is expected to come on-stream in mid-1991.

### **Business news in brief**

**Coates Brothers,** the printing ink and resin manufacturer report first half pre-tax profits of  $\pounds 18.5m$ (+8.8%) on a turnover of  $\pounds 190.4m$ (+13.8%).

**PPG** in the US has acquired Olympic Homecare Products and Lucite Home Products for \$130m.

**Tioxide Group PLC** report first half pre-tax profits of  $\pounds 93.2m (+12\%)$  on a turnover of  $\pounds 340.4m (+18\%)$ .

**Manders** report first half pre-tax profits of  $\pounds 3.3m (+23\%)$  on a turnover of  $\pounds 46.2m (+60\%)$ .

Hoechst UK Group report 1988 pretax profits of £23.8m with increased exports of £65m on sales of £408m and the Hoechst Group report pretax profits of DM 4086m (+31%).

### **US Focus**

From our American Correspondent – Abel Banov, Co-publisher of the American Paint & Coatings Journal.

### A revolution in the making

For the past year, several suppliers of automotive paints have been quietly developing products for a radically new approach to spray-gun painting of new automobiles. Known as the UNICARB<sup>TM</sup> System and developed by Union Carbide Corporation, the method employed by them, it is claimed, will reduce solvent content of coatings by 30 to 70 per cent, depending on the formulation.

Supercritical carbon dioxide is the major solvent. The coating, as it arrives at the painting site, does not resemble conventional paint because it is a concentrate, with the consistency of syrup. It contains just enough conventional solvent so that it can be pumped into a chamber that can be retrofitted to existing spray guns. Here it is combined with carbon dioxide that is pumped in at the same time and made supercritical; this means that its temperature and pressure are such that it is not quite a liquid or a gas, but for some esoteric reason it has remarkable solvating power.

In the chamber the coating is thinned to sprayable consistency. When sprayed the  $CO_2$  dissipates into the air, and the product with its slower-evaporating coalescing solvents is deposited on the surface.

### Process to be licensed

Developed by Kenneth Hoy, a renowned coatings researcher for UCC, the process is to be licensed to spray gun manufacturers, and applicators. A test at an auto plant is about to be made to confirm earlier successful work and, if necessary, to work out bugs. Later, work will be done to develop procedures and products for wood finishing. Auto refinishing will be next, and before long, it is expected, small chambers will be developed for field spray application.

Observers believe the new system will have considerable impact on the industry's ability to meet worsening restrictions on release of solvents into the atmosphere and that it may arrest the growth of high-solids, water-reducible and powder coatings. (See page 428).

### A new multi-color process developed by PPG

At a new styling center dedicated recently by PPG Industries at Troy, Mich., a striking new product was exhibited. Called Lava Flow, it is a multicolor paint of considerable beauty created by spraying a dense paint over a still-wet lacquer.

The product is being shown for the first time—as part of the company's 1993 display of paint colors and matching interior materials. Significantly, the Lava Flow paints are exhibited on the bottom portions of fenders.

### Powder coatings for auto exteriors

PPG is reported to be ready to market a line of powder coatings for automotive exteriors, with provision made for the necessary quick color changes. The company is already furnishing powders used for undercoats to impart chip resistance. Use of powder coatings in autos until now has been restricted to under-the-hood items.

### Propylene glycols and ethers

With evidence growing that a number of ethylene glycols and ethylene glycol ethers are suspect as health hazards, many users have been evaluating, and in some instances already switching to, propylene glycol ethers; the switch is not on a direct pound-for-pound substitution, but little difficulty is reported in formulating.

### Driers and high-solids enamels

Extensive research went into devising new methods of formulating high solids architectural coatings to meet stringent solvent restrictions in California, which limit solvent content to 250 gms per liter.

New alkyds were developed by Cargill and Reichold Chemical Co, which required considerable trial and error in formulations before satisfactory drying could be reached.

Combinations of cobalt and certain accelerators made by Manchem and Mooney Chemical Co enabled several Californian companies to provide satisfactory products using these resins. Mooney's product is called Alusec 591, which is based on an aluminium chelate: Manchem's is Manosec CD44, a mixed metal product. When suitable quantities of accelerators were added to conventional driers, improved dry' and tack-free time resulted. These results were found by researchers connected with a resin company.

### Products

### Croda launches flexible epoxy acrylate

C oda Resins has introduced a new flexible epoxy acrylate – Crodaplast UVE U2/50 – to complement its existing range of resins for cure by UV. The excellent flexibility of Crodaplast UVE U2/50 is combined with good compatibility which will allow the formulator to fully or partially replace acrylates, urethanes or polyesters, to give reduced costs. Crodaplast UVE U2/50 contains no acrylic acid and therefore has a very low odour level.

For further information Enter K201

### New printed board coating

Crown has developed a series of water-based emulsion coatings for application to printed board which can be applied in-line in the printing process. The emulsion coating can be used as a gloss overprint lacquer to enhance or protect the board. Alternatively, it can be used as a sealer coat; this application cuts down on the amount of spray powder used in the printing process, seals the substrate and stops scuffing and rubbing.

For further information Enter K202

### New organosol copolymer

Vinnol<sup>®</sup> H 25/40 M from Wacker-Chemie is a newlydeveloped copolymer containing carboxyl groups. Its excellent solubility in solvent mixtures highly blended with alcohols and aromatics and outstanding adhesion to metals make it ideally suited to formulate organosols.

For further information Enter K203

### New ethyl silicate binder

Thomas Swan & Co Ltd has introduced Ethyl Silicate 40, an ethyl ester/polysilic acid formulation. With particular uses in high-specification coatings designed to protect ferrous parts against water and other environmental aggression, Ethyl Silicate 40 is a quick-drying binder for zinc-rich primers and anti-corrosion paints and exhibits excellent properties of adhesion in these products.

For further information Enter K204

### Equipment

### Strastint dispensers

Strastint International Pty Ltd of Australia have opened a UK subsidiary to market, distribute and support their range of paint colourant, mixing equipment both here and throughout Europe.

A range of models is available from 20 ounce single pump units for dispensing direct from large drums to machines with 16 canisters for trade, industrial or retail applications.

The unique feature of the double pump on each canister may well be the secret of the success in other

Strastint 21-PD dispenser



### OBS appointed new distributor for palletising robots



*P* ackaging systems specialists PMN, of Denmark, have appointed OBS Machines of Milton Keynes, exclusive UK distributors, for their range of palletising robots and shrink wrapping equipment for the paint, ink and allied industries. The new agreement in conjunction with OBS's other distributorships for Jorgensen Engineering (conveyors and container accumulating tables) and De Vree (filling systems) enables the company to act as main contractor and equip complete container handling, filling and packaging lines.

Already well established in the UK market with systems operating with the two major decorative paint manufacturers, PMN equipment has a reputation for efficiency and reliability. The computer controlled palletising robot is extremely versatile, being easily reprogrammed to accept different can sizes, shapes or pallet layouts. Operating at standard conveyor height, the PMN robot has powerful hydraulically inflated 'fingers' or a mechanically actuated pick-up system to easily lift and stack cans, pails, cartons or sacks in excess of 50 kg three high.

countries. The double pump offers a combination of large volumes in one stroke plus – by using the secondary pump – extremely accurate small amounts, so that, for example the 53 PD model can dispense over 5 ounces in one stroke to 1/256 of an ounce. These settings are also lockable which means that repeated measures in small production runs can be handled easily.

For further information Enter K206

### Ascott salt spray cabinets

Ascott Analytical Equipment has recently entered the field of paint/surface coating testing, with the launch of a new range of British manufactured salt spray cabinets: a unique design of roof enables it to either hinge and latch or be completely removed for all-round access during loading and unloading. A slide rail mounted salt





Ascott salt spay cabinet: Model 5450/A

spray atomising jet is provided and when coupled with a choice of load support racking, each cabinet can be tailored exactly to meet individual customer requirements.

For further information Enter K207

### New Tintometer glossmeter

The Lovibond<sup>®</sup> Glossmeter, a portable instrument incorporates optics for 20° and 60° incidence and meet BS 3900 and ISO 2813.

For further information Enter K208

### Literature

### **BASF industrial coatings**

A comprehensive technical brochure on coating systems, applications and services for industrial metal finishing has been published by BASF Coatings + Inks. The publication (10pp) is entitled "Coatings for the Protection of Agricultural and Material-Handling Equipment". For further information Enter K209

### New specialist wood finishes range from HMG

S pecialist surface coatings manufacturer H Marcel Guest has extended its high performance product range to include wood finishes, for the furniture and joinery industry. The company has produced a catalogue of standard shades and finishes, which are available for immediate delivery at competitive prices, and also through its R&D laboratory it is able to develop coatings to individual customer specifications.

For further information Enter K210

### Meetings

### **Paint Industries Club**

Programme for 1989/90 season: <u>Dinners</u> 6 February 90, Piccadilly Hotel, Manchester.

6 March 90, Park Lane Hotel, London.

Ladies' Night 15 December 89, Intercontinental, London.

Golf Day

13 July 90, Beckhamstead.

Chairman of the PIC for 1989/1990 is Jim Coldrey; Barry Wood, is President for a second year; Geoff Watson is Vice President, supported by John Collingwood and Philip Hanscombe as committee members. The membership subscription for the next season is £75; the guest fee will be £30. Hon-Secretary: Philip Medcalf, Cuprinol Ltd, Adderwell, Frome, Somerset BA11 1NL.

### **Calling all golfers!**

Les Moss of Elem Chemicals Ltd., is organising a trip to the Algarve for members of the paint, resin and chemical industries. Leaving on 21 January 1990, participants will enjoy seven days of golf and lots of 19 holes! The cost will be approximately £208. Details from: Mr L. Moss, Elem Chemicals Ltd., Cedar House, 7 Little Orchard, Carlton Road, Woking, Surrey GU21 4HG.

### People

### **Macpherson Woodfinishes**

Macpherson Woodfinishes, a division of Macpherson Paints and part of the Finnish multinational Kemira, has appointed **Doug Rowson** as technical product manager. Mr Rowson joins the company from Intercoat where he was woodfinishing technical manager for six years and has over 17 years' experience in woodfinishing technology.



D. Rowson

### **International Paint**

The Special Business Group of International Paint's Felling based Protective Coatings division has appointed **Brendan O'Donnell**, PhD, 33, Technical Manager Flooring. His role will include solving technical problems for salesmen and advising/supervising contractors and applicators. Dr O'Donnell first joined International in 1980 as part of their Research & Development team.

### **New SBPIM President**

The Society of British Printing Ink Manufacturers has elected Mr C. D. Dane to be their President following Mr A. W. Welton vacating the position.

### Scott Bader

Scott Bader Company Limited has announced two changes to its Senior Management Team:



Arne Strand joins the Company as Business Manager, General Products Division. Arne is 40 and was previously Europe and Eastern Block Manager for the Marine Industry in the Drew Ameroid Corporation.



Brian Elgood moves within the company to become Head of Purchasing and Public Affairs. Brian, 50, is the current chairman of the British Resin Manufacturers' Association.

# Rheology - a matter of survival for the Sun Dew

The Sun Dew is an attractive plant which secretes drops of glistening sticky liquid from its tentacles to attract insects.

Unfortunately for the insects, once they land on the apparently tasty meal, the tables are turned.

The sticky drop's hold the insect fast, whilst the tentacles close, and the insect is eventually digested by the plant. The rheology of the sticky drops is essential to the Sun Dew's survival. Their structure allows the drops to flow and trap the insect whilst having the strength and elasticity to hold the potential meal despite its struggles.

The Carrimed CSL Rheometer can measure and quantify such rheological properties for a whole range of materials.

This computer-controlled instrument uses the techniques of flow, creep and oscillation to characterise the properties of a whole range of materials. These properties can be used to predict and control the behaviour of the materials during manufacture, storage and use.





As part of our philosophy of total customer support, software for the CSL Rheometer is continually updated, free of charge, during the first two years of ownership.

Through this service, and our regular User Seminars and free Analysis reports, Carrimed customers have access to the most up-to-date information in the field of Rheology.

Carrimed offer a wide selection of viscometers and rheometers ranging from simple quality control viscometers, to a rheometer measuring complex rheological phenomena. They include Weissenberg Rheogoniometer, Elongational Viscometer, Viscolog, RV8 Viscometer.

Don't be stuck with outdated equipment. Try the Carrimed CSL Rheometer in your own laboratory.

Send for full details of the demonstration package and your copy of the free brochure. You won't have to struggle any more.





CARRI-ME

For greater understanding Glebelands Centre, Vincent Lane, Dorking, Surrey, RH4 3YX. England. Tel: (0306) 886180

Enter K103 on Reader Reply Card

### Jordan Award Paper

# Wood finishes – field and laboratory tests

### by I. Melville and L. A. Simpson, Tioxide Group PLC, Stockton-on-Tees, Cleveland TS18 2NQ, UK

### Introduction

Tioxide began to take an active interest in wood finishes about four years ago. The reason for this being an increase in activity within this area, which was reflected in the number of publications in various journals (e.g. References 1, 2 and 3) and more significantly in the number of new products appearing on the market. With many of these new products came claims of extended lifetimes due to increased flexibility and improved film permeability allowing the timber to breathe. In order to evaluate these claims and to compare these modern coatings with a more traditional system, an exhibition of wood finishes was set up at the Tioxide weathering station at Carlton in North East England.

One of the problems with such a programme is the categorisation of wood finishes, which is generally recognised as a difficult area. Rather than limit the investigation from the very outset, most types of finish available in the UK DIY market were considered. During much of the discussion the finishes are categorised as white and non-white, obviously this is a sweeping categorisation but for the purposes of this paper seems appropriate because it divides the finishes examined into two approximately equal groups. Further, the testing of white and non-white finishes differs in the areas of chalking and colour assessment, and finally when the results of various tests are considered, this categorisation makes the discussion reasonably straightforward.

The investigation has also involved laboratory testing, concentrating on flexibility and permeability in an attempt to obtain laboratory results which can be related to, or used to predict or explain, the results of field trials.

### Experimental

In any evaluation of an exterior finish the most important results are those obtained from exterior exposures. In the case of wood finishes this is also true, but not exactly straight-forward. Difficulties arise in the choice of timber. what type; hard or soft wood; early or late wood. Having decided what type of timber to use there is still the question of how the surface should be prepared, should it be freshly sawn or sanded, flat or moulded. Choices made in these areas will undoubtedly influence the results of weathering trials. In this investigation the timber used was edge-grained Western red cedar. This type of timber has been widely used in many of Tioxide's weathering trials as the quality is such that it provides a reasonably reproducible substrate, allowing comparisons to be drawn between finishes applied to different pieces of timber. Despite the care taken in the selection of a substrate, it must be recognised that when working with timber some faults will occur in finishes which are due solely to defects in the substrate. To allow for the occurrence of such defects finishes were at least applied in duplicate.

Another difficulty with wood finishes is the state of the timber during application. As manufacturers are no doubt well aware, there are few cases where wood finishes are applied under what would be called ideal conditions, particularly in the DIY market. The sort of problems encountered include application to unsealed and weathered timber, which means the wood finish has to cope with conditions which are only minor considerations at the formulation stage. In this investigation some finishes were applied in non-ideal situations, to try and assess performance under as wide a range of conditions as would be met in practice.

The exposures tested have included finishes applied to fresh timber following the recommendations of the manufacturer (see Figure 1). In this case moulded panels were used. Prior to the application of the finish the back and sides of the panels were primed and scaled with an aluminium scalant. This test was designed to provide results under conditions of application which are as close as can be expected to "ideal". Maintenance of the finishes was also carried out whenever it was judged necessary. The exposed panels were tested for gloss, colour, dirt retention, erosion, cracking, flaking, chalking, and porosity.





The next series of panels, shown in Figure 2, was applied to moulded panels again following the manufacturers recommendations. In this case one end of the panel was not primed or sealed and during exposure the unsealed end was supported on a piece of absorbent oasis. In this way the unsealed timber was open to water for long periods of time allowing water to be absorbed along the grain of the timber. Taking up water in this way, should result in changes in the dimensions of the timber leading to increased cracking of the finish applied to the timber. Measurements carried out on these exposures were cracking, flaking, erosion, and porosity.

#### Figure 2 Unsealed exposures



A further set of finishes was applied to moulded panels which had been weathered for six months (see Figure 3). Prior to the application of any finishes the backs and sides of the panels were primed and sealed. Once more the finishes were applied following the recommendations of the manufacturer. This set of exposures was intended to model the situation where either a coating fails, leaving an area of timber exposed to the elements for some time prior to repainting, or the case where fresh timber lies around a building site before being used. The tests carried out on these exposures were gloss, dirt retention, colour, cracking, erosion, flaking and chalking.

#### Figure 3 Weathered timber



The final set of exposures was applied to flat panels as single coats only, the idea being to accelerate any defects which arise due to film erosion. A photograph of this test series is shown in Figure 4. By using flat panels any problems due to poor edge build are avoided. Tests carried out on this series of exposures were cracking, erosion, flaking and porosity.

### Figure 4

Single coat exposures



In summary, four series of finishes were exposed under varying application conditions. These will be referred to as "ideal", unsealed, weathered and single coats.

Some explanation is required to describe the assessments carried out during the weathering trials.

### Gloss

Gloss measurements were made at three month intervals, on a washed area of the panels using a Byk-Mallinckrodt single head glossmeter with a  $60^{\circ}$  head attachment.

### **Dirt retention**

Dirt retention was assessed on a scale from 10 to 0 with 10 indicating no dirt visible and 0 a surface completely covered with dirt.

### Chalking

Chalking was assessed for white finishes and was rated against photographic standards given in an ASTM method. The scale employed ranges from 10 for no chalking to 0 for severe chalking.

### Cracking, flaking and erosion.

Cracking, flaking and erosion were also assessed against ASTM photographic standards. Values from 10 to 0 were assigned to each film with 10 indicating no failure and 0 severe failure.

### Colour

Colour was assessed in two ways. For white finishes the rating was made against ceramic standards, which vary from a very blue-white at a rating of 12 to a brown-white at a rating of 1. For non-white samples standards were kept unweathered for comparison. The exposed panels were compared with the internal standards and rated as being darker, slightly darker, similar, slightly lighter, or lighter than the standard, and according to these ratings assigned values from 0 to 4 respectively.

### Porosity

The reason for measuring porosity was to try and follow changes in film permeability and water uptake of the panels. Porosity was assessed using the simple technique of spraying a panel with fine water droplets and examining the pattern formed on the panel. A scale of 1 to 5 was used with 1 indicating that all of the water remained as droplets on the surface of the timber and 5 showing that the water was completely absorbed immediately after spraying.

### Laboratory testing:

To complement the above field trials, selected finishes were also subjected to various laboratory tests. These included measurement of film permeability, water uptake and release in a wetting/drying test, and assessment of flexibility using a fatigue testing machine developed by Tioxide.

### Film permeability

Film permeabilities were measured using detached films. The films were prepared by drawing down on a flat PTFE substrate using ductor blade and shims (250µm). The films were allowed to dry for 4 days before removing from the substrate and then allowed a further 3 days drying. Measurements were obtained using a Payne cup, by weighing into the cup a portion of water (20g) and then securing the film to the top of the cup using sealing wax. The film was secured with the surface exposed to air during drying facing the water during the permeability measurement. The sealed cup was placed in a desiccator over dry silica gel. At the beginning and end of each day the weight of the cup, film and water was recorded. From this data the weight loss per unit time was calculated. Upon completion of the test the film thickness was measured and the permeability expressed in units of (mg.mm)/(cm<sup>2</sup>.day). Expressing the permeabilities in this format allows the results to be expressed with allowance made for differences in film thickness.

#### Spray cabinet testing

Water uptake and release through a selection of films was measured using a modified salt spray cabinet. The cabinet was altered to spray fresh water, at  $25^{\circ}$ C, for a two hour period and then to circulate air at  $25^{\circ}$ C for the next twenty two hours. Each panel was weighed just before the water spray started and then two hours after spraying had stopped i.e. when the surface of the timber had been dried by the circulating air. The spray cabinet test was continued for two weeks and a plot of panel weight against exposure time gave a history of water uptake and release for each finish. Pine was used as the substrate for this test, panels six inches long being cut from four by one inch timber. In all cases the ends were primed and then sealed with an aluminium sealant. Each of the coatings tested was applied following the manufacturers recommendations.

#### Flexibility

Flexibility measurements were made using the fatigue life tester developed by Dr L. A. Simpson<sup>4</sup>. This instrument, which is shown in Figure 5, subjects a film applied to a steel shim to a series of stress cycles and measures the number of cycles required to induce cracking in the film. The idea of the instrument is that the continuous cycling of the shim models the movement of a dimensionally unstable substrate such as timber. Obviously the instrument subjects the film to a more rapid movement than occurs in the field but the results obtained give a good comparison with those given by exposure trials. To accelerate the test further and to make the conditions more realistic, the coated shims were weathered in a Marr weatherometer for a period of 500 hours prior to testing. The results obtained from the fatigue machine are plotted as the natural logarithm of the number of cycles to failure (Nf) against the natural logarithm of the dry film thickness (t).

#### Figure 5 The fatigue life tester



### **Results and discussion**

The finishes examined in this paper were obtained in one of two ways, firstly a number of manufacturers provided samples which they wanted to be included in the trials, and secondly, products which were not in the original set of finishes were obtained from DIY stores. In all, this gave a range of 72 samples (some of which were undercoats or primers) or a total of 61 finishing systems. A summary of the samples obtained is shown in Table 1. No attempt has been made to categorise these systems except into white and non-white finishes for the purposes of colour and chalk assessments. In Table 1 the finishes have also been divided into water based and solvent based categories. Interestingly, this division shows that the white finishes had a higher water based proportion than the non-whites. This is, no doubt, due to the large number of white water based acrylic systems for exterior finishing.

#### Table 1 Samples obtain

mples	obtained	

	Water based	Solvent based	Total
White	13	17	30
Non-white	5	26	31
	18	43	61

The results of exposure trials have been recorded over a two year period and in this paper the points of note arising from these trials will be highlighted. The format to be followed here will be to consider each of the tests carried out and look at the performance of particular finishes showing good and poor results. In doing this the performance of various films will be compared for application to timber in different states of repair. The first point to be reported concerns the films exposed under "ideal" conditions. After monitoring these panels for one year the changes observed in the non-white finishes suggested that it would be wise to have these panels recoated. Not all of the non-white finishes required recoating, but in order to compare them all on an equal basis, all were repainted. To allow for inconsistencies in the timber three panels were exposed for each of the non-white finishes used in the "ideal" application test. Of these three only two were repainted, leaving one panel to show what the performance would be without maintenance. Most of the measurements made show exactly the results expected, following trends exhibited by the majority of finishes exposed to natural weathering.

### Averaged performance of finishes

To give an overall impression of the exterior exposure results an average for the various coating types and application conditions is given in Table 2. From this table it can be seen that numerical values were not assigned to cracking, erosion or flaking until after one year. The reason for this being that during the first year of exposure there was relatively little breakdown. Any film defects noted during this period were noted without assigning ratings to each of the panels. In fact most of the averages for these three tests were reasonably high when first measured, the only exceptions being the erosion results, particularly for the non-white finishes, which was primarily the reason for repainting these after one year.

### Chalking and colour

The results of the chalking and colour tests should be mentioned. Chalking was, of course, only measured for the white finishes exposed under "ideal" and weathered timber conditions and was only measured at yearly intervals. The results obtained, as can be seen from the averages shown in Table 2, were of the sort to be expected showing some increase in chalking as the exposure time is increased. Colour measurements are difficult to compare because two different scales were used for white and non-white samples. In the case of the white samples, under both exposure conditions, a gradual yellowing of the colour was observed. The non-white samples do not show any obvious trends, on average they appear to be becoming darker but, in the case of finishes

### Table 2 Averaged results for all panels exposed

						E	posu	re ti	me (mo	nths	)		
Test	Exposure	Repainted	Colour	0	3	6	9	12	13 1	6	19	22	25
Chalk	'Ideal'		white					9.16					7.63
Chalk	Weathered		white					9.87					7.72
Colour	'Ideal'		white	9.36	8.29	8.24	8.23	8.97	8.5	5 8.	52	8.14	8.08
Colour	'Ideal'	12 months	non-white	2.41	2.10	2.13	2.05	2.14	1.18 1.0	03 0.	79	0.71	0.58
Colour	'Ideal'		non-white	2.07	2.11	2.18	2.07	2.07	1.00 2.2	23 1.	86	1.81	1.63
Colour N	Weathered		white	9.83	8.66	8.53	8.45	9.33	8.8	89 8.	92	8.74	8.74
Colour N	Weathered		non-white	1.23	0.74	0.83	0.76	1.09	0.2	27 0.	54	1.06	0.85
Dirt	'Ideal'		white		7.35	7.30	6.67	6.55	6.5	52 6.	50	6.43	6.57
Dirt	'Ideal'	12 months	non-white		10.0	10.0	10.0	10.0	10	.0 10	0.0	10.0	10.0
Dirt	'Ideal'		non-white		10.0	10.0	10.0	10.0	10	.0 10	.0	10.0	10.0
Dirt V	Weathered		white		7.34	7.55	7.38	7.22	7.0	8 7.	24	7.08	7.09
Dirt N	Weathered		non-white		10.0	10.0	10.0	10.0	9.9	95 9.	95	9.95	9.95
Gloss	'Ideal'		white	69.1	65.8	62.2	60.6	57.9	52	.4 49	.0	47.8	47.1
Gloss	"ideal"	12 months	non-white	14.0	9.9	9.9	9.6	8.1	15.2 11	.2 11	.0	10.6	9.3
Gloss	"Ideal"		non-white	13.4	10.0	9.3	9.6	8.2	7.	3 6.	.7	6.1	5.5
Gloss	Weathered		white	57.8	56.6	54.5	53.0	48.3	42	.4 42	.0	40.4	36.7
Gloss	Weathered		non-white	16.4	12.5	12.6	12.7	11.9	10	.4 11	.5	9.9	8.5
Flaking	'Ideal'		white						10	.0 9.	98	9.98	9.98
Flaking	'ideal'	12 months	non-white						10	.0 9.	83	9.59	9.45
Flaking	"Ideal"		non-white						9.4	13 7.	52	6.77	6.57
Flaking	Unsealed		white						9.1	95 9.	43	8.71	8.69
Flaking	Unsealed		non-white						9.	11 7.	95	7.05	6.84
Flaking	Weathered		white						10	.0 9.	95	9.75	9.50
Flaking	Weathered		non-white						9.3	84 7.	76	7.20	6.73
Flaking	Sgl coat		white						10	.0 9.	93	9.87	9.79
Flaking	Sgl coat		non-white						9.0	88 8.	58	8.21	7.96
Cracking	'Ideal'		white						9.9	97 9.	93	9.84	9.81
Cracking	'Ideal'	12 months	non-white						9.1	95 9.	84	8.68	8.72
Cracking	'Ideal'		non-white						9.9	91 9.	86	8.41	8.32
Cracking	Unsealed		white						9.9	90 9.	67	8.69	8.52
Cracking	Unsealed		non-white						9.6	55 9.	50	7.92	7.66
Cracking	Weathered		white						10	.0 10	0.0	9.28	9.04
Cracking	Weathered		non-white						9.8	88 10	0.0	8.04	7.90
Cracking	Sgl coat		white						9.9	98 9.	93	9.45	9.34
Cracking	Sgl coat		non-white						9.0	67 9.	34	7.38	7.44
Porosity	"Ideal"		white	1.02	1.00	1.00	1.02	1.06	1.0	09 1.	17	1.34	1.20
Porosity	ldeal	12 months	non-white	1.07	1.07	1.05	3.48	3.40	1.02 1.0	00 1.	41	2.16	3.19
Porosity	'ideal'		non-white	1.07	1.07	1.00	3.70	3.25	3.4	13 3.	95	4.20	4.39
Porosity	Unsealed		white	1.00	1.00	1.00	1.02	1.33	1.	10 1.	14	1.36	2.14
Porosity	Unsealed		non-white	1.00	1.00	1.11	1.79	1.87	1.7	4 2.	37	2.61	3.42
Porosity	Sgl coat		white	1.04	1.02	1.24	1.32	1.34	1.8	94 1.	73	1.86	2.12
Forosity	Sgi coat		non-white	1.06	1.04	2.00	3.40	3.61	4.	2 4.	48	4.66	4.64
Erosion	Ideal	10	white						9.1	3 9.	81	9.78	9.78
Erosion	'ideal'	12 months	non-white						9.8	3 9. 	45	0.80	0.76
Erosion	lineeriad		white						7.5		40	0.18	0.14
Erosion	Unsealed		white						8.9		19	0.21	8.12
Erosion	Weathersd		non-white						8.4	0 7.	34	7.05	0.89
Erosion	Weathered		white						9.7	0 9.	33	0.42	0.43
Erosion	Sal cost		white						8.8	. a.	< 4 0.0	1.19	9.00
Erosion	Saloost		wille						0.5	0 0.		0.30	0.29
Erosion	Sgi coat		non-white			_			1.1	3 7.	43	0.90	0.70

applied to weathered timber, there is the possibility that the colour has become as dark as it will get and is starting to go lighter. The finishes applied to panels under "ideal" conditions, not surprisingly, show a strong darkening effect after being repainted.

### Dirt

The most striking difference found in the averaged results table is in the dirt retention values. The non-white samples have shown very little in the way of dirt pick-up, in contrast to the white finishes, which, after only three months were showing the presence of dirt. This was to be expected but it does highlight one of the main advantages of non-white finishes, and one that is worth bearing in mind when considering finishes for areas that are difficult to clean.

#### Gloss

Gloss measurements were also limited to finishes applied to "ideal" and weathered timber. Once again the averages shown in Table 2 show the results to be much as one would expect. In this case the non-white finishes which have predominantly low gloss maintain a fairly steady value throughout the tests. The white finishes on the other hand are mostly glossy initially, and show a significant drop in gloss over the two year exposure period. Comparison between the white finishes applied to "ideal" and weathered timber reveals that the weathered timber application tends to give reduced gloss. However, after two years weathering there is relatively little difference between the glosses of coatings applied to "ideal" or weathered timber. The results discussed here are, of course, only dealing with average performances and within each set of exposures there will be finishes which have performed very well and, similarly, those which have performed very badly. Before dealing in detail with particular finishes, the remaining averaged results should be considered.

### Porosity

The averaged porosity results reveal a significant difference between the white and non-white finishes. In each series exposed the non-white panels gave higher porosity ratings than the whites. After twelve months exposure the non-white finishes applied to "ideal" timber showed a large increase in porosity, after repainting the porosity was reduced, but after another year of exposure the porosity rating had again increased. The highest porosity ratings for both white and non-white finishes was given by the single coated panels, but even here the non-whites were much higher than the whites. The best result for the non-white finishes was given over unsealed timber, where the porosity was probably reduced because of increased water uptake through the unsealed end of the timber.

#### Erosion

The erosion results again show the white finishes to give a better average performance in all of the exposure series. The most interesting results here are those obtained for the non-whites at sixteen months for finishes applied to "ideal" timber. These show considerable erosion, as they had done at twelve months when it was decided to recoat two of the three panels on exposure. After recoating the erosion values improved, but by two years, breakdown is again apparent. One unexpected result was the erosion results for non-white finishes applied to "ideal" timber which gave more erosion than the finishes applied in other test series. There are two possible explanations for this obvious anomaly, firstly after repainting there is only one test panel for each of the non-maintained non-white finishes and, secondly the number of finishes exposed in the unsealed and weathered timber series was less than those in the "ideal" series. Both of these factors would be capable of shifting the averaged values to give an anomalous result. Surprisingly the single coat applications do not give the poorest results for the white or non-white finishes. This is most likely due to the use of flat panels, as erosion was mostly found around the moulded edges of panels in other exposure series. For the white finishes the poorest result was obtained under "ideal" conditions, with the next poorest result being given by the single coated flat panels.

### Flaking

In many ways the flaking results follow the trends set by the erosion results, but in this case there was less difference between white and non-white "ideal" panels after twelve months. However, after another year of weathering there was a significant difference between the maintained and nonmaintained non-white panels. Again the final average for the non-maintained non-white finishes appears anomalously low, and the same reasoning as applied to the erosion results must be used here. Once again the single coated panels are giving better results than would have been expected and this must be due to the absence of moulded edges. For the white panels the poorest result is given over unsealed timber. The non-white finishes give poor results over "ideal", unsealed and weathered timber. The generally poor results given by the unsealed timber are probably due to the higher water content of the timber resulting in lower adhesion.

### Cracking

The averaged cracking results show practically no failure after sixteen months exposure, but after two years breakdown of the finishes has begun. White finishes applied under "ideal" conditions show an advantage over non-whites. Also, the maintenance work carried out at twelve months appears to have made little difference to the crack ratings for the non-white panels. The results obtained under the other exposure conditions show the same trend with white finishes giving less cracking than the non-whites. The worst result for the white finishes was given by the unsealed panels, this is as expected with the ingress of water leading to expansion of the timber which many of the finish may be unable to follow. In the case of the non-white finishes the single coated flat panels gave the poorest results, this was not expected but suggests that with thin coats the water uptake through the film may be increased. This may be more of a problem with the non-whites as they generally are of lower build than the white finishes.

### Selected performance of finishes

Having summarised the overall results of the exposure tests by way of looking at averaged performances, it is now appropriate to look at the performance of selected finishes. The results which will be considered here are gloss, erosion, flaking, porosity and cracking.

### Gloss

Gloss results are commonly used in the assessment of white gloss paints, in the context of wood finishes this measurement is probably less common because of the generally lower gloss values of wood finishes. Some of the samples used in the exposure trials were however reasonably glossy and so such a measurement seemed appropriate for all finishes. The gloss results shown here are taken from finishes applied to "ideal" panels. Figure 6 shows gloss results for high gloss samples with good gloss retention, these results were obtained from white finishes. In Figure 7 examples of finishes with high initial glosses but poor gloss retention are shown, this figure shows the performance of one of the glossier non-white finishes (NW7). Also shown in Figure 7 is the effect of repainting after one year of exposure. Immediately after repainting a high gloss finish results, but after another year of weathering the gloss has fallen back to a value similar to that given before repainting.

### Figure 6



### **Erosion and flaking**

The results given in erosion and flaking tests followed similar patterns and so both of these will be discussed together. To give an idea of the spread of results obtained the erosion and flaking results of four finishes will be examined. Two of these finishes were white and will be designated W1 and W2 the others being non-white will be referred to as NW1 and NW2. These finishes were chosen because they gave a wide variation in the results given for erosion and flaking tests. The results obtained after two years exposure are shown in Table 3 and show that the best non-white finishes (e.g. NW1) gave as good a performance as a good white finish (W1). However, NW2 falls considerably below the performance given by W2. The results in brackets for "ideal" exposures show the ratings for panels which were repainted after one year of weathering. These results show that, even for finishes giving a poorer performance, if the correct maintenance schedule is followed good erosion and flaking resistance can be achieved. Another point to note from this table is the poorer erosion resistance of W1 when tested as a single coat. This is most likely due to the absence of two coats of undercoat in the single coat test and consequently any erosion of the finish coat will be more readily observed.

### Table 3

### Erosion and flaking results after 2 years exposure

TEST RESULTS									
Finish	NW1 Erosion Flake		NW2 Erosion Flake		W1 Erosion Flake		W2 Erosion Flake		
Exposure type "Ideal"	10(10)	10(10)	4(9)	4(10)	10	10	10	10	
Unsealed	10	10	5	6	9	10	8	8	
Weathered	9	9	4	5	9	10	7	10	
Single coat	10	10	7	8	8	10	8	10	

10 - no failure 0 - severe failure

### Porosity

The porosity results showed a clear difference between white and non-white finishes. In general the non-white finishes gave high porosity ratings but there was a few samples which gave similar porosity ratings to the white finishes. In the same way there was a small number of white finishes gave high porosity ratings but there were a few with the overall trend shown for white finishes. As examples of these finishes NW1, NW2, W1 and W2 will again be used. After two years of weathering the results shown in Table 4 were obtained. The trends shown by these results are the same as those given by the erosion and flaking tests. The best non-white finishes give an equivalent performance to a good white finish, and with regular maintenance a poorer finish can give a performance similar to that of a typical white finish. If no maintenance is carried out on the poorer non-white finishes their porosity ratings soon become inferior to those of the average whites.

### Table 4

Porosity results after 2 years exposure

Finish	NW1	NW2	<b>W</b> 1	W2	
Exposure type					
"Ideal"	1(1)	5(1)	1	2	
Unsealed	2	3	2	3	
Single coat	3	5	2	3	

1 = non-porous 5 = highly porous

#### Cracking

The averaged cracking results again showed the white finishes to have an advantage over the non-whites, this is also clear upon examination of the results for individual finishes. As a comparison of performance the samples NW1, NW2, NW3, W1, W2 and W3 have been used, the crack ratings following two years of exposure, being shown in Table 5. As in the previous tests this table shows that similar performances are found between the best white and non-white finishes when applied under "ideal" conditions, although in the example shown here there is some difference on unsealed and weathered timber. Poorer non-white finishes appear more prone to cracking than the poorer white finishes, although regular maintenance will give improved performance. NW3 and W3 are water based and have been included here to show the relatively good crack resistance given by such finishes.

#### Table 5

Cracking results after 2 years exposure

	CRACK RATINGS								
Finish	NW1	NW2	NW3	W1	W2	WЗ			
Exposure type									
"Ideal"	10	9	10	10	9	10			
Unsealed	8	7	7	10	7	10			
Weathered	7	6	9	10	9	10			
Single coat	10	7	10	10	10	8			

10 - no cracking 0 - severe cracking

#### Laboratory testing:

In addition to the above exposure results a number of laboratory tests have been used to examine various finishes. The intention of the laboratory tests was to obtain data on the finishes which could be compared with natural weathering results. The tests employed were compared with porosity and cracking results. The results from the permeability and spray cabinet tests being compared with porosity results, and the flexibility tests with crack ratings.

### Permeability and spray cabinet testing

A number of results from the spray cabinet test are shown in Figures 8 and 9. Plots such as these give information on water release as well as water uptake, but for the purpose of this work only the total water uptake over the two week period will be considered. A summary of porosity ratings, spray cabinet and permeability results is given in Table 6. The porosity results shown in Table 6 are those obtained after two years exposure for finishes applied to "ideal" timber. The finishes tested in the spray cabinet were all freshly applied and had not been weathered and all gave porosity ratings of 1.

### Table 6

Porosity, permeability and spray results

Finish	NW1	NW2	NW3	W1	W2	WЗ
Porosity rating 2 years "Ideal"	1(1)	5(1)	1(1)	ï	2	1
Water uptake (g)	3.1	3.5	5.3	2.1	4.3	4.6
Film thickness (µm)	150	100	150	210	120	165
Permeability (g.µm)/(cm².day)	0.24	0.14	2.14	0.26	0.18	1.90

The table shows only a selection of results, but to give an indication of the range of water uptakes, a minimum of 2.1g and a maximum of 7.8g was found. The results obtained were spread evenly throughout this range with white and non-white samples producing similar results. The film permeability results were spread over a range from 0.11 to 4.10 (mg.mm)/ ( $cm^2.day$ ) with both white and non-white finishes giving similar results. The permeability results reflect more accurately the paint medium with solvent based paints falling in the range 0.11 to 0.61 (mg.mm)/( $cm^2.day$ ), whilst water

based systems gave values from 0.63 to 4.10 (mg.mm)/ (cm<sup>2</sup>.day). Two of the finishes shown in Table 6 W3 and NW3 are water based and it is significant that these have the highest water uptakes in the series. From these results there does appear to be a relation between film permeability and water uptake, at least for finishes which show large differences in permeability. For finishes which have similar permeabilities the relation between water uptake and permeability does not appear to hold. In such cases it is likely that film build plays an important role. The film thicknesses shown in Table 6 were obtained from the permeability measurements, these values give an idea of the film build for each of the finishes and so one would expect W1 to have the highest film build of this series. When these relative film thicknesses are taken into account it helps to explain the apparent discrepancies between water uptake and permeability values. In the case of W1 and W3 the situation is further complicated by the use of two coats of undercoat with each finish. However, this only emphasises the effect of increased film thickness reducing the water uptake and helps explain why W1 gives such a low value and also why W3 gives only a slightly greater water uptake than W2 despite large differences in permeability. Comparing NW1 and NW2, film thickness again appears to have an influence on the relation between permeability and water uptake and so despite the higher permeability of NW1 the higher build results in a lower water uptake. Having established a tenuous relationship between the two laboratory tests there appears to be little correlation between these and the porosity ratings. Following the above discussion on the effect of film build, the test most likely to show any relation to porosity will be the spray cabinet test as this tests the finishes applied in the same way as used for exterior exposures. However, there appears to be little relation between the porosity results and either of the laboratory tests. Porosity measurements on the panels used for the spray cabinet test all gave ratings of 1, and perhaps a better test would have been to weather the test panels for some time prior to using the spray cabinet. To do this however, gets away from the object of carrying out a laboratory test to give an indication of what could be expected during weathering. An alternative approach of weighing the exposed panels was considered but was thought to be impractical, because each finish exposed would have to go on a separate panel which would prevent the use of controls to check on the consistency of the timber.

### Figure 8

Spray cabinet results - white finishes



### Flexibility

The flexibility of a series of finishes was tested using a fatigue testing machine. A selection of the results given by the test are shown in the next two figures. Figure 10 shows the results obtained for W1, W2 and W3. Figure 11 gives the results for NW1, NW2 and NW3. The fatigue life plots are

logarithmic graphs of the number of cycles to fracture against the film thickness. Flexible paints will appear high on the chart with low gradients i.e a large number of cycles will be required to induce fracture and the influence of film thickness will be reduced. Films of lower flexibility will appear lower on the chart with steeper slopes. In Figure 10 W2 clearly gives a poorer result than W1 and W3. Overall W3 appears to be the best of the three examples having a lower slope and a high number of cycles to fracture. This is generally in agreement with the cracking results shown in Table 5. The results shown in Figure 11 also give good agreement with Table 5, picking NW3 out as the best and NW2 as the poorest of the series. In Figures 10 and 11 both of the water based finishes W3 and NW3 showed good crack resistance. Figure 12 shows further results for water based white finishes comparing W3 with W4 and W5. From the graph W4 gives a similar result to W3 and **Figure 9** 





Figure 10

Fatigue test results - white finishes



Figure 11 Fatigue test results – non-white finishes



this result was typical of that found for water based white finishes, but not all were the same as shown by W5. Table 7 shows the crack ratings of these finishes and again a good comparison is found between the fatigue test results and the exposure data. Figures 13 and 14 show fatigue test results for solvent based finishes with Figure 14 showing two finishes which gave poor crack resistance. The results given in these figures can be compared with weathering results given in Table 8. In Figure 13 the order of performance is clearly NW4 is best with NW5 poorest, which once again agrees with the **Table 7** 

Cracking in water-based fin	ishes after 2 years exposure
-----------------------------	------------------------------

	CRACK RATIN	GS
WЗ	W4	W5
10	10	10
10	9	8
10	10	9
8	8	7
	W3 10 10 10 8	CRACK RATIN W3 W4 10 10 10 9 10 10 8 8

10 = no cracking 0 = severe cracking

exposure results. A comparison of the fatigue plots for NW1 and NW5 shows both to have very similar slopes. When the exposure results are compared NW1 is found to have given a much better result, thus emphasising the importance of height on the fatigue life graph. In Figure 14 the result for NW7 is clearly poor as it falls low on the chart, but also significant here is that the intercept values for NW6 and NW7 are lower than those given by any other films tested and indicate that

### Figure 12

Fatigue test results - water-based finishes



Figure 13

Fatigue test results - solvent-based finishes



for the thinnest films failures are occurring at around 25,000 cycles. This is very low indeed with most films tested at this

thickness lasting 100,000 cycles without failure at which point the test was terminated. If this factor was not taken into account the NW6 fatigue test result would appear to be good, it is therefore important that care is taken in the interpretation of such measurements. Examination of Table 8 shows that as in the fatigue test NW7 gave poor results in exposure trials. NW6 gave much better results than NW7 as one would expect from Figure 14. The results obtained from the fatigue test equipment have shown good correlation with the results given by the exposure trials.

### Table 8

Cracking in solvent	-based	finishes	after	2	years	ex	posure
---------------------	--------	----------	-------	---	-------	----	--------

NUMBER OF TRANSPORTED AND ADDRESS OF TAXABLE ADDRESS		and the second sec								
	CRACK RATINGS									
Finish	NW1	NW4	NW5	NW6	NW7					
Exposure type		lenile more								
"Ideal"	10	10	7	8	2					
Unsealed	8	10	7	7	0					
Weathered	7	9	7	6	4					
Single coat	10	8	9	з	0					

10 • no cracking 0 • severe cracking

#### Figure 14



### Conclusion

The results of field tests have shown little difference between modern wood finishes and traditional systems. At present the exposure trials are only two years old and as time passes some of the advantages claimed for the new systems may become apparent. For example although there are no current signs of failure in the traditional systems a time may come when catastrophic failure occurs which will require stripping back to bare wood before repainting. However some of the non-white finishes have already been repainted because of erosion, particularly in the region of moulded edges. With such finishes erosion is to be expected and it has to be decided when repainting is necessary, it may be that the test panels have been assessed too critically and repainted before it was absolutely necessary. The decision to repaint was also influenced by the results of the porosity tests which showed that as erosion progressed the films became increasingly porous. Even though repainting was carried out one of the three panels was left without any maintenance and this will be used to give some indication of how long these finishes will last before complete failure. In some cases where maintenance was not carried out discolouration of the timber is already visible. Where flat panels are to be used or sharp edges can be avoided the problem of erosion will be less troublesome. One of the principal advantages shown by the non-white finishes was the reduced dirt retention values and this is worth bearing in mind when painting areas which are likely to pick up dirt.

Laboratory testing of the finishes concentrated on permeability and flexibility. The results of the spray cabinet and permeability tests bore little relation to the porosity values measured during exposure trials. However, some relation was observed between the permeability and water uptake results, especially when film thickness was taken into account. The results of permeability measurements did not suggest that finishes which were labelled microporous etc. were any more permeable than others. In fact finishes with such labels were found to have permeabilities which ranged over almost the full range of permeabilities measured. ranging from 0.14 to 4.10 (mg.mm)/(cm<sup>2</sup>.day). The best indicator of film permeability was whether the finish was water or solvent based. The water based finishes were found to have permeabilities which were about ten times those of solvent based finishes.

The fatigue test machine proved very useful in the prediction of crack resistance. Measurements on water based and solvent based white and non-white finishes all gave good correlation with the results of field tests.

### Acknowledgements

The authors acknowledge the permission of the directors of Tioxide Group PLC to present this paper and wish to thank Mr E. Boon, Mr I. Bullock, and Miss P. Taylor for their work on this project.

### References

- Miller, E. R. and Boxall, J., *Hols als Roh und Werkstoff*, 1984, **42**, 27.
- 2. Boxall, J., JOCCA, 1984, 67, (2), 40.
- 3. Kleive, K., JCT, 1984, 58, 740, 39.
- 4. Rutherford, D. J. and Simpson, L. A., PPCJ, 1987, 177, 653.

Christian, continued from p.446

### Summary

Aqueous dispersions used to make up environmentally acceptable wood coatings are gaining steadily in market importance. Aqueous parquet varnishes in particular, based on acrylate/polyurethane dispersions, have already been introduced in a number of European countries.

In the development of wood stains and glazing varnishes, new perspectives are certain to be opened up in the form of dispersions with high block stability. Particularly as these dispersions also stand out because of their repairability, be this in the form of the trouble free sanding they permit or the good subsequent adhesion they afford — even on varnish bases which have received no prior treatment.

Paper presented at the 1988 Symposium of the Materials Knowledge Society, Amsterdam, Netherlands.

Affrossman et al., continued from p.453

- 5. Cochrane, J. and Harrison G., J. Phys. E., 1972, 5, 47.
- 6. Pethrick, R. A., Jacobsen, F. M., Mogensen, O. E. and Eldrup, M., J. C. S. Faraday II, 1980, 76, 225.
- Ferry, J. D., "Viscoselastic Properites of Polymers" 3rd Ed., chap 5D., J. Wiley, New York 1980.

### Polymethacrylate dispersions for wood preservation: Their manufacture, application and characteristics

H. D. Christian, Degussa AG, Industrial and Fine Chemicals Division, Applied Research and Technical Services Dept. – Organic Chemicals, 6450 Hanau-Wolfgang, Federal Republic of Germany

### 1. Introduction

**D**ispersions for paints have been manufactured on a major scale for over 40 years and are currently used in the Federal Republic of Germany as binding agents for more than one third of all paints, varnishes and similar products. Other highly significant areas of application for dispersions are textile finishing, paper making and coating as well as the formulation of dispersion adhesives. There are also numerous other, smaller areas of application.

Aqueous plastic dispersions have the following advantages over binding agents containing solvents:

□ they are odourless and physiologically unobjectionable,

□ they do not give rise to ventilation problems, since there is

no solvent evaporation during film formation,

□ they are neither flammable nor explosive,

□ they can be diluted in water,

□ the necessary equipment/utensils are cleaned in water,

□ dispersions are manufactured by an emulsion polymerisation process which is simple and inexpensive.

Its constituent monomers: styrene, vinyl ether, vinyl chloride, vinyl ester, ethylene, butadiene, ethyl acrylate and methyl acrylate are used either on their own or in most cases mixed together.

Pure acrylate dispersions consist wholly of methacrylic and acrylic acid derivatives. They are notable for their

□ High chemical resistance (weather resistance and high resistance to alkali),

□ excellent fastness to light (no yellowing),

 $\Box$  good mechanical characteristics (high resistance to abrasion).

□ low water absorption, yet high water vapour permeability,

□ extremely low CO<sub>2</sub> permeability.

Pure acrylate dispersions are therefore ideal for use in areas where properties such as high resistance to alkali, little tendency to yellowing and high waterproofing are required. Their main areas of application until now have been:

□ building protection (external and internal paints, synthetic resin bonded plasters, coloured stone finishes),

□ concrete protection,

□ glazing varnishes,

wood stains and parquet varnishes.

Their use in the production of corrosion protecting paints, plastic paints and paper coatings is gaining steadily in importance.

### 2. Chemical composition of dispersions

The properties of a dispersion are to a large extent determined by the structure of its monomers, the auxiliary material system and physical factors such as solids content, viscosity, particle size and distribution.

### 2.1 Monomer structure

By combining hardening methacrylates such a methyl methacrylate (MMA) with plasticising acrylates, usually nbutyl acrylate, it is possible to vary the

□ MFT value (minimum film-forming temperature),

 $\Box$  elasticity.

 $\Box$  hardness.

 $\Box$  and adhesiveness,

#### of the films.

These factors are all interdependent. In general, raising the MFT value, for example by adding more MMA, will bring about a reduction in elasticity and adhesiveness.

By using smaller quantities of other acrylates, it is possible to produce pure acrylate dispersions as required. By adding hydrophilic monomers (such as methacrylic acid) for example, it is possible to influence rheology. waterproofing, pigment wetting and adhesion on a variety of bases. By adding the appropriate comonomer, dispersions can be made to dissolve in solvents. Difunctional monomers (e.g. butanediol-dimethacrylate) permit cross-linking and lead to insoluble, harder films.

Dispersions can also be polymerised by a multi-stage procedure, resulting in polymers which are very different in terms of their physical and painting properties than current dispersions manufactured according to conventional procedures.

In this way, it is possible to manufacture, among other things, core/shell polymers which, for example, exhibit a high degree of block stability at low film-forming temperatures.

#### 2.2 Auxiliary material systems

Dispersion are heterogeneous systems and have a tendency to coagulate. This is prevented by the use of auxiliary material systems such as emulsifiers or protective colloids. Emulsifiers are molecules with both hydrophilic and hydrophobic properties.

There are three known types of emulsifier, namely the anionic, non-ionic and cationic emulsifiers. In general, polymer chemists tend to use non-ionic or anionic emulsifiers. also of importance are cellulose ether protective colloids, for example hydroxyethyl cellulose, carboxymethyl cellulose, and polymer mixtures such as carboxymethyl hydroxyethyl cellulose.

From the above range of auxiliary materials, it is possible to influence the following properties of dispersions:

particle size, shear strength, solid content, electrolyte stability, pigment compatibility, pigment wetting, adhesion, waterproofing and viscosity.

The additives represent 2-10% of the final mixture.

Since dispersions differ widely from systems containing solvent, it is necessary to explain at this point the most important terms used to describe them.

### 2.3 Particle size

The particle size of dispersions ranges between 0.04 and 0.20 $\mu$ m, and therefore lies between that of pure solutions (0.01 $\mu$ m) and that of suspensions (>1 $\mu$ m). Particle size is usually given as an average value. Of the properties governing its application, particle size distribution is of particular interest. It can be varied by way of the manufacturing procedure, and has a decisive influence on the quality of film formation.

### 2.4 Film formation

The process by which dispersion films form is completely different from that in the case of conventional solvent-based paints. As the dispersing water evaporates, the dispersion becomes more concentrated, producing capillary forces which compact and deform the polymer particles so that they are packed densely when the film eventually dries.

At the contact surfaces of the spheres, the auxiliary materials enveloping the polymer particles are either absorbed by force into the polymers or the remaining gaps. The particle reflux and form a homogeneous mass. However, when viewed under an electron microscope it can be seen that the particles still retain their original structure. The particles will only "fuse together" provided the temperature is well in excess of the film's MFT value.

The more evenly the individual polymer particles fuse together, the better the quality of the dispersion films. Dispersions with smaller particle sizes ranging from 0.06-0.08µm tend to exhibit a higher degree of packing.

As already mentioned briefly in the discussion on monomers, the MFT value can be set by using an appropriate combination of hardening and softening monomers. Another possibility is to add temporary external softeners, so-called auxiliary film-binding agents. These usually take the form of organic solvents, and are added to the dispersions. The auxiliary film-binding agent evaporates, leaving the film hardened as appropriate.

### 3. Areas of application

### 3.1 Wood varnishes

Aqueous wood and furniture varnishes have now been in use by industry for almost a decade. Since their introduction. systems of this type have been subject to continuous further development and optimization. However, a real breakthrough has not yet been achieved in the furniture industry. Only during the past 2 years have positive trends began to develop, in particular with regard to Acid curable paints which give off formaldehyde, as well as the new German Clean Air Order (TA-Luft).

Aqueous wood paints already represent a qualitative alternative to nitro-cellulose paints. Acrylate and/or polyurethane dispersions form the basis of this paint system (Table 1).

In the Federal Republic of Germany, product testing institutions such as the "Stiftung Warentest" are also partly responsible for the fact that aqueous wood stains, parquet and glazing varnishes are becoming available, at least in DIY.

### Table 1

Comparison of the properties of aqueous paints with those of conventional systems

	Hardness and scratch resistance	Resistance to abrasion	Chemical load
Aqueous acrylate	Moderate to good	Good	C-B
Aqueous polyurethane	Good	Very good	C-B
Nitro-cellulose			
varnish	Moderate	Moderate	D-C
Acid curing varnish	Good to very good	Good	В
Polyurethane varnish	Good	Very good	В

Aqueous parquet varnishes in particular are gaining steadily in market importance. In practice, varnishes of this type are manufactured on the basis of acrylate/polyurethane dispersions (Formulation 1). Extensive tests carried out by our Applied Research and Technical Services Department have shown that pure acrylate dispersions with high filmforming temperatures or a high MMA content do not necessarily lead to the manufacturer of highly wear resistant parquet varnishes. As already mentioned, here too particle size and distribution as well as the correct binding agent matrix, among other things, are decisive for the quality of the varnish and its resistance to wear.

### Formulation 1

Provisional suggested formulation for an aqueous parquet varnish based on Degalex® VP-EM 174

	Ĩ	Parts by weight
1. Degalex <sup>®</sup> VP-EM 174		700.0
2. Flatting agent TS 100, 10% aqueous paste		200.0
3. Agitan® E 255 or Foamex® 805	defoamer	0.5
4. Water		39.0
5. Acticid <sup>®</sup> EP, paste	preservative	1.5
6. Propylene glycol		10.0
7. Tafigel <sup>®</sup> VP PUR 40,	polyurethane thick	. 4.0
8. Lanco <sup>®</sup> Glidd PMW	wax emulsion	40.0
<ol> <li>Tego Glide<sup>®</sup> 100, 50% in methoxy butanol</li> </ol>	slip additive	5.0
		1000.0

Solid content : app. 31% Viscosity (Haake VT 180) : app. 650 mPas

Preparation : mix item 2 with water to form paste, disperse in item 1, and stir into mix made up of items 3-9.

- Application : spraying on rolling out - depending on viscosity pouring out -
- Test data : Resistant to chemicals acc. to DIN 68861, Part 1 C Abrasion loss app. 30mg after 1000 revolutions of Taber Tester (CS 10, 500g)

Suppliers:

- Item 1/2 Degussa AG, Frankfurt
  - 3 Münzing Chemie, Heilbronn or Tego Chemie, Essen
    - 5 Thor Chemie, Spever
    - 6 Hoechst AG, Frankfurt
    - Münzing Chemie, Heilbronn 7
    - 8 Langer GmbH & Co KG, Ritterhude
  - 0 Tego Chemie, Essen

Another welcome aspect is the fact that an acrylate/polyurethane dispersion requires less organic solvent because of its special composition.

The test to determine wear resistance was carried out on an oak parquet. Three coats totalling 360g wet varnish per m<sup>2</sup> (30% solid content) were applied to it, each of these coats receiving a rub-down (using sandpaper, grade 320) after drying. Appropriate test samples were cut out of the coated parquet sections and examined after 24 hours drying, 7 day and 60 days storage at room temperature.

A Model 503 Taber Abraser with 500g contact load and Calibrase CS 10 friction rollers were used for testing. The amount of abrasion loss was determined gravimetrically by measuring the differences in weight of the individual test samples after 100, 200, 300, 500 and 1000 revolutions (Tables 2, 3).

Despite its low organic solvent content, this binding agent is outstanding because of its excellent wetting behaviour which enables open-pored coats of varnish to be applied. Flatting agent TS 100, one of a wide variety of such agents, has proven to be an ideal product for optimising resistance to abrasion.

To increase chemical stability, it is also possible to use cross-linking agents based, for example, on carbodiimide. From our own experience, however, cross-linking density and consequently resistance to chemicals cannot be compared to those achieved using aziridine cross-linking agents.

### 3.2 Wood stains

Dispersions-based aqueous wood stains have also been able to establish themselves on the market in recent years. Although they do not exhibit the same degree of penetration as stains containing solvent, and although their block stability frequently leaves a lot to be desired, the results they achieve

### Table 2Determining wear resistance

Taber Abraser CS 10, 500g	Acrylate/PU MFT acrylate 25°C	Acrylate/PU MFT acrylate 14°C	Acrylate/PU MFT acrylate 0°C	S I V	tandar barque arnishe	d t s
				Α	В	С
Abrasion loss			1			
in mg						
100 revolutions	4.7	0.9	5.7	14.6	8.1	3.5
200 revolutions	11.4	4.4	10.6	22.8	18.7	11.2
300 revolutions	16.2	5.1	15.7	31.2	26.1	14.5
500 revolutions	22.5	11.5	32.9	45.8	42.3	31.0
1000 revolutions	36.8	27.2	47.1	76.3	69.3	47.0
Chemical load acc. to DIN	C/D	С	D	С	С	С

### Table 3

Comparison of the wear resistance of aqueous systems with that of systems containing solvent

Taber Abraser CS 10, 500g	Aqueous acrylate/PU	Systems containing solvent 2K - Polyurethane	Acid curing varnish
Abrasion loss			
in mg			
100 revolutions	0.9	6.0	1.1
200 revolutions	4.4	7.2	2.5
300 revolutions	5.1	8.6	4.4
500 revolutions	11.5	11.4	9.5
1000 revolutions	27.2	23.3	22.8
Chemical load acc. to DIN 68861, Part 1	С	В	В

in weathering tests, as the following slides show, are very For respectable.

Åfter only 500 hours of QUV weathering in 4-hour cycles of UV radiation/condensation, the colour and quality of the wood stains containing solvent and those which can be emulsified in water deteriorated considerably. By way of comparison, although a few of the dispersion-based, aqueous wood stains exhibited a change in colour, they were otherwise unaffected.

As is widely known, acrylate resins tend to absorb very little UV light — if any at all. Consequently, in the case of weakly pigmented and in particular colourless coats of paint, the wooden base which needs to be protected from the effects of the environment becomes rapidly decomposed through exposure to UV light. This effect can be reduced to a minimum by the use of UV absorbers.

Aqueous wood stains can be made up without difficulty. For example, the suggested Formulation 2 shows they are generally composed of transparent, finely granular iron oxide pastes, as well as dispersions, rheological additives and, of course, water; if necessary, the previously mentioned UV absorbers are also added.

#### 3.3 Dispersion glazing varnishes

In recent years, pure acrylate dispersions have risen in importance in the Federal Republic of Germany in the manufacture of glazing varnishes. Consequently, production figures for dispersion paints rose from 12,974 tons in 1985 to 14,645 tons in 1986 and then to 16,430 tons in 1987.

Due to the low pigment volume concentration of paint systems of this kind, this is a predestined area of application for pure acrylate dispersions. The reason for this, as already discussed, is the outstanding resistance to weathering displayed by the binding agent which, in terms of gloss retention and elastic behaviour, outclasses conventional alkyd resin varnishes.

### Formulation 2

Provisional suggested formulation for an aqueous wood protecting stain, walnut colours based on Degalex $^{\circledast}$  VP-BF 150

		Parts by weight
1. Degalex <sup>®</sup> VP-BF 150		500.0
2. Agitan® E 255	defoamer	2.0
3. Luconyl <sup>®</sup> Red 2817	pigment	24.0
4. Luconyl® Black 0060	pigment	3.0
5. Tafigel <sup>®</sup> VP PUR 40	polyurethane thick	2.0
6. Mergal <sup>®</sup> KM 101 A	preservative	3.0
7. Südranol® 230	wax emulsion	18.0
8. Water		448.0
		1000.0
		1000 C

9. If necessary, Tinuvin® 1130

Preparation : Start by stirring item 1 slowly

Add items 2-8 according to numerical order.

### Suppliers:

- Item 1 Degussa AG, Frankfurt
  - 3/4 BASF AG, Ludwigshafen
  - 2/5 Münzing Chemie, Heilbronn
  - 6 Riedel de Haen AG, Seelze
  - 7 Süddeutsche Emulsionswerke GmbH, Mannheim
  - 9 Ciba-Geigy, Basel

However, even pure acrylate dispersions exhibit differences regarding their resistance to weathering for the following possible reasons:

- 1. Composition of the binding agent
- 2. Polymerisation procedure
- 3. Particle size
- 4. Polymerisation procedure

When formulating gloss paints, it is important to test the suitability of the various auxiliary material systems, in particular with respect to their glossiness, block behaviour and storage stability.

Numerous series of experiments carried out by our

company have shown that pigment wetting agents are of decisive importance to the subsequent quality of the varnish film. Tried and tested materials in this area are ammonium salts of polyacrylic acid, tertiary acetylene glycol as well as appropriate combinations of the two, and, among others, wetting agents based on nonyl phenol.

Storage stability is also influenced decisively not only by the wetting agent, but also by reheological additives such as polyurethane thickener.

In this respect, it should be ensured that the organic solvents are well balanced in order to promote, among other things, rheology, gloss, drying behaviour and block stability.

By special process of multi-stage polymerisation, it is possible to manufacture dispersions for both wood stains and glazing varnishes which are particularly outstanding because of their high block stability at low film-forming temperatures and their good elasticity.

Dispersions of this kind are destined to play a dominant part in the formulation of wood stains and gloss paints in particular.

Aqueous glazing varnishes with alkyd-resin-like properties are currently produced using pure acrylate dispersions with an MFT (min. film-forming temp.) of 18-25°C.

This in general enables block-stable paint coat systems to be produced for external use.

Since organic, temporary solvents have to be used to reduce the MFT — these still evaporate from the varnish film after several months — one runs the risk of applying brittle, hard paint coat systems which consequently have a tendency to crack.

Interesting perspectives open up for the varnish chemist in the form of acrylate dispersions which form highly blockstable varnish films despite their low film-forming temperature of 0°C, and moreover afford excellent wet adhesion.

One glance at Fomulation 3 will show that their production does not involve any special contrivances or "exotic" additives. On the basis of this, the following comparisons were drawn between it and standard, commercially available glazing varnishes with regard to the following criteria:

 $\Box$  block stability,

- □ wet adhesion,
- □ gloss,
- □ processability,
- □ weathering behaviour,
- $\Box$  repairability.

Both premature block stability and block stability at higher temperatures are still frequent major drawbacks of glazing varnishes.

Block stability is assessed at our factory as follows:

At room temperature and in normal air conditions, a  $200\mu$  wet film is spread on lenetta foil using a squeegee. After drying for 7 hours, the film is cut into sections of 5cm × 5cm, and the superimposed surface coats of varnish weighted using a 1kg stone weight over a surface area of  $20\text{cm}^2$  at  $+50^\circ\text{C}$  for one hour.

After being allowed to cool at room temperature, both films are separated by hand, and the surface coat of varnish inspected visually. After drying for 24 hours, the same block test is carried out, this time with a 2kg stone weight acting on the surface coat of varnish to be tested.

Varnish films are given grade 0 if they exhibit neither pressure points nor gloss variance. Moving down the scale, grade 5 stands for a varnish film which is either so severely blocked that the two films cannot be separated or has sustained more than 50% damage after the films have been separated.

A further important test criteria is the wet adhesion of dispersion varnishes; these are generally tested on artificially aged, unground alkyd resin bases.

#### **Formulation 3**

Provisional suggested formulation for dispersion varnishes based on  $Degalex^{(0)}$  VP-BF 150

	and a second	Parts by weight
1. Water		94.0
2. AMP	pH-stabilizer	3.0
3. Mergal <sup>®</sup> KM 101 A	preservative	1.0
4. Intrasol® NP-6	Wetting/	16.0
5. Propylene glycol	solvent	40.0
<ol><li>Methoxy butanol</li></ol>	solvent	14.0
7. Texanol <sup>®</sup>	solvent	1.0
8. Agitan <sup>®</sup> E 255	defoamer	0.6
9. Kronos® 2190	pigment	200.0
10. Trafigel <sup>®</sup> VP-PUR 40	polyurethane thickener	10.0
11. Degalex <sup>®</sup> VP-BF 150		610.0
12. Südranol® 340	wax emulsion	10.0
13. Agitan <sup>®</sup> E 255	defoamer	0.4
		1000.0

Solid content : app. 46%

Pigment volume concentration : app. 17%

Viscosity (Haake VT 180) : app. 2800 mPas

Gloss (Lange 60°) : app. 75%

(Lange 20°) : app. 48%

Preparation: Mix items 1-8, then add item 9 and stir in; next add items 10-13, stirring in slowly.

#### Suppliers:

tem	2	Angus Chemie, Ibbenbüren	
	3	Riedel de Haen, Seelze	
	4	Stockhausen GmbH, Krefeld	
	5	Rühl Chemie, Friedrichsdorf	
	6	Hoechst AG, Frankfurt	
	7	Krahn Chemie, Hamburg	
	8/10/13	Münzing Chemie, Heilbronn	
	9	NL Kronos Titan GmbH, Leverkusen	
	10	Rohm & Haas GmbH, Frankfurt	
	11	Degussa AG, Frankfurt	
	12	Süddeutsche Emulsions Chemie	

- GmbH, Mannheim-Neckarau
- Table 4

### Varnish properties

	Suggested	Standard	dispersion	paints
	formulation	Α	B	' C
Block stability	++	+	-	
Wet adhesion	+	-	+-	-
Gloss				
Lange 60°	75	75	72	70
20°	50	45	43	39
Grid test				
acc. to DIN 53151	0	3	1	1
+ adhesive tape			-	
QUV weathering	+	+	+	+-

After a cotton wad saturated in distilled water has been allowed to act on the surface of the varnish for 8 hours, the section affected is cut in a crosswise manner. After this, adhesive tape is stuck down diagonally acrosss the cut section and then peeled off violently. Dispersion varnish films whose surfaces exhibit no damage after 72 hours drying at room temperature may be regarded as sufficiently adhesive when wet (Table 4).

As mentioned previously, gloss and weathering behaviour are, among other things, dependent on the suitability of the pigment wetting agent; however, associated rheological additives such as polyurethane thickener or acrylate thickener also have a major influence on gloss and brilliance. In addition to this, so-called serum formation or creaning is influenced by the suitability of the polyurethane thickener.

# **Cracking of furniture surfaces**

by T. Sparkes, Cabinet Materials Technology Section, Furniture Industry Research Association (FIRA), Maxwell Road, Stevenage, Herts, SG1 2EW, UK

Examples of surface cracking can be seen on many items of furniture manufactured long ago and now on display in museum collections or stately homes. Even today, problems of surface cracking are reported from time to time on modern furniture manufactured from solid wood, wood veneered panels finished with clear lacquer and painted medium density fireboard (MDF). Where the cause of these problems cannot readily be identified, the supplier of the finishing or surfacing material is often called in for discussions with the furniture manufacturer. In those instances where the finish is believed to be suspect, the supplier will need to suggest an alternative finish with a high probability of overcoming the problem. Even if the finish is not at fault, the supplier should be able to identify a more likely cause in order to maintain the customer's confidence in the original finish. As FIRA has carried out several research projects concerned with surface cracking and been involved, often with finishing materials suppliers, in fault investigations, a summary of the accumulated findings on this subject would seem to be appropriate for a wood finishing issue of the Journal.

One of the first points to emerge from these investigations was that surface cracking is a complicated phenomenon caused by interactions between core materials and finish with ambient conditions both at the time of manufacture of the furniture and its subsequent use having an overriding effect on the nature of the cracking. Most cracking is in fact caused by movement of the substrate in changed ambient conditions and a failure of the finish to accommodate that movement. Whilst finishes can be formulated to have sufficient elasticity to follow the movement within the substrate, the supplier has to take note of other finish performance requirements, the need of a reasonable level of resistance to heat, spilled liquids and mechanical damage for instance. A practical finish will be a compromise between these conflicting requirements often with an additional requirement of fast drying/curing times.

#### Finishes on solid wood

FIRA recommends that solid wood for the manufacture of furniture be kiln dried to  $10\pm2\%$  for interior applications in the UK. At this level, achieved by an average relative humidity of about 50% rh appropriate to an intermittently heated interior, the moisture content of the finished items will not change sufficiently to cause any deterioration at the place of use. Exposure to extreme conditions on either side of this mean level can however result in problems.

Wood can expand by 1 to 2% across the grain if the moisture content increases from 10% to 16 or 18% at 85% rh. As an example of the effect of exposure to damp conditions, the finished on traditional beech chairs imported from Central Europe cracked during a period of extended storage in an unheated warehouse in the winter. The cracks in the lacquer followed approximately the grain direction of the underlying wood but no evidence of corresponding cracking within the wood could be seen in a high power microscopic examination. As beech, together with ramin or birch are classified (Table 1) as large movement timbers<sup>1</sup> the risk of cracking of finishes applied to these timbers is known to be high. In extreme exposure conditions, flaking of the lacquer can be expected following the initial cracking.

In another example, the clear lacquer on solid wood lipped and veneered table tops cracked over the relatively wide maple lippings during a period of storage, again in an

### Table 1

Classification of timbers in terms of across the grain movement in response to changes in moisture content.

Small	Medium	Large
Afrormosia	Ash	Beech
Agba	Elm	Birch
Douglas Fir	Keruing	Ramin
Iroko	Oak	
Mahogany	Scots Pine	
Obeche	Sapele	
Teak	Utile	
	Maple	

unheated warehouse. The lacquer on the veneer over the chipboard was free from cracking. The localised cracking developed further when the panel was stored for several months at 85% rh at FIRA.

FIRA has also been asked to examine and comment on cracks which have appeared in the paint finish over joints in two sets of solid wood kitchen doors. In both instances maple had been used. This timber is classified at the top end of the medium movement category. Some differential movement of the two pieces of wood on either side of a joint is considered to be inevitable as the wood's moisture content changes at different times of the year. A paint formulated to accommodate this highly localised movement would probably not have sufficient durability for use on kitchen doors. Experience has however indicated that polyurethane based systems have the best combination of elasticity and durability.

#### Plywood panels

The problems of cracking of finishes applied directly to plywoods manufactured from large movement beech or birch veneers are well known, but this type of cracking is of little consequence in furniture nowadays, mainly because of the substitution of these plywoods by other materials. The problem, attributed to the opening up of lathe checks in the rotary cut veneers when the finished plywood panels were exposed to dry conditions, was researched at FIRA several years ago<sup>2</sup>. One recommendation referred to the use of plywood dried down to a low moisture content before painting so that any opened cracks could be filled as part of the finishing treatment. Provided the finished panels were not subsequently exposed to even drier conditions, no further cracking would be expected. Another recommendation related to the use of a resin impregnated paper bonded to the plywood before painting to prevent any cracks originating within the surface veneer of the plywood from reaching the paint finish. Both treatments have been shown to be effective in controlled conditioning investigations.

Plywood cracking can also occur in panels which have been surfaced with a decorative veneer under certain conditions. If, for instance, the decorative veneer is bonded to the plywood with its grain parallel to the grain of the surface veneer of the plywood, any cracks developing within the plywood can easily break through the decorative veneer which has little strength across the grain to resist cracking. In theory, this type of cracking can easily be avoided by crossing the grain of the decorative veneer with the grain of the plywood but in practice, plywood core panels are often specified for reproduction furniture which may be surfaced with exotic veneers such as curl mahogany or burr walnut with no preferred grain direction.

Similar difficulties exist when using a straight grain veneer on a table top with a white line inlay separating it from a cross banded veneer running round the perimeter of the table in traditional style. The only recommendation here is to bond a flat cut veneer with no tendency to lathe checking across the grain of the plywood, before bonding the decorative veneer with its variable grain direction. Another effective preventative treatment involves the use of a special cross banding fibre underlay between the plywood surface and the decorative veneer. This material is used successfully by some UK manufacturers of reproduction furniture.

Alternatively, the plywood cracking problem can be avoided altogether by using chipboard or MDF as a core material. These materials do not have a grain direction which is responsible for the cracking problems associated mainly with temperate hardwood plywoods.

#### Wood veneered panels

The possibility of cracking of the surfaces of wood veneered plywood panels has already been noted in relation to the opening of lathe checks in an underlying plywood veneer. Surface cracking can also occur as a result of loss of moisture from the veneer itself regardless of type of core material, the cracks closely following the grain direction of the decorative veneer.

For applications in modern buildings with good heating arrangements for the winter months, FIRA normally recommends that finishes be applied when the veneered panels have a moisture content of  $10\pm 2\%$ . This requirement can be achieved by storing the veneers in moderately dry conditions before pressing and then processing the veneered panels in dry conditions. The conditions in which the furniture or components are stored immediately before finishing are particularly critical. A relative humidity not in excess of 50% rh is recommended. The relationship between relative humidity and wood moisture content is shown in Figure 1.

Cracking of the more popular straight grain veneers rarely occurs although exceptions have been noted when items have been stored in an unheated area for more than a few weeks before finishing during the autumn/winter period. Several veneer cracking problems investigated by FIRA have been attributed to exposure of furniture or veneered panels manufactured by a sub-contractor to damp conditions for several weeks while in transit to another factory where the finish is to be applied.

Cracking of the so called exotic veneers is however more common. The main difficulty here is that these veneers are brittle and, at the FIRA recommended moisture content of 10%, probably too distorted for any preparation to be carried out without severe splitting of the veneers. These brittle veneers have to be wetted to improve their handling characteristics. The excess water is then removed by "flattening" stacked veneers in a warm press. Provided a sheet of dry absorbent material is inserted in the centre of the stack to absorb excess moisture, this treatment is usually quite effective in bringing the moisture content down to the recommended level or thereabouts. The time in the press can be varied, but two hours at  $60^{\circ}$ C is thought to be adequate provided sufficient absorbent material is included within the stack in the press.

Bonding veneers with urea formaldehyde or polyvinyl acetate adhesive inevitably increases the moisture content at the surface of the panel. A medium adhesive spread of about 120g/m<sup>2</sup> is recommended subject to achieving a satisfactory bond. Having regard for the nature of exotic veneers, an upper limit of 80°C pressing temperature is considered to be desirable with a correspondingly extended pressing time to improve the wetting out of the back surface of the veneer.

After pressing, the veneered panels should be stored in relatively dry conditions to allow the moisture from the adhesive to dissipate. If the ambient conditions in the factory are not considered to be dry, FIRA recommends that completed items be stored in a special dehumidification area for a minimum of one week before finishing. With the dehumidifier controlling the atmosphere at about 40% rh, the moisture content of the panel surfaces will reduce to 8% or thereabouts. Some companies assume that storage in a swarm area is sufficient to dry out the surface but as the

### Figure 1

Moisture content of timber at various humidities (the figures for different species vary).



Relative humidity of air at 15°C (%)

moisture content of wood is related directly to relative humidity, control of relative humidity in isolation is known to be more effective and less expensive to operate. Simple dehumidifiers are available at around £450. Any cracks which develop during this drying out process can be filled at the first stage of the finishing process. Water based stains or fillers should not be used after this drying out procedure as localised swelling of the veneer in contact with water would close up the cracks.

A research investigation at FIRA using lacquered veneered chipboard blocks in different rooms in five houses with intermittent heating showed that the yearly average moisture content of finished items was 10/2%. Somewhat lower moisture contents were noted during the winter heating period but the differences were not sufficient to have any deleterious effect on the finished surfaces. Veneer cracking is mainly a problem with furniture used in buildings with 24 hour heating, large hotels, accommodation for the elderly, stores or offices. An investigation in these buildings carried out by FIRA showed that the moisture contents of lacquered veneered blocks dropped to 6-7% in January/February.

The cause of these low moisture contents can be identified by noting the effect of the increase in temperature of cold air brought in from outside on the relative humidity of the warmed inside air. Reference to the psychrometric chart in Figure 2 shows that outside air at  $0^{\circ}$ C, 80% rh will have a relative humidity of about 20% rh when heated to 20°C. The so called air conditioning systems fitted in buildings are often only concerned with the control of temperature, cooling in summer and heating in winter. Full air conditioning including control of relative humidity is not too popular at present because of the risk of contamination of the water. In industrial premises, atomised water systems can be used to increase the relative humidity in areas where sensitive processes are carried out. Several furniture factories processing large amounts of solid wood have fitted these humidifiers

#### Figure 2

Psychometric chart showing that air at 0°C 80% rh has a relative humidity of 20% rh at 20°C.



in the roof space to prevent excessive drying out of machined components as they pass through the factory.

Veneer cracking is seen to be essentially a problem resulting from the response of veneers to ambient conditions at the time of manufacture of the furniture and the conditions of exposure of the finished furniture. Contrary to some manufacturers' expectations, lacquers do not stabilise the moisture content of the underlying veneers, they merely delay the first appearance of any cracks. Whilst a more flexible lacquer will absorb some of the movement of the veneer, a lacquer with good performance in other respects cannot be expected to bridge over open cracks in the veneer.

#### Lacquer cracking

The last type of cracking to be considered can be attributed to a change in the nature of the coating as its ages. independent of substrate. Whereas plywood and veneer cracks have a preferred direction, lacquer cracks characteristically follow random directions, often curling and branching out to form a craze pattern.

A lacquer is necessarily formulated with hard resins which impart durability to the coating but this same hardness is associated with a degree of brittleness which can result in crazing. A properly formulated lacquer will include a plasticiser which will control the flexibility of the coating, thereby reducing the risk of cracking. Problems are however more likely to occur as the build of lacquer increases. The lacquer applied to a table top or sideboard top may craze within a few months while the same lacquer applied to vertical surfaces remains free from cracks. This difference in performance can be attributed to the heavier coating of the tops.

As lacquer crazing may develop over a period of many months, identification of the cause of the crazing after it has occurred may be difficult, particularly if the details of the complete finishing system are no longer available. The control of lacquer crazing is in the hand of the formulator. The cold check test, involving exposure of a lacquered panel for one hour at 60°C followed by one hour at room temperature and then one hour at  $-20^{\circ}$ C, this cycle repeated up to thirty times, uses thermal shock to identify potential weaknesses in a lacquer. The results of the cold check test do however have to be interpreted with circumspection particularly when applied to convertible systems as the nature of a coating may change during the first period at 60°C. An acid catalysed lacquer that performs well in the cold check test may craze when used by a company which does not have heat curing facilities to fully cure the lacquer. The experience of a lacquer manufacturer using well proven formulations should be used to complement the cold check test.

Problems of paint crazing on the edges and to a lesser extent on the surfaces of MDF are sometimes reported. Crazing on the edges can be caused by the swelling of the MDF as it picks up moisture from the atmosphere taking it beyond a typical level of about 6% at the time of manufacture. A more common cause however is the application of a high build of paint to ensure a satisfactory finish on the relatively porous edges of MDF. Some companies have used as many as six coats. The two pack sealers specially formulated for MDF edges have however largely overcome the problems of edge porosity and a satisfactory finish can be obtained using an appropriate sealer, followed by basecoat and topcoat.

Three types of surface cracking have been identified in this article. Cracking of finishes on plywood rarely occurs nowadays because plywood has largely been replaced by materials which do not have a grained surface. MDF in particular. The general requirement of open finishes for the *Continued on p.451* 

# The involvement of ETAFF in the development of wood finishes throughout Europe

by A. H. Rieck, D.F.C., Chairman, Sonneborn & Rieck Ltd, 91-95 Peregrine Rd, Hainault, Ilford, Essex IG6 3XH, UK

The idea of like minded family companies in Europe and Scandinavia getting together to pool their research efforts in formulating finishes for wood was brought about by BAYER Germany and BAYER, Italy, suggesting that it would be better if VERNICI MILESI in Italy and SONNEBORN & RIECK in the UK worked together on the problem of UV curing of polyester finishes instead of working separately to achieve the same result, with an obvious saving in development time.

Mr G. Milesi discussed this with Mr A. Rieck and it was decided not only to co-operate on UV curing, but to include the entire wood finish range used by the furniture industries in Europe and Scandinavia, and it was also decided to ask other family companies in the same field on the understanding that there would only be one company from each country to avoid undue competition between members, which is essential if information is to be exchanged freely.

The first meeting was arranged at the delightful villa of Mr Milesi at San Remiggio, near Pallanza, overlooking Lake Maggiore, in September 1969.

The association was named ETAFF (European Technical Association Furniture Finishes). It was decided the language to be used would be English and for this reason Mr A. Rieck was made Chairman.

The companies involved at the first meeting were:

Austria – A. & V. Frenkel Belgium – Van Galen-Van der Sande British Isles – Sonneborn & Rieck France – Bouvet Societe de Vernis Italy – Vernici Milesi Sweden – Klint Bernhardt & Co. Spain – Productos Solrac Switzerland – Gromalto A.G.

The object was to exchange technical information freely, without royalty payments and therefore to avoid technical information being used against the company supplying it. There would be only one member for each country and no export campaign would be mounted into another member's country, although exports could take place with prior agreement of the other member. At the time of formation there was no competition between the members, but this did change as time went on, which put a strain on the Association.

It was agreed that there would be regular management meetings and meetings of the paint technicians taking place in each country in rotation.

Rotation projects were to be decided on and commercial co-operation developed on the purchase of raw materials.

It was hoped to eventually set up a separate research laboratory contributed to by all the members. This in fact was never achieved.

At the next meeting in France in 1970, it was decided to invite ARTI-WERK JANSEN of Germany to join, making the membership to nine.

At the London meeting in 1970 it was decided to take out a joint licence agreement with RELIANCE UNIVERSAL INC, Louisville, USA, for their total range of finishes, including resins. RELIANCE are one of the largest producers of wood finishes in the USA and with this

agreement the very different technology of the States was added to that of Europe.

In 1973 it was decided to extend the operation of ETAFF to include the offering of licence agreements for the technical know-how accumulated by the members to paint companies outside Europe, and the first to sign up was PINTURAS MONTANA of Venezuela, to be followed by ELVOLAC of South Africa.

SOLRAC of Spain resigned as a member and the vacant membership for Spain was filled in 1977 by Industrias Quimicas Nabersa, and in the same year TABOUR ASKAR PAINTS LTD of Israel were invited to join.

In May 1979 the last meeting of ETAFF was held in Haifa, Israel. The break up occurred due to the difficulty of keeping the momentum going with the different nationalities having very different views of how things should be run and also the fact that ownership of these family companies was changing. Of the membership of nine, only Milesi of Italy, Nabersa of Spain and Sonneborn & Rieck of Great Britain remain truly family companies. Klint Bernhardt were taken over by Alfort Cronholm, as was Arti-Werk. Bouvet was bought by Dexter of the USA, Van der Sande was taken over by Reliance of the USA.

The co-operation lasted ten years. The idea was excellent, but it is doubtful whether with the present groupings of companies in the paint industry it would ever be achieved again. Great friendships were built up between owners, managers and chemists of the companies involved and much was gained, even in small problems such as which matting agent was best for a particular purpose or the best method of milling pigments.

The projects studied during the ten years were electron beam and ultra violet curing, powder coating on wood, air assisted electrostatic spraying, infra-red fast cure coatings for finishing lines, suede finishes and alcohol and water based lacquers to meet environment problems, which were being met especially in Scandinavia even in those days. With the advent of moulded plastic parts being used in the furniture industry, finishes for this substrate were also studied. Pigmented finishes in general were also discussed from the point of view of the best selection of pigments, extenders, matting agents and methods of production.

Of all the projects undertaken, it has been UV curing which has really taken off in Europe. When ETAFF was formed, Italy was most advanced with several immensely long drying lines for flat panels already installed. These were based only on the low voltage Actinic UV tubes giving one watt per centimetre and virtually no heat emission. Therefore heavy coatings of polyester could be applied without fear of the lacquer bubbling. These coatings were then sanded flat and a coat of clear or pigmented polyurethane applied to give a very full finish which could be gloss or matt. A similar situation later applied in Spain and to some extent France, but in the northern part of Europe including Scandinavia the fashion was for thin open grain finishes, which could be obtained with two coats of a low solid cellulose or precatalysed modified cellulose lacquer dried by hot air and infra-red lamps.

The use of the low voltage Actinic Lamps was impossible in the UK, and other northern European furniture and door  $% \left( {{{\rm{D}}_{{\rm{E}}}} \right)$ 

factories, since there was far too little space for the long finishing lines required in curing UV polyester by this method.

The Philips HTO Lamps, which were then available, gave around 30 watts per centimetre and would have considerably shortened the drying lines, but the high amount of infra-red heat emitted by these lamps caused bubbling of the lacquer and this ruled out their use.

It was not until around 1969 that lamps giving 60-80 watts per centimetre with sophisticated air cooling, which limited the surface heat to as low as 35 degrees centigrade, became available and then UV curing lines became a very interesting method of drying thin coatings of lacquer on veneered flat panels.

By changing from precatalysed or acid curing lacquers to UV cured products, considerable savings were made, both from the point of view of energy consumed and the cost per square metre of the lacquer itself. Although the cost per litre of the UV lacquer was considerably higher due to the fact that it was virtually a 100% solid product, far less was applied to achieve the same final film, thickness.

At this time virtually all the cellulose, precatalysed and acid catalyst lacquers being used on flat bed finishing lines were applied by curtain coater. With the change to UV, the reduction in film weight could not be achieved by this method, since there is a limit to how fast the conveyer can go and how thin the curtain can be made before it breaks. A change to roller coating was essential. This meant that the tolerance of the thickness of the panels had to be controlled carefully. It is perhaps ironic that of all the flat panel finishing in the UK, the first to go to UV was flush door production, where the honeycomb construction inside the door made them notoriously poor for thickness control and large amounts of money was spent by the door manufacturers to bring the thickness tolerance between 0.5 and 0.8mm.

The early UV lines throughout Europe were based on polyester resins and styrene monomer. Although the raw material cost of the acrylic products are far higher, there is the advantage of the final finish being far more resistant with better adhesion and faster curing. In Italy and to some extent Spain, the polyester resins are still popular, since they are very often needed only as a base on which a final coat of polyurethane is applied. There was some resistance to the styrene monomers in the early days due to their tendency to irritate the skin, but the problem has been reduced in recent monomers and also the operators are trained to take precautions when handling these monomers. In the early days of ETAFF, when the high voltage HTQ lamps were only available with their high emission of heat, UV curing found a particular use as a fast method of drying heavy UV polyester fillers which were punched into the pores of chipboard by the use of a reverse roller coater. After curing the surface was sanded flat using a specially adapted belt or drum sander. Being virtually a 100% solids product, this gave an excellent foundation for a final finish of pigmented acid catalyst or polyurethane applied by curtain coater. In some cases a pigmented basecoat was roller coated on to the filled chipboard and woodgrain printed. The final clear finish over the graining inks could be the UV cured lacquer, acid catalyst or polyurethane. These systems remained popular in bedroom, office and kitchen furniture until the advent of woodgrain printed paper or PVC foils and in the case of kitchens low pressure laminates.

The other major development during this period was the growth in popularity of the solid oak kitchen unit door and the finishing of these was greatly advanced by the growing use of automatic spray plants operating across the flat bed conveyer, since the curtain coating of shaped doors of this nature was impossible. In the UK and Scandinavia acid catalysed urea formaldehyde lacquers are used with greatly enhanced water and heat resistance. In France, Italy and Spain, polyurethane remains popular.

In the UK and Scandinavia for hand and automatic spraying application acid catalyst lacquers remain the most used since polyurethane with the complication of the free isocyanate in the curing agent remains a problem with the operators. The wearing of air fed masks is being accepted slowly. In Germany, Italy and Spain, polyurethane has always been accepted, and in these countries the emission of free formaldehyde from the acid curing lacquers is seen as a greater hazard than the isocyanate. This is especially so in Germany where the restrictions of the emission of free formaldehyde whether from the chipboard, adhesive for the veneer or the lacquer are controlled stringently. It is interesting that polyurethane lacquers hold the free formaldehyde into the chipboard thus reducing the amount emitted over a period by the door or completed piece of furniture.

So throughout Europe we see the increasing popularity of UV curing. The ever increasing use of automatic spray plants where moulded doors are used and the ever present divide of the UK and Scandinavia with acid catalyst lacquers and France, Germany, Italy and Spain with polyurethane.

Still a considerable volume of cellulose and precatalysed lacquers are being used throughout all countries, especially where reproduction furniture is popular in the UK and Belgium.

The idea of getting like minded laboratories to work together, as in ETAFF, is an excellent one, but a difficult one to achieve, since in the end companies always end up competing with each other and then there is little inclination to exchange technical information freely. With the problems over the environment, waste disposal and health and safety, it is a shame that this is a fact.

Sparkes, continued from p.449

UK market has reduced the number of lacquer crazing faults but the possibility of high build finishes on reproduction furniture has to be considered by lacquer manufacturers supplying this sector of the market.

The problems of cracking of curl and burr veneers are well known and acceptable in the long term provided the cracks that develop after several years' exposure to variable interior conditions are only just visible. Wide cracks that develop during the first winter heating period are not acceptable. Sufficient information on the control of veneer moisture contents and prefinishing conditioning treatments is available to reduce the risk of this type of cracking. The same considerations apply to furniture manufactured with straight grain mahogany and oak veneered panels for use in well heated buildings. Prolonged dry conditions during the winter will result in veneer cracking unless the recommendations first developed for the control of exotic veneer cracking are applied to furniture manufactured for use in these buildings. Whilst the lacquer manufacturer can help by supplying properly plasticised systems, the elimination of veneer cracking is largely dependent on controls applied by the furniture manufacturer.

#### References

- The movement of timbers, Department of the Environment, Building Research Establishment Technical Note No. 38.
- 2. Sparkes. A. J., The cracking of finishes on birch plywood materials, *JOCCA*, 1979, **62**, 55-58.
- 3. The prevention of veneer cracking, FIRA Technical Report No. 27.

### Transactions

### A versatile method of characterizing cure in filled reactive polymer systems

### by S. Affrossman, A. Collins, D. Hayward, E. Trottier and R. A. Pethrick,\* Department of Pure and Applied Chemistry, Thomas Graham Building, University of Strathclyde, Cathedral Street, Glasgow G1 1XL, UK

\* To whom communications should be addressed.

#### Abstract

A design is presented for a versatile method for the determination of both the increase in viscosity and the time to gelation for reactive polymer systems and solvent drying paints.

### Introduction

An increase in viscosity leading to the formation of a stable three dimensional gelled network is a characteristic property of many paints, powder coatings, composites and thermosetting filled systems<sup>1</sup>. Gelation is a property which is often quoted as being characteristic of a particular system and a variety of methods have been developed to allow<sup>2</sup>.

In the majority of applications the mixture of interest, in the form of a low viscosity fluid, is heated or exposed to a controlled environment. Subsequent solvent loss or reaction gives an increase in the viscosity eventually leading to a value of  $10^6$  Pa.s being reached. At this point the system is said to have gelled<sup>1</sup> and is solid in its appearance. A number of methods use the point at which immobilization of a probe occurs as a method of defining the point of cure. Typically this time is determined by the activation of a mechnical trip or the observation of the point at which the probe is broken, as in the case of the cocktail-stick apparatus.

All these methods ignore the valuable information which is potentially available from observation of the increase in the viscosity which occurs during the formation of the solid matrix. Ideally, the increase in the viscosity of a fluid could be measured using a conventional cone and plate or rotating cylinder viscometer. These methods however contain limitations. Allowing the mixture to cure to an insoluble mass produces damage to the drive and sensor mechanism as well as potential damage of the precision fabricated cones, plates and cylinders.

The method described here, whilst lower in precision than expensive commercial cone and plate viscometers, is sufficiently sensitive to allow relative changes in the viscositytime profile to be investigated, as well as providing a determination of the time required for the system to achieve cure.

### Experiment and theory

The apparatus involves an extension of the conventional probe method and uses observation of the damping of the motion of the probe as a method of determining the viscosity of the fluid, Figure 1. The probe is connected to a constant amplitude and frequency driver by a spring, with the result that the amplitude and phase of the motion of the bottom of the spring are directly related to the degree of damping produced by the gelling fluid. The motion of the probe is sensed by a linear variable differential transformer. Comparison of the in-phase components of the amplitude of the motion and the phase shift can be used to calculate the rheological properties of the curing system.

The limitations on the method are associated with the structure of the sensor system. A large plate would be

difficult to support and if placed in a narrow gap would produce excessive stirring of the fluid. The size and shape of the probe has been chosen to provide the largest possible surface area whilst also producing a minimal disturbance of the fluid. During the development of this method a wide variety of probe structures were tried ranging from flat discs, cylinders and large plates to rings. The structure used appears to give the correct compromise between sensitivity and minimal perturbation of the system whilst allowing large viscosity changes to be measured during the course of the cure process.

#### Figure 1

A schematic of the cure monitor.





The demodulated output of the LVDT is compared with the driving force of the linear motor using a phase sensitive detector. Although both the in-phase and quadrature components of the probe displacement are available only the amplitude of the in-phase signal is normally recorded on a chart recorder, allowing observation of the time evolution of the cure.

The temperature is carefully controlled, but in a curing system there will always be an exotherm and in a low thermal conductivity fluid this can lead to drift in the temperature of the experiment. The frequency of oscillation was varied, however a value of 2Hz appeared to be optimal for most systems. The amplitude of the probe motion was also variable between 0.1mm and 3mm, a value of 0.5mm appeared to be optimal for many systems. The area of the plate contacting the fluid was typically 3mm<sup>2</sup>.

An analysis of the system shown in Figure 1 is based on the following assumptions:

i) The amplitude of the driving motor is fixed, irrespective of the probe amplitude. In practice the difference in compliance between the motor suspension and the coupling spring mean that motor amplitude is practically independent of the probe amplitude.

ii) The mass of the probe is negligible, i.e. the resonant behaviour of the probe and spring can be neglected. Since the operating frequency is more than a decade lower than the resonant frequency of the system this assumption is justified. iii) The change in the probe/material contact area with probe movement is negligible. Some finite change in the area is inevitable but with the correct design of probe the effects are minimal and would in any case show up as 2nd harmonic components in the probe displacement. Such harmonics are rejected by the phase sensitive detector.

iv) The force on the probe due to the material is purely a viscous drag, no elastic forces or stirring of the liquid is considered. The validity of this assumption is discussed below.

Equating the forces at the lower end of the coupling spring gives:

$$k(P_1(t) - P_2(t)) = \eta A dP_2/dt$$
(1)

where k is the spring constant,  $P_1$ ,  $P_2$  are the instantaneous displacements from equilibrium at points 1 and 2 respectively,  $\eta$  is the shear viscosity of the material and A is geometric factor related to the probe/material contact area.

Since  $P_1(t)$  is of the form  $P_1\cos(\omega t)$  a solution of equation (1) is:

 $P_1\cos(\omega t) - P_2\cos(\omega t) - P_2\sin(\omega t) = (\eta \omega A/k) \{-P_2\sin(\omega t) + P_2\cos(\omega t)\}$ (2)

where  $P_2$  and  $P_2^{\circ}$  are the in-phase and quadrature component of  $P_2$ . Equating sine and cosine terms separately

 $P_1 - P_2 = (\eta \omega A/k)P_2^{"}$  and  $P_2^{"} = (\eta \omega A/k)P_2^{"}$  (3)

solving for  $P_2$  and  $P_2^2$ :  $P_2 = P_1/(1 + (\eta \omega A/k)^2)$  (4a)

and

 $\mathbf{P}_{2}^{n} = \mathbf{P}_{1} \eta \omega \mathbf{A} / k \{ 1 + (\eta \omega \mathbf{A} / k)^{2} \}$ 

The viscosity  $\eta$  can therefore be obtained directly from observation of the damping occuring at point 2.

#### **Results and discussion**

In order to test the validity of the method the damping coefficients for a liquid whose viscosity is accurately known as a function of temperature were obtained. The liquid used was capable of being supercooled and is an oligomer of polyphenyleneoxide-SANTOVAC 5. The sample used had been previously measured by the viscoelastic group at Glasgow University<sup>3,4,5,6</sup> and the data for the damping coefficients at various values of the viscosity are shown in Figure 2. The agreement with the simple theory is good over the range of viscosities examined, allowing for the arbitrary geometric factor A. A more rigorous analysis would allow calculation of the latter factor (Ferry<sup>7</sup>) but for our purposes the calibration with materials of known viscosity is sufficient.

As indicated above, the instrument was calibrated using a liquid whose viscosity changes by several orders of magnitude over a relatively short range in temperature. Using this calibration curve it was then possible to investigate the cure of a simple two part epoxy resin system as a function of temperature. The cure chosen for this study, Figure 3 was a 1:1 mixture of the diglycidylether of bisphenol A (Ciba Geigy MY750) and triethylenetetramine. At the lowest temperature, 283K the cure occurs slowly and the viscosity changes occur over a relatively long period. In contrast, the plots obtained at higher temperatures indicate a much more rapid increase in the viscosity, consistent with the fast rate of reaction and less possibility of relaxation of the matrix during the curing process. The cure time for the reaction can be associated with the time at which the mixture has achieved a

certain viscosity. As the temperature increases the cure time drops markedly, consistent with the thermally activated nature of the curing process.

### Figure 2

The in-phase probe amplitude vs. viscosity for SANTOVAC 5 over a range of temperature.



#### Figure 3

(4b)





The apparatus is capable of providing viscosity-time profiles for a curing or drying system and has been successfully used for the investigation of the cure of powder coatings composed of resin and filler particles.

#### Acknowledgements

The authors wish to acknowledge the support of Tioxide and the Ministry of Defence in the form of studentships for ET and AC, the SERC for provision of a research associate for DH and the Royal Society for a Paul Instrument Fund grant for purchase of the phase sensitive detector equipment.

#### References

- 1. Macosko, C. W., Brit. Poly. J., 1985,17, 239.
- Musatti, F. G. and Macosko, C. W., Poly. Eng. & Sci., 1973, 13, 236.
- Eastwood, A. E., Cochrane, J., Harrison, G., Lamb, J., and Phillips, D. W., Glasgow University. Unpublished data.
- Barlow, A. J., Erginsav, A. and Lamb, J., Proc. Roy. Soc. A 1969, A309, 473. Continued on p.442

### **Chester Conference Paper**

# **Finishes and furniture research**

by M. Charity, Furniture Industry Research Association (FIRA), Maxwell Road, Stevenage, Herts, SG1 2EW, UK

### Summary

Finishes and furniture have both to be fit for purpose and also suitable for the fashion and market place of the time.

FIRA has worked with paintmakers and furniture manufacturers for over a quarter of a century. FIRA's work in testing, research and consultancy will be described and the state of the art commented upon.

In the *Cabinet Maker* for May 1961 an article appeared entitled: "F.I.R.A.: Furniture Industry Research Association Founded. Full Details of New Independent Organization."

Although the Furniture Development Council had existed for some time before, this does set a date for the beginning of what I would call serious test and laboratory work related to furniture.

It is now twenty-eight years later. FIRA employs just under a hundred staff and currently carries out work to the value of about £2.8 million a year. We come out "right" financially as well which is something not that easy in R&D.

At a guess I would say that the work in FIRA directly related to oil and colour chemistry approaches  $\pounds 0.25$  million a year. In a sense, however, all furniture involves finishes, adhesives, resins, foils as an essential key to its integrity in performance and to its acceptability in the marketplace. Consequently FIRA's profile in these areas is a high one. What is the most important aspect of this work?

I would say that it is FIRA's ability to trouble-shoot faults, (Figure 1) because enabling production to continue satisfactorily is crucial to a manufacturing member, but several members of staff would say that it was the development of standards (Figure 2). Whilst most consumers would probably say that price and appearance were the most important things about buying furniture, what they really ought to say is "performance in use".

The maintenance of good appearance as an aspect of performance is important and is an area where the expectations of consumers have increased enormously. The performance of finishes has also improved greatly in, say, thirty years, but it is not easy to keep up with expectation.

Needless to say structural performance has always been important, but again the majority of users now blame the manufacturer when failures occur. At one time they might

### Figure 1

Trouble shooting a veneering fault.



have blamed the children. Misuse is hard to prove.

Product Liability is important. Woe betide the manufacturer if someone is injured because a glued joint fails, or perhaps, more likely, when the furniture is properly designed, the glue is inadequately applied. No method yet exists for non-destructive testing of chair joints. What an excellent area for a club R&D project. Five years ago such a project would have been, and indeed a limited investigation at FIRA was, abortive in finding a method available at reasonable cost and speed. I believe technology has brought that particular horizon much nearer and we ought to pounce.

When I was a boy, not that long ago, a kitchen centred around a large wooden table that was scrubbed every day, and often several times a day, and gradually took on a marvellous and appealing typical appearance. Nostalgia would be a most saleable finish. The first furniture I made at school, if trays, chess-boards, coffee tables and stools count as furniture, was wax finished. Later we graduated to french polishing.

Small boys have a lot to thank chemists for when it comes to mealtimes.

Polished furniture in the home reacted catastrophically to heat, water and almost any other liquid, (Figure 3), even to being kept "for best" in a damp drawing room. Bloom from damp came off readily with Brasso.

There is now an entire spectrum of finishes and facings, for the whole range of furniture requirements. Reproduction furniture has to make a different compromise between appearance and resistance to misuse to that of a contemporary table intended for the kitchen-diner.

It is most important that the furniture manufacturer, the specifier and the user's expectations are all honoured. Standards and tests are the only way of ensuring that ideal. Tests for furniture finishes developed at FIRA have gradually become British Standards and are now accepted in many countries. In addition to the pass or fail aspect many furniture manufacturers find the ratings helpful in relating performance levels to the application. Wardrobe interiors do not require a resistance to wet heat. The excellent high gloss of an elegant ornamental table can be utterly unsuitable for a table intended for an office, or for fine work where glare might make it impossible to use uncovered. There are about a dozen frequently used tests for furniture finishes.

Figure 2 The lacquer adhesion or crosscut test.



Today FIRA not only carries out thousands of paid for tests each year, but it sells equipment for carrying out tests, holds courses on finish standards and tests (Figure 4) and licenses manufacturers to make test equipment it has developed.

This development work has thus been profitable for FIRA itself, but how much more profitable it has been for FIRA members who have avoided complaints and returns, and how profitable for the industry as a whole that unreasonable standards from abroad are avoided by our specialist's knowledge, work and authoritative representations internationally.

It is worth pointing out that this benefit goes further than at first sight. Consortiums of architects and civil engineers bidding for contracts to build and furnish abroad find it worthwhile to show that FIRA expertise and standards will be used to ensure fitness for purpose.

A recent area of research at FIRA which benefits many sectors was that on formaldehyde.

Until a few years go it was generally the view that formaldehyde was a "safe" substance because it would make its presence felt through the irritation it caused long before the concentration became dangerous.

FIRA research showed that formaldehyde concentrations in furniture factories and warehouses were below the safety levels except in one or two rare cases of small, unventilated storerooms in factories.

The view of the safety of formaldehyde changed with tests

#### Figure 3

Assessing the Resistance to wet-heat using equipment developed at FIRA.



Figure 4

Resistance of Paint Finish on a metal substrate to scratching.



on animals in America and the reaction of children in Scandanavia to formaldehyde in schoolrooms enclosed on all sides by formaldehyde bearing materials. German research led to the use of a large chamber test. This involved great cost, total pieces of furniture, and difficulty since no such apparatus existed in this country.

Extensive and successful work at FIRA led to the FIRA-DOMBEY method. This method is now well tested and documented<sup>1</sup>. It enables small test pieces to be used. It is quick and the apparatus is now being produced for sale and is cheap enough for many companies to possess (Figure 5). Moreover its very existence, and the data it has produced, has enabled cogent arguments to be presented against the other method. It has been the only way of countering a proposal which could prove a major restraint of trade for British producers.

FIRA testing and standards work is important. If something is not up to scratch it's essential to know as soon as possible and the customer needs to know that the standard has been reached if the product is to be acceptable. A good testing service has always to be available for members.

Trouble shooting and consultancy is equally important. The importance of trouble shooting I hardly need to underline; if the product cannot be despatched because of a mysterious fault in the finish then any FIRA member expects and will get urgent help. Consultancy relates closely to profit.

I think the notion of profit has become blurred, particularly in private companies because the taxman and accountants make the decision whether to take salaries, directors fees or profit on pragmatic and legal grounds. Economic theory, however, says that you receive a profit because you take a risk. I don't think people think hard enough about risk. Many of the rules of thumb stop people thinking.

Consultants are more involved with risk and profit because they are involved with change. A new finishing line, robotic spraying, a different finish, whatever it may be, involves change and innovation (Figure 6 and 7).

Often the consultant is asked: "What plant should we buy?" If he is worth his salt he should ask: "Why do you want to change the plant? What are you really after?"

He should not just produce comparisons of efficiency and price without asking these questions. Efficiency, price and return considered alone may disguise the real problem or the real objective. They may hide a risk.

Having said that, the customer has a perfect right to say: "all I want is . . . ."

FIRA does a lot of consultancy work and it encompasses everything from the complete planning of a new factory on a greenfield site to the simpler exchange:

#### Figure 5

The new FIRA-DOMBEY method for Assessing the Emission of Formaldehyde from Furniture Surfaces.



"Why doesn't our door pass the potable spirit test any more?" "Because too much cellulose was put in the AC lacquer to make it dry quicker."

Research and Development exists so that the industry can innovate and not decay. And do that at minimum risk.

Within limits research and development at FIRA can be said to be done at short term risk in order to avoid a long term decay. The risk is for the industry because it needs innovation, and because it is member money in part that is spent and for FIRA because research and development is a difficult wicket.

The window through which successful research can be done is getting narrower.

Eliminate the long term: "It's not your job, the industry isn't interested in the long term."

Eliminate the short term: "It's too close to the marketplace."

Eliminate the relevant and down to earth: "It's not high technology".

Eliminate continuing programmes and ones that cannot be

#### Figure 6

Reverse Roller-Coater for the application of Acrylic Lacquers for Curing by U.V.



### Figure 7

Edge Impact Test for Assessing the Resistance of Post-Formed Edges of Kitchen Worktops to Damage.



done in two years.

It does not leave a lot of room for winners does it?

R. A.'s were set up to aid companies that could not afford, or would not afford, research themselves. Their set-up followed studies which had shown the need.

One, for instance, showed that a team was more productive than one or two persons because of more interaction. Other studies showed what was happening in competing countries.

The furniture industry has a typical need for an R. A. because it is fragmented, diverse, and composed of comparitively small companies. It has real competition from abroad and a need to innovate to continue to export effectively.

Member support, year after year, such as FIRA, has from a hard-headed industry proved FIRA's relevance.

Yet the funds for FIRA's DTI contracts to go together with our member's cash to do effective R&D are cut.

Let's not whine: FIRA still manages to come out the right side of R and D and so do its members, but events do indicate the need for club projects and remember these can be vertical as well as horizontal. A vertical project might involve a paintmaker, FIRA, a furniture company.... a horizontal one a group of suppliers and FIRA.

Profitable research and development can have many aspects. It can be for individuals, companies, the organization itself, for industry in general, for government. It can be long or short term, be almost certain of a good outcome, or be "far out". In short it involves a lot of experience and judgement and, by and large, FIRA has proved itself.

After their clothes what people most come into contact with, what adds most to their comfort at home and in the workplace is furniture.

Furniture is nothing without its presentation: its finish, shape, proportions, feel.... because without its presentation it is only a group of artefacts. People might as well sit on logs and sacks and eat from planks. Compared to fifty years ago, furniture already competes in the same purses, pockets and wallets against TVs, HIFIs, MIDIs, VHS, Microwaves, Freezers, cars and video cameras. Holidays are now taken abroad and are twice as long. I think that furniture will only keep its markets if it constantly proves to be reliable when used. It will expand its markets only if it innovates.

Profits are thus dependent, in the end, on how much research and development is done.

It is perilous to restrict R&D. Perilous for us, for industry and inevitably for countries.

#### Reference

1. S. Dombey, *JOCCA*, 1989, **72**(3), 108.



JOCCA



# QUALITY

the competitive edge uality products start with quality testing. With more than 40 years of service, experience, and technology in materials testing and evaluation, we can help you design a test program that will give realistic data on product quality and performance.

Find out why we outperform our competition, and how we can help you outperform yours. Make the move to <u>QUALITY</u>!

DSET LABORATORIES, INC. Box 1850 Black Canyon Stage I Phoenix, Arizona 85027 USA Telephone: 602-465-7356 1-800-255-DSET Telefax: 602-465-9409 TWX: 910-950-4681 DSET PHX EVERGLADES TESTING LABORATORY FLORIDA DIVISION OF DSET 16100 SW 216th Street Miami, Florida 33170 USA Telephone: 305-245-3659 Telefax: 305-245-9122





Ramsbottom, Bury, Lancs BLO 9BA, England. Tel. (0706) 824191. Telex 635265 Enter K105 on Reader Reply Card **Precis Papers:** In this and the next few issues of JOCCA there will be published in the Horizons Section of the Journal the precis of a number of papers which were received for publication by the late Mr D. S. Newton. The Honorary Editor, Mr J. R. Taylor has refereed these papers and notified Council of their planned publication in precis format. Should readers require further information on these subjects please contact the author(s) whose address for communication is indicated below the title of each paper.

### Copolymerisation of vinyl maleopimarate acid anhydride with styrene and alkyd resins from the prepared copolymer

#### by P. Kumar, M. C. Shukla and A. K. Vasishtha\* Harcourt Butler Technological Institute, Kanpur-208002, India.

#### \* To whom all correspondence should be addressed.

#### Abstract

The vinyl maleopimarate acid anhydride (VMPA) was prepared by reacting maleopimaric acid with vinyl acetate in presence of mercuric acetate and sulphuric acid as catalysts. It was purified by a repeated crystallization process using acetone as solvent. The purity of the prepared VMPA was checked by determining its melting point, acid value and IR spectroscopy. Thereafter, VMPA was copolymerised with styrene using azobisisobutyronitrile as an initiator by the solution polymerisation process. The amount of initiator was optimised to get clear product. The alkyd resin was prepared by using VMPA-styrene copolymer, DCO fatty acids and ethylene glycol. The prepared alkyd resin was characterized by determining its acid value, viscosity and colour. The film properties of the alkyd resin were studied in clear as well as pigmented coatings. The results of the coatings show that the film properties of the prepared alkyd are superior over the conventional alkyds made from phthalic anhydride in respect of hardness and resistance to acid and alkali. Moreover, these coatings also have good anticorrosive properties.

### Stoving coatings from water soluble alkyd resins based on maleopimaric acid

by M. C. Shukla and A. K. Vasishtha\*, Harcourt Butler Technological Institute, Kanpur-208002, India.

\* To whom all correspondence should be addressed.

### Abstract

Water soluble alkyd resins were synthesized from maleopimaric acid and DCO fatty acids. These alkyds were cured by stoving with methylated melamine formaldehyde (MMF) resin — stoving temperature, curing time and level of curing agent were optimised. The MMF cured films of alkyd resins showed good flexibility, hardness, and water, solvent and acid resistance.

### **Copolyamides of rosin**

by R. Panda\* and H. Panda<sup>†</sup>, Research & Development Section, the Indian Turpentine & Rosin Company Limited, P.O. Clutterbuckganj-243502, Bareilly (U.P.), India.

† Devashish Consultants (P) Limited, 1, Station Road, P.O. Clutterbuckganj-243502, Bareilly (U.P.), India.

\* To whom all correspondence should be addressed.

### Abstract

Different polyamides were synthesized by mixing dibasic acids and diamines. A percentage of the dibasic acids were replaced by rosin. The resulting products were termed copolyamides. Its different properties e.g. thermal, electrical and tensile were evaluated for its commercial exploitation.

### 458

# Effect of some parameters on the controlled release of styrene butadiene rubber containing copper sulphate monohydrate.

by F. M. Helaly and A. S. Badran, Laboratory of Polymers and Pigments, National Research Centre, Dokki, Cairo, Egypt.

### Abstract

Controlled release styrene butadiene rubber copper sulphate monohydrate composite is a new means for fighting snails which are the intermediate host of schistosomiasis, they live in stagnant fresh water of streams that branch from the river Nile. The product was used to release copper ions  $(Cu^{2+})$  into water of different qualities such as tap water and Nile water. The amount of  $Cu^{2+}$  leached varies depending upon the constituents of water. Also, the presence of blowing agent substance in rubber formulations was found to increase the leaching rate of  $Cu^{2+}$ . The investigated formulations were effective in killing snails in Nile water. The presence of mud had caused a dramatic drop in the mortality rate of snails at the initial exposure.

Mould growth inhibitor from maleopimaric acid by R Panda\* and H Panda†, Research & Development Section, the Indian Turpentine & Rosin Co. Ltd., P.O. Clutterbuckganj-243 502, Bareilly (U.P.), India.

† 1, Station Road, At;PO Clutterbuckganj-243 502, Bareilly (U.P.) India.

\* To whom all correspondence should be addressed.

#### Summary

Different polyimide-polyamide resins were prepared by reacting monochlorides of maleopimaric acid (MAC) with various diamines. These resins can be utilized as a mould growth inhibitor.

Design of paint formulations on the basis of solubility parameters of resins, pigments and solvents: Assessment of their performance

by M. V. Ram Mohan Rao, K. V. S. N. Raju and M. Yaseen, Organic Coatings & Polymers division, Regional Research Laboratory, Hyderabad-500 007, India.

### Abstract

The information available about the solubility parameters of solvents, resins and pigments has been used in designing solvent blends for red iron oxide in 66% linseed oil/pentaerythritol/phthalate alkyd. An individual blend of solvents for the paint formulations was so selected that it contains a good solvent and a non-solvent, two non-solvents or two  $\theta$ -solvents. The volatile content (solvents) was maintained the same in each paint formulation prepared in different blends. The apparent viscosity data indicate that the interaction among resin, pigment and solvents is better when paints are prepared in blends of non-solvents. The influence of various blends of solvents on the properties of paint coatings weathered indoors for 10, 50, 150 and 270 days has been studied. It is found that the addition of certain amount of strongly hydrogen bonded solvents to a good solvent or to a non-solvent enhances the solvency power of the blend as well as the interaction of the resin solution with the pigment. The results did not show any significant difference in the properties of paints prepared in various solvent blends when tests were conducted on initially air-dried coatings. On the other hand, the weathered coatings of paints prepared in blends of non-solvents exhibited much better properties than the coatings of paints prepared in conventional or in the commonly used solvents.

### Maleopimaric acid based water soluble stoving coating compositions

by M. C. Shukla, S. Kulshreshtha and A. K. Vasishtha\* Harcourt Butler Technological Institute Kanpur-208002 India

#### \* To whom all correspondence should be addressed.

### Abstract

Water soluble alkyd was prepared from linseed oil, glycerol, maleopimaric acid and phthalic anhydride combination by monoglyceride process. For comparison purposes two other water soluble alkyds were also prepared from trimellitic anhydride and phthalic anhydride combination, and phthalic anhydride alone, separately. Water soluble pigmented coating compositions were prepared from these water soluble alkyds using water soluble methylated melamine formaldehyde resin as curing agent and TiO<sub>2</sub> as pigment. The coating compositions were cured by heating at 160°C for 30 minutes. The film properties of all three pigmented coatings were determined and compared. It was observed that the overall mechanical and chemical properties of the films of coating based on water soluble alkyd made from maleopimaric acid and phthalic anhydride combination were superior over the films of coatings based on trimeltic anhydride and phthalic anhydride combination, and phthalic anhydride alone. The films of coating based on phthalic anhydride alone gave comparatively poor mechanical and chemical film characteristics.

### Separation of components of laccaic acid by thin layer chromatography

by K. M. Prasad, N. Prasad, A. K. Ghosh and B. B. Khana, Indian Lac Research Institute, Namkum, Ranchi 834 010 India.

### Summary

A simple method has been evolved for the separation of individual components of laccaic acid (lac dye), as such by TLC on cellulose coated plates. There exists a possibility of the lac dye having some more components than reported previously.

### Styrene copolymerisation of isomerised rubberseed (Hevea Brasilliensis) oil and its alkyd

### by M. S. Saxena and A. K. Vasishtha\*, Harcourt Butler Technological Institute, Kanpur-208002, India.

\* To whom all correspondence should be addressed.

### Abstract

Refined rubberseed oil was isomerised and subsequently copolymerised with styrene monomer by solvent method. Marked improvement in drying time and film properties were observed in the styrenated oil.

Styrenated alkyds of the rubberseed oil were also prepared by pre-styrenation and post-styrenation processes and their film properties were compared with the unstyrenated alkyds. The alkyds prepared by the post-styrenation process gave better film properties than the alkyds prepared by the prestyrenation process.

### Studies on the formulation of ideal antifungal paints and their evaluation techniques

by D. Bagchi\* Research & Development Division, Berger Paints India Limited, Howrah - 711 103, India.

\* Present Address: Chemistry Department, Bowling Green State University, Ohio 43403, USA

### Summary

Antifungal paints helps to provide long lasting paintwork along with protection of the substrate from fungal attack. Paints have been prepared using different types of binders, namely alkyd resin, tributyl tin oxide modified alkyd resin, acrylic emulsion, antifungal pigments and fungicides. The fungicidal activity of different paints have been evaluated microbiologically against Aspergillus sp., Penicillium sp., Rhizopus sp. and Sacchromyces sp., predominantly occurring fungi of eastern India.

Rigid polyurethane foam from rosin by R. Panda<sup>†</sup> and H. Panda<sup>\*</sup> Research and Development Section, the Indian Turpentine and Rosin Company Limited, P.O. Clutterbuckganj-243502, Bareilly (U.P.) India.

<sup>†</sup> Devashish Consultants (P) Limited, 1, Station Road, P.O. Clutterbuckganj-243502, Bareilly (U.P.) India.

\* To whom all correspondence should be addressed

### Abstract

A number of polyester modified rosins with foam formulation have been utilized to prepare rigid urethane foams. These chemicals are compatible and processable in urethane foam formulations and less flammable than foams derived from other conventional type glycols. Acceptable foam properties were also obtained when compared with other commercial foams.

### Bleaching of rubber, melon and oilbean seed oils.

I. Effects of concentration of bleaching agent. by J. A. Ibemesi\* and M. C. Idigo\*\*, Department of Pure and Industrial Chemistry, University of Nigeria, Nsukka, Anambra State, Nigeria.

\* To whom all correspondence should be addressed. \*\* Present address: Anambra State Polytechnic, Oko, Anambra State, Nigeria.

#### Summary

The effects of concentration of fuller's earth (FE), activated charcoal (AC) and FE/AC mixture on the bleaching behaviour of oils of rubber seed (RS), melon seed (MS) and oilbean seed (OBS) have been studied.

Values of degrees of bleaching monitored by UV/visible absorption measurements indicate that FE is the most effective bleaching agent for the three oils, followed by FE/AC; on the other hand, oil retention is least using AC, followed by FE. The oil of OBS is the most readily bleached with optimum degrees of bleaching in the range of 82-93%, while the oils of RS and MS show comparable bleaching responses which range from 43% (using AC) to 88% (using FE).

The observed oil retention values are in the range of 30-64%. However, considerable reduction in oil retention has been achieved at degrees of bleaching that are close to the optimum by using 75% of optimum amounts of FE and FE/AC mixture (for the three oils). 50% and 17% of optimum amount of FE for oils of MS and OBS respectively.

### Bleaching of rubber, melon and oilbean seed oils, II. Adsorption energies and isotherms at optimum bleaching temperature

by M. C. Idigo<sup>†</sup> and J. A. Ibemesi<sup>\*</sup>, Department of Pure and Industrial Chemistry, University of Nigeria, Nsukka, Anambra State, Nigeria.

\* To whom correspondence should be addressed.

† Present address: Anambra State Polytechnic, Oko, Anambra State, Nigeria.

### Summary

The bleaching of oils of rubber, melon and oilbean seeds have been carried out using fuller's earth, activated charcoal and a mixture of the two at varying temperatures (30-120°C). Also, bleaching isotherms of the three oils have been obtained at 80°C.

The three oils showed varying optimum bleaching responses in the temperature range of 60-105°C depending on the bleaching agent used. Also, their adsorption enthalpies and activation energies varied but were all under 10 kcal mol<sup>-1</sup>. Physisorption, therefore appeared to predominate over chemisorption. The results of the isotherm study showed the Freundlich's isotherm to be generally applicable.

# Radiation curable abrasion resistant coatings based on rosin modified pentaerythritol and trimethylol propane triacrylates.

by R. Panda<sup>\*</sup> and H. Panda<sup>†</sup>, Research & Development Section, the Indian Turpentine & Rosin Co. Ltd, P.O. Clutterbuckganj - 243 502, Bareilly (U.P.), India.

† 1, Station Road, P.O. Clutterbuckganj 243 502, Bareilly (U.P.), India.

\* To whom all correspondence should be addressed.

### Abstract

Rosin modified pentaerythritol and trimethylol propane triacrylates were prepared and its radiation curing rate and abrasion resistance were measured.

### Effects of kaolin clay extender concentration on the bond quality of vegetable tannin — formaldehyde adhesives

by T. O. Odozi, C. O. Onu\*, O. Akaranta and A. T. Onosode\*\*, Departments of Chemistry (Applied Chemistry Unit) and \* Chemical Engineering, University of Port Harcourt, Port Harcourt, Nigeria. \*\* African Timber and Plywood Co. Ltd., Sapele, Nigeria.

### Summary

The effects of Kaolin Clay and variations in PVC on the practical adhesion of red onion skin and mangrove park tannin — formaldehyde adhesives, using plywood as bonded substrate having been investigated. Results show that the practical adhesion (shear strength) and wood failure values are highest at the CPVC of each glue system. Results also show that pot life of the glues decreased with increasing pigmentation with the optimum level of clay pigmentation being in the range of 10-12% PVC. The overall performance was best with the mangrove bark tannin based adhesives (glues 1 and 3).

Thermal degradation and characterization of poly(methylmethacrylate) prepared in presence of Egyptian delta titano magnetite ore (EDTMO).

by A. B. Moustafa, M. A. Diah<sup>\*</sup>, S. M. Sayyah<sup>\*\*</sup> and A. S. Badran, Laboratory of Polymers and Pigments, National Research Centre, Dokki, Cairo, Egypt)<sup>\*</sup> Faculty of Education at Domiat, Mansoura University, and<sup>\*\*</sup> Faculty of Science, Al-Azhar University, Nasr City, Cairo.

### Abstract

The mean average molecular weights for the polymers degraded in absence and presence of Egyptian delta titano magnetite ore (EDTMO) were found to decrease with an increase of both time and temperature.

Column chromatographic separation of glyceryl aleuritates

by M. Mukherjee, R. N. Majee, Shravan Kumar and S. N. Mukherjee\*, Division of Chemistry, Indian Lac Research Institute, Namkum, Ranchi, Bihar, India

\* Department of Chemistry, St. Xavier's College, Ranchi, Bihar, India.

### Summary

Column chromatographic separation of glyceryl mono-, di-, and trialeuritates from their mixture has been described.

Prediction of solubility parameters of some industrial solvents at different temperatures.

by K. Venkatsubramanian, S. B. Halligudi and M. M. Taqui Khan, Central Salt and Marine Chemicals Research Institute, Bhavanagar 364 002, India

### Summary

The solubility parameters of a number of industrial solvents have been calculated using known molar volumes. Hildebrand's equation and reduced Gunn and Yamada's equation for the range 25-70°C. A critical analysis of the previous work by Jayasri and Yaseen has revealed that some of their conditions have to be considerably modified when rigorous mathematical derivations are taken into account. A new, simple approximate way of correlating molar volume with the solubility parameter has been suggested. Results analysed in detail show a linear variation for: (i) (v) <sup>1/2</sup> and b in terms of therise in temperatures and homologation and (ii) temperature and  $\delta$ . An attempt has been made to interpret

### Procedure

Because of the advent of computers there is a tendency to predict values of experimental parameters especially when these experiments are difficult to perform or give variable and confusing results as in this case. In the process design, even approximate values would be of great help, when accurate values are not available. The authors have been looking into ways of predicting the solubility parameters over a wide range of temperatures, between 25 to 70°C. As a first step in this analysis the molar volumes at different temperatures by using the reduced Gunn and Yamada's equation; the reference molar volume at 25°C was derived from the known value of the density D, using the realation M = V/D. The use of reduced Gunn and Yamada's equation was preferred over others as results from other methods do not give significantly different values and in the reduced equation, at least one of the parameters, the reference molar volume at 25°C is known with certainty from experimental measurements. The resulting molar volumes are believed to be accurate within 3%. The main limitation is that the factorT /T<sub>c</sub> (reduced temperature) should lie between 0.2 and 0.8; this has been adhered to for want of a better alternative.

### **Results and Discussion**

The solubility parameters of solvents having the same functional groups were arranged in a series of increasing molecular weights (molar volumes). It was observed that these values show an increase in the solubility parameter values with increasing molar volumes in the cases of ethers and hydrocarbons i.e. they have negative slopes. In all other cases, they have positive slopes.

### Conclusions

Accurate measurements of the solubility parameter directly would involve measuring at least two properties, partial molar volume and enthalpy of vaporization. Extension to high temperature, with the range stipulated by Gunn and Yamada's equation, is valid for nonpolar solvents. Additional work is necessary to understand why differences exhibited by polar compounds within a group vary. The solubility parameter is dependent on the substitution in the structure as shown in the cases of calculated values for three xylenes. Extension to involve dissolution of gases and mixed solvents is under way.

### Ammonolysis of maleopimaric acid

by R Panda\* and H Panda† Research & Development Section, the Indian Turpentine & Rosin Co. Ltd, P.O. Clutterbuckganj, Bareilly-243502(U.P.), India.

† Devashish Consultants (P) Limited, 1, Station Road, P.O. Clutterbuckganj-243502 Bareilly (U.P.), India.

\* To whom all correspondence should be addressed.

### Abstract

Utilizing the readily available maleopimaric acid derived from levopimaric acid, the synthesis of the dimerized nitrile of maleopimaric acid is described.

### The feasibility of using natural tannin resinified bitumen as decorative wood finishes (varnishes).

by T. O. Odozi and C. O. Onu\*, Departments of Chemistry (Applied Chemistry Unit) and Chemical Engineering\*, University of Port Harcourt, Port Harcourt, Nigeria.

### Abstract

The feasibility of improving the decorative value of bitumen by adding resins based on onion skin tannin and its benzoyl derivatives is discussed. The resinified bitumens showed good gloss characteristics and a drastic reduction in drying time. The water and chemical resistances were equally satisfactory.

### Unsaturated polyesters modified rosin for inhibiting rocket propellants

by H. Panda and R Panda\* Research and Development Section, The Indian Turpentine & Rosin Co. Ltd., P.O. Clutterbuckganj-243502, Bareilly (U.P.), India.

#### \* To whom all correspondence should be addressed.

### Abstract

Four unsaturated rigid polyesters based on propylene glycol, isophthalic acid and maleic anhydride were synthesized and modified with gum rosin. They are characterized for heat, alkali and acid resistance, gel time, exotherm peak temperature, tensile strength, percentage elongation, bond strength, water and nitroglycerine absorption and were evaluated for rocket propellant inhibitors.

### Water soluble epoxy resin fatty acid esters by N. Krishnamurti, M. M. Shirsalkar and M. A. Sivasamban, Regional Research Laboratory, Hyderabad 500 007, India.

### Summary

Several important factors are to be considered while designing water soluble epoxy resin fatty acid esters having excellent storage and hydrolytic stability. A number of chemical approaches that meet the desired requirements were explored and discussed.

### Thin layer chromatographic separation of glyceryl aleuritates

by M. Mukherjee, R. N. Majee, Shravan Kumar and S. N. Mukherjee\* Division of Chemistry, Indian Lac Research Institute, Namkum, Ranchi, Bihar, India.

\* Department of Chemistry, St. Xavier's College, Ranchi, Bihar, India.

### Summary

Thin layer chromatographic technique has been found to be useful in separating glyceryl mono-, di- and tri-aleuritates from their mixture.

Standardisation of lac dye for use as a food colour by K. M. Prasad, N. Prasad, A. K. Ghosh and B. B. Khanna, Indian Lac Research Institute, Namkum, Ranchi -834010, India

### Summary

The characteristics such as melting point, volatile matter, ash content, solubility, chromatographic behaviour and absorption analysis of lac dye (laccaic acid) to be used as a food colour have been studied.

### Solution properties of shellac : unperturbed dimension of shellac and its constituents

### by M. K. Mishra, Chemistry Division, Indian Lac Research Institute, Namkum, Ranchi - 834 010, India.

### Summary

Unperturbed dimension  $\langle \tilde{R}^2 \rangle_o$  and polymolecularity correction factor  $q_{KMSH}$  of shellac and its constituents have been estimated by viscometric measurements.

### From the General Secretary



The Implications of Just-in-Time

A prominent direction sign with the letters OCCA, pointing off the Otley Road, indicated the venue for the West Riding Section's autumn symposium on The Implications of Just-in-Time. The Bodington Hall campus of the University of Leeds provided excellent conference facilities for this one-day meeting on 14 September. The only criticism of university venues for residential meetings is the somewhat spartan study/bedroom accommodation provided. Many universities are now addressing this problem through the provision of purposebuilt accommodation and given the range of study and leisure facilities and catering, university venues could regain the conference market from hotels.

The excellent organisation provided by the West Riding Committee was able to benefit from Priory House marketing and publicity expertise, which is now able to provide comprehensive support for Sections in the organisation of their meetings.

The choice of the topic concentrating on "modern management" technology rather than the safer option on "based subject matter" had a high risk element for the organisers, but widespread publicity through press releases, direct mailings and editorial comments in JOCCA ensured that the registration leaflet reached its target audience. The attendance of 67, although down on initial expectations, included a high proportion of senior managers, many of whom were non-members and unfamiliar with the Association and its activities. Already two delegates had applied for membership as a result of attending the symposium and other applications are expected.

Papers and two discussion sessions were presented at the symposium and the programme was so arranged that the earlier papers discussed the philosophical and theoretical aspects of Just-in-Time, followed by papers on the practical application of the technique in paint and related manufacturing industries.

The papers from Bob Trick (Huddersfield Polytechnic), Graham Tidman (Tidman Industrial Engineering Services) and Professor John Oakland, the guru of statistical process control (University of Bradford) laid the fundamental basis for the Just-in-Time concept from the organisation, human resource and total quality management aspects. Delegates were provided with a very helpful glossary of terms and by lunch time were made more

JIT Symposium Speakers (excl. Grahame Tidman) and some of the organisers (0), (L to R): Graham Miles, Dave Dockray, Bob Trick, John Oakland, John Piggot, Keith Smith, Dave Simpson (0) and Rob Lewis (0).





JIT symposium delegates

than aware that Just-in-Time was more than a sophisticated tool to keep stock levels low, but represented a total management concept embracing the whole of the manufacturing or service process.

By the afternoon, delegates were eager to learn of practical examples of the techniques available and these were provided by Graham Miles (PPG), John Pigott (Crown Berger Europe) and David Dockray (Coopers & Lybrand Associates). The speakers demonstrated that no easy solutions were offered, it was not just a question of purchasing the latest software package, but through education and the commitment of the workforce. suppliers and indeed customers, the Just-in-Time philosophy could . lead to their mutual success.

Delegates went home from the symposium better educated, but perhaps still slightly puzzled. They were certainly eager to learn more of the techniques and on this measure the meeting was a success.

The West Riding Section are to be congratulated on their excellent symposium. A selection of the papers presented will be published in JOCCA.



### **OCCA** Meetings

### London Section

Colour in fashion

The 51st Annual General Meeting of the London Section was held on Thursday, 20 April 1989, at the Naval Club, Hill Street, Mayfair. The meeting was followed by a presentation given by Ms L Szpala of Marks & Spencer plc entitled 'A History of Colour in Fashion'.

Ms Szpala began by discussing the psychology of colour and how colour influences mood and feeling. The history of colour was then outlined prior to illustrating the natural fibres that are coloured and how the colours are applied. Initially natural dyes were applied to natural fibres. These dyes were typically extracted from shellfish. insects and vegetables. The extraction process was both difficult and laborious. The industrial revolution saw cotton becoming the most important fibre and the development of synthetic dyes and fibres. This development allowed greater flexibility in the colouring of textiles. Changes in fashion and in particular clothes styles resulted from this. These changes have manifested themselves in the eighties as more sophisticated clothing which is increasingly colour co-ordinated.

Ms Szpala concluded her presentation by illustrating how colour is developed by the retailer in the High Street. Formulation of a clear colour policy for each season is determined in advance. Colours are matched and coordinated, and specifications set which are strictly adhered to by colour measurements. Fabrics are selected and physical properties are measured. Garments are made in clean modern dye houses to these tight specifications and quality control is imperative. The results of this is that newly designed clothes are introduced each season to the general public in the High Street.

Following this interesting presentation, a lively question time ensured. Mr Brian Gilliam proposed the vote of thanks which was wholly endorsed by the audience.

G. J. Steven

### **DECEMBER JOCCA:** Report on Wood Finishes Symposium

### Manchester Section

Works visit: Allied Colloids

On Monday, the 11 September 1989, the 1989/90 session commenced with a joint Manchester and West Riding Section visit to Allied Colloids Ltd, Bradford, a total of 65 members and guests from the two sections participating. After being warmly welcomed on arrival, the party was provided with protective coats and glasses, split into groups, and escorted round the plant.

Allied Colloids is split into six factories on the one site, where everything from small batch production to large continuous processes are carried out, some 1,200 different products being manufactured on this one site.

Allied Colloids started manufacturing at the site in the mid-1930s and have expanded steadily on the same site since, particularly in the last few years, so that some 1,200 employees now work at what is a very large and impressive plant.

On completion of the tour everyone was escorted to the hospitality suite where a buffet and alcoholic beverages were provided, and to conclude a most enjoyable evening, Mike Nixon-who had organised the visit-was presented with a cake, it being Mike's 40th birthday

Manchester and West Riding Sections would like to thank Allied Colloids Ltd, and the many staff, who helped to make this a very interesting and worthwhile visit.

M. G. Langdon

### | Midlands Section

### Cape Hill Brewery visit and **J. Newton-Friend lecture**

The last two meetings of the Midland Section were held away from the usual venue, the Clarendon Suite, Stirling Road, Edgbaston.

Bass, Mitchells and Butlers Ltd provided the April venue for the Midland Section AGM at their Visitor Centre at Cape Hill, Smethwick, Whilst members attended to business in the lecture room, which had been the old factory fire station, guests relaxed in the adjacent bar.

After the formal meeting the group were given a comprehensive guided tour of the brewery which was followed by a buffet.

The final meeting of the Midland Section was the J. Newton-Friend Lecture, traditionally a social event to round off the season of technical meetings.

This year, members and guests met on 18 May for an evening at the Birmingham Botanical Gardens for a tour of the grounds followed by dinner

Professor D. Skelding led the OCCA party around the gardens and greenhouses providing a full commentary which covered the site, its development and a brief history of virtually all notable plant species encountered.

M. J. Round



Members and guests of the Midland Section during their visit to Bass, Mitchells and Butlers Cape Hill Brewery.



### **OCCA** Meetings

### **Transvaal Section**

Isando brewery visit

The meeting arranged for 26 July 1989 took the form of a visit to the Isando brewery of South African Breweries.

The plant visit was preceded by a short lecture and video recording on the history and production of beer with emphasis on South Africa.

The earliest written records of beer brewing were produced in ancient Babylon. Beer accompanied the spread of civilization throughout Europe. It was here that beer was first spiced with hops to create the piquant flavour that is still enjoyed.

Beer brewing was established in the Cape in 1696 when a brewery was established by Rupert Mensing on the orders of the 'Council of Seventeen' in Holland. The predecessors of South African Breweries (SAB) have been active in South Africa for 100 years. A series of amalgamations has resulted in the present large conglomerate.

Beer is produced in South Africa from barley, maize, hops, yeast and water. It is essential that the best quality materials be used and that the malting, kilning, brewing and packaging are all carried out under strict control.

After the introduction the party of 25 visitors were conducted through the brewery where some of the processes previously described were seen in practice.

Particular interest was shown in the old section of the brewery (which is no longer operated) with huge copper vessels all brightly polished.

After the tour through the brewery the guests were entertained to snacks and given an opportunity to sample the products.

A most enjoyable visit was had by all and the section conveyed their thanks to SAB.

### Productivity

On 16 August 1989 the Section was addressed by Dr J. H. Boer, Director of Industries of the National Productivity Institute, on the subject 'The Importance of Productivity Improvement'.

The objective of improving productivity is to improve the living standards of all people.

Important parameters are:

□ Population growth,

 $\Box$  Growth in the gross domestic product (GDP), and

□ GDP per capita.

In developed countries such as USA, Japan, UK, Switzerland and Germany the GDP exceeds the population growth. Unfortunately in South Africa the opposite condition exists with conditions being similar to those in Mexico.

The National Productivity Institute acts as a catalyst to bring about greater productivity. Improvements in productivity depends on an attitude of mind aimed at constant improvement, a will to improve and faith in progress. Problems arise from five main sources; these being the population explosion, a negative work ethic, a serious lack of managerial skills, an unequal education system and union resistance.

In the period 1980-1987 just under 250,000 jobs were created. Unfortunately most of these new jobs were in the government sector, with central government creating almost 200,000 jobs and local authorities, provincial administration, statutory bodies, etc, creating a further 100.000. The mining industry created 50,000 and other private sector enterprises a further 50,000. However, there was a decrease of 150,000 jobs in public business, construction and manufacturing where it is important to create more jobs. In this same period the population increased by 5 million.

In examining annual growth rates in GDP in the period 1981-1987 South Africa has performed poorly, eg. Republic of China 5.7%, India 3.3%, Thailand 2.8% and Brazil 2.2%. South Africa with a negative growth rate of 1.7% is included with African and South America countries. When labour productivity per hour is examined South Africa is the poorest performer of the countries examined.

The lecture was followed by an active discussion of the problems existing in the South African economy.

The vote of thanks proposed by Mr Clive Peddie was heartily endorsed by the audience.

R. E. Cromarty

# West Riding Section

### **Bugs & Biocides**

The first lecture of the 1989-90 session was held at the Mansion Hotel, Leeds, on Tuesday, 19 September. Biologist John Gillatt was given time out as Technical Service Manager at Thor Chemicals to present a well-prepared review of "spoiling species", delivered in excellent humour to a 45-strong audience.

Differences between bacteria, fungi and algae were explained with reference to the mechanisms and conditions favouring their growth. The many ways in which bacterial and fungal attack manifest themselves such as viscosity loss, odour, gassing in the wet state were identified together with their effects on films through induced cracking and visual deterioration of coatings.

Sources of contamination such as water, organic and inorganic raw materials were indicated, whilst plant design, house-keeping and methods of operation could all contribute to the initiation and spread of spoilage by providing "favourable" conditions.

Control and prevention of attack through proper use of broad spectrum biocides and fungicides were proposed to minimise risk to products. A review was given of the chemical types and examples of biocides and fungicides in current use.

Questions were followed by a vote of thanks proposed by Jim Hemmings and endorsed by the audience, all of whom subsequently enjoyed the excellent buffet and bar sponsored by Thor Chemicals.

J. Hemmings 🔳

### **OCCA** News

### New members

The sections to which new members are attached are shown in italics together with the country, where applicable.

### **Ordinary members**

Badenhorst, W. A., BSc (Transvaal) Bunford, D. J., BSc, MSc (London) Careless, M. A., BSc (London) Chapman, R., BSc (Midlands) Deamer, D. F. (Thames Valley) De Beer, G. H. (Transvaal) Dunlop, A. A. (Transvaal) Fallon, P. N. (Manchester) Haythornthwaite, D., BSc (Manchester) Jacobs, C. B., BSc (Cape) Kelly, N. M., BSc, PhD (West Riding) Lowe, G. B. (Midlands) McLeod, A. I., PhD (London) Pointon, M. J., BA (Midlands) Powell, W. K. (West Riding)

### **OCCA** News

Sikka, K. R. A. (General Overseas — Pakistan) Small, F. M. (Newcastle) Taylor, B. H. G. (Manchester) Walker, M. J. (West Riding) Ward, J. B. (London) Webster, G. C., BSc (London) Wiggett, R. D., MSc (Transvaal)

Associate members Bathers, P. (Midlands) Keown, L. (Cape) Lindquist, T. K. (Cape) Smith, G. A. (Cape)

**Registered student** 

Smith, T. J. (West Riding)

### **Classified Advertisements**

JOCCA CLASSIFIED ADVERTISEMENTS FOR:

SITUATIONS VACANT AND WANTED

SERVICES

PLANT & EQUIPMENT

FOR SALE AND WANTED

CONSULTANCIES

SPARE CAPACITY

### PREMISES FOR SALE AND WANTED

Copy can be accepted up to 25th of month prior to publication.

Write, telephone, telex or fax your requirements to:

F. D. Craik, JOCCA, Priory House, 967 Harrow Road, Wembley, Middlesex, England HA0 2SF.

Telephone 01-908-1086 Telex 922670 (OCCA G) Fax 01-908-1219

To reach our total readership of over 22,000 directors, managers, chemists in 84 countries.

### SITUATIONS VACANT

## Laboratory Manager Paint and Varnish

### The Company.

S. Dyrup & Co. A/S is an international concern in the paint and varnish industry with a total of nearly one thousand employees located at the head office in Copenhagen and subsidiaries and agencies throughout most of Europe. Europe is considered our home market. The product range Dyrup sell on the Danish market provides the basis for a broad export drive. Outside Europe Dyrup's business is conducted through license agreements or associated companies.

### The position.

We are seeking a Laboratory Manager for our Paint Laboratory in the Research and Development Department, who, in addition to supervision of the laboratory personnel, will be responsible for the development and control of our waterborne coatings for wood. The position is situated in Copenhagen.

### The candidate.

A person, aged 30 to 40, should have a chemically related degree supplemented by 5-8 years' experience in paint and varnish industry. The ideal profile combines decision making competance with analytical sense and creative ability.

We can offer an exciting opportunity in a company that is committed to thinking in new directions, and a salary that reflects your qualifications. Further information about the vacancy can be obtained from the Head of Research and Development, G. K. Thomsen on 445 3169 1255, Direct applications to "the Personnel Department".

### S. DYRUP & CO

Gladsaxevej 300 DK-2860 Seborg Denmark

### **Classified Advertisements**



### **Classified Advertisements**

### SITUATIONS



JOTUN-HENRY CLARK LTD

# PROCESS ENGINEER South Humberside

JOTUN is a leading international group of paint manufacturing companies with their head office based in Norway. The Group has subsidiaries worldwide and we have recently opened a new production plant and distribution centre in South Humberside. This plant will use the latest production equipment and will supply major parts of Europe with marine paints and heavy duty coatings.

We urgently require a Process Engineer whose responsibilities will be to establish, optimise and supervise production formulations, based upon the information received from the central Research & Development laboratory. In addition to this, the successful candidate will be expected to handle trouble shooting that might arise in relation to the production process.

Applicants should have at least three years experience of working in a relevant industry and an HND in chemistry or similar qualification and applicants should have a sound knowledge of paint technology or comparable skilled trade. Attractive salary plus generous benefits package.

Please apply with a detailed C.V. to: Quality Assurance Process Manager, Jotun-Henry Clark Limited, Stather Road, Flixborough, Scunthorpe, South Humberside, DN15 8RR.

# The Exhibition for the Surface Coating Industry 16-17 May 1990

Harrogate International Centre, North Yorkshire, England.

For further information and pre-registration contact:

OCCA Priory House, 967 Harrow Road, Wembley, HAO 2SF Tel: 01-908 1086 Fax: 01-908 1219 Telex: 922670 (OCCA G) or telephone the SURFEX HOTLINE 0942 865438



# The New Generation

The versatile BENTONE SD series of rheological additives is outstandingly easy to use. Pregelling and polar activators are no longer necessary – simply incorporate them directly into the millbase. You can thus increase manufacturing flexibility and reduce labour and raw material costs. **Simplicity itself...** 

For more information on the BENTONE SD series contact

### STEETLEY MINERALS LTD.

P.O. Box 2, Retford Road, Worksop, Notts. S81 8AF U.K., Tel. (0909) 475511, Telex 547901

### NL CHEMICALS EUROPE, INC.

rue de l'Hôpital 31, B-1000 Brussels, Tel. (02) 5120048, Telex 24662



BENTONE is a trademark of NL Chemicals, Inc.

Enter K102 on Reader Reply Card