Evaluation of Synthetic Polymers for Conservation.

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Abstract.
A series of simple tests that can be performed on polymers without special equipment is described.

Key words.
Polymers, test methods, solubility, hardness.

Introduction.

Conservators often have to choose new polymers for coating, consolidation and adhesive purposes. The reason for this can be that the product they normally use has disappeared from the market. They might want to use a better product. Or perhaps a special job requires a product with properties that the traditional material does not fulfil.
Often the practicing conservator has only a short time and little equipment to test his product. He also sometimes lacks basic knowledge of the material that he is going to evaluate.
In this article I will try to sum up how the conservator can make the right choise in spite of these obstacles.

Literature search.

First the conservator should try to find out what has been written about the proposed product in the conservation literature. This part is perhaps the most important, and fortunately several monographs on polymers for conservation have appeared recently. One of these is a broad but thorough introduction to the organic materials used in conservation[1].
The Getty Conservation Institute has published two volumes on the properties of cellulose derivatives[2,3].
The preprints from several conferences on materials for conservation are also valuable sources of information[4-8].
Finally the Conservation Information Network should be mentioned. This on-line information system operated by some of the world's major conservation institutions contains a data base on materials in which a huge amount of information can be found[9].

Manufacturer's information.

The next step would be to check the manufacturer's literature.
The available data sheets often give a lot of information on the properties of the product, but very often information can not immediately be compared with the information on other manufacturers products because different test-methods and units are used to express the properties.

Identification of the product.

The manufacturer normally will tell you what the main ingredients in his products are.
Unfortunately the minor components (stabilizers, plasticizers etc.) which have a great influence on the long term stability are seldom mentioned.
It would of cause be possible for an analytical laboratory to identify some of the minor components, but a full recipe for a typical polymer formulation is often very difficult to obtain even for the most well equipped laboratory.

Normally the conservator should go for products which according to the data sheets contain as few additives as possible. Such products are used as raw material in the adhesive and coatings industry where they are modified with a lot of additives to suit different purposes. But the conservator should avoid these commercial formulations, which are very seldom supposed to meet the demand of e.g. long term stability. In cases when it is necessary the conservator himself should modify the raw material to suit a special purpose.

Test procedures.

In general the conservator should not put to much experimental effort in identifying his product unless he can cooperate with a well equipped laboratory with polymer experience[10]. He should rather depend on literature and manufacturers' information and concentrate on investigation of general properties of the product.
A first step should be to test the proposed material on valueless samples similar to the material that is going to be treated and in a process that simulates the conservation process as much as possible. That will give the conservator a general idea of the properties of the product, wetting ability, penetration, gloss and strength.
Then one should prepare samples of the polymer in the dry state. Thin films can be applied to clean microscope slides. Thicker samples or free films can be cast in polyethylene moulds.
On the films the softening point, gloss, solubility and hardness can be estimated, light or heat aging tests can be performed.
On the thicker casted samples colour, transparency, strength and other mechanical properties can be evaluated.
When tests are made one should always run a parallel series of tests on samples of one or more well known and well regarded products to compare the properties of the new polymer with the old material.
After the test results have been evaluated and the product has passed the trial the actual process can be performed. When the job has been done successfully one should not forget to inspect the object at a certain interval of time to check if the treatment lasts in the long term.

The test methods.

Determining pH and dry matter.

Many emulsions contain additives that can make them pretty basic or acid.
Thus in emulsions and aqueous solutions the pH should be checked with pH-sticks (e.g Merck Neutralit, Acilit and Alkalit) or a pH-meter.
The amount of solid in a solution or an emulsion is estimated by weighing an amount and then letting it dry, weigh again and calculate the percent of dry matter. This can suitably be done when solid samples are made.

Preparation of solid samples:

The polymer solution or emulsion can be brushed or sprayed onto degreased microscope slides. Application often has to be repeated in order to get a suitable layer thickness (c. 0.1 mm). Disposable polyethylene lids for storage bottles are suitable as moulds for casting thicker samples. One should be aware that the complete setting of such a film might take several weeks at room temperature, because the last few percents of solvent evaporate very slowly. Application of vacuum or slightly rising the temperature might speed up the process. The polymer is dry when the weight is constant.

Thickness:

The thickness of the samples should be measured by a micrometer or, for the thin film the microscope can be used. First the microscope is focused on top of the film and then on the bottom. From the difference in adjustment the thickness can be calculated, when it is known how

much one turn of the fine adjustment knob raises or lowers the tube.

Softening point:
Although the glass transition temperature (the temperature at which the polymer changes from a hard solid to a soft flexible material) is difficult to determine in a conservation lab without special equipment, it is however often given in the manufacturer's information sheets. A rough estimate of the temperature around which the polymer softens can, however, be made by aid of a temperature controlled spatula.
Many popular adhesives have glass transition temperatures below room temperature and they will pick up dirt if they are left with an unprotected surface.

Hardness:
The are many methods of estimating the hardness of a film. One of the simplest is the pencil hardness test. The test in which the hardness is expressed as the hardness number of a pencil that can just scratch the film. In a proposed standardization of the test it is suggested that the lead of the pencil is stripped of wood for a distance of a centimeter[11]. The lead should then be squared by sand paper. The test is performed by holding the pencil in the writing position at 45° and then pushing it forward against the film.The pressure should be just short of breaking the lead. Any scratching of the surface seen in oblique light indicates that the pencil is harder than the film. The same brand of pencil should be used in order to get reproducible results.
Staedtler lumograph 100: 6B, 5B, 4B, 3B, 2B, B, HB, H, 2H, 3H, 4H and 5H have proved to be suitable.

Strength measurements:

The conservator often judges the strength of a polymer (an adhesive, a consolidant or a coating) by its performance in practice. But a measurement of the strength of an adhesive bond or of a free polymer film can be effected on a tensile test machine several methods are described in the conservation literature[5]. If a tensile test machine is not available, home made equipment with loads and levers can easily be constructed. ideas can be found in the Paint Testing Manual[12]. One should bear in mind the a constant climate and homogenous samplesare very important in order to get reproducible results when strength tests are performed.

Solubility tests:
In the method of Feller & Bailie a series of 11 solvents with rising solvent power ranging from pure cyclohexane via toluene to acetone and with 8 different mixtures of the three in between is used to test the solubility of resins[13].
In the test a cotton swap soaked in the less polar solvent is rolled over the film on a microscope slide, without applying any pressure, for one minute. Then the effect is judged and if nothing has happened you repeat the test with the next solvent in the series until you get a solvent that removes the film.
Another convenient solubility test was proposed by McCrone[14]. The test is performed on a slide under the microscope and involves very small particles of e.g. polymers.

Conclusion.
In many situations the conservator will learn more about a material and its performance by making his own simple tests that has been developed by himself, in stead of having a special test program run at an expensive commercial laboratory.

References and Notes.

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