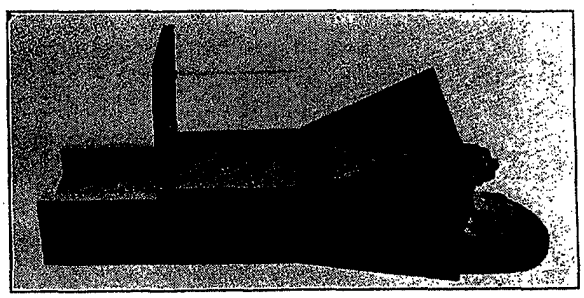

Figure 1—Apparatus for Determining Rate of Evaporation

half of which are controlled by a thermostat, supplies the heat. Humidity may be controlled by large evaporating dishes filled with a solution of a definite concentration of sulfuric acid. In practice sulfuric acid was found to be unnecessary. The humidity within the cabinet changed so slowly that when using water alone a test could be completed before any appreciable humidity change had taken place. The lower compartment also contains a motor-driven fan to promote air circulation. The upper compartment contains a rotating drum, motor-driven from the outside. A circular shelf is built around the bottom of this drum to hold the test panels. Sufficient panels for a given test are placed on this shelf around the drum, the entire cabinet is brought to the conditions desired, and the panels are then flow-coated with the respective test lacquers through a small hole in the top of the cabinet. The drum is then rotated until the panels are dry and the relative degree of blush is noted. Humidity is calculated from readings of wet and dry bulb thermometers placed in the upper compartment of the cabinet. This apparatus can be built in any shop at a very small cost.

In this apparatus consistent checks can be obtained on a series of lacquers over a range of temperature and humidity. Relative blush resistance of a series of lacquers as determined by this apparatus is the same at varying temperatures and humidities. Relative blush resistance was judged in two ways. The relative degree of blush at a given temperature and humidity was noted and the blush resistance of each member of a series of lacquers under test was noted as temperature and humidity were gradually increased, and each member in turn blushed. The dew point rather than the humidity is the critical factor in determining whether a given lacquer will blush.

RATE OF EVAPORATION—The method of determining rate of evaporation makes use of a small air tunnel as shown in Figure 2. At previous meetings the desirability of a standard method for determining rate of evaporation has been mentioned. It is believed that an air tunnel such as this could be developed into a definite standard. Weighed, ground-glass-covered dishes are partially filled with equal weighed volumes of the solvents under test. These dishes are then placed in the air tunnel, the covers removed, and the fan started. At intervals of time the air is turned off, the covers are placed on the dishes and the dishes weighed. The loss is recorded in per cent and refers to either weight or volume. Humidity has practically no effect on rate of evaporation. Temperature has a very decided effect. It was found that when the temperature was kept within ± 0.5° C. checks could be obtained on a given solvent within a range of 2 per cent.

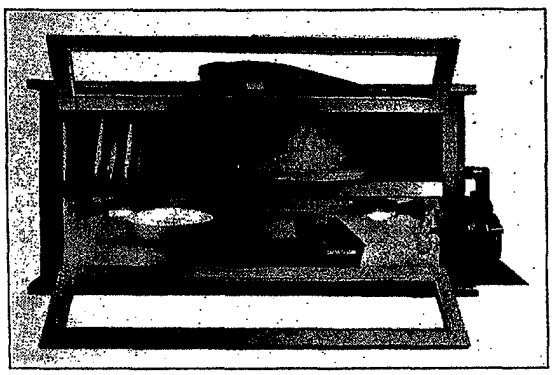

Figure 2—Apparatus for Determining Blush Resistance

In standardizing this test it would be necessary to use a standard test liquid as a basis of comparison rather than to attempt to build standard air tunnels. A standard test liquid could be such a thing as a carefully purified fraction of butyl acetate. In running this test a constant voltage should be used on the fan motor or a rheostat and voltmeter should be in the line to control voltage.

Effect of Various Driers on Linseed Oil Films during Aging[1]

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THIS paper shows the relationship, during aging, of acid value, iodine number and solubility of linseed oil films containing different concentrations of lead, manganese, and cobalt. It presents a continuation of previously reported experiments,[2] in which it was concluded that the acid value of linseed oil films containing cobalt acetate as a drier is an increasing function of the drying time; and of other experiments[3] which attempted to show that the iodine number of linseed oil films during drying bear a general inverse relationship to the acid value and the concentration of the cobalt bears a definite relationship to the decreasing iodine number.

Experimental Procedure

The refined linseed oil that was used in these experiments had the following constants:

[1] Presented under the title "The Effect of Age on the Acid Value and Iodine Number of Linseed Oil Films Containing Various Concentrations of Lead, Manganese, and Cobalt Driers" before the Division of Paint and Varnish Chemistry at the 76th Meeting of the American Chemical Society, Swampscott, Mass., September 10 to 14, 1928.

[2] Evans, Marling, and Lower, IND. ENG. CHEM., 18, 1229 (1926).

[3] Evans, Marling, and Lower, IND. ENG. CHEM., 19, 640 (1927).

Acid value	2.8
Iodine number (Wijs)	176.0
Molecular weight	780.0
Refractive index at 20° C.	1.4815
Specific gravity at 15.5° C.	0.933

The linseed oil was heated in Pyrex beakers to 270° C. and the drier was added slowly. The temperature was held at 265–270° C. for 30 minutes, in order that the drier might be completely dissolved. The prepared oils were poured into glass bottles, tightly stoppered, and allowed to age for 1 week before the films were prepared.

The treated oils were brushed on glass plates (37 × 50 cm.) and one coat was applied to each glass. The approximate weight of oil for each surface was 4 grams. The coated plates were placed approximately 1 inch (2.5 cm.) apart in wooden racks in a glass-covered box and free circulation of air was supplied from an air-pressure line. The box was located near a west window in the laboratory. Only diffused light reached the films and the temperature ranged from 20° to 30° C. during the 3 months of aging. No attempt was made to regulate the humidity of the test cabinet.

Similar films were exposed to a 15-cm. mercury arc light at a distance of 75 cm. from the arc, the temperature of the cabinet being 40° to 50° C. The oil films were removed from the glass plates with a safety-razor blade and digested in a solution of 2 parts toluene and 1 part alcohol by volume. The digestion was continued for from 1 to 5 hours, according to the solubility of the film. The digestion was made in Pyrex flasks and heated over a hot-water bath. The insoluble material remaining at the end of 5 hours was measured by filtering through fine cotton cloth and washing with toluene-alcohol solution. The residue was dried to constant weight in an electric oven and weighed. The acid value was calculated on the soluble portion of the film. The free acid was titrated from the toluene-alcohol oil film solution with 0.1 *N* alcoholic potash, using phenolphthalein as the indicator. The end point was very indefinite, and the alcoholic potash was added at a regular rate until a pink color showed in the solution. This reading was recorded. Then 0.2 cc. was added and if the color was a deep red the previous reading was taken as the end point. The iodine number was determined by the Wijs method for shellac. The solubility was fairly satisfactory, although the films did not completely dissolve in a few instances.

Table I—Linseed Oil Films Containing Lead Acetate as Drier

Age	Physical Appearance of Film	Acid Value	Insoluble in Toluene-Alcohol Soln.	Iodine Number
Days			*Per cent*	
	0.2 PER CENT LEAD			
1	Wet	20.0	None	82.0
2	Set, slightly tacky	41.0	None	46.0
3	Dry, slightly tacky	48.0	None	40.0
23	Dry, slightly tacky	57.0	None	30.0
36	Slightly soft	60.0	None	28.0
50	Slightly sticky	63.0	None	27.0
59	Slightly sticky	64.0	Trace	27.0
73	Slightly sticky	64.0	19	27.0
94	Considerably sticky	66.0	30	27.0
	2.0 PER CENT LEAD			
1	Set	36.0	None	60.0
2	Dry, slightly tacky	45.0	None	48.0
3	Dry, slightly tacky	48.0	None	44.0
23	Dry, slightly tacky	60.0	None	34.0
42	Slightly soft	65.0	Trace	27.0
50	Slightly sticky	66.0	Trace	26.0
59	Slightly sticky	66.0	Trace	26.0
73	Slightly sticky	66.0	Trace	26.0
94	Slightly sticky	66.0	Trace	26.0

Table II—Linseed Oil Films Containing Manganese Acetate as Drier

Age	Physical Appearance of Film	Acid Value	Insoluble in Toluene-Alcohol Soln.	Iodine Number
Days			*Per cent*	
	0.02 PER CENT MANGANESE			
1	Set	34.0	None	70.0
2	Dry, slightly tacky	40.0	None	60.0
7	Dry, slightly tacky	56.0	Trace	28.0
20	Slightly soft	90.0	Trace	23.0
38	Slightly soft	98.0	Trace	20.0
58	Very soft	108.0	4	16.0
79[a]	Semi-paste	110.0	6	16.0
	0.20 PER CENT MANGANESE			
1	Set	38.0	None	60.0
2	Dry, slightly tacky	42.0	None	54.0
7	Dry, slightly tacky	65.0	Trace	30.0
20	Slightly soft	100.0	Trace	12.0
28	Considerably soft	110.0	Trace	12.0
38	Considerably soft	118.0	Trace	12.0
58	Very soft	134.0	Trace	12.0
79[b]	Semi-paste	140.0	1	12.0

[a] Refractive index at 20° C., 1.4885.
[b] Refractive index at 20° C., 1.4875.

Discussion

The results are given in Tables I to IV.

In Table I the acid values and iodine numbers have progressive changes until the fiftieth day, after which they remain constant. The lower lead concentration attains a 30 per cent insolubility, while the higher lead concentration has only a trace of insoluble at the ninety-fourth day of aging.

In Table II the acid values increased to the end of the aging period, while the iodine numbers reached the minimum value earlier. The insoluble portion was greater in the lower manganese concentration than the higher, at the end of the aging period. The films of both concentrations at the end of the aging period gave a semi-paste condition and had enough flowing properties to determine the refractive indices. These values are 1.4885 for the lower concentration and 1.4875 for the higher. These values are lower than the refractive index of heavy heat bodied linseed oils.[4]

Table III shows the higher cobalt concentration to have a higher acid value, lower iodine number, less insoluble, and greater flowing properties than the lower concentration at the end of the aging period. The refractive index of the higher cobalt concentration was 1.4900, while the low cobalt

[4] Frishkorn, Larsen, Marling, and Shepherd, Paint Mfrs.' Assocn. U. S., *Tech. Circ.* **341** (November, 1928).

Table III—Linseed Oil Films Containing Cobalt Acetate as Drier

Age	Physical Appearance of Film	Acid Value	Insoluble in Toluene-Alcohol Soln.	Iodine Number
Days			*Per cent*	
	0.015 PER CENT COBALT			
1	Set	61.0	None	36.0
2	Dry, slightly tacky	75.0	None	28.0
3	Dry, slightly tacky	77.0	Trace	27.0
14	Dry, slightly tacky	82.0	Trace	25.0
27	Dry, slightly tacky	82.0	Trace	20.0
33	Slightly soft	83.0	Trace	18.0
50	Slightly tacky	84.0	Trace	18.0
64	Slightly sticky	84.0	8	18.0
84	Slightly sticky	88.0	20	18.0
	0.30 PER CENT COBALT			
1	Set	75.0	None	31.0
2	Dry, slightly tacky	92.0	Trace	26.0
3	Dry, slightly tacky	98.0	Trace	23.0
14	Dry, slightly tacky	112.0	Trace	17.0
33	Slightly soft	123.0	Trace	13.5
40	Very soft	130.0	Trace	13.0
50	Very sticky	136.0	Trace	13.0
64	Very sticky	142.0	Trace	13.0
84[a]	Semi-paste	144.0	Trace	13.0

[a] Refractive index at 20° C., 1.4900.

Table IV—Linseed Oil Films Exposed to Mercury Arc Light, without Drier and with Two Concentrations of Cobalt Acetate

Age	Acid Value	Insoluble in Toluene-Alcohol Soln.	Iodine Number
Hours		*Per cent*	
	WITHOUT DRIER		
2	27.0	None	61.0
4	40.0	Trace	45.0
8	48.0	4	34.0
16	60.0	24	24.0
	0.015 PER CENT COBALT		
2	38.0	None	49.0
4	54.0	2	35.0
8	68.0	19	30.0
16	86.0	33	22.0
	0.30 PER CENT COBALT		
2	46.0	None	46.0
4	78.0	10	26.5
8	110.0	33	20.0
16	123.0	34	18.0

concentration was not soft enough to make a refractive index determination.

Table IV gives the comparison of linseed oils films without drier and with two concentrations of cobalt in the mercury arc light. All these films show an increasing acid value and decreasing iodine number during the 16-hour exposure period. The acid value of the lower cobalt concentration reached 86 in 16 hours, while the same cobalt concentration required 84 days in the indoor aging test to reach an acid value of 88. Also the insoluble portion was greater in the mercury light exposure. The insoluble portion was greater in the higher cobalt concentration. This condition was reversed in the indoor aging tests. The iodine numbers reach a lower limit and the acid values reach a higher limit in the higher cobalt concentration than the linseed film without drier or the lower cobalt concentration during the same time period.

Summary

1—Linseed oil films containing two concentrations of lead, manganese, or cobalt drier increased in acid value and decreased in iodine number during indoor aging.

2—Linseed oil films containing the higher concentration of cobalt or manganese gave the highest acid values and the lowest iodine numbers; these films also showed the greatest flowing at the end of the aging period. The two lead concentrations reached a similar acid value and iodine number; these films showed no evidence of flowing properties.

3—The lower drier concentration of linseed oil films with lead, manganese, or cobalt had the greater insoluble percentage in a toluene-alcohol solution at the end of the aging period than the higher concentration of the same drier.

4—Linseed oil films containing manganese as a drier gave a more plastic film at a low concentration than either lead or cobalt at the end of the aging period. The higher cobalt concentration gave a more plastic film than the higher lead concentration.

5—Linseed oil films without drier or with cobalt drier in mercury-arc light exposure showed an increase in acid value and decrease in iodine number during the 16-hour period. This agrees with the results of the linseed oil films of similar cobalt concentration in indoor aging.

Reflection Factors of White Paints[1]

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The effects of the addition of known amounts of carbon black, Prussian blue, and aluminum powder upon the brightness and the hiding power of white paints are measured. Small amounts of carbon black or of Prussian blue decrease the brightness only slightly and increase the hiding power markedly. With larger amounts of the colored pigments the decrease in the brightness becomes relatively more pronounced. With very small amounts of Prussian blue the ratio of the increase in hiding power to the decrease in brightness is greater than with carbon black. The addition of aluminum powder greatly increases the hiding power, but lowers the brightness and causes the dry film to have a flecked appearance. The use of aluminum powder in undercoats for white finishing coats is of advantage.

TWO of the most important optical properties of a paint are its brightness and its opacity or hiding power. Both properties are dependent upon the color and the particle size of the pigment, upon the ratio of the refractive index of the pigment to that of the vehicle, and, to a lesser extent, upon the oil absorption and the structure of the pigment particles. There is, however, no necessary and universal relationship between opacity and brightness. Colored paints are usually more opaque than white ones although the white paints reflect a larger fraction of the incident light. In the true white paints high reflecting power is usually associated with high hiding power.

When a beam of light falls upon the surface of a paint film, a portion of the light is reflected from the surface of the film itself. For any given paint the fraction of the light thus reflected at the film surface is constant and independent of the thickness of the film. The amount of this "surface reflection" depends upon the roughness and the texture of the surface; paints which dry to a glossy film show less surface reflection than do "flat" or "eggshell" paints.

A portion of the light which actually enters the film is reflected at the interfaces between the pigment and the vehicle while the remainder penetrates to the underlying base surface. The amount of light reflected from within the film increases with the film thickness up to the point at which the film becomes so thick that it is opaque; further increase in thickness of film produces no further increase in the amount of light reflected. The total amount of light reflected from an opaque film may be termed the "ultimate brightness" of the paint.

The ultimate brightness is a function of the opacity of the paint and of the transparency of the pigment and the vehicle of which the paint is composed. Of truly white paints made from transparent pigment and transparent vehicle, those which are the most opaque will show the highest brightnesses. The addition of a dark or colored pigment decreases the brightness but increases the opacity. When only small amounts of the dark pigment are added, there is usually a very marked increase in hiding power accompanied by relatively small decrease in brightness. In certain cases where extremely high brightness is not required—as, for example, in undercoats for white finishing coats—the addition of a small amount of dark pigment should make it possible to increase the opacity and thus to decrease the amount of paint required to hide the underlying surface. The investigation described in this article was undertaken for the purpose of determining quantitatively the effects of small amounts of dark pigments upon the brightness and the hiding power of a few typical white paints.

Experimental Work

MATERIALS USED—Pure refined linseed oil from North American seed was used. The pigments were lithopone, zinc oxide, white lead (basic carbonate, by Dutch process), white lead (basic carbonate, by Carter process), sublimed white lead (basic sulfate), barytes (ground native barium sulfate),

[1] Received December 7, 1928.