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By

Y. SANKARANARAYANAN, M. Sc.

INDIAN LAC RESEARCH INSTITUTE
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Etch primers (sometimes called wash primers) consist essentially of an organic, alcohol-soluble resin medium (commonly polyvinyl butyral) pigmented with a basic zinc chromate to which is added, shortly before application, an alcoholic solution of phosphoric acid. Modifications of formulation are possible within the broad requirement of resin, acid and chromate.

The objective of the work to be described in this paper was to find the conditions under which shellac could be used successfully in the etch primer concept preferably in a single-pack composition as distinct from the more usual but somewhat less satisfactory 2-pack form commonly found to be necessary. The reasons prompting the idea were that shellac is an organic resin medium containing hydroxy groups, is alcohol-soluble, is capable of forming metallic compounds and might be capable of forming co-ordinated metallic complexes; all factors which, as will be seen, have some bearing upon the matter. The first mix ever made with shellac using ordinary zinc chromate pigment showed an unusually long pot-life compared with the established type of 2-pack etch primer as judged by application quality.

The Historical Background

Etch primers were developed during the Second World War by the Bakelite Corporation in the U.S.A. whilst seeking better and more practicable techniques for the painting of wet steel surfaces of ships and other metallic structures than the normal method of applying dilute phosphoric acid as a wash after wire-brushing and the usual mechanical preparation given to metal surfaces. Since then etch primers have been recognised as an outstanding contribution to the problem of corrosion protection particularly on aluminium and light alloys although the use is not confined to non-ferrous metals. The primers dry quickly and provide a near-perfect base for subsequent painting.

The first step in the development was to dilute the phosphoric acid with alcohol. The resin Polyvinyl butyral was added because it is soluble in alcohol and was known to have excellent adhesion when used as safety glass; it was soon found to have excellent adhesion to metals. The addition to the mix of basic zinc chromate as a rust-inhibitive pigment completed the sequence of the original development. The results were excellent so long as the material was used within a few hours; otherwise there was first some deterioration in performance and very soon the mixture became impossible to apply.

Many people have taken up the study of etch primers (indeed numerous proprietary brands of such primers are on the market) and most particular attention has been given to the problem of making a single-pack composition but without much success. So far the best results have always been obtained with a 2-pack system in which the phosphoric acid component is added to the mix some 15 to 30 minutes before use and then the material is applied within three or four hours. Thus it is preferable not to mix more material than can be used during one working period—morning or afternoon. Actually it must be admitted that this procedure occasionally involves waste but to attempt to use up old material invariably leads to disappointment.

In Technical Paper No : 205 in this series entitled "Wash Primers for Metals", which should be read in conjunction with this paper, the subject is treated in general terms. It deals with, for example, the mechanism of action of the process, the effect of variation in the pigment components (mostly different chromates) and in the resin components (that is to say, phenolic and epoxy resins, polyvinyl acetate and chloride copolymers used alone or in combination with polyvinyl butyral) and with a variety of topics bearing upon the deterioration of etch primers on storage and on the nature of the films produced: a brief but encouraging reference is also made therein on the use of shellac as a medium for etch primers.

The early etch primers gave rise to blistering conditions specially on underwater exposure, but that tendency could be mitigated and water resistance improved by substituting up to half of the butyral resin with spirit-soluble phenolic resin with a reduced phosphoric acid content.

The films produced by etch primers are extremely thin (usually less than 10 μ)*, which up to a point is probably a good thing, but a painter likes to see something worthwhile as a result of his labour. This viewpoint has led to the opinion being expressed that it would be advantageous if the very thin film of the normal etch primer could be built up into the thickness of an average paint film (say about 30 μ) and so contribute substance to the subsequent paint system as does a more ordinary priming paint. Whilst the work described in this paper proceeded, this point was kept in mind, for shellac seems to have some potentiality in this direction and some of the most promising films tested ranged from 20 to 25μ in thickness.

The Chemical Nature of the Process

First it must be clearly stated that etch priming is not a part of the metal cleaning process—prior cleaning and the removal of scale is essential because the etch primer must make contact with the metal. For the same reason etch primers will serve no purpose when applied over other paint.

Looking at the matter broadly it may be

* 25μ = *One-thousandth inch.*

explained that the metal is thoroughly "passified" or rendered inert to corrosive influences through the oxidising power of the chromate ions (provided by the chromate pigment) and that the presence of suitable resin results finally in the formation, in part at least, of organo-metallic complexes (probably chromate-phosphate) which are precipitated over active areas of the metal surface after the manner in which other protective oxide layers are formed. Thus, in phosphatising processes such as "bonderising", a method commonly applied to steel, in which the liquid is an acidic solution of iron and manganese phosphates, it is usually supposed that a film of these phosphates (about 2/10,000ths inch thick) is deposited integral with the steel. In chromatising processes the deposited film is believed to be a chromium oxide film of uncertain composition. In some metal treatment processes, phosphoric acid and chromic acid are used together. Anodising is another surface treatment process applied to aluminium in which the metal is made the anode in an electrical circuit whereby there is controlled oxidation so that the anodic layer can be greatly varied within wide limits in its texture, porosity and thickness.

