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UNIVERSITY OF LOUISVILLE.

THE EFFECT OF HEAT
ON THE RESISTANCE OF VARNISH.

A Dissertation

Submitted to the Faculty
Of the Graduate School of Arts and Sciences

(College of Arts)

In Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE.

Department of Chemistry

by

Leonard C. Brecher.

1922.

THE EFFECT OF HEAT ON THE RESISTANCE OF VARNISH.

INTRODUCTION.

* * *

Varnish and its use has been known since ancient times. Altho the knowledge of varnish has been attributed to the Japanese as early as 500-600 B.C., Tschirsch and A.D. Stevens say that the Japs did not possess this art originally, but that they probably acquired it from the continent during the third century.¹ Nevertheless, varnish did not come into general use until the middle ages. In the 12th century, a monk by the name of Theophilus published the first directions for making an oil varnish, but it was not until 1790 in England, and between 1820 and 1830 in France and Germany, that a factory was established for the commercial production of varnish.²

In general, a varnish may be defined as a homogeneous, sticky, viscous solution of resins, of a colloidal nature, which when applied to a surface in a thin coat, dries to a hard, smooth, glossy surface. The color of varnish varies considerably, depending on the grade and on its use. Pale varnishes are generally sought, yet there are many dark varnishes of excellent

quality. The following scale gives an idea of the degree of color of varnish.

A solution of 0.25g $K_2Cr_2O_7$ in 100g pure concentrated H_2SO_4 is equivalent to a very light varnish.

A solution of 2.00g $K_2Cr_2O_7$ in 100g pure concentrated H_2SO_4 is equivalent to a medium varnish.

A solution of 4.00g $K_2Cr_2O_7$ in 100g pure concentrated H_2SO_4 is equivalent to a dark varnish.

Varnishes may be divided into two main classes, according to the manner in which the film dries. The varnishes of the first class, which is the largest and most important, are known as oil varnishes. These varnishes dry mainly by the oxidation of the oil, which forms a tough, elastic film. The secondary drying in these oil varnishes is caused by the evaporation of the volatile vehicle, and by the polymerization of the constituents. On the whole, the drying of an oil varnish is of a chemical nature.³ The varnishes of the second class are called spirit varnishes. These dry merely by the evaporation of the solvent, and there is practically no chemical action. The gum is transferred from a lump form into a thin sheet by means of the solvent. The most important example of this class is shellac, which is the hardened secretion of the lac insect, dissolved in alcohol.

Since my work has been based on oil varnishes and since the general usage of the term "varnish" implies an oil varnish, I shall speak only of oil varnishes and use the term "varnish."

Varnish generally contains four ingredients. 1-Resin, 2-Drying oil, 3-volatile thinner, 4-Drier.

The resins are numerous and vary from the hardest, such as amber and zanzibar, down to the softer ones, such as South American and Cochin China. Some of the more widely used resins, or "gums" as they are known in commerce, are Congo and Kauri, which are of medium hardness.

The oils which receive the greatest use are first and foremost, linseed oil, and secondly, Tung or China Wood Oil. Linseed oil has always been, and still is, the standard oil in varnish making. It is only in the last decade that Tung oil has come into prominence. It is unexcelled for some purposes, especially in the manufacture of cheap rosin varnishes. Cold pressed walnut and poppy seed oils are also used to a slight extent, and any other oil could be used that contained a high percentage of linolenic, iso-linolenic and linolic acids. Stated in another manner, any oil having

an iodine number over 120 would be admissable, the linseed oil must have a minimum I number of 178.⁴

The volatile thinners used are many, and differ according to the nature and uses of the varnish. Spirits of turpentine and wood turpentine are used, tho they polymerize in drying, giving a soft film which tends to make the varnish tacky. Petroleum spirits, benzene, denatured alcohol and wood alcohol also find wide usage. Without the addition of a volatile thinner, the solution of the resin in oil would be too viscous to apply properly.

The driers for varnish are both of an organic and inorganic type, and their action is of a catalytic nature. The inorganic driers are the oxides of lead and manganese, which must be of a high quality in order not to injure the varnish. The prominent organic driers are salts of lead and manganese resinates and linolates. Lead driers in linseed oil varnishes increase the moisture absorption and the whitening of the film when it is exposed to water. In polymerized oils, lead driers increase the resistance of the film to water, but they also increase the emulsification properties of the varnish much more than do manganese.⁵ It has also been found that lead driers increase the turbidity of a varnish more than

other driers do.⁶ In general manganese is less injurious than lead, but it takes only a small amount of any drier, usually about .01-2%.⁷

In making varnishes, great care must be taken in the melting and the dissolving of the resins. From 10-25% of the original resin must be distilled before the residue will dissolve in the varnish vehicles.⁸ The resins are usually crushed to pea size and from 100-150 lbs. are placed in a cylindrical, flat bottomed copper kettle about the depth of its diameter. The kettle is placed on an iron truck which is rolled over a coke fire just below the level of the floor. The "gums" are then melted and it is during this process that the volatile portions are lost, tho some factories recover the distillate, which is known as copal oil.⁹ Hot boiled oil is now added and the mixture of oil and resin is cooked and the driers are added. When the mixture has reached the right consistency, the kettle is withdrawn and allowed to cool. Then it is properly reduced with the volatile thinners, such as benzine and turpentine.¹⁰ In England with the better grade of varnishes, the practice is to allow the varnish to age from six months to several years, in order to allow any dirt or "foots" to settle. In the United States, the modern method is

to pump the varnish to a centrifuge, and then let the varnish stand for a period of three to six months.

The quality and nature of the varnish depends as much on the proportion of oil used as it does on the kind of resin. The color of the varnish will be paler if the resins have been well selected and the oil used is from ripe seed and is properly bleached.

The hardness of the varnish depends 1st, on the type of resin, and 2nd, on the amount of oil used. The more oil used, the softer will be the resulting film. This is due to the nature of linoxyn, which is tough and elastic. Brilliancy also depends both on the type of "gum" and on the amount of oil used. This is due to the fact that the index of refraction of the oil is less than that of the resin. The greater the proportion of resin, the greater will be the brilliancy.¹¹

Varnishes that contain less than 12 gallons of oil to 100 lbs. of "gum" are called "short." These varnishes are hard and brilliant and are capable of being rubbed and polished. They are always used for interior work as they are not resistant enough to weathering. Those varnishes containing 20 gallons or more of oil are termed "long" varnishes. Due to the larger percentage of linoxyn, the end product of linseed oil oxidation,

they are tough and elastic and capable of withstanding moisture. Varnishes of this type, such as "sper varnish", while they have gained impermeability, have lost the brilliancy of a "furniture varnish."

As a result of the complexity of varnish constituents, there is no general method of analysis in wide use. The tests are largely physical, and are based on "performance" rather than on chemical composition. The manufacturer who purchases varnish wants to know how the varnish will "stand up" and act, so this information is ascertained by practical tests. However, if the composition of a varnish must be known, an approximation can be made.

Upon investigation of the various methods for the analysis of varnish,¹² I believe that the best scheme yet published is that one given by Holly.¹³ This, or any other procedure, to be of value, must have extensive analytical data with which to compare the results. That is, the values on a great number of varnishes of known composition must be at hand in order that the results shall have a meaning.

The common physical tests are as follows:¹⁴

1. The dried varnish film is immersed in water for a number of hours. Varnishes of appoor grade or of little

oil turn white more quickly than others.

2. The varnish film is dried on glass or white enameled tin and the color of the film is compared to that of the standard. The time of drying "dust free" and "hard" is noted as is also the condition of a freshly cut edge. If the edge is brittle and produces dust, a short varnish is indicated, but if the edge is elastic and ragged, a long varnish is indicated.

3. The viscosity is many times determined by the air bubble method.¹⁵ The varnish is placed in a bottle and the bottle inverted. The time that it takes the air bubble to rise is compared to that of a standard sample which is inverted at the same time. As standards, a series of mineral lubricating oils is taken, each oil representing a known viscosity. This method is quick, and in the hands of an experienced person is accurate for all practical purposes. However, for scientific work, a viscometer must be used. All Gravity types are inaccurate. For research work the Herschel modification of the Bingham & Green Plastometer is recommended, but for general industrial work the Mac-Michael or Doolittle torsional viscometers are best.¹⁶

4. But the main test of a varnish is the manner in which it acts in use. Accordingly Government and

other specifications are allowing much more latitude than formerly in the composition of varnish. As long as the varnish will "stand up" under the required conditions, that is all the purchaser cares about, consequently the chemical analysis of a varnish is a secondary matter. It is only when a varnish is to be duplicated or compared, that the value of a chemical analysis is evident.¹⁷

In order to determine the physical properties of the varnish, the manufacturer applies it to panels so as to parallel the conditions in the factory or place in which it is to be used.¹⁸ Tests which are applied to a varnish just after the film has dried, should be repeated after a duration of about two weeks. In fact, Dr. A. P. Laurie states that a varnish film does not attain its maximum hardness until it is about twelve months old.¹⁹ The varnish which appears to be at first the best of several others, may, after the lapse of time be a poor varnish. This variation is generally caused by the type and the amount of drier used. The film which may appear elastic at first may resolve itself into a lustreless or brittle one. Adulterants or excess of drier may produce serious defects. It is a generally established fact that at different states of drying or

at different ages of the film, there is a difference in the properties of the dried coat. Likewise it is agreed that a rise in temperature hastens the drying time. This is due to the increased rate of evaporation of the volatile thinner and to the increased catalytic action of the "oxygen carriers" or driers. Then the question is raised, "what effect has this rise in temperature on the properties of the film?" It would seem that an increased temperature would increase the hardness and the brittleness of the film and perhaps by reducing its elasticity, make the film less durable for some types of work. In order to establish this theory the following experiments were made.

EXPERIMENTAL.

In order to determine the effect of chemical action on heat-treated varnish, a series of varnish films was made at various temperatures, ranging from air temperature (70°F) to (220°F.) After a number of trials on films which had been prepared previously, a solution of tenth-normal sodium hydroxide (N/10 NaOH) was adjudged to be the best reagent of several acids and alkalies of various strengths. The films were made on small porcelain dishes of uniform size, and lcc of a high grade rubbing

varnish was flowed into each one. The varnish in the dishes was dried at the determined temperature for 24 hrs. and then allowed to rest at room temperature for another 24 hrs. At the end of this period 10cc of N/10NaOH were put on each film. These dishes together with a blank sample were then put under a glass cover for 24 hrs. At this time the film was washed free from alkali and the alkali was titrated with N/10HCl, using phenolphthalein as the indicator. From this titration the amount of alkali that interacted with the varnish film was determined, and is expressed in the table as follows:

TABLE NO.1

Dish #	Temp. C	No. of cc N/10 NaOH	Remarks.
49	22	3.60	Films moveable with finger and wrinkled before adding alkali.
50	22	3.70	
37	33	3.20	Films moveable with finger and wrinkled before adding alkali.
38	33	3.25	
33	40	3.45	Films moveable with pressure of finger & slightly wrinkled before adding alkali.
34	40	3.35	
29	48	2.00	Films firm to touch, wrinkled after exposure to alkali.
30	48	2.65	
45	57	3.25	Films wrinkled after exposure to alkali. About $\frac{1}{2}$ crispy and loose.
46	57	3.00	
41	65	0.30	Films firm to touch. Smooth after exposure to alkali, with small soft spots.
42	65	0.45	
3	75	0.35	Film smooth after exposure to alkali.
4	75	0.30	
5	80	0.15	Film smooth. Few small blisters after heating. Alkali had no visible effect.
6	80	0.20	
9	85	0.20	Film smooth. Darker after heating. Alkali had no visible effect.
10	85	0.20	
13	94	0.20	Blistered & films darkened after heating. Alkali had no visible effect.
14	94	—	
17	103	0.15	Films smooth and darkened as if they had been burned. Alkali had no visible effect.
18	103	0.15	

Considerable difficulty was experienced in the control of the temperature. The volatile constituents of the varnish seemed to affect the thermostatic control of the oven causing a rise in the temperature. The temperature would remain constant until the introduction of volatile material caused the temperature to rise from 10% to 15%. At 100°C there was only a 3°C increase. After three or four hours the temperature would gradually fall to its former level or become constant at some new lower level. The temperatures given about are the average temperatures to which the film was exposed. As was to be expected, there was more variation at high temperatures than at low temperatures. Any volatile substance such as benzene, ethyl ether, or petroleum ether produced corresponding rises in temperature. It also appears probable that the volume of the oven contents has an influence on this phenomenon of vapor pressure.

A second series of varnish films was dried at the same time with the dishes of the first series, and was treated in the same manner. However, two weeks air-drying were allowed, after the dishes had been heated, and before the alkali was added. The results obtained are expressed in Table No. 2. It will be noted that the films dried at low temperatures wrinkled on standing.

This wrinkling occurred in the center of the film where the varnish was about 1 MM. deep. There are a number of theories on the wrinkling of varnish films. Vollman²⁰ claims that highly volatile thinners are apparently conducive to wrinkle formation and that white light causes more wrinkles than red or no light. On the other hand, Wolff says that light of long wave lengths (red or orange) appears to produce wrinkles, while that of short wave lengths (colorless and blue) favors smooth drying.²¹ Again, Ragg disputes this theory and states that wrinkling is due to heat swelling the undercoating.²² Whatever may be the cause, the higher temperatures seem to have hardened the coating or to have dried it so thoroughly that no wrinkling could have taken place.

TABLE NO.2

Dish #	Temp C°	No. cc of N/10 NaOH	Remarks.
51	22	6.00	Films clear & smooth after 2 weeks, but moveable to touch. All of films soft & wrinkled after adding alkali.
52	22	5.45	
39	33	4.20	Films slightly wrinkled & moveable to touch before adding alkali. About $\frac{3}{4}$ of film loose & wrinkled after.
40	33	4.15	
35	40	4.10	Films slightly wrinkled & hard before adding alkali. About $\frac{1}{2}$ wrinkled & white after adding alkali.
36	40	4.10	
31	48	3.65	Films wrinkled after 2 weeks but hard & clear. About $\frac{1}{2}$ loose & crisp after adding alkali.
32	48	3.00	
47	57	4.40	Films slightly wrinkled but firm to touch before adding alkali, about $\frac{2}{3}$ loose afterwards.
48	57	4.00	
43	65	5.50	Films smooth before adding alkali, about $\frac{2}{3}$ wrinkled & soft after.
44	65	5.85	
53	73	0.50	Films smooth & hard before adding alkali. Slightly wrinkled but firm afterwards.
54	73	0.25	
7	80	0.10	Films blistered slightly. Alkali had no visible effect.
8	80	0.25	
11	85	0.30	Films blistered slightly and darkened. Alkali had no visible effect.
12	85	0.20	
15	94	0.10	Films darkened. Alkali had no visible effect.
16	94	0.15	
19	103	0.00	Films darkened. Alkali had no visible effect.
20	103	0.10	

After washing the films, which had been exposed to the higher temperatures, free from alkali, the thin portions of the film on the edge of the dish curled up and peeled off. While the alkali was still on them, they appeared to be unaffected, but a few minutes after washing the peeling commenced. This is possibly due to the fact that the heat and the thinness of the film caused the varnish to be greatly oxidized and polymerized, and this together with the action of the alkali produced a brittleness in the film. The force of the washing may then have caused the peeling.

It will be noted from a comparison of table No.1 with table No.2 that more alkali was required to react with a film that had been dried two weeks than was required for one that was acted upon immediately. This is different from what would be expected, for the film having the longest time to dry would be harder and drier, consequently this film would be expected to be more resistant to alkali than a more recent film. To test this phenomenon further, three sets of films were prepared at intervals of about two weeks. The films were all dried at room temperature which averaged about 22° C. At the end of seventy two hours, 10cc of N/10 NaOH were added to two of the films and after 24 hrs. this alkali was

titrated with N/10 HCl. One week later, the two remaining dishes in each set were treated in the same manner. The results are as follows:

TABLE NO.3.

After 72 hrs.				No. 1 week and 72 hrs.			
No.				No.			
A ₁	-4.35cc	N/10	NaOH used.	A ₂	-4.75cc	N/10	NaOH used.
B ₁	-4.30cc	"	"	B ₂	-5.10	"	"
C ₁	-4.35cc	"	"	C ₂	-5.85	"	"
D ₁	-4.55cc	"	"	D ₂	-5.35	"	"
E ₁	-5.05cc	"	"	E ₂	-5.30	"	"
F ₁	-5.05cc	"	"	F ₂	-5.85	"	"

In order to determine the effect of heat on the elasticity and the water-resistant qualities of varnish, the following series of films were made on tin plates. Tin plated sheet iron which had been enameled white on one side was cut into strips 5" long and 2½" wide. Four pieces were dipped into the high grade finishing or "rubbing" varnish used above, and four others were dipped into a varnish containing a small amount of barytes and known to the trade as "surfacer" or "1st coater". After the strips had drained they were suspended in the oven at the desired temperature for 24 hours.²³ The strips were then allowed to rest at air temperature for another 24 hour period. At this time one tin strip bearing the "surfacer" varnish and one strip bearing the rubbing varnish

were bent double over a 3mm. rod with the enameled surface on the outside. Exactly two weeks later two more from the set of eight were bent in the same manner and the behavior of the dried film, both on the convex and concave sides of the bend, was noted.

TABLE NO. 4.
Films 48 hours dry.

Fin Strip	Temp. C°	Condition at convex bend.	Condition at concave bend.
#8 Fin.	22	*8 Few light hair lines	Lustre Dulled.
#8 Sur.	22	8 Lustre Dulled	Loose & scaled
#7 Fin.	34	7 Few light hair lines	Lustre Dulled.
#7 Sur.	34	7 Lustre Dulled	Loose & scaled
#6 Fin.	44	6 Few light hair lines	Lustre Dulled
#6 Sur.	44	5 Few hair lines	Loose & scaled
#5 Fin.	55	4 Few hair lines	Hair Lines
#5 Sur.	55	6 Few hair lines	Loose & scaled
#1 Fin.	58	2 Eight hair lines	Hair lines & scaled
#1 Sur.	58	3 Hair lines & scaled	Loose & scaled
#2 Fin.	69	1 Light hair lines	Many hair lines & scaled
#2 Sur.	69	2 Hair lines & scaled	Loose & scaled.
#4 Fin.	78	3 Many light hair lines	Hair lines.
#4 Sur.	78	4 Few Hair lines	Loose & scaled
#3 Fin.	89	5 Hair lines & scaled	Lustre Dulled
#3 Sur.	89	1 Hair lines & scaled	Loose & scaled

* Numbered in order of their being most affected.

TABLE NO. 5.
Films 16 days old.

Tin Strip	Temp. C°	Condition at convex bend.	Condition at concave bend
#8 Fin.	22	*8 Few light hair lines	Lustre Dulled
#8 Sur.	22	8 Lustre Dulled	Loose & scaled
#7 Fin.	34	7 Few light hair lines	Lustre Dulled
#7 Sur.	34	7 Lustre Dulled	Loose & scaled
#6 Fin.	44	6 Few hair lines	Lustre Dulled
#6 Sur.	44	6 Light hair lines	Loose & scaled
#5 Fin.	55	5 Few hair lines	Lustre Dulled
#5 Sur.	55	5 Light hair lines	Loose & scaled
#1 Fin.	58	4 Hair lines & scaled	Many hair lines & scaled
#1 Sur.	58	4 Hair lines & scaled	Loose & scaled
#2 Fin.	69	3 Hair lines & scaled	Hair lines & scaled
#2 Sur.	69	3 Hair lines & scaled	Loose & scaled
#4 Fin.	78	2 Many hair lines & scaled	Many hair lines & scaled
#4 Sur.	78	1 Many hair lines & scaled	Loose & scaled
#3 Fin.	89	1 Many hair lines & scaled	Many hair lines & scaled
#3 Sur.	89	2 Many hair lines & scaled	Loose & scaled

*Numbered in order of their being most affected.

The varnish did not adhere so well to the tinned side as it did to the side of the strip which had been enameled. This accounts for the fact that the concave side was affected more than the convex side of the bend.

Two weeks after the last film of the series was dried, each film was scratched with a knife in or-

der to determine the influence of heat on the elasticity. Elastic or "long" varnishes will "ribbon" under the knife blade, whereas "short" and hard varnishes chip or "dust". The "surfacers" was so short that no difference could be detected between the effects of the various temperatures. The rubbing varnish, which was short by its nature, did not show any marked differences, yet the higher temperatures produced a harder film, as determined by the conditions of the cut edge.

To determine the water-resistant qualities of the various films, one strip of tin was taken from each set. All the strips were placed in city water at the same time and at least two weeks after the last film had been prepared, so that the films were thoroughly dried. The finishing varnish, being of a higher grade than the "surfacers" required more time to show the effect and so the two varnishes were treated separately.

TABLE NO.6.

Finishing Varnish-Continuous Exposure.

Strip.	Temp. ^o C	After 9 hrs.	After 17 hrs.	After 21 hrs.
#8	22	Slightly white	*2 White	*2 White
#7	34	Slightly white	1 White	1 White
#6	44	Not affected	3 Fairly white	3 White
#5	55	Not affected	4 Slightly white	4 Slightly white
#1	58	Not affected	5 Slightly white	5 Slightly white
#2	69	Not affected	6 Slightly white	6 Slightly white
#4	78	Not affected	7 Very " " white	7 Very " white
#3	89	Not affected	8 Not affected.	8 Whitish cast.

Strip	Temp. ^o C	After 31 hrs.	After 48 hrs.
#8	22	*2 Very White	*2 very White
#7	34	1 Very White	1 Very White
#6	44	3 very White	3 Very White
#5	55	4 White	4 White
#1	58	5 White	5 White
#2	69	6 Slightly white	6 Nearly white
#4	78	7 Very " " white	7 Slightly white & crazed
#3	89	8 Whitish cast	8 Very " white & crazed

*Numbered in order of their greatest whiteness.

TABLE NO. 7.

Surfacing Varnish--Continuous Exposure.

Strip.	Temp.°C.	After 3 hrs.	After 5 hrs.
#8	22	*2 Slightly white	*2 White
#7	34	1 White	1 White
#6	44	3 Slightly white	3 Slightly white
#5	55	4 Very slightly white	4 Slightly white
#1	58	6 Not Affected	7 Blistered
#2	69	7 Not Affected	8 Blistered
#4	78	5 Blistered- Very slightly white	5 Much Blistered Slightly white
#3	89	8 Not affected.	6 Much Blistered

Strip.	Temp.°C.	After 8 hrs.	After 14 hrs.
#8	22	*2 White	#6 Very White
#7	34	1 White	5 White
#6	44	3 White	7 Very White
#5	55	4 Slightly white	8 White
#1	58	7 Slightly Blistered and " " White	3 White & Blistered
#2	69	8 Slightly Blistered and " " White	4 White & Blistered
#4	78	6 Slightly White ½ washed off	2 White 2/3 washed off
#3	89	5 Slightly white 2/3 washed off	1 All off.

*Numbered in order of their greatest whiteness.

#Numbered in order of their being most affected.

All observations were made on the tinned side of the strip as the whitening of the varnish was not apparent against the white background of the enameled side. Block claims that if a varnish does not turn permanently white when it is exposed to water, the varnish does not necessarily lack durability.²⁴ DeWaele suggests that the films might act as semi-permeable membranes,²⁵ while Wolff claims that altho the film is waterproof, yet it is not gas proof.²⁶ Gardner shows that while a film may be relatively moisture-proof, it may not be water-proof.²⁷

CONCLUSIONS.

Tables #1 and #2. Higher temperatures produce a varnish film that is more resistant to the action of alkali than lower temperatures produce.

Tables #1-#2 and #3. With the particular varnish under investigation, time produces in the dried film, compounds which react with alkali.

Tables #1 and #2. Higher temperatures dry a thick film more quickly and thoroughly than do low temperatures, thus preventing wrinkle formation.

Tables #1 and #2. High temperatures cause a rapid evaporation of the volatile thinner and an evolu-

tion of volatile products. Blisters are formed, thereby destroying the value of the film, tho this would probably not occur in a thin film.

Tables #4 and #5. Higher temperatures produce a film that is less elastic than one produced by lower temperatures. There is apparently no difference between films bent immediately after the heat treatment and those bent after a lapse of two weeks. No conclusion can be drawn however, as the difference may be so slight that it cannot be detected by this method. Further investigation is indicated, using a long oil varnish.

Tables #6 and #7. Higher temperatures produce a film that is more resistant to water than films produced by lower temperatures. It is to be noted that while the varnish in table #6 resisted water for 48 hrs., yet this same varnish when exposed to weathering in a driving rain for 16 hrs., was completely washed from wood panels.

It was also noted that higher temperatures produced a film that was more resistant to solvents such as alcohol, benzene and turpentine, than one produced by lower temperatures.

While these tests may hold true for just these particular varnishes, yet the results as a whole would seem capable of being applied to oil varnishes in general, since all oil varnishes are based on the same principles.

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