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Review of Samples from the 1994 CCI Workshop "Varnishes: Authenticity and Permanence" after 15 Years of Natural Ageing

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The purpose of this 1994 workshop was to introduce participants to traditional and modern varnishes and to compare their characteristics and handling properties. Twelve test panels from the workshop were brought to the Centre de conservation du Québec (CCQ) in Quebec City and mounted on a wall in the paintings lab, where they were left to age for fifteen years. Visual comparisons were made to evaluate differences in colour change and gloss. It was concluded that adding Tinuvin 292 to mastic and dammar varnishes to inhibit premature yellowing (in the absence of UV light) is very important since all unstabilized varnishes made with these resins discoloured to some degree. Most proprietary varnishes showed no discoloration. However, those based on ketone resins gave less consistent results. It was particularly encouraging to see how well the Regalrez 1094 samples have aged. Their superior performance with regard to yellowing (with or without the addition of Tinuvin 292) and their rapid solubility in isooctane after 15 years of natural ageing may make Regalrez a suitable varnish for acrylic paintings. Surprisingly, four different unstabilized varnishes based on copal-oil formulations show only a trace of discoloration. It remains to be determined how these varnishes would age in environments where UV light is not filtered.

Cet article fait un constat sur le vieillissement naturel d'échantillons de vernis appliqués sur des panneaux peints, créés lors de l'atelier de l'ICC en 1994. Le but de l'atelier était de faire connaître aux participants des vernis traditionnels et modernes et de les comparer. Un jeu de douze panneaux a été exposé pendant quinze ans sous les conditions ambiantes de l'atelier des peintures au Centre de conservation du Québec. Les observations présentées sont des évaluations comparatives faites par des restaurateurs. En conclusion, lors de l'emploi du mastic ou du dammar, il est essentiel d'ajouter un stabilisant, comme le Tinuvin 292, afin d'empêcher le jaunissement prématuré de ces vernis (en l'absence de rayons ultraviolets). Ces mêmes résines non stabilisées ont toutes jauni. Il est rassurant de constater que la plupart des vernis synthétiques testés n'ont pas jauni. En contrepartie, la qualité du vieillissement de vernis à base de résine cétone demeure incertaine. Le Regalrez 1094 a donné un très bon rendement, sans ou avec l'ajout de Tinuvin 292. Sa solubilité rapide dans des hydrocarbures, tels que l'isooctane, faciliterait son application ainsi que son retrait éventuel des peintures acryliques. Quatre vernis différents à base d'huile-copal (non stabilisés) ne démontrent qu'un soupçon de jaunissement. Il reste à savoir quel type de vieillissement auraient présenté tous ces vernis sous une quantité appréciable de lumière ultraviolette.

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Introduction

In 1994 (September 20-21), the Canadian Conservation Institute (CCI) hosted a professional training workshop entitled "Varnishes: Authenticity and Permanence." The purpose of the workshop was to introduce participants to traditional and modern varnishes and to compare their characteristics and handling properties.

During the course of this two-day event, each participant created a large set of test panels to keep and study. The panels consisted of pre-primed artists' "canvas" boards measuring 35.5 cm x 45.7 cm, which were subsequently coated with various paint media. Most of the boards were primed with an additional layer of Winsor & Newton (W&N) lead white oil paint (Flake White), while other background colours (either oil- or acrylic-based) were also chosen, including black, brown, red, and blue. The paint layers were applied either as flat, even coats or textured with brushwork to simulate low impasto. Newer varnishes, proprietary commercial varnishes, and 19th century varnishes recreated from recipes in artists' manuals were then brushed onto the panels in thin vertical strips. On most of the panels, a narrow strip along the left edge was left unvarnished to serve as a control sample. Detailed recipes and a list of suppliers and materials for the preparation of the different varnishes have been published elsewhere.[1] A list of the modern varnishes tested and their constituent polymer or resin is presented in **Table I**.

One set of twelve test panels was brought to the Centre de conservation du Québec (CCQ). In 1994, the boards were mounted on a wall in the paintings lab adjacent to a north-facing window. They have aged in a controlled environment similar to museum conditions in a northern climate. After a fifteen-year lapse of time, it was decided to evaluate the appearance and the relative performance of the samples under these naturally-aged conditions.

The light in the paintings lab is a mixture of daylight and fluorescent lighting. During the day, the light levels adjacent to the panels were approximately 1,000 lux, as measured with an Elsec 764 Environmental Monitor. It would have been highly instructive to see how the panels would have aged in an environment with an appreciable amount of UV radiation. However, UV light is filtered in the CCQ paintings lab and it generally does not exceed 50 microwatts per lumen.

Table I. Composition of the Modern Varnishes. Sources for these formulations are as follows: [a] Analysis by Scott Williams, published in Appendix IV 'The Composition of Commercial Artists' Varnishes and Media', in: Carlyle and Bourdeau, 1994 (Ref. 1); [b] Samet, Wendy (compiler), *Painting Conservation Catalogue, vol. 1: Varnishes and Surface Coatings*, 1998. (Ref. 2); [c] Manufacturer's information.

Varnish	Formulation (main Constituents)
Talens Rembrandt Picture Varnish [a]	polycyclohexanone/formaldehyde ("ketone") resin
Laropal K 80 [a]	polycyclohexanone/formaldehyde ("ketone") resin
W&N Artists' Gloss Varnish (Oil Colour) [a]	polycyclohexanone/formaldehyde ("ketone") resin
MS2A [b]	chemically reduced cyclic ketone resin (reduced or hydrogenated/saturated cyclohexanone-co-methylcyclohexanone)
Paraloid B-72 [a]	ethyl methacrylate / methyl acrylate copolymer 70/30
W&N Conserv-Art Picture Varnish [b]	Mixture of 9 parts poly(iso-butyl methacrylate) (i.e. Paraloid B67) to 1 part polycyclohexanones (i.e. Laropal K 80)
Golden MSA Varnish with UVLS [b]	n-butyl methacrylate / iso-butyl methacrylate copolymer solution
Golden Polymer Varnish with UVLS, Gloss [a]	methyl methacrylate / n-butyl acrylate copolymer emulsion (includes a significant amount of acrylic or methacrylic acid)
Soluvar Gloss Picture Varnish (Liquitex) (1988 sample) [a]	poly(iso-butyl methacrylate) solution
Stevenson Acrylic Gloss Medium & Varnish [a]	methyl methacrylate / ethyl acrylate copolymer emulsion
Daniel Smith Gloss Picture Varnish [c]	unidentified methacrylate polymer
Regalrez 1094 [b]	hydrogenated hydrocarbon (HC) resin (100% hydrogenated oligomers of styrene and alpha-methyl styrene)
Arkon P 90 [b]	hydrogenated hydrocarbon (HC) resin (a fully saturated alicyclic hydrocarbon)
Beva UVS Finishing Varnish [b]	hydrogenated hydrocarbon (HC) resin (the cyclo-aliphatic hydrocarbon resin Escorez 5380) [Escorez 5380 was replaced by Regalrez 1094 in 1996]

The varnishes were applied by hand in thin brush layers to replicate bench practice. For the most part, they were applied as single layers, but on some panels two layers of the same varnish (or two layers of different varnishes) were superimposed. The resin content of the varnish solutions was standardized among participants at the workshop. The application, hence film thickness, was directed in terms of a uniform application method, but the individual application of varnishes likely resulted in variations from sample to sample and from board to board. All the sample areas of the boards were evenly covered, well delineated, and identified. The numbering of the panels in the present article refers to the original numbers used during the1994 workshop. The abbreviation "Exp." denotes any of a series of experimental panels improvised by participants during the workshop.

The observations presented here are subjective visual evaluations made by paintings conservators, as opposed to quantitative scientific findings. We noted the extent of varnish discoloration, the overall appearance of the coatings, their solubility in mild solvents, and the effect of the hindered amine light stabilizer (HALS) Tinuvin 292.

Varnish Discoloration

Table II presents a summary of the comparative degrees of varnish discoloration observed in the samples on seven panels with white backgrounds: panels 1, 2, 3, and 4 and three experimental panels, Exp. 1, 2, and 4. Although the differences between many of the samples are subtle, the degrees of discoloration have been classified ranging from "not yellow" to "very yellow." Generally speaking, the discoloration labelled "trace of yellow" or "slightly yellow" could be considered acceptable alterations on most paintings. When known, percentage resin by weight/volume and solvent used are given.

Synthetic Resins and Proprietary Varnishes

There were several surprises and some disappointments with regard to varnish discoloration. It was reassuring to see that most of the synthetic varnishes used by conservators today have not discoloured to any significant degree after 15 years. These include Paraloid B-72 (on panels 2 and Exp.1) and Regalrez 1094 (on panels 2, 3, Exp. 1, Exp. 2, Exp. 4).

Of the two MS2A samples, one showed a trace of yellow discoloration (Exp.1), while the other did not (Exp. 2). It is important to note that the MS2A samples were not stabilized with the hindered amine light stabilizer (HALS) Tinuvin 292. Unfortunately, not enough information has been preserved on the composition of these two samples to postulate a reason for the discrepancy in the way they have aged.

Table II. Varnish Discoloration Noted on White Test Panels from the 1994 CCI Workshop, "Varnishes: Authenticity and Permanence".
All varnishes are unstabilized, unless stated otherwise (ie.+ Tinuvin 292, highlighted in bold). The panels identified with the abbreviation "Exp." denotes any of a series of experimental panels improvised by participants during the workshop. When known, percentage resin by weight/volume and solvent used are given.
Note: The generic term "mineral spirits" was used during the workshop for a variety of hydrocarbon solvents with varying amounts of aromatic content, such as odourless mineral spirits (< 0.1% aromatics), Stoddard solvent (18% aromatics), and Super High Flash (99.8% aromatics).

Varnish (solvent)	Not yellow	Trace of yellow	Slightly yellow	Moderately yellow	Very yellow
Natural (Rosin, Copal, Shellac)					
62% Rosin (turpentine) [panel 1]					**x**
Sandarac+copal+rosin mixed resin varnish (turpentine) [panel 1]				**x**	
25% Sandarac - Roberson's White Hard, ven.turp (ethanol) [panel 1]		**x**			
9% Pontianak Copal-oil varnish (linseed oil + turpentine) [panel 1]		**x**			
9% Anime Copal-oil varnish (linseed oil + turpentine) [panel 1]		**x**			
9% Manilla Copal-oil varnish (linseed oil + turpentine) [panel 1]		**x**			
9% Kauri Copal-oil varnish (linseed oil + turpentine) [panel 1]		**x**			
37% Shellac - Field's White Lac (ethanol) [panel 1]		**x**			
Dammar					
31% Dammar B1 (turpentine) [panel 1]		**x**			
31% Dammar B4 (mineral spirits/xylene) [panel 2]			**x**		
31% Dammar B3 (xylene) [panel 3]			**x**		
31%Dammar B2 (mineral spirits/xylene) [panel 3]			**x**		
31%Dammar B1 (turpentine) [panel 3]			**x**		
Dammar (xylene) [panel Exp.1]			**x**		
31% Dammar B4 (Stoddard solvent/xylene) + **Tinuvin 292** [panel 2]	**x**				
Mastic					
31% Mastic A1- Neil's Best 1833 (turpentine) [panel 1]				**x**	
31% Mastic A1 (turpentine) [panel 2]				**x**	
31% Mastic A1(turpentine) [panel 3]				**x**	
31% Mastic A8 (mineral spirits/xylene) [panel 3]				**x**	
31% Mastic A9 (xylene) [panel 3]				**x**	
31% Mastic A1 (turpentine) +**Tinuvin 292** [panel 2]	**x**				
Ketones					
15% Laropal K 80 (mineral spirits) [panel 2]	**x**				
Laropal K 80 (mineral spirits) [panel Exp.2]		**x**			
Talens Rembrandt Picture Varnish [panel 2]	**x**				
Talens Rembrandt Picture Varnish [panel 4]			**x**		
W&N Artists' Gloss Varnish (Oil Colour) [panel 4]			**x**		
MS2A (mineral spirits) [panel Exp.1]		**x**			
MS2A (mineral spirits) [panel Exp.2]	**x**				
Acrylics					
15% Paraloid B-72 (xylene) [panel 2]	**x**				
Paraloid B-72 [panel Exp.1]	**x**				
Soluvar Gloss Picture Varnish (Liquitex) [panel 2]	**x**				
Soluvar Gloss Picture Varnish (Liquitex) [panel 4]	**x**				
Golden MSA Varnish with UVLS [panel 4]	**x**				
Golden Polymer Varnish with UVLS [panel 4]	**x**				
Stevenson Acrylic Gloss Medium & Varnish [panel 4]	**x**				
Daniel Smith Gloss Picture Varnish [panel 4]	**x**				
W&N Conserv-Art Picture Varnish [panel 4]	**x**				
Hydrocarbons (Aliphatics)					
Regalrez 1094 (mineral spirits) [panel Exp.1]	**x**				
Regalrez 1094 (mineral spirits) [panel Exp.2]	**x**				
5% Regalrez 1094 (mineral spirits) [panel Exp.4]	**x**				
30% Regalrez 1094 (mineral spirits) [panel Exp.4]	**x**				
50% Regalrez 1094 (mineral spirits) [panel Exp.4]	**x**				
40% Regalrez 1094 + Kraton 1657 (Stoddard solvent) [panel Exp.4]		**x**			
25% Regalrez 1094 + **Tinuvin 292** (mineral spirits) [panel 2]	**x**				
25% Regalrez 1094 + **Tinuvin 292** (mineral spirits) [panel 3]	**x**				
25% Regalrez 1094 +**Tinuvin 292** + Kraton G1650 (mineral spirits) [panel 2]	**x**				
25% Regalrez 1094 +**Tinuvin 292** + Kraton G1650 (mineral spirits) [panel 3]	**x**				
Arkon P-90 (mineral spirits) [panel Exp.2]	**x**				
Beva UVS Finishing Varnish [panel 4]	**x**				

Varnishes based on Regalrez 1094, made with a variety of different hydrocarbon solvents and at different concentrations, performed very well with respect to yellowing (regardless of the presence or absence of the stabilizer Tinuvin 292). Only one of the ten samples of Regalrez 1094 has slightly discoloured. While the slightly discoloured sample contained no UV stabilizer, it did contain Kraton rubber G1657, a viscosity modifying additive (Kraton G1657 was later replaced by G1650). Today, the addition of Kraton rubbers to Regalrez varnish formulations is no longer deemed necessary and has largely fallen from practice. The only sample (unstabilized) based on the hydrocarbon resin Arkon-P90, a resin introduced in paintings conservation around 1990 but largely supplanted by Regalrez 1094, has not discoloured.

Of the nine commercial proprietary varnishes that were on Panel 4 (6 acrylics, 2 ketones, and 1 hydrocarbon), only two have discoloured. The solvent-based varnishes that have not discoloured include: Soluvar, W&N Conserv-Art, Golden MSA, Daniel Smith Gloss and Beva UVS Finishing Varnish. The aqueous acrylic dispersions, Golden Polymer Varnish and Stevenson Acrylic Gloss Medium & Varnish, have also performed well in this regard.

However, some proprietary commercial varnishes based on ketone resins showed inconsistent behaviour with regard to discoloration, namely, W&N Artists' Gloss Varnish and one of the two Talens Rembrandt varnish samples. Similarly, the two varnishes made with the ketone resin Laropal K-80 dissolved in mineral spirits also gave mixed results on different panels. One shows a trace of discoloration (Panel Exp. 2), while the other (Panel 2) does not. Again, not enough information about the sample preparation was preserved to explain this discrepancy. However, the inconsistent performance of the ketone varnishes seen here appear to illustrate De la Rie's contention that the inherent chemical instability of these resins makes them undesirable for use in varnish formulations.[3] We can exclude MS2A varnish from this category since it is based on a reduced, cyclic ketone resin that is chemically less reactive than its non-reduced counterpart.[4]

Natural Resins and Traditional Varnishes

The relative performance of mastic and dammar merits some scrutiny. The formulations that include the addition of 3% Tinuvin 292 have not discoloured, in sharp contrast to those without Tinuvin 292. Be they traditional or contemporary recipes, the ***unstabilized*** mastic and dammar samples have all discoloured to some degree (Panels 1, 2, 3, and Exp. 1). This concurs with de la Rie's findings on artificially aged samples published in 1990.[5]

On panels 1, 2 and 3, the unstabilized mastic samples exhibited more discoloration than the unstabilized dammar samples, supporting empirical observations by many conservators that unstabilized mastic varnish may be more prone to darken or turn yellow than unstabilized dammar. The difference between the UV fluorescence of the unstabilized mastic and dammar samples is best observed on Panel 3. The intensity of the fluorescence is proportionate to the degree of discoloration observed. Under UV light, the fluorescence of the unstabilized mastic varnish samples has a more yellowish cast than the unstabilized dammar samples. In contrast, the ***stabilized*** mastic and dammar varnishes do not show the characteristic yellowish-green fluorescence associated with aged natural resins because they have not discoloured significantly.

Surprisingly, the four copal-oil varnishes based on historic recipes on Panel 1 (diluted to 9.5% in turpentine) still look very good, exceeding all expectations for them. Although these samples were not stabilized with Tinuvin 292, they show only the slightest trace of discoloration. Hindsight has shown that varnishes based on copal resins are less than ideal for use on paintings since they tend to darken and discolour over time. They were traditionally used for coatings on coaches, furniture and musical instruments. One can safely assume that the oil component will eventually darken and render these varnishes more insoluble. Other traditional varnishes on Panel 1 based on rosin or sandarac resins (unstabilized) did not fare nearly as well, with all of them showing yellow discoloration to some degree. The shellac/alcohol varnish also shows a trace of yellow.

Saturation and Gloss on Coloured Paint Layers

In this exercise, the term saturation refers to the relative (light-dark) value of the colour of the underlying paint as seen through the varnish. A poorly saturating varnish allows for more light scattering and makes the underlying colour appear lighter. We often require varnishes to saturate and enhance the depth of darker colours. There are many factors that affect the perceived saturation, including the choice and concentration of resin, choice of solvent, varnish application method, texture and porosity of the underlying paint, and the refractive index of the varnish coating. Interconnected with saturation is gloss, which can range from low gloss (matte appearance, low reflectance) to high gloss (shiny appearance, high reflectance).

Comparative observations were made to assess the relative ability of the different varnishes to saturate the blue, red and dark brown paint layers. The evenness of the varnish coatings and their gloss were also compared. It must be said that these comparisons were difficult to make, given the limited number of samples and their small size. One could also question the pertinence of making such comparisons when equivalent resin concentrations were not used to prepare the samples.

Carlyle ***et al.*** have reported extensively on the ageing characteristics of the varnishes on these panels.[6,7] The authors also discussed the use of traditional varnishes versus dammar or modern synthetic varnishes for authenticity of appearance when varnishing paintings dating from periods prior to the first two decades of the 19th century. One of the questions raised during the 1994 workshop was whether the appearance of dammar or any modern synthetic varnish compared favourably with the

appearance of traditional 19th century varnishes such as mastic or copal. Some general observations along these lines can be made from looking at four of the panels (1, 5, 6, and 8).

On Panel 1, the four copal varnishes (9.5% in turpentine) all have a very matte, low gloss compared to the mastic and dammar samples (31% in turpentine), which are both significantly glossier. This marked difference is likely due to the differences in resin concentration. However, no significant differences were observed in the appearance of the various mastic and dammar samples at equivalent resin concentrations. Furthermore, the appearance of Paraloid B-72 was often indistinguishable from the mastic and dammar on many of the coloured panels. This is an unexpected observation, since the acrylic varnish is based on a resin with a lower refractive index, as well as a larger molecular size and weight, which influences its ability to level out and conform to a painted surface.

The purpose of Panel 5 (option 2) was to compare the appearance of natural versus synthetic resins, applied in single and double layers on a dark brown paint layer. This panel juxtaposes a high molecular weight resin, such as B-72 (15% in xylene) with resins of lower molecular weight, such as Regalrez 1094 (25% in mineral spirits), MS2A (36 % in mineral spirits), mastic (31% in different solvents), and dammar (31% in different solvents). The trend observed on Panel 5 comes as no surprise: most of the varnishes applied in a single layer have a very low gloss, while those applied in double layers have a higher gloss. The greatest discrepancies in the appearance of the varnishes are seen when they are applied as a single layer. The unevenness in the appearance of many of the samples on this panel may be due to solvent effects or to variations in the application technique. The addition of the Kraton rubber (amount unspecified) doesn't affect the gloss of the Regalrez 1094 samples on this panel. The gloss of the Regalrez 1094 is surprisingly low when applied in one layer, but it increases somewhat when applied in two layers. The varnish with the most consistent appearance on this panel is the MS2A; it is the only coating that retained an even, glossy appearance, whether applied in one or two layers. This is perhaps due to the greater resin concentration.

On Panel 6i (option 1) four broad swaths of varnish were applied over a very dark brown oil paint layer: mastic (31% in turpentine), dammar (31% in 1:1 mineral spirits / xylene), Regalrez 1094 (25% in mineral spirits + Kraton G1650), and Paraloid B-72 (15% in xylenes). All these varnishes have an even, homogeneous gloss. The mastic and dammar varnishes are virtually identical, and are both the most glossy and the most saturating of the samples. Surprisingly, it is difficult to distinguish them from the B-72. One might have expected the B-72 to appear less saturating than the mastic and dammar. On this panel, the Regalrez 1094 is both the least saturating and the least glossy varnish, likely due to the addition of the Kraton rubber (amount unspecified). The similarity in appearance of Paraloid B-72 and dammar applied to a black acrylic paint layer was also observed on panel Exp.3.

On Panel 8, the varnishes were brushed onto blue paint made with different binding media – two oil-based and one acrylic-based. The overall appearances of Regalrez 1094 (with and without the addition of Kraton rubber), dammar, mastic, and Arkon P 90 are indistinguishable when applied over the acrylic paint. However, the mastic and dammar varnishes are both glossier and more saturating than the Arkon P 90, Regalrez 1094, and B-72 when applied to the W&N oil tube paint. A slight discoloration of the unstablized mastic and dammar varnishes on this panel may be responsible for this effect. As noted on Panel 6, the mastic and dammar varnishes are again indistinguishable from each other. Here, the Arkon P 90 (25% in mineral spirits) is the only varnish that retains a glossy, even appearance on all three blue paint media, especially when viewed in specular light.

Lastly, Panel 7 shows double layers of different (unstabilized) varnish combinations applied over red paint layers of three different media – two oil-based and one acrylic-based. The glossiest varnish on this panel (a double layer of 31% mastic in turpentine) also gives the deepest colour saturation. This might be explained by the presumed yellowing of the mastic varnish, which would alter the perceived red hue. Four other varnish pairings on this panel are virtually indistinguishable from one another: dammar over B-72; dammar over dammar; mastic over copal; and copal over mastic. These pairings provide equally homogeneous, glossy surfaces on all three paint media. This further reinforces the notion that mastic and dammar varnishes are generally indistinguishable. It is interesting to note that, in these layering systems, the red paint appears to be slightly better saturated when a varnish containing a relatively low molecular weight resin (dammar) is placed uppermost at the air interface, over a varnish with a higher molecular weight resin, such as Paraloid B-72. In the reverse instance, where the B-72 is placed over the dammar, the surface appears to be a little less saturated and glossy.

Solubility Tests

Solubility tests were conducted on the varnish samples on panels 1, 2, 3, 4, and 8, using small cotton swabs rolled back and forth over a small test area. No solubility problems were encountered. All the hydrocarbon-based varnishes (Beva Finishing Varnish, Regalrez 1094, Arkon P 90) were easily soluble in pure isooctane. The other synthetic varnishes, as well as those based on natural resins (including copal-oil), were readily soluble in either a 1:1 mixture of isopropanol and isooctane or a 1:1 mixture of ethanol and isooctane.

Conclusions

These findings may provide assistance to the artist or the conservator searching for appropriate resins, solvents, and stabilizing agents for varnish formulations. They may also serve as a reference for others who have similar panels from the1994 workshop or for those who have access to paintings varnished with products from this period.

While interesting, the observations presented on the commercial proprietary varnishes may or may not be relevant today, since they relate to products dating from 1994, and manufacturers may change their formulations at any given time. This suggests that study samples should be kept of commonly available products from both the conservation field and commercial sources.

It was reassuring to see that most of the synthetic resin varnishes used today by conservators have not discoloured to any significant degree after 15 years. It was particularly encouraging to see how well the Regalrez 1094 varnish performed overall, since it is a relatively new product in the conservation field. Its superior performance with regard to yellowing (with or without the addition of Tinuvin 292) and its rapid solubility in isooctane after 15 years of natural ageing may also make it a suitable choice for varnishing sensitive surfaces and acrylic paintings.

Dammar varnish (and to a lesser degree, mastic varnish) is still prized today for its aesthetic qualities and ease of reversibility. Since dammar continues to be widely used in North America and Europe, the importance of adding Tinuvin 292 to inhibit premature yellowing (in the absence of UV light) cannot be overemphasized. The same holds true for mastic varnish. By extension, this is probably also the case for synthetic resin varnishes, such as MS2A, although this hypothesis was not specifically tested in the experimental design of the workshop.

None of the modern varnish samples replicate the low gloss of the copal-oil varnishes in this study, but this is likely due to significant differences among the resin concentrations employed. Mastic and dammar varnishes are generally indistinguishable when used at equivalent resin concentrations. In fact, it comes as little surprise that varnishes with resins of relatively low molecular weight and similar refractive indices tend greatly to resemble one another.

The nature of the paint substrate greatly affects the gloss of a varnish and its ability to saturate a painted surface. For example, all the varnishes applied to acrylic paint consistently appear glossy, whereas differences in saturation and gloss become much more apparent when the same varnishes are applied to various oil paint substrates.

Information is still required on the natural ageing of these varnishes (with and without the addition of stabilizers, such as Tinuvin 292) in environments where UV light is not filtered. Instrumental monitoring in future studies could also help to quantitatively evaluate the changes in colour and gloss as the samples age. It should be very instructive to follow the changes in these varnishes over the next 15 years and beyond.

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1. Carlyle, L, and J. Bourdeau, *Varnishes: Authenticity and Permanence Workshop Handbook.* Canadian Conservation Institute, 1994. This reference contains lists of the suppliers, as well as the materials and solutions used to prepare all the varnish samples on the test panels examined in this paper.

2. Samet, Wendy (compiler), *Painting Conservation Catalogue, vol. 1: Varnishes and Surface Coatings* (Washington D.C.: AIC,1998). Formulations, often based on manufacturer's information, can be found at the following pages: MS2A: p. 82; W&N Conserv-Art Picture Varnish: p. 186; Golden MSA Varnish with UVLS: p. 180; Regalrez 1094: p. 109; Arkon P 90: p. 118; Beva UVS Finishing Varnish: p. 129; Escorez 5380: p. 125.

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