It may well be, of course, that the organo-metal complex film (or deposit as it probably is) needs to be strengthened with the natural film formed by the polyvinyl butyral or other material used. Indeed the film produced from polyvinyl butyral, although thin (seldom more than about 3 or 4/10,000ths inch), is remarkably coherent and strong in itself; it is substantially unaffected by water, highly corrosion-resistant in its own right, and what is most important, it adheres most strongly to both ferrous and non-ferrous metals provided they are really clean. Certainly the films, after the first day, become increasingly resistant to organic solvents, notably acetone.

By looking at the matter in greater detail some interesting facts emerge, which influence one's thinking as to what happens in this highly complex situation.

Thus it is certain that the reaction of phosphoric acid on the chromate pigment releases chromate ions and presumably the products are chromic acid and zinc phosphate. The latter, if produced at the metal surface along with some iron phosphate, might reasonably be expected to make a tight bond with the metal, something much more effective than the deposition of the fully developed product of a reaction between the steel (say) and zinc phosphate.

It has also been noted that the rate of loss of phosphoric acid (in 2-pack primers) depends upon the nature of the zinc chromate used (notably its basicity), the total amount of phosphoric acid and the total amount of water present in the mix. At the minimum water-content, corresponding to the water-content of 85% H_3PO_4, the phosphoric acid disappears only very slowly but it is consumed first more rapidly,and then very rapidly, as the water-content of the mix increases. That is one of the reasons why the results with one-pack primers have not been particularly good even though the acid and water-contents of the mix have been reduced to a minimum.

The resin also is by no means a passenger providing a kind of cement. It is doing something more than that. Chromium compounds or complexes described as methacrylate chromic chlorides have been used for holding glass fibres to polyester resins by the established technique of fibre glass impregnation. On this evidence, it seems likely that any vinyl compound at least could be expected to link with chromium oxide or chromium phosphate and if vinyl compounds do so then presumably other resins with appropriate linkages may be expected to do something similar.

Certainly the polyvinyl butyral soon becomes insoluble which probably means the disappearance by linking of its hydroxy or near hydroxy groupings. What is more remarkable, however, is the disappearance of the solvent alcohol presumably by oxidation to aldehyde. It is the simple primary alcohols that disappear by oxidation and which make the best etch primers. More oxidation-resistant alcohols like the tertiary butyl and amyl alcohols do not make satisfactory etch primers. Thus the oxidation of the alcohol seems to be an essential part of the process and that oxidation must be through the chromium which means the reduction of some hexavalent chromiums to trivalent chromium; such trivalent chromium meeting phosphoric acid presumably forms chromium phosphate.

In this maze of complicated reactions between the components and the metal and between the components themselves there is obviously going to be competition particularly for both the phosphoric acid and chromic acid which seems to suggest that the balance of those components is important. Desirable ratios seem to be :

resin to pigment
1 to 1 (more exactly about 1.06 to 1)
pigment to acid
2 to 1 („ · „ „ 1.90 to 1)
resin to acid
2 to 1

The phosphoric acid soon yields chromic acid. That could oxidize hydrogen atoms emerging from cathodic areas, take iron into solution and produce chromium phosphate from the reduced chromium. A mixed zinc phosphate/iron phosphate layer possibly with some chromium phosphate could be formed. Other chromic acid oxidizes the alcohol and the near-hydroxy groups in the organic resin which operation could result in structures capable of embracing the co-ordinated valencies of chromium and phosphorus into organo-metallic complexes with a cloud of metal-oxygen-organic linkage. At any rate that is one idea as to what may happen. Even more detailed suggestions have been made but in view of the great uncertainty it is unwise to pursue the details of structure any further here.

Testing

Presently the results of certain tests on panels will be reported but it is important to state in the most definite manner, the limitations of such tests lest too much be made of them on a strictly arithmetical basis.

Etch primers do not provide a part of a conventional paint system and it is unreasonable to expect them to respond to conventional short-term tests after the accepted manner. Exposure tests by accelerated weathering and by salt spray on panels carrying an ordinary finishing paint over the etch primer are useful but tests on etch primers alone, the purpose of which is to promote good adhesion to the metal, are usually limited to scratch hardness and the bending test over mandrels. Of these scratch hardness was the best but results showed considerable variations not only between different metals as was to be expected but on the same metal at different times. Nevertheless so long as too close an appreciation is not made of the arithmetic of the results the test is to be commended; a microscopic study of the physical nature of the scratch mark, that is to say whether the edges of the mark were jagged and torn or not also helped considerably one's appreciation of the facts.

Certainly the decline in the value of 2-pack primers over the hours of application is clearly reflected in the scratch-hardness

figures and similarly the reduced water-sensitivity of primers containing some phenolic resin.

Experimental

The "control" wash primer used in this work was a commercial product based on polyvinyl butyral; its composition was understood to be within the formula range usually regarded as typical, namely

for the pigment base :

polyvinyl butyral resin	9%—11%	by weight
zinc chromate (basic or tetroxy type)	9%—11%	„ „
ethyl alcohol	60%	„ „
butyl alcohol	20%	„ „

for the acid component :

phosphoric acid ($85\%H_3PO_4$)	18%	by weight
water	16%	„ „
ethyl alcohol or isopropyl alcohol	66%	„ „

Four parts of the pigment base to be mixed with one part of the acid component all by weight.

In the original U.S. Patent—2,525,107 a typical composition for a 2-pack primer is given as :

pigment base :

polyvinyl butyral (Vinylite XYHL)	7.2	parts	by weight
zinc tetroxy chromate	6.9	„	„
talc	1.1	„	„
ethyl alcohol (95%) or isopropyl alcohol (99%)	48.7	„	„
butyl alcohol	16.1	„	„
	80.0		

acid component :

phosphoric acid ($85\%\ H_3PO_4$)	3.6	parts	by weight
water	3.2	„	„
ethyl alcohol (95%) or isopropyl alcohol (99%)	13.2	„	„
	20.0		

A modified formula given in specification CS. 2626 is :

pigment base :

polyvinyl butyral (abbrevd.—p.v.b.)	13.0	parts	by weight
zinc tetroxy chromate	12.0	„	„
asbestine	2.0	„	„
industrial methylated spirit (64° OP or 90.38% by wt.)	36.0	„	„
ketonic solvents	37.0	„	„
	100.		

acid component :

phosphoric acid ($85\%\ H_3PO_4$)	6.5	„	„
n-butyl alcohol	36.5	„	„
industrial methylated spirit (64° OP or 90.38% by wt.)	7.0	„	„
	50		

To use mix in the proportions indicated.

The films of this control primer when applied to the different metal panels (size $5\frac{1}{2}'' \times 4''$) after cleaning and degreasing usually gave a dry weight of 0.16/0.17g. which corresponds to film thickness approaching 3μ.

When shellac in solution in alcohol was substituted for p. v. b. in the above formulae containing the active zinc tetroxychromate gelation occurred during milling but not so much with the less active zinc chromes. These gave promising results and were in general reasonably stable in one-pack compositions.

It was found that this thickening of shellac with zinc tetroxychromate or with zinc oxide or other reactive pigments could be avoided by first treating the shellac with

magnesium oxide whereby the acidity of the shellac is neutralised while the viscosity of its solutions is kept down to a workable level. Other metallic oxides, such as zine oxide, produce a similar result but not in such a satisfactory manner.

The method of treatment is to boil, under reflux, on a water bath, the solution of lac in alcohol (using 100 g. shellac. The shellac used throughout this investigation was dewaked blonde in 100 g. ethyl alcohol) with (2.5 g.) magnesium oxide. Gradually some thickening takes place and after 5 hours' refluxing the mixture is further thinned, while still hot, with (50 ccs.) ethyl alcohol and (50 ccs.) toluene, allowed to cool and filtered to remove the debris including some residual magnesium oxide. The solutions of shellac so produced are in this text described as "modified" shellac.

2-Pack Primers Based on " Modified " Shellac and Zinc Tetroxy-Chromate

The modified shellac solution, prepared as described, was used to produce a series of six etch-primers in which the phosphoric acid content was varied. The basic formulation for each of them was 35g. of the above shellac solution (containing approximately 10g. modified lac) in each of which was ground 10g. zinc tetroxy-chromate. The acid consisted of 0, 1, 2, 3, 4, 5 or 6g. of 85% phosphoric acid in ethyl alcohol.

After two hours' grinding the primers so produced were brushed on clean, degreased aluminium panels. The films were allowed to dry and harden for 24 hours before scratch hardnesses and flexibilities were determined as in Table I.

TABLE I: **Effect of Varying Proportions of Phosphoric Acid with Shellac on Scratch Hardness and Flexibility of Etch Primer**

Percentage of 85% Phosphoric Acid on Shellