Introduction

GENERAL

During the past few decades, advances in organic chemistry have resulted in the appearance on the market of a wide range of new synthetic materials, commonly referred to as plastics, certain of which are of potential value in conservation. The enterprising conservator chooses from among all the materials available those best suited to his needs, and it is the purpose of this report to survey the various kinds of synthetic materials which have already been used in conservation or appear to have proved their worth.

This report will consider substances that are intended to remain in contact with museum objects over long periods of time from one occasion for conservation to the next. Materials such as picture varnishers, adhesives, consolidants, and permanent supports are in mind, in contrast to materials that might be used for the temporary support or treatment of an object.

It is first of all necessary to realize that these synthetic materials are not to be regarded as mere substitutes for materials of natural origin: many of the synthetics possess a combination of physical and chemical properties which is not to be found in any natural material. Thus, for example, there is now available a wide range of wax-like materials (which, as a class, might conveniently be referred to as cements) that show a combination of properties not known in any of the naturally occurring waxes. For this reason, synthetic materials afford the opportunity to develop improved and more reliable methods of conservation.

However, the number of synthetic materials now at the disposal of the aspiring conservator is so large that he may well become confused in his attempt to select the most suitable type for his particular needs, and be bewildered by the large number of trade names used to describe materials of essentially the same type. It cannot, therefore, be too strongly emphasized that no synthetic material should be used in conservation unless its properties are reasonably well known. This implies that the composition of a synthetic material—as indeed also of a natural material—must be known in all essential details so that its permanence and properties can be accurately assessed.

It is not sufficient to rely on the class of polymers, e.g., polyacrylate, polyvinyl, or even on the type, e.g., polymethyl methacrylate, because other unspecified ingredients may have been added to some products which may have potentially undesirable properties from the point of view of their use in conservation. The position in this respect is improving, however, and most manufacturers now provide sufficient details as to composition, so that products of proven quality can be selected.

CHEMICAL STRUCTURE OF SYNTHETIC RESINS

From the chemical point of view, most of the synthetic materials described in this report have a so-called polymeric structure, i.e., they are made up of long chains or networks of simple repeating units (monomers). Thus, for example, in the case of polyvinyl acetate—one of the simplest of such polymers—the repeating unit consists of molecules of vinyl acetate (CH₂COOCH₂CH₃) which are joined together in a long chain, which may contain as many as 20,000 such units. This is expressed by writing the essential chemical formula for polyvinyl acetate as:
The conservation of cultural property

\[ \text{[CH} \text{CH} \text{CH} \text{COO]} \]

where \( n \) specifies the number of monomer units in the chain. The physical properties of individual polymers will depend upon the average number of monomer units in the chain; this is often designated as the degree of polymerization (DP = \( n \)).

Synthetic resins may be divided into two main groups, namely, the thermoplastic and the thermostetting, which are fundamentally different in structure. In the case of thermoplastics, the monomeric units are linked together so as to form two-dimensional linear chains, with the result that the material is soluble in an appropriate solvent or range of solvents and remains permanently fusible.

Thermostetting resins, on the other hand, are characterized by the fact that the monomeric units are linked together by chemical bonds to form a three-dimensional network; such materials are infusible and insoluble in all solvents, although they may swell to form a gel with certain solvents, or be chemically broken down by certain reagents to form soluble products. Thermostetting resins were originally so called because they were only formed under the influence of heat as the result of a chemical change. It should, however, be noted that some of the new resins in this category can be produced without the application of heat; these are usually referred to as "cold setting resins" since their production is induced by the use of special hardeners and catalysts at room temperature. Also, it should be noted in this connection that, under certain conditions, linear thermoplastic resins may be converted into infusible insoluble resins. The phenomenon is referred to as cross-linking, because chemical bonds or links are formed between the linear chains, which are thereby converted into infusible three-dimensional networks.

PLASTICIZERS

Plasticizers are materials which are often added to synthetic resins in order to modify their physical properties, and in particular to confer added flexibility to a resin which may be too brittle.

There are fundamentally two types of plasticizers. One classification calls them primary and secondary. The primary plasticizer is a true solvent for the resinous material being plasticized. The secondary plasticizers are only partially miscible with the original substance and are added to make them compatible. Another method of classifying plasticizers is to designate them as volatile and non-volatile.

A plasticizer must remain in the film long enough to keep it flexible throughout a useful lifetime. In many industrial applications, a relatively volatile material such as dioctyl phthalate will remain in the film for a sufficient length of time to be of practical value. A limitation to the use of such materials in conservation is that the relatively volatile plasticizers eventually leave the film either by evaporation or migration. The use of volatile plasticizers in picture varnishes, for example, is avoided because of the possibility that the plasticizer might migrate into the paint, softening or otherwise altering its properties.

The non-volatile polymeric plasticizers are generally in the molecular weight range 800 to 2000. Their greatest limitation is their low compatibility. Such large molecules are not easily miscible with materials. The third component necessary for miscibility may be relatively volatile. Incompatible materials often separate: a secondary plasticizer often oozes out of a coating in time.

Bearing the general term in mind, one can see that "plasticizers" are certainly necessary and traditionally used in conservation. Gum elemi, Venice turpentine and honey perhaps might be considered to be plasticizers. The use of the modern plasticizers described above has not, however, been widely employed in conservation. The reasons for avoiding the volatile type of plasticizer are clear. But the possibility of applying certain of the polymeric types remains an intriguing one, and requires further study.

Certain polymers are said to be "internally plasticized. This is not a particularly suitable designation, but it implies that the flexibility of the resinous material has been built into it or is inherent in its particular molecular structure. The flexibility that it possesses will not vary, because there is no added component which might evaporate or change with age. Many of the newer materials that have been used in conservation are said to be internally plasticized.
Synthetic materials used in conservation

Certain cases may also be necessary to add a catalyst in order to increase and control the rate of the reaction.

Reversibility

Reversibility is a principle upon which the conservator should be explicit. The term is used here in the sense that a conservation method can be reversed if anything unexpected should happen, so that the object can be recovered in its original state undamaged. This principle is paramount when any material, whether natural or synthetic, is applied to a very valuable object, e.g., a painting, and in such cases applies absolutely. However, in the conservation of many archaeological objects, particularly where consolidation is necessary, it may be considered permissible to carry out an irreversible process using materials which have been thoroughly tested on trial objects.

Trade Names, Producers and Manufacturers

The question of trade names is a most difficult problem in the field of synthetic materials. Thus, the same basic trade name may be used to cover a wide variety of chemically distinct resins, and it may also happen that a trade name is retained while the composition of the resin is altered without notice. In the present report an attempt has been made to collect together the trade names of the most important producers of the synthetic materials discussed and to indicate, where possible, the chemical nature of the material.

A distinction should be drawn between producers and manufacturers. The former are the primary makers of the synthetic materials, whereas the latter form the synthetic materials into sheets, rods, or finished articles. This report lists only the main producers.

Note on Sources

The greater part of the information in these tables has been compiled from producers, technical leaflets and booklets, and where possible confirmed by independent sources. The authors have, of course, also made extensive use of their own published and unpublished material. Much useful information is to be found in IIC Abstracts and Studies in Conservation.
For general information on properties of plastics see the following.


Thermoplastic varnishes

INTRODUCTION

The materials in the lists below are all thermoplastic polymers of good general durability which have found uses in conservation, primarily as varnishes, but also as adhesives, retouching media, etc. Polyvinyl acetate and the poly-methacrylates are the two groups of thermoplastics generally considered the most durable under outdoor exposure tests.

No material, of course, is absolutely permanent, and it should be emphasized that inclusion in these lists does not imply a recommendation for indiscriminate use. All the materials discussed below can be obtained in solid form without additives. Polymers whose stability could perhaps be made satisfactory by the addition of stabilizers, and polymers that require plasticizers for good performance are not included.

A protective coating must have reasonable toughness in order to be successful. That is, it must possess a certain minimum strength and it must be able to stretch somewhat without cracking. It is known that, up to a certain point, increasing the average molecular weight of a polymer will increase the strength of the film and give them greater ability to elongate. Therefore, the characterization of polymers through some measurement that indicates the average molecular weight is an important specification. The viscosity of a solution of resin at 20 per cent solids concentration in toluene has been taken as a rough indication of the average molecular weight and has been designated the 'viscosity grade' of the resin. Other arbitrarily chosen concentrations are just as useful, such as the 8.6 per cent solution of polyvinyl acetate in benzene, or the 4 per cent solution of polyvinyl alcohol in water that will be found in tables below.

Thermoplastic polymers can usually be alternatively graded according to degree of polymerization, that is to say, according to the number of monomer units that go to make up an average chain. In general, the higher the degree of polymerization the more viscous the solution at a given concentration, the higher the softening point, the slower the rate of solution, and the rougher the film.

Polymers of any one type are, however, as stated above, more conveniently graded by their viscosity under standard conditions. A low viscosity grade indicates a low degree of polymerization. It is often difficult to ascertain with certainty the degree of polymerization, so that only approximate figures, extrapolated from a few known figures, can be given below. These should not be accepted as final but have been included because they give some idea of the length of the molecule chains with which we are concerned.

APPEARANCE OF VARNISHES

As experience has continued to grow in the handling of a number of new materials, the evidence has become quite clear that practically every solvent-type varnish, containing simply a resin and solvent, can be handled in such a way as to give a range of gloss. This may be accomplished either by the addition of matting agents, by spraying techniques, or by other methods. Hence, for the widest versatility, a varnish should be capable of the highest gloss likely to be required. It could then be made as matt as desired in any particular application. The appearance of a varnish and its handling qualities are also controlled to a considerable degree by the formulation of the solvent. As in many areas of craftsmanship, considerable experience is necessary in the proper selection...
The conservation of cultural property

of solvents for coatings and in the proper application by spraying. These subjects are more extensive than can be treated here, but attention is called to them to indicate that these two factors, which are not inherent properties of a varnish or resin, nevertheless have considerable influence upon their appearance.

Our opinion of the appearance of a surface is strongly influenced by its gloss. One can say that it is generally easier to get a higher gloss with a resin of low degree of polymerization (D.P.) than with a high D.P. become resistant to flow at an earlier stage in the drying. Therefore, because of shrinking (through the continued loss of solvent) and the lack of mobility of semi-dry varnish, the roughness of the paint surface tends to be reproduced in the varnish surface. Thus, if the paint is matt, a varnish with a high degree of polymerization will tend to be matt. In extreme cases, it will also look as though it had been 'fuzzed'. (This does not apply to emulsions, which dry by a somewhat different mechanism.) If the surface of an old painting is very porous and it is desirable to 'bring out the colours' most effectively, coatings based on resins of low molecular weight seem to penetrate and wet the porous paint more effectively than those based on resins of high molecular weight.

The appearance of a varnish should remain unchanged for as long a period as possible. Blinding of a film and bloom are defects that may show up at an early stage in films of dammar, mastic, and resin A/2 and M/2. These defects are far less likely to be encountered in coatings of the other synthetic resins listed below.

Certain coatings have a tendency to collect dust. Many synthetic resins attract dust by acquiring a static electrical charge, but there are various ways of minimizing this and it has not proved to be unduly troublesome. Much more important is the capacity of certain resins to hold fast, and even to imbibe, dust that falls on them. The property that affords the best indication of this tendency is known as the 'second-order-transition temperature' or 'glass temperature', $T_g$, of the material. Resinous materials do not exhibit sharp melting points but a more gradual 'second-order transition'. If the $T_g$ of a resin is above the temperature of the room, the resin will be in a rather hard, glassy state. If, on the other hand, the $T_g$ of the resin is much below the temperature of the surroundings, the material will be in the rubbery or highly viscous liquid state: materials tend to stick to it. For example, the $T_g$ of polyacetyl butyl methacrylate is about $20^\circ$C, and films of this material have a tendency to imbibe dirt at temperatures found in many rooms. An indication that a resin has a $T_g$ value much below room temperature is the fact that the bumps of resins in the container flow together or conglomerate after long storage. As a rule of thumb, such resins are to be avoided for protective coatings. Occasionally, when thin coatings of this type are applied, a second coat of harder material can be applied on top.

The synthetic resins listed below are colourless as film. They are also highly resistant to discolouration. The natural-resin varnishes, on the other hand, have a tendency to discolour. In the criticism and evaluation of varnishes, it is possible that the complete absence of colour is a minority.

A failure of adhesion can affect the appearance of the coating through light being reflected by cracks and fissures. An outstanding case is polyvinyl alcohol which has been found, in experimental tests, to have insufficient adhesion on most kinds of paint.

It is sometimes stated that the refractive index (R.I.) of a varnish is an important property. The R.I. is a measure of the extent to which light is bent when it enters a material from the air. Theoretically, the R.I. of a varnish can affect the appearance of a painting in three ways:

1. The higher the R.I., the more light is reflected from the top surface.
2. The higher the R.I., the less the light gets out of the coating into the air again, because of total internal reflection.
3. The higher the R.I., within reason, the less light will be reflected at the varnish-oil interface.

The effect of variations in the refractive indices of different varnishes is often much smaller than the differences in gloss owing to the relative smoothness and roughness of the upper surface of the varnish. Yet, if any of the factors above are important, it is perhaps the first.  

1. Effect 1 can be demonstrated when the illumination is diffuse, i.e., comes from many directions, which is a common situation. In such a case the darks of a person rendered darker than with other varnishes likely to be encountered. This RI effect is small, so this varnish must be compared under similar conditions of gloss, etc.

—G. Thompson
SUMMARY

Loss of glass through too high a degree of polymerization. Avoid high-molecular-weight resins, e.g., polystyrene, which lose glass unevenly in the first few months. MSIEA, which does not have this defect unless applied thickly, should be chosen in preference.

Loss of glass due to bloom and wrinkling. Only a consideration with AW2 and MS2, which may lose glass unevenly in the first few months. MSIEA, which does not have this defect unless applied thickly, should be chosen in preference.

Dust collection. Lumps which fuse together or conglomerate in storage indicate a resin with a low Tg. Such a resin may collect and hold dust, particularly in hot climates. Trouble will be found with polyvinyl butyral methacrylate (but not polyvinyl and ethyl methacrylate) and with the very low viscosity polyvinyl acetates (viscosity 25 and less).

Refractive index. Not a major consideration.

Adhesion. Polystyrene alcohol has poor adhesion to smooth surfaces.

LIST OF MATERIALS

Polyvinyl acetate

Chemical formula. The molecular chains are composed of the following unit:

\[-\text{CH}_2-\text{CH}^-\]
\[\text{CH}_2\text{OO}\]

Properties.

Stability. Good stability to light. Severe exposure may increase sensitivity to water but should cause yellowing, and evidence available suggests that the polymer remains fully soluble (not cross-linked).

Solubility. Can be dissolved, on the one hand, in toluene and the aromatic solvents, on the other hand in the lower alcohols with small solutions of water. Also soluble in esters and ketones. Relatively unaffected by aliphatic hydrocarbons. Slightly swollen in water, especially the lowest viscosity grades (see Table 1).

Mechanical properties. Grades of low degree of polymerization (or left in tables below) give soft films with a tendency to curl. Highly polymerized grades are tough and honey. Softening point. From 60°C to over 200°C with increasing degree of polymerization (for Tg see Table 1).

Viscosity for enamels. For single-coat varieties, avoid high viscosity on the one hand and too soft a resin on the other; a viscosity in the range about 4 and 15 (see Table 1).

Polyvinyl alcohol

Chemical formula. This resin is produced by the partial or complete hydrolysis of polyvinyl acetate to form units of the formula

\[-\text{CH}_2-\text{CH}^-\]
\[\text{OH}\]

Various grades are available (see Tables 2, 3, 4), depending on the degree of hydrolysis and the degree of polymerization required.

Properties.

Stability. Good stability to light. According to one manufacturer prolonged exposure results in slight loss of strength (e.g., chain breaking) rather than a loss of solubility (due to cross-linking). However, in strong light and dry conditions slight cross-linking will also occur. Yellowing and insolubility result from heating above 100°C.

Solubility. Water is the only practical solvent. Consequently the polymer is very resistant to petroleum solvents, oils, and fats. Contrary to what might be expected, grades of high acetate content dissolve most readily in cold water, while completely hydrolyzed grades require some heating (85-90°C). Low-viscosity grades dissolve more quickly. Weak solutions with no disinfectant may be subject to mold growth. To combat this, low concentrations of chlorinated phenols may be added.

Softening point. Can be heat-sealed at 120°C to 130°C. The glass transition temperature (Tg) of high-viscosity grades is about 85°C.

Mechanical properties. Good strength and flexibility for all grades, though strength is greater for grades of high degree of polymerization. Strength depends on humidity, but medium acetate grades will remain coherent.
Table 1. Polystyrene Resins

<table>
<thead>
<tr>
<th>Trade name</th>
<th>V15</th>
<th>V20</th>
<th>V25</th>
<th>V30</th>
<th>V35</th>
<th>V40</th>
<th>V45</th>
<th>V50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leatan (Borden)</td>
<td>1.3</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
</tr>
<tr>
<td>Gelco (Sashinigani)</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
<td>0.7</td>
<td>0.6</td>
<td>0.5</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Merlool (Merco)</td>
<td>1.5</td>
<td>1.4</td>
<td>1.3</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
<td>0.9</td>
<td>0.8</td>
</tr>
<tr>
<td>Resplex (Rhode-Poulenc)</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
<td>1.4</td>
<td>1.2</td>
<td>1.0</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>Viscap (Walker)</td>
<td>3.0</td>
<td>2.8</td>
<td>2.6</td>
<td>2.4</td>
<td>2.2</td>
<td>2.0</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Viscap (Montanplastics)</td>
<td>4.0</td>
<td>3.8</td>
<td>3.6</td>
<td>3.4</td>
<td>3.2</td>
<td>3.0</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Viscap (Basellin, Union Carbide)</td>
<td>5.0</td>
<td>4.8</td>
<td>4.6</td>
<td>4.4</td>
<td>4.2</td>
<td>4.0</td>
<td>3.8</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Approx. DP
- 150
- 200
- 250
- 300
- 400
- 500
- 600
- 700

Table 2. Polystyrene Alcohols (Low acetate: 87.5-100 per cent hydrolysis)

<table>
<thead>
<tr>
<th>Trade name</th>
<th>V15</th>
<th>V20</th>
<th>V25</th>
<th>V30</th>
<th>V35</th>
<th>V40</th>
<th>V45</th>
<th>V50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone (Reyhore)</td>
<td>95.01</td>
<td>95.10</td>
<td>95.20</td>
<td>95.30</td>
<td>95.40</td>
<td>95.50</td>
<td>95.60</td>
<td>95.70</td>
</tr>
<tr>
<td>Ethanol (Du Pont)</td>
<td>70.05</td>
<td>70.10</td>
<td>70.15</td>
<td>70.20</td>
<td>70.25</td>
<td>70.30</td>
<td>70.35</td>
<td>70.40</td>
</tr>
<tr>
<td>Getricol (Sashinigani)</td>
<td>15.0</td>
<td>15.05</td>
<td>15.10</td>
<td>15.15</td>
<td>15.20</td>
<td>15.25</td>
<td>15.30</td>
<td>15.35</td>
</tr>
<tr>
<td>Gohornol (Nippon Syn. Chem. Tokyuto)</td>
<td>15.0</td>
<td>15.05</td>
<td>15.10</td>
<td>15.15</td>
<td>15.20</td>
<td>15.25</td>
<td>15.30</td>
<td>15.35</td>
</tr>
<tr>
<td>Lenzol (Borden)</td>
<td>18.0</td>
<td>18.05</td>
<td>18.10</td>
<td>18.15</td>
<td>18.20</td>
<td>18.25</td>
<td>18.30</td>
<td>18.35</td>
</tr>
<tr>
<td>Muryol (Hoechst)</td>
<td>10.0</td>
<td>10.05</td>
<td>10.10</td>
<td>10.15</td>
<td>10.20</td>
<td>10.25</td>
<td>10.30</td>
<td>10.35</td>
</tr>
<tr>
<td>Polyvinyl (Wacker)</td>
<td>8.0</td>
<td>8.05</td>
<td>8.10</td>
<td>8.15</td>
<td>8.20</td>
<td>8.25</td>
<td>8.30</td>
<td>8.35</td>
</tr>
<tr>
<td>Pervit (Kunststoff)</td>
<td>8.0</td>
<td>8.05</td>
<td>8.10</td>
<td>8.15</td>
<td>8.20</td>
<td>8.25</td>
<td>8.30</td>
<td>8.35</td>
</tr>
<tr>
<td>Rhodophan (Rhode-Poulenc)</td>
<td>8.0</td>
<td>8.05</td>
<td>8.10</td>
<td>8.15</td>
<td>8.20</td>
<td>8.25</td>
<td>8.30</td>
<td>8.35</td>
</tr>
<tr>
<td>Viscap (Montanplastics)</td>
<td>8.0</td>
<td>8.05</td>
<td>8.10</td>
<td>8.15</td>
<td>8.20</td>
<td>8.25</td>
<td>8.30</td>
<td>8.35</td>
</tr>
</tbody>
</table>

1. Viscosity is quoted in centipoises as that of an 87.5 per cent solution in benzene. Note that the producers of Gelco use this as their designation.

2. Viscosity is quoted in centipoises as that of an 87.5 per cent solution in water at 25°C.
and tack-free up to about 90 per cent relative humidity. Polystyrene has an unusually low permeability to those atmospheric gases which are not very soluble in water, notably oxygen.

Estimated approximate degree of polymerization related to the viscosities in Tables 2 to 4.

<table>
<thead>
<tr>
<th>Viscosity</th>
<th>5</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP</td>
<td>200</td>
<td>1,000</td>
</tr>
</tbody>
</table>

**Polyvinyl formal, acetal, and butyral**

**Chemical formula.** These are thermoplastic polymers obtained from polyvinyl alcohols by partly reacting with formaldehyde, acetaldehyde, and butyraldehyde respectively. For example, the formula of polyvinyl butyral is:

\[
\begin{array}{c}
\text{CH}  \\
\text{H}_2
\end{array}
\]

**Properties.** Stability to light very good. As with polyvinyl alcohols, heating above 100°C may cause some insolubility. Solubility. The formals dissolve only in limited strong solvents, the acetals and butyrals in alcohol, acetone, and aromatic hydrocarbons. Mechanical properties. All form tough films, the formals the hardest, the butyrals similar to polyvinyl acetate. The butyrals have been suggested as picture varnishes, but are not widely used for this purpose.

**Producer.** Polyvinyl formal: Formvar (Shawinigan); Mowital F (Hoechst); Rhovinal B (Rhône-Poulenc).

Polyvinyl acetals: Alvac (Shawinigan); Rhovinal A (Rhône-Poulenc).

Polyvinyl butyrals: Butvar (Shawinigan); Mowital B (Hoechst); Rhovinal B (Rhône-Poulenc); Vinylite XY5G and XYHL (Bakelite); Piloform (Wacker).

Most of the above products are available in various grades, according to degree of polymerization (ranging from 100 to 1,000) and polyvinyl alcohol and acetate contents.

**Polymerolayets.**

Chemical formula. The molecular chains are composed of the following units:

\[
\text{CH}_3 \quad \text{CH}_2 \quad \text{CH}_2 \quad \text{CH}_2 \quad \text{CH}_3 \\
\text{H}_2 \text{O} \quad \text{H}_2 \text{O} \\
\text{CH} \quad \text{CH}_2
\]

Properties. Stability. Good stability to light. Stable up to melting points. A tendency to become insoluble due to cross-linking through the action of light without any change in appearance has been noted in certain polymericlactates, particularly iso-butyral (but not in the case of methyl).

Solvents. The poly-butyral methacrylates can be dissolved in aromatic hydrocarbons such as toluene, and even in turpentine, and in petroleum solvents having about 25 to 33 per cent aromatic content. Polyvinyl methacrylate is more difficult to dissolve, but will give a relatively low viscosity solution in an 80/20 mixture of toluene and methyl alcohol.

Mechanical properties. Tough and glass-clear films. Methyl methacrylate is the hardest, n-butyral methacrylate the most elastic. Poly-n-butyral methylacrylate has a pronounced tendency to hold dust (see p. 310).

Glass temperature (Tg). Methyl, 103°C; ethyl, 65°C; n-butyral, 22°C.

**Producer.** A wide range of producers will supply solutions and emulsions of methacrylate and acrylate polymers. Polymethyl methacrylate is most common in sheet form (see p. 316).

The following producers supply in solid form with no additives.
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Du Pont Polychemical Department

Elvacite 2004, 2005, 2100 and 2101 polymethyl methacrylate
Elvacite 2404 polyethyl methacrylate
Elvacite 2404 poly-butil methacrylate
Elvacite 2404 poly-isobutil methacrylate
Elvacite 2406 50/50 copolymer of a butyl and iso-butil methacrylate
Elvacite 2103 Methacryl butyl methacrylate copolymer
Elvacite 2014 Methacrylate copolymers

Rohm and Haas (U.S.A.):

Acryloid B 27 Methacrylate ethyl methacrylate copolymer

A NOTE ON ACRYLIC EMLISIONS

Emulsions of undisclosed compositions have not been included in this section on thermoplastic varnishes. However, studies at Mellon Institute indicate that Rhoplex AC 53 (Rohm & Haas, U.S.A.) is highly resistant to cross-linking, and forms a glossy transparent film. Rhoplex AC 53 may be based on an acrylic methacrylate copolymer similar to Acryloid B 27, although of higher molecular weight. It has a non-tensive dispersant, and has successfully

Table 1 Polyvinyl alcohols medium acetal (85% water content)

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Vol.</th>
<th>20</th>
<th>50</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcosol</td>
<td>86.05</td>
<td>88</td>
<td>100</td>
<td>88</td>
</tr>
<tr>
<td>Ethanol</td>
<td>10.0</td>
<td>10</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Glycerol</td>
<td>10.0</td>
<td>10</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Glycol</td>
<td>10.0</td>
<td>10</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Lemon</td>
<td>10.0</td>
<td>10</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Methyl</td>
<td>10.0</td>
<td>10</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Polyone</td>
<td>10.0</td>
<td>10</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Rhodanil</td>
<td>10.0</td>
<td>10</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Vinal or</td>
<td>10.0</td>
<td>10</td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>

1. Viscosity in centipoises at 75% water content.

Table 2 Polyvinyl alcohols high acetal (75% water content)

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Vol.</th>
<th>20</th>
<th>50</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcosol</td>
<td>86.05</td>
<td>88</td>
<td>100</td>
<td>88</td>
</tr>
<tr>
<td>Ethanol</td>
<td>75.0</td>
<td>75</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Glycerol</td>
<td>75.0</td>
<td>75</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Glycol</td>
<td>75.0</td>
<td>75</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Lemon</td>
<td>75.0</td>
<td>75</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Methyl</td>
<td>75.0</td>
<td>75</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Polyone</td>
<td>75.0</td>
<td>75</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Rhodanil</td>
<td>75.0</td>
<td>75</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Vinal or</td>
<td>75.0</td>
<td>75</td>
<td>50</td>
<td>30</td>
</tr>
</tbody>
</table>

3.4
undergone seven years of outdoor exposure as an emulsion paint medium.

Acryloids (Rohm and Haas, U.S.A.) are known as Paraloids in Europe, and Rhoplexes are known as Primals. The numbers and letters remain the same, e.g., Acryloid B-72 = Paraloid B-72, Rhoplex AC-51 = Primal AC-13. Rohm and Haas (U.S.A.) is not connected with Rohm and Haas (Federal Republic of Germany).

**RESINS A2W, MS2, MS2A**

These resins have found favour as picture varnishes because they are similar in handling qualities and mechanical properties to the natural resins, dammar and mastic. They are, however, more resistant to yellowing and oxidation, and of the three MS2A is the most permanent.

Also like dammar and mastic, though soluble in white spirit when fresh, the films require stronger (more polar) solvents for removal as time goes on. Eventually a proportion of ethyl alcohol or similar solvent will be required, though this stage will be reached very much later with MS2A than with A2W or MS2.

A2W, MS2, and MS2A are all as brittle as the natural resins, and this is their main shortcoming. Commercial varnishes using these resins contain plasticizers.

According to tests carried out at the National Gallery, London, A2W and MS2 do not bloom so readily as the natural resins, but lose gloss through wrinkling just as badly, though they may take longer. Resin MS2A, unless applied thickly, is most unlikely to wrinkle or bloom.

**Chemical nature.** A2W and MS2 are composed of cyclohexansone and methyl cyclohexanesone units, linked by reaction with formaldehyde with an average of about seven units per chain.

MS2A is made from MS2 by chemically reducing the ketone groups to hydroxyl groups, thereby increasing the stability.

**Properties.**

- **Solubility.** All can be dissolved in low-aromatic petroleum spirit, but are affected by most organic solvents, including alcohols.
- **Mechanical properties.** Brittle and easily reduced to powder by abrasion, when fully dried.
- **Softening point.** 80-90°C.

**Producers.**


MS2 and MS2A: Howards of Hiford (United Kingdom); Howards and Sons Ltd., P.O. Box 993, Cornwall, Ontario (Canada), Canadian distributors.

**Protective coatings for antiquities.**

In the case of certain metallic antiquities it is often necessary to apply surface coatings either to prevent tarnishing or to limit the ingress of moisture vapour which is liable to activate salts that may cause corrosion. To prevent tarnishing, the surface coating must be relatively impermeable to such gases as hydrogen sulphide, and at the same time it must not cause an unpleasant sheen on the object. Specially formulated lacquers known as Excelene and Frigelene based on cellulose nitrate have long proved satisfactory for bronze and silver objects in the British Museum. In the case of iron objects which must be protected against moisture vapour, microcrystalline waxes such as Cimoloid have been found to be effective (see below, 'Synthetic waxes'). These synthetic waxes are preferable to either the beeswax or paraffin waxes previously used.

Objects which tend to flake or have a friable surface also need to be protected against possible damage due to careless handling. For this purpose the application of emulsions of polyvinyl acetate or polyvinylacetates or of a solution of soluble nylon (see below) has proved satisfactory, because they do not exert undue contraction. Lacues can be made to have a pleasant matt appearance.
Transparent sheets

INTRODUCTION

Thin, transparent, flexible sheets have been used as supports, on one or both sides, for thin, delicate material, such as textiles, parchment or paper. Thicker sheets, which can be moulded to shape, are an unobtrusive support for fragile or fragmentary material, such as corroded metal.

Apart from their use on the objects themselves, synthetic sheets have many uses in the laboratory, studio or workshop.

Two types of sheet in commonest use are polyethylene (polythene), and cellulose, regenerated or acetylated (regenerated: Cellophane; acetylated: cellulose acetate; safety film). These are so common in most countries that they can be bought in shops or stores. Their manufacturers are therefore not given in the list below.

Polyethylene cannot be regarded as a highly stable material, since it becomes yellow and more brittle with age. The addition of a filler such as carbon black greatly increases its durability, but reduces its usefulness to the conservator. At the time of writing, most of the polyethylene on the market is considered to be low-density polyethylene. A high-density polyethylene is now being produced, which is stiffer, has a higher softening point, and is slightly more transparent.

Polypropylene, in the form now available, carries these same properties a little further.

High-density polyethylene can now be obtained as a permeable sheet, known as Vyon, from Porous Plastics Ltd., Dagenham Dock, Essex (United Kingdom).

Regenerated cellulose and cellulose acetate are perfectly clear flexible films commonly used for wrapping. They are only moderately stable to light, and become brittle in course of time due to loss of plasticizer. Where a more durable film of this type is required, cellulose acetate-butyrate (CAB) is to be recommended, though here the addition of plasticiser is necessary for the purposes of manufacture, and this may be leached out or migrate. Nitrocellulose sheet (cellulose) is not recommended for conservation, since it is highly inflammable, and darkens on exposure to light. Paper objects, stored in unstabilized nitrocellulose envelopes have been destroyed by the products of decomposition, principally nitric acid.

Two synthetic sheet materials of excellent durability and toughness are polymethyl methacrylate and polyethylene terephthalate.

Polymethyl methacrylate is one of the acrylics (polymethacrylates and poly(methyl methacrylates)), most of which have good stability to light. It is highly transparent, but as a substitute for glass it has the disadvantage of being easily scratched and of storing an electric charge which attracts dust. This latter defect can be remedied by applying a polish supplied by the manufacturers; it is, incidentally, one from which most plastics materials suffer because of their good electrical insulating properties. The earlier forms of polymethyl methacrylate tended to craze in sunlight. The addition of a stabilizer has greatly reduced this tendency.

Polyethylene terephthalate is better known as the synthetic fibre Terylene (Dacron). It is also available in sheets as thin as 6 microns, and has found use as a non-adhesive film in hot-seal relining. It is exceptionally strong.

Among the vinyl polymers, the commonest in sheet form are polyvinyl chloride (PVC), polyvinylidene chloride (PVDC, Saran), and poly(styrene). Though satisfactory for many short-term uses in the studio and laboratory, they are none of them sufficiently stable to merit their inclusion in this list of conservation material.
All the above polymers are thermoplastics, that is to say they are softened by heat, and can be dissolved, though sometimes with difficulty. There are no highly flexible sheets among the thermosetting (insoluble) resins. These resins are now common in the form of rigid sheets known as laminates. They are made from melamine-formaldehyde, urea-formaldehyde, or phenol-formaldehyde (though this last tends to darken), and are widely used as tough surfacing materials (Formica, Waccete, Bakelite, Tufnol—note that these trade names may also be used to describe other materials). They have little direct application to conservation processes, except as supporting and structural materials in museum display.

**FILMS FOR LAMINATION**

For documents which have become brittle and are too fragile to be handled without risk of damage, a special process of strengthening has been devised in which the document is laminated between plastic films. Films based on polyvinyl chloride are not recommended for the permanent lamination of valuable archival material, since there is the possible risk that, under unfavourable conditions of storage, degradation of the film may occur with the formation of chlorine-containing compounds which might damage paper documents. Films of plasticized cellulose acetate have been successfully used for lamination of documents for a number of years, and these may be considered reasonably safe, if the specifications drawn up by the United States National Bureau of Standards (NBS Monograph No. 5) for the cellulose acetate and plasticizers are adhered to.

If adhesives are used for attaching the lamination film to the document, it is essential that the adhesive should be one which is soluble in an organic solvent, so that the process of lamination can be reversed if necessary.

In cases where pressure-sensitive adhesive tapes are used for the repair of documents, care should be taken to ensure that the adhesive used will not tend to exude in the course of time from the tape. Many of the self-adhesive tapes are only intended for temporary use, but special 'permanent' tapes are now available commercially in which a specially formulated adhesive is used which shows no tendency to exude.
The conservation of cultural property

Table 6

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Producer</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhovan II</td>
<td>M and B Planca, 1125 Goddess Street, London W 1 (United Kingdom)</td>
<td>1 and 2</td>
</tr>
<tr>
<td></td>
<td>Cypo, 106, boulevard Hauzmann, Paris 6e (France)</td>
<td></td>
</tr>
<tr>
<td>Kodakel</td>
<td>Eastman Kodak</td>
<td></td>
</tr>
</tbody>
</table>

The above sheets are manufactured from Eastman Kodak CAB.

Degree of polymerization, 200 to 300 units.

For the manufacture of sheets, a low viscosity CAB, having acetate 0-15 per cent of theoretical maximum, butyrate 48-57 per cent, would be chosen.

Properties:

Stability. Superior to cellulose acetate or regenerated cellulose. Comparable to acrylics; moisture resistant; contains plasticizer for manufacturing purposes.

Solvency. Soluble in ketones (acetone), esters, 80/20 toluene/ethanol. Relatively unaffected by aliphatic hydrocarbons, water.

Softening point. In the region of 120°C.

Table 7: Polyethylene terephthalate (see Table 5)

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Producer</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mylar</td>
<td>Dupont</td>
<td>6-10</td>
</tr>
<tr>
<td>Mellinex</td>
<td>ICI</td>
<td>9-10</td>
</tr>
<tr>
<td>Hostaphan*</td>
<td>Fakwro Reheus (Pol. Rep. Germany)</td>
<td>10-10</td>
</tr>
<tr>
<td>Terphane</td>
<td>Cipo</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23, avenue Montaigne, Paris 10 (France)</td>
<td></td>
</tr>
<tr>
<td>Diacetol</td>
<td>Mitsubishi Kasei, Kogyo Co., Tokyo (Japan)</td>
<td></td>
</tr>
<tr>
<td>Luminar</td>
<td>Rayon Co., Tokyo (Japan)</td>
<td></td>
</tr>
</tbody>
</table>

1. Type I has been treated to reduce water change; is very slightly elastic.
2. Available as double film with polyethylene—Type PE.

Properties:

Chemically similar to Dacron or Terylene (see below under ‘Textiles’).

Exceptionally high strength, and consequently available in very thin sheets.

Unsuitable for outdoor exposure, due to some sensitivity to ultra-violet light.

Very high softening temperature: melts at about 230°C, and can be used up to about 200°C. Cannot be heat-sealed at all easily.

Normally contains no additives.

Note. A large range of cross-linking polymers can be obtained in liquid form for varnishes, paints, adhesives, and glass-fibre reinforced plastics. Some of these can easily be cast into sheets. In this category come the epoxy resins, noted for their high adhesive power (see under ‘Adhesives’).
Adhesives and consolidants

ADHESIVES

The main purpose of this section of the report will be to discuss certain fundamental aspects of adhesives and to consider those classes of synthetic resins which have proved of value in the realm of conservation.

Classification.

Adhesives can be classified under different headings, e.g., their chemical nature, physical state, or particular application, but in the present context the most appropriate method of classification is that based on the nature of the reaction whereby the adhesive sets. To make a strong joint a liquid adhesive must be solidified, and this can be achieved in various ways. There are four main classes:

1. Setting due to change in temperature alone, i.e., the freezing of a solid solvent (such as water). This class is exemplified by the various types of animal glues which have been used successfully, for example, in the relining of canvas paintings.

2. Setting due to change in temperature accompanied by loss of solvent (usually water). This class includes resorcinol and its derivatives.

3. Setting due to loss of solvent only. This class includes resorcinol and its derivatives.

4. Setting due to chemical reaction. This class includes the many new types of synthetic-resin adhesives which contain a liquid which remain in a liquid state until they are caused to set by the addition of a chemical (so-called hardener) which leads to the formation of an insoluble solid. There are two important groups in this class, in the first, loss of volatile matter, usually water, occurs during the setting reaction, whereas in the second the setting reaction occurs without loss of any volatile material. In the former group are included the phenol- and urea-formaldehyde resins and their various modifications, and in the latter group are the epoxy and polyester resins.

This particular method of classification has been chosen because it serves to emphasize one particular property which is of paramount importance as regards the use of adhesives in the restoration of museum objects. This is the question of the amount of shrinkage which may occur when an adhesive sets.

Thus, in the case of adhesives of classes 2 and 3 which set by loss of solvent, and of those of class 4 in which the setting reaction involves loss of volatile matter, there is considerable shrinkage which can produce stresses that may weaken the adhesive joint or cause distortion of the bonded complex. On the other hand, the adhesives of class 4 in which the setting reaction occurs without loss of volatile matter do not shrink to any appreciable extent; these adhesives therefore merit particular consideration in conservation, since certain of them approach in some respects almost the ideal type of adhesive—namely, a liquid adhesive which is a 'potential solid' and can be converted into the actual solid state at a controlled rate at room temperature with scarcely any shrinkage.

It must, incidentally, be noted that an adhesive of the same chemical type may be
The conservation of cultural property

included in more than one of the above classes, depending upon its mode of application. Thus, for example, a thermoplastic material such as polystyrene, might be utilized as a solidification of the molten polymer (class 1), by sedimentation of a solution or emulsion of the polymer by loss of solvent (class 3), or by solidification as the result of a chemical reaction of the polymer dissolved in the monomer (class 4).

The adhesives considered in the above classification are usually referred to as "structural" adhesives. This term is used to denote the essential difference between these adhesives which solidify on setting and the so-called "pressure-sensitive" adhesives which remain as viscous, permanently tacky liquids, and are most familiar in the form of adhesive tapes.

Thermoplastic adhesives

The individual synthetic resins in this group which have been used in conservation are as follows.

Polyvinyl acetate. This material is available either as a white solid which is soluble in a variety of organic solvents or in the form of aqueous emulsions. It is essentially a polar substance and might be expected to set by

Polyvinyl alcohol. This material is produced by the hydrolysis of polyvinyl acetate, whereby a number of acetyl groups are split off and replaced by hydroxyl groups. A number of different grades are available which differ in the degree of polymerization and the extent to which hydrolysis has occurred. The substance is strongly polar, is insoluble in most organic solvents but completely soluble in cold water if about 75 per cent of hydroxyl groups are present. A solution of a good-quality polyvinyl alcohol should be practically neutral and should remain so even stored for a long period. It has been used in the gluing of fragile textiles, such as flags, to plastic supports (see Tables 2-4). Polyvinyl alcohol. These are prepared by reacting polyvinyl alcohol with various aldehydes, such as formaldehyde, acetaldehyde or butyraldehyde. The materials are white solids soluble in organic solvents, and are normally used as solvent adhesives. Polyvinyl formaldehyde has been recommended as an adhesive for the attachment of delicate textiles to supports, as it does not tend to stain the textile, though it requires strong solvents for its removal. Polyvinyl butyral is better in this respect.

Acrylates. Esters of acrylic and methacrylic acid have been used in the preparation, by copolymerization of suitable monomers, of a wide variety of materials of potential value as adhesives. In general their properties are similar to polyvinyl acetate adhesives, and they are available commercially either as solutions in organic solvents or as emulsions (Brodacril, Elvacite, Mehanol, Plexisol, Plexitol, Vedril, Venacyl).

Synthetic rubber. Varieties of synthetic rubber produced by copolymerization of such substances as butadiene, styrene and acrylonitrile have been utilized in the preparation of adhesives. The special virtues of these adhesives are their capability of developing specific adhesion between a large variety of adherents and the fact that, if the adhesive is subjected to stresses, its high elongation permits it to absorb much of the strain without causing rupture of the bond. They can be used either as solutions in organic solvents or as emulsions.

Cellulose derivatives. One of the first of the synthetic-resin adhesives to be developed was cellulose nitrate (usually incorrectly called nitrocellulose). This has been used extensively in conservation in the form of a solution of an appropriate grade of cellulose nitrate in equal
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sual and should-
period. It has
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butaraldehyde,
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ses, and they
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ions (Bedacryl,
ls, Flexol, Vedril,
synthetic rubbe-
ion of such
such as acrylo-
e prepa-
ating the adhe-
ng a good specific
ity of adheren-
e is subjected to
absorb
rperse of hot
ations.
be first of the
developed was
called nitr-
e extensively in
solution of an

parts of vinyl acetate and acetone. It was found par-
mically suitable for the repair of such materials as
posters, porcelain and glass. Subsequently, deriva-
tives of a similar type such as cellulose acetate and
cellulose caprate, dissolved in an organic solvent, have
been used as adhesives.

Also derivatives of cellulose have been produced
which are soluble in water and have adhesive ac-
tion; these include the ether derivatives, ethyl and
methyl cellulose and the derivative known as sodium
carboxymethyl cellulose. These water-soluble com-
ounds are useful as general-purpose adhesives in the
textile and paper field (Celacol, Cellobase,
Courlose, Modocol). Soluble nylon. This is a special chemically
modified form of nylon (e-hydroxymethyl
nylon) which is produced by treating nylon
with formaldehyde. It is available as a white
powder which is soluble in methyl or ethyl
alcohol and in industrial methylated spirits or
in a mixture of 70 parts of these alcohols with
30 parts of water. The solution tends to gel at
room temperature, but liquefies on warming
at 80°C. It is particularly useful in cases where
it is desirable to use a mobile, non-squamous
adhesive; also the adhesive film has a fair degree
of flexibility and does not tend to exert contractile
forces when used, for example, in the reassem-
bly and varnish paint on a tempera wall-
painting (Elvamide, Maranyl, Caltron CA,
Soluble Nylon).

Thermosetting adhesives (cold-setting)

Urea-formaldehyde and melamine-formaldehyde.
These types of materials, produced by
the action of formaldehyde on urea or melamine,
have found extensive use as adhesives for wood.
They have completely displaced the phenol-
formaldehyde types of resin which tended to
darken and are not suitable in conservation.

These resins set by a chemical reaction between
the actual resin component and a hardener,
and the mode of application can be varied according
to the way in which the hardener is mixed with
the resin component. There are three main
variations, namely:

1. The hardener is added to the resin in a given
proportion to give a mixture which sets
within a given short period of time.

2. The hardener is applied to one adherent
and the resin to the other, and the two
surfaces are held together under pressure
until the adhesive system sets.

3. The adhesive is supplied as a dry powder
consisting of resin plus hardener to which it
is only necessary to add water to obtain an
active adhesive system which can be applied
in the conventional manner.

Special hardeners have been developed to suit
particular needs. Certain urea-formaldehyde
adhesives can be used as so-called gap-filling
adhesives in which relatively thick glue-lines
are used to form a strong permanent bond.
Such gap-filling adhesives are clearly of potential
value in the repair of museum objects in which
the parts to be joined cannot be made to
match exactly (Aerolite, Casamite, Melocol,
Sumbond).

Epoxy (or ethylene) resins. These resins are
among the latest additions to the range of
synthetic adhesives; they consist essentially of
a viscous resin component having an epoxy
ring which is reacted with a suitable hardener
(of which there are many) to produce a liquid
system which sets to the final solid state without
the evolution of any volatile material. This
means that the setting takes place without
appreciable shrinkage, so that no strains are set
up which might cause distortion of the glued
assembly. Furthermore, these resins are the
most versatile type of adhesive yet produced;
they can form strong bonds between all kinds
of surfaces. The adhesive produced in a
variety of forms, as solids, liquids, or pastes,
so that the conservator can choose the particular
type most suitable to his immediate needs
(Araldite, Lekutherm, Permigle, UHU-plus).

Cross-linked acrylics. Recently a special type of
adhesive (Acralite 50) based on an acrylic resin
which can be cross-linked by a special hardener
has been introduced as a fast-setting adhesive; it
is particularly suitable where high bond strength
and water resistance are required. The adhesive
is prepared ready for use by adding hardeners
to the resin solution.

Miscellaneous

Eastman 910 adhesive. This is a new and unusual
type of adhesive which differs from conventional
adhesives in that it does not set by loss of solvent
not by chemical reaction induced by a hardener.
The material is a mobile liquid cyanoacrylate
monomer which can be caused to polymerize
to a solid under pressure. Thus the adhesive
bond is produced by merely brushing a thin
film of the monomer on one of the clean
degassed surfaces, placing in intimate contact
with the other surface and applying manual
pressure for a very short period of time. High
bond strength is built up between almost every
kind of material. It is particularly useful for the
repair of glass objects. The hardened resin is
soluble in dimethyl formamide.

CONSOLIDANTS

The need to restore mechanical strength to
objects which have been rendered fragile as a
result of exposure to adverse conditions or to
impregnate a fragile surface are constantly
recurring problems in conservation. The
traditional materials were either beeswax or
solutions of natural resins, such as shellac.
However, these suffer from certain dis-
advantages, and the introduction of synthetic
materials offers the possibility of developing
improved methods of consolidation. These may
considerably be considered under the following
headings.

Synthetic waxes

Microcrystalline waxes. These are semi-synthetic
waxes isolated as by-products from the refining
of petroleum. They have a microcrystalline
structure which confers on them a pliability in
marked contrast to the brittle paraffin waxes.
They are obtainable in a wide range of melting
points and physical consistencies from hard to
soft (see Index: Cosmoloids).

Polyethylene glycol waxes. Polyethylene glycols
are polymers of ethylene glycol. The lower
members of the series are viscous liquids, the
intermediate members pastes, and the higher
members are solids having the physical appear-
ance of waxes, but distinguished from ordinary
waxes by the fact that they are freely soluble in
water at room temperature. Trade names in
U.S.A. and the U.K. are 'Carbowax' and 'PEG',
and on the European Continent 'Polywachs'.
Two examples will indicate the potential value
of these waxes as consolidants. Carbowax 1500
can be used to restore flexibility to ancient
leather which has become brittle and fragile
owing to dessication, and Carbowax 400 has
been successfully used to replace the water in
fragile waterlogged wooden objects in such a
way as to prevent deformation and to confer
mechanical strength.

Modified waxes. The development of amorphous
high-molecular-weight thermoplastic copolymers
of ethylene and vinyl acetate has made possible
the imparting of plastic-like properties to waxes,
which can bond based on paraffin waxes or
micro(waxes to compete effectively with high-
quality polymeric coatings. These copolymers
are marketed, both in the U.S.A. and Europe,
under the trade mark Elvanol.

Solvents of synthetic resins

The synthetic resins described under 'Adhesives'
can be used in suitable solutions for the consoli-
dation of fragile objects. This technique works
reasonably well in the case of porous objects
such as bone and ivory, but in other cases the
need for the solvent to evaporate usually results
in the formation of a skin or resin on the surface
unless impregnation can be carried out under
vacuum. This imposes severe limitations on this
technique of consolidation.

Non-solvent resins

The availability of the non-solvent types of
synthetic resin which can be applied as mobile
liquids that solidify on site at room temperature
under the influence of a hardener offers a new
approach to the problem of consolidation. The
system is very flexible and the conditions can
be altered to suit particular needs; the setting
time can be varied by suitable choice of hardener
or by the addition of an accelerator, and the
degree of resilience of the set resin can be
varied by the addition of a plasticizer or by
altering the nature of the resin.

From a chemical point of view the resins
employed are the following:

Polyesters. These materials are produced by a
reaction between a polyhydroxy alcohol and a
polybasic acid. A large variety of products are
available depending upon the particular nature
of the reacting components. They are often mixed with other solvents (Bondasilite, Crysol, Legeval, Palatal, Strayl).

Epoxy (thermoset) resins. These are chemically similar to the resins already discussed as adhesives. The special types of resins which have been produced commercially as casting resins are the ones which can be best adapted to serve as consolidants. The most important feature of these materials is the fact that they set at room temperature without appreciable shrinkage. Various compositions can be chosen for the consolidation of metals, wood and stone (Araldite, Epophen, Lekatherm).

Polyurethane resins. These are available as a two-component system of a polymer together with the monomer in which a catalyst is dissolved. The solid polymer is mixed with the liquid monomer plus catalyst to form a mobile liquid or paste which sets at room temperature. In some preparations there may be appreciable shrinkage (up to 10% per cent), but recently a material produced under the trade name Technovit merits special mention as it is claimed to set with very slight shrinkage. For this reason it has proved of particular value in the restoration and consolidation of glass and metal objects (Technovit, Tenisol, Pleugon M555).
Ultra-violet absorbers are chemicals which absorb ultra-violet radiation. Added to transparent sheets or varnishes they function as filters allowing visible light to pass, but removing the ultra-violet. Thus the transparent material, while remaining almost colourless, is able to protect colours and materials which are liable to be deteriorated by ultra-violet radiation.

Among the many chemicals which have been proposed for the absorption of ultra-violet light, there are two important classes available in pure powder form: the benzophenones and the benzotriazoles.

The varieties of benzophenone available vary (a) in strength of ultra-violet absorption, and (b) in solubility and compatibility characteristics. As far as our knowledge goes, there is no great difference in permanence among these varieties, and there is therefore no point in choosing a weak absorber when a smaller quantity of a stronger absorber will do the same job. Consequently the weaker absorbers (except for two water-soluble varieties) have not been included in the list below.

To remove substantially all radiation of wavelength shorter than 3000 Angstroms only a strong absorber should be considered in a thin film such as a varnish, since the concentration of one of the weaker absorbers would become prohibitively high.

**Ultra-violet absorbing powders**

Substituted benzophenones (see Table 8). Formula of benzophenone, with substitution numbers:

![Benzophenone structure](image)

**Table 8.**

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Products</th>
<th>Formula</th>
<th>Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>UVinal D 10</td>
<td>Azonix</td>
<td>2,5-dihydroxy-2'-methyl - 4'-methoxy</td>
<td>Alcohol, esters, ketones.</td>
</tr>
<tr>
<td>UVinal D 49</td>
<td></td>
<td>2,5,5'-dihydroxy - 4'-methoxy</td>
<td>Ethers, ketones, solvents.</td>
</tr>
<tr>
<td>UVinal 400</td>
<td></td>
<td>Mixed amount of hydroxy and methoxy</td>
<td>Alcohol, esters, ketones.</td>
</tr>
<tr>
<td>UVinal D 94</td>
<td></td>
<td></td>
<td>Water.</td>
</tr>
<tr>
<td>Cyasorb LV 34</td>
<td>Cyanamid</td>
<td>As UVinal D 49</td>
<td></td>
</tr>
<tr>
<td>Cyasorb LV 214</td>
<td></td>
<td>2'-hydroxy - 4'-methoxy - 3'-p-sulphophthalic</td>
<td>Water.</td>
</tr>
</tbody>
</table>

**Table 9.**

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Products</th>
<th>Formula</th>
<th>Compatibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tinosorb P</td>
<td>Geigy</td>
<td>Both hydroxyphenyl benzotriazole derivatives.</td>
<td>Cellulose esters.</td>
</tr>
<tr>
<td>Tinosorb 140</td>
<td></td>
<td></td>
<td>Polysaccharide.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Polymethacrylate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Polystyrene.</td>
</tr>
</tbody>
</table>
a smaller quantity of a will do the same job. weaker absorbers (except for varieties) have not been below. substantially all radiation of less than 4000 Angstroms only should be considered in a varnish, since the concentration weaker absorbers would dry high.

2 powders

name (see Table 9). Formula with substitution numbers:

![Formula](image)

<table>
<thead>
<tr>
<th>Solubility</th>
<th>Alcohol, esters, ketones.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Water.</td>
</tr>
<tr>
<td>Condensation</td>
<td>Cellulose esters</td>
</tr>
<tr>
<td>Polymethylacrylate; polystyrene</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Producer</th>
<th>Formula</th>
<th>Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPS</td>
<td>Eastman Kodak</td>
<td>p-oxaldehyde</td>
<td>Alcohol, ketone, aromatic and aliphatic hydrocarbons.</td>
</tr>
<tr>
<td>RMB</td>
<td></td>
<td>Resorcinol monophenol</td>
<td>Alcohol, ketone.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Producer</th>
<th>Thickness (mm)</th>
<th>UV absorber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plexiglas UF-1 and UF-3</td>
<td>Rohm &amp; Haas (U.S.A.)</td>
<td>0.3-6</td>
<td>Non stated.</td>
</tr>
<tr>
<td>Orbea UF-1 and UF-3 (outside U.S.A.)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Producer</th>
<th>Thickness (mm)</th>
<th>UV absorber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast sheet Formula L 825 Colour L 424</td>
<td>Ansell</td>
<td>75.150 microns</td>
<td>A specific</td>
</tr>
<tr>
<td>Cellosolve S 461</td>
<td>Brush Celanese</td>
<td>1.5 mm only</td>
<td>0.05 per cent of Tinuvin P by weight of sheet.</td>
</tr>
<tr>
<td>Rhodamine U Incolor (clear)</td>
<td>Rhone-Poulenc</td>
<td>0.1 mm</td>
<td>Not stated.</td>
</tr>
</tbody>
</table>

Triazoles (see Table 9). Formula of hydroxyphenyl benzotriazoles:

![Formula](image)

Others (see Table 10)

Ultra-violet-absorbing sheets

Polyvinyl methacrylate and cellulose acetate sheets are available in which UV-absorbers have been incorporated. For thicker sheets, up to perhaps 5 mm, the methacrylates mentioned should be considered. They are much more expensive, but more durable. Cellulose acetate is not the ideal material for thin sheets because of its limited durability (cellulose acetate butyrate would be better), but more permanent materials are not yet on the market. Cellulose acetate should give 5-10 years’ service in temperate countries.

Polyvinyl methacrylate (see Table 11). UF-3 is a stronger UV absorber than UF-1, and is therefore to be preferred wherever its slight yellow tint can be tolerated. UF-4 may also be obtained in tube form to fit over fluorescent tubes.

Cellulose acetate (see Table 12). Ultra-violet-absorbing varnishes

It is a simple matter to add one of the powders listed above to a varnish solution, and then to compound one’s own ultra-violet-absorbing varnish. Any such varnish ought at the very least to be tested for the following: (a) compatibility (i.e., unimpaired clarity) of absorber in fresh film; (b) continued compatibility (in some cases the absorber crystallizes out after weeks or months); (c) ultra-violet absorption curve of fresh film; and (d) ultra-violet absorption curve of the aged film (in certain synthetic oil varnishes, the life of an ultra-violet absorber may be greatly reduced).
The conservation of cultural property

The application on to glass of an ultra-violet-absorbing varnish which will be invisible is difficult, since brush strokes, tears, and runs are readily noticed in clear films, and also since the thickness of the film must be controlled to give correct absorption.

Because of the above difficulties there is much to be said for using a manufactured varnish and employing skilled work in its application (see Table 14).

Note. At the time of going to press, information has been received that a "safety glass" is manufactured consisting of two layers of glass with a UV filter between them. The UV filter is an American Cyanamid benzophenone in polynyl butyral. Trade name: Palteban UV 193.

A diffusing form is also available, Northlite UV 193, with 70 per cent transmission of visible light, a UV filter, and good anti-radiant heat properties. No museum tests have yet been done on these products, though theoretically they should be highly satisfactory. Manufacturer: Shatterproof Safety Glass Co. Ltd., Port Elizabeth (South Africa).

MOULDING AND EMBELLISHING MATERIALS

In making replicas of museum objects it is essential to choose moulding materials which will not have any deleterious effect on the surface of the objects. Possible dangers to antiquities which are undergoing a process of moulding arise from several causes. These include the following:

1. The presence of substances in the moulding material which may react with the object.
2. Lack of resilience in the mould which may enable it to lock on to aspersions on the object and cause them to be broken away when the mould is removed. This difficulty may be overcome by the adoption of a piece-moulding technique.
3. Adhesive properties which may have the same result as above.
4. Liberation of excessive heat during setting of the moulding material.

It is the material and condition of the antiquity that determines which of the causes listed above is dangerous in any particular case. A further property of moulding materials which is of interest is its degree of shrinkage, and the possibility of swelling the mould back to its original dimensions again.

Many synthetic materials have been introduced as moulding materials. Among these which may be considered suitable for the moulding of antiquities are the products listed in Table 14.

Table 14

<table>
<thead>
<tr>
<th>Producer and trade name</th>
<th>Chemical type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICI: Welvac</td>
<td>Polyvinyl chloride copolymer.</td>
</tr>
<tr>
<td>Krynacuk: Nalcoflex</td>
<td>Polyethylene rubber.</td>
</tr>
<tr>
<td>Bayer: Siliprene.</td>
<td>Silicone rubber.</td>
</tr>
<tr>
<td>Mouldland Silicones: Silastem.</td>
<td>Silicone rubber.</td>
</tr>
<tr>
<td>ICI: Silwax.</td>
<td>Silicone rubber.</td>
</tr>
<tr>
<td>Venturer: Remulite.</td>
<td>Rubber latex.</td>
</tr>
</tbody>
</table>

In using these synthetic materials it must be noted that in certain cases it may be necessary to apply an isolating or release film to the surface of the antiquity in order to facilitate removal of the mould or to prevent possible staining of the surface, particularly in the moulding of antiquities of a porous nature.

Details of isolating materials can be obtained from the producers. The most suitable for use

Table 15

<table>
<thead>
<tr>
<th>Trade name</th>
<th>Manufacturer</th>
<th>Resin type</th>
<th>UV absorber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>William Grace, London S.W. 4 (United Kingdom).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Synthetic materials used in conservation

may
be
used
for
the
protection
of
antiquities
and
is
therefore
suitable
for
making
moulds
of
objects
which
can
withstand
heating
to
the
required
temperature.
The
other
materials
are
all
cold
setting,
and
have
been
successfully
used
for
the
moulding
of
a
wide
variety
of
antiquities.
They
are
characterized
by
their
resilience
and
relatively
small
degree
of
shrinkage.

Textiles

A
number
of
synthetic
materials
can
be
fabricated
in
the
form
of
textiles
which
possess
certain
advantages
over
natural
textiles
and
can
be
used
as
supports.
These
materials
are
characterized
by
their
tensile
strength,
durability,
relative
dimensional
stability
to
moisture,
and
freedom
from
attack
by
moths
and
fungi.

The
most
important
textiles
used
in
conserva-
tion
are
shown
in
Table
15.

Of
these
textiles,
the
nylons
are
noted
for
their
very
high
strength
and
the
polyesters
for
greatest
resistance
to
creasing.
All
except
the
triscrates
are
unaffected
by
moisture,
bacteria,
and
mould
growth.
Many
are
available
as
relatively
thick
and
strong
monofilaments
(e.g.,
nylon),
and
some
find
this
their
only
suitable
textile
form
(polyethylene,
polypropylene,
PVC,
Teflon).
Nylon
and
the
polyesters
can
be
obtained
in
a
wide
range
of
weights,
from
fine
gauze
to
heavy
canvas.

Certain
textiles,
such
as
PVC
and
PVDC
(Saran,
Velon,
Tygon,
Rhovyl),
have
not
been
included
because
they
are
not
regarded
as
highly
stable
materials.
For
the
same
reason,
triscrates
should
be
avoided
for
permanent
treatment,
though
their
special
properties
may
give
them
other
uses
in
the
conservation
laboratory.
The conservation of cultural property

### Table 17: Textiles

<table>
<thead>
<tr>
<th>Type of textile</th>
<th>Chemical structure</th>
</tr>
</thead>
</table>
| **Polyamides (Nylons)** | Made in one of two ways: (a) by linking amino of an aminoacid, e.g., Nylon 6-<sup>a</sup>: 
\[ -\text{NHCO} \text{CH}_2\text{CO-} \text{CH}_2\text{NH} - \text{CH}_2\text{CO-} \] 
(b) by joining alternately a diamine acid with a diamine, e.g., the common nylon, Nylon 6-<sup>b</sup>: 
\[ -\text{CO-CH}_2\text{CH}_2\text{CO-} \text{NH-CH}_2\text{CH}_2\text{NH-} \] |
| **Polyesters** | Polyoxyethylene terephthalate: 
\[ -\text{OCH}_2\text{CH}_2\text{O-} \text{CO-} \text{CH}_2\text{CO-} \] |
| **Acrylics** | Polycrystalline: 
\[ -\text{CH}_2\text{CH-}n \] |
| **Modacrylics** | Copolymer of acrylonitrile and vinylidene chloride. |
| **Triacetates** | Cellulose triacetate (see Formula, p. 31), R', R'', R''' = CH<sub>3</sub> — CO-CH<sub>2</sub>- |
| **Polyamides** | Reemac, Wyvone, Velon (U.S.A.), Courlene, Courlene XJ (high-density polyethylene), (U.K.). |
| **Polypropylene** | (U.K.), (U.S.A.), (Italy). |
| **Polyurethane** | (Japan). |
| **Polyester** | Tetlon (U.S.A.). |

<sup>a</sup> The n mole numbers signify the number of carbon atoms in the main (Nylon 66 has 6 carbons in the diamine acid and 6 in the diamine).

<sup>b</sup> Made insoluble by crosslinking with, e.g., formaldehyde.
### Index of Trade Names

In this list are included a selection of the trade names given by various producers to the most important synthetic materials used in conservation, except textiles, which are given in Table 11, page 318.

#### Abbreviations used in the trade names list:
- **M/F** = melamine-formaldehyde;
- **PV** = polyvinyl;
- **PVA** = polyvinyl acetate;
- **PVC** = polyvinyl chloride;
- **U/F** = urea-formaldehyde.

#### Trade Names Table

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Chemical Type</th>
<th>Producer</th>
<th>Adhesive</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acryla</td>
<td>Acrylic</td>
<td>Robin &amp; Haas (Fed. Rep. Germany)</td>
<td>Adhesive.</td>
<td>331</td>
</tr>
<tr>
<td>Acrylic</td>
<td>Acrylic</td>
<td>Mitsubishi Rayon Co. (Japan)</td>
<td>Sheet.</td>
<td>337</td>
</tr>
<tr>
<td>Acryl</td>
<td>Acrylic copolymer</td>
<td></td>
<td>Varnish.</td>
<td>334</td>
</tr>
<tr>
<td>Acrilex</td>
<td>U/F</td>
<td>Robin &amp; Haas (U.S.A.)</td>
<td>Adhesive.</td>
<td>335</td>
</tr>
<tr>
<td>Acrilan</td>
<td>PVA</td>
<td>Ciba</td>
<td>Varnish</td>
<td>336</td>
</tr>
<tr>
<td>Acrylon</td>
<td>PV alcohol</td>
<td>ICI</td>
<td>Adhesive</td>
<td>337</td>
</tr>
<tr>
<td>Acrilan.</td>
<td>PV formal</td>
<td>Akzo</td>
<td>Adhesive</td>
<td>338</td>
</tr>
<tr>
<td>Acrylon</td>
<td>Bisphenolphenol</td>
<td></td>
<td>Varnish</td>
<td>340</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Epoxy</td>
<td>Shurtex</td>
<td>UV-absorbing varnish</td>
<td>345</td>
</tr>
<tr>
<td>Acrylic</td>
<td>Polyacrylamide</td>
<td></td>
<td>Adhesive/consolidant.</td>
<td>341</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Citro</td>
<td>Allied</td>
<td>Adhesive and varnish.</td>
<td>353</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>BASF</td>
<td>Bataine</td>
<td>Adhesive and varnish.</td>
<td>354</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>ICI</td>
<td>Consolidate</td>
<td>Consolidate</td>
<td>355</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Bondaglas</td>
<td>Consolidate</td>
<td>Consolidate</td>
<td>356</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Solvitec</td>
<td>Shurtex</td>
<td>Adhesive</td>
<td>357</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>PV formal</td>
<td>ICI</td>
<td>Adhesive</td>
<td>358</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>PV formal</td>
<td>ICI</td>
<td>Adhesive</td>
<td>360</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Solvitec</td>
<td>Union Carbide</td>
<td>Consolidate</td>
<td>361</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Polyethylene glycol wax</td>
<td></td>
<td>Adhesive</td>
<td>362</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>U/F</td>
<td>Union Carbide</td>
<td>Adhesive</td>
<td>363</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>PVA.</td>
<td>Leuna Lovell, Northfield, Massachusetts (U.S.A.)</td>
<td>Adhesive</td>
<td>364</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Cellulose.</td>
<td>Leuna Lovell</td>
<td>Adhesive</td>
<td>365</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Soluble cellulose.</td>
<td></td>
<td>UV-absorbing sheet</td>
<td>366</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Cellulose acetate</td>
<td></td>
<td>Adhesive</td>
<td>367</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Soluble cellulose.</td>
<td></td>
<td>UV-absorbing sheet</td>
<td>368</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Cellulose.</td>
<td>ICI</td>
<td>Ascor Beinrider &amp; Lawrence, 9 Savoy St., London W.C.1 (U.K.)</td>
<td>Consolidate.</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Soluble cellulose.</td>
<td></td>
<td>Adhesive</td>
<td>370</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Polyacrylamide</td>
<td></td>
<td>UV-absorbing sheet</td>
<td>371</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Acrylon.</td>
<td>Eastman Kodak, Du Pont</td>
<td>Adhesive</td>
<td>372</td>
</tr>
<tr>
<td>Acrylon.</td>
<td>Acrylic.</td>
<td>Eastman Kodak</td>
<td>Adhesive</td>
<td>373</td>
</tr>
</tbody>
</table>

1. The addresses of the major producers are given in the Index of Producers.
<table>
<thead>
<tr>
<th>Trade name</th>
<th>Chemistry</th>
<th>Producer</th>
<th>Reference</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasound</td>
<td>Polyethylene (soluble in dimethyl acetamide)</td>
<td>Du Pont</td>
<td>Adhesive</td>
<td>511</td>
</tr>
<tr>
<td>Fisalol</td>
<td>PVC</td>
<td>Du Pont</td>
<td>Varnish/adhesive</td>
<td>514</td>
</tr>
<tr>
<td>Elvanol</td>
<td>Vinyl copolymer</td>
<td>Du Pont</td>
<td>Wax modifier/adhesive</td>
<td>518</td>
</tr>
<tr>
<td>Epon</td>
<td>Epoxide</td>
<td>Shell Chemicals</td>
<td>Casco</td>
<td>522</td>
</tr>
<tr>
<td>Epoxylite</td>
<td>Epoxide</td>
<td>Mariott Ltd.</td>
<td>CONSOLIDATED</td>
<td>533</td>
</tr>
<tr>
<td>Feldspar UV 355</td>
<td>Benzophenone</td>
<td>W. C. Heraeus &amp; Co.</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Fonanite</td>
<td>Pentaerythritol tetrakis(3-ethyl-4-hydroxybenzoate)</td>
<td>Bayer</td>
<td>UV-absorbing sheet</td>
<td>526</td>
</tr>
<tr>
<td>Magna-Max</td>
<td>Pentaerythritol tetrakis(3-ethyl-4-hydroxybenzoate)</td>
<td>Bayer</td>
<td>Adhesive</td>
<td>521</td>
</tr>
<tr>
<td>Marquay C 210/P</td>
<td>Soluble nylon</td>
<td>Imperial Chemicals</td>
<td>Varnish/adhesive</td>
<td>523</td>
</tr>
<tr>
<td>Melamine</td>
<td>Melamine UF</td>
<td>Union Carbide</td>
<td>CONSOLIDATED</td>
<td>533</td>
</tr>
<tr>
<td>Methacryl</td>
<td>Methacrylate</td>
<td>Hoechst</td>
<td>Adhesive</td>
<td>525</td>
</tr>
<tr>
<td>Modacryl</td>
<td>Acrylate</td>
<td>Du Pont</td>
<td>Varnish/pressure sensitive tape</td>
<td>524</td>
</tr>
<tr>
<td>Polyamide</td>
<td>Polyamide</td>
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With their principal agents in other countries

AMCEL Celanese Corporation of America, 1.0 Madison Avenue, New York 16, N.Y. (U.S.A.)
United Kingdom Celanese Corporation of America, 47 Old Bond Street, London W. 1.
France 8, place Vendome, Paris.
Italy Soc. Ustica, Via Generale Alluise, 8, Milano.
India Industrial and Allied Chemicals, Bombay.
Japan Percy Trean, Tokyo.

ANTARA Antara Chemicals 451 Hudson Street, New York 14, N.Y. (U.S.A.)
United Kingdom Fine Oils and Chemicals Ltd., Cadiz Street, Manchester 1.

ANTISOL DEVELOPMENTS Antisol Developments, 28 Blackfriars, Manchester (United Kingdom).

BASF Badische Anilin und Soda Fabrik A.G., Ludwigshafen am Rhein (Federal Republic of Germany).
U.S.A. BASF Inc., 571 Park Avenue, New York 22, N.Y.
United Kingdom Allied Colloids Ltd., 2 The Green, Richmond, Surrey.
France Imaco S.A., 5, rue Alfred de Vigny, Paris.
Italy SASEA, via Matteo Bandello, 6, Milano.
Sweden AB Triga, PB 1064, Kungsportsavenyn 53-55, Gotenburg.
India Chemicals Private Ltd., POB 181, Kasuri Buildings, Jamshedji Tata Road, Bombay 1.

Japan Color-Chemco Trading Co. Ltd., Tsuzuki Building, no. 9, 4-chome Honcho, Nihombashi, Chuo-ku, Tokyo.

BAKELITE Bakelite Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. (U.S.A.)
Italy Chem-Plast, via Carducci, 21, Milano.
India National Carbon Co., PO Box 2370, Industrial Products Division, Calcutta.
Japan Tomoe Engineering Company, Minazawa, Building, 1-chome, Gunza 1, Chuo-ku, Tokyo.


BORDEN Borden Chemical Company, 350 Madison Avenue, New York 17017 (U.S.A.)

BRITISH CELANESSE British Celanese Ltd., Celanese House, Hanover Street, London W. 1 (United Kingdom).

1. The list of manufacturers was established by the Centre. Unfortunately, there was not sufficient information concerning products manufactured in all of the countries of the world.
2. European headquarters: AMCEL Europe, 211, avenue Louise, Brussels (Belgium).
The conservation of cultural property


United Kingdom Herbert G. F. Greenham, 41/43 Dover Street, London W.1. France SOGEP, 41, avenue Kléber, Paris-16e. Italy Eigenmann & Veronella, Piazza S. Maria Beltrade, 8, Milano.


Japan Chemiyus Ltd., 8th floor, Chiyoda Shimb Building, 2-chome Kyobashi, Chou-ku, Central PO Box 1123, Tokyo.


France ICI (France) S.A., boite postale 105, 69, rue Ampère, Paris-17e.

Germany (Fed. Rep.) ICI (Deutschland) GmbH, Schumaninkai 17, Frankfurt am Main. Italy Beghe & Chiappetta, via Iroviso 21, Milano.

Sweden Svenska ICI, Box 184, Gothenburg. India ICI (India) Private Ltd., PO Box 182, GPO, Calcutta 1.

Japan ICI (Japan) Ltd., GTO Box 411, 8th floor, Palace Building No. 10, 1-chome, Marunouchi, Chiyoda-ku, Tokyo.

KAUTSCHUK Kautschuk GmbH, Leebachstrasse 21, Frankfurt am Main (Federal Republic of Germany).

MO & DOMSO MO & Domso AB, Strandvagen 1, Stockholm (Sweden). U.S.A. Gaston Johnstone Corporation, 14-64 45th Street, Long Island City, 3, N.Y.

United Kingdom Modo-Products, 4/6 Savile Road, London W.1. France Seppe S.A., 70, avenue des Champs-Elysées, Paris 8e.

Italy Gei & Heidenreich, piazza Castello, 20, Milano.

Japan F. Kusunose & Co. Ltd., Central PO Box 209, Osaka.

MONTECATINI Montecatini, via P. Turati, 18, Milano (Italy). U.S.A. Chemical Corporation, 2 Broadway, New York 4, N.Y.


Germany (Fed. Rep.) Mowag-Chemie GmbH, Basellerstrasse 37, Frankfurt am Main.

Sweden Aktiebolaget Tref, Skeppargatan 26, Stockholm 14.

India R. K. Dhand Eastern Ltd., 133 Mahamand Gandhi Road, Fort, Bombay.


PECHINEY-SAINTE GOBAIN 16, avenue Maxroo, Paris 8e (France).

REVEREY REVEREX Ltd., 31-33 Strand, London, W.C.2 (United Kingdom).

RIHÔNE-POULENC Societe des Usines Chimiqques Rhône-Poulsenc, 21, rue Jean-Goujon, Paris-9e (France).


U.S.A. Rhodia Inc. N.Y., Central Building, 330 Park Avenue, New York 11, N.Y.

Italy Luigi Clivio, via Matteo Bandello, 6, Milano.

Germany (Fed. Rep.) Herbert Bahr, Grosse Bornstrasse 13, Hamburg 11.

Sweden Aktiebolaget Trebeck, Postfach 16077, Stockholm 16.

India Volta Ltd., Graham Road, Ballard Estate, PO Box 199, Bombay.

