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Factors Affecting the Appearance of Picture Varnish

Among the factors that affect the appearance of a picture varnish of the spirit type, one might consider that the refractive index of the resin would play a major role. Refractive index has entered the literature regarding picture varnishes, yet I do not recall that its role has ever been demonstrated. There has certainly not been sufficient discussion of the subject to reach agreement on whether the refractive index should be low (*1*) or similar to that of aged linseed oil (linoxyn) (*2*). In seeking to develop new protective coatings for the artist and conservator, our laboratory gave consideration to this problem. This report presents reasons for believing that variations in the refractive index of the resin, within the range 1.43 to 1.54, play a relatively minor, if not negligible, role in determining the appearance of spirit varnishes on the surface of paintings. Particular attention is drawn to variations in appearance that are attributable to differences in the viscosity grades of the resin.

Fresnel's law relates the intensity of reflected light in terms of the angle of incidence and the refractive index. Under the restricted condition of perpendicular incidence, the Fresnel equation may be simplified to

$$I = \left(\frac{n-1}{n+1}\right)^2$$

where I is the intensity of light of unit amplitude which is reflected and n is the refractive index. With this equation, values as follows may be calculated: $n = 1.1$, 0.23 percent reflection; 1.3, 1.7 percent; 1.5, 4.0 percent; 1.7, 6.7 percent. These values are essentially those attained at angles of incidence up to about 40 deg.

The range of refractive indices in organic coatings applied in the conservation of art objects is limited and is perhaps no more than 0.17. Limitation is understandable if only atoms of carbon, hydrogen, and oxygen are to be used in building the molecules of durable thermoplastics. By calculations from the simplified Fresnel equation, it is estimated that a linoxyn film of refractive index 1.57 (near the upper limit) would reflect 4.9 percent of the incident light. A film of refractive index 1.467 (near the lower limit) would reflect 3.6 percent. If reflection at the varnish-oil interface is considered, application of a varnish of refractive index 1.57 would result in no reflection and application of one of refractive index 1.467 would result in less than 1-percent reflection.

Frequently, then, in picture varnish, we are concerned with absolute differences in reflection of no more than 1 or 2 percent. This is close to the limit of the sensitivity of the eye. Over a wide range of intensities, the relative threshold of just-perceptible-brightness is about 1 percent of the intensity level to which the eye is adjusted (*3*).

Regardless of the proportion of incident light which is reflected, one's impression of a surface is strongly influenced by the relative sharpness or diffuseness of the reflected light. Methods of expressing the distribution of the reflected light are aspects of "gloss" or "glossiness." Judd (*4*) lists five types, five ways of expressing gloss: specular gloss, contrast gloss, distinctness-of-image gloss, sheen, and bloom.

If one observes only the reflected light, the relative change from 3.6 to 4.9 percent is considerable. However, in viewing a painting, the eye is perhaps adjusted to the general level of illumination in the room. An absolute difference of 1 to 2 percent is frequently negligible in comparison with variations in diffuse reflection—that is, gloss. In their investigation of ceramic glazes, Dinsdale and Malkin (*5*) found that the measured and observed gloss did not follow in the order of increasing refractive index from 1.51 to 1.66.

Even with porous paint, experiment has demonstrated that the fluidity of a varnish at a given concentration of resin can play a greater role than refractive index in determining appearance. A lean paint of Bakelite polyvinyl acetate AYAT and ultramarine was prepared. The paint did not rub off when it was rubbed with the hand, and yet it was porous to the applied varnishes. When the coat of varnish had dried, the value of the blue was noted simply as "dark" or "light." Table 1 shows that varnishes prepared with resins of high viscosity grade apparently do not form an intimate contact with the paint, with the result that the color appears light irrespective of the refractive index. Practical applications immediately come to mind when one does not wish to darken colors in pastels and porous paints.

The truly outstanding difference between the properties of the traditional picture varnishes, dammar and mastic, and those of many proprietary polymers is not in their refractive indices, but in the viscosity of their solutions. In place of intrinsic viscosity, we have used the viscosity at 20 percent solids by weight in toluene at 70°F as a convenient measure to characterize resins, giving it the name "viscosity grade." A similar measurement has been used to classify chlorinated rubber (*6*). On this scale, dammar, mastic, and resin AW-2 (Badische Anilin und Soda Fabrik) have a viscosity grade between 1.2 and 1.3 centipoises (cp) whereas Bedacryl 122 X (I.C.I.) and Lucite 44 (du Pont) *n*-butyl polymethacrylate have values about 48. Compared with dammar resin, polymers of high viscosity grade resist flow at a relatively low concentration of solids. As the solvent evaporates beyond this point, the film tends to conform to the contours of the paint surface (*7*). In this manner, a

Table 1. Color of lean polyvinyl acetate-ultramarine paint when varnished.

Varnish resin	Solvent	Color	Viscosity grade (centipoise)	Refractive index of resin
Experimental polymethacrylate	Cycloparaffins	Light	22	1.48
Experimental polymethacrylate	Cycloparaffins	Dark	8	1.48
AW-2	Cycloparaffins	Dark	1.2	1.52
Dammar	Turpentine	Dark	1.3	1.53
Bakelite polyvinyl acetate AYAB	Toluene	Dark	9	1.467
Bakelite polyvinyl acetate AYAT	Toluene	Light	114	1.467
Polyvinyl alcohol	Water	Light	~400*	1.51

* Value determined in water.

varnish formulated with a resin of high viscosity grade tends to be less glossy than the dammar type, which is able to remain fluid, continuing to level itself, until much more of the solvent has departed.

Among museum authorities, interest in refractive index has centered about the appearance of coatings of polyvinyl acetate. The polymer long used in America, Bakelite vinyl resin AYAF (similar to the earlier Vinylite A), is one of relatively high (80 centipoises) viscosity grade. The formulation of Reid, originally presented by Stout and Gettens, (*8*) was tested in our laboratory and found to give poor distinctness-of-image gloss when it was sprayed on window glass, with the spray gun at a distance of 10 to 20 inches from the glass. In a control test, the gun emitted 35 to 70 ml of toluene per minute. Changes in formulation of the solvent markedly altered the gloss. This laboratory has for several years drawn the attention of museums to polyvinyl acetate polymers of 40- and 9-centipoise viscosity grade (*9, 10*).

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References and Notes

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7. G. N. Bruxelles and B. H. Mahlman, *Official Digest Federation of Paint and Varnish Production Clubs* 351, 299 (1954).
8. G. L. Stout and R. J. Gettens, *Mouseion* 17, 107 (1932).
9. A paper describing the significance of viscosity grade in relationship to the elongation-at-break of the coating is in preparation.
10. I am indebted to A. E. A. Werner, Research Laboratory, British Museum, London, for the sample of resin AW-2, and to R. Sneyers, Lab. Central des Musées de Belgique, Brussels, for the sample of Bedacryl 122X.

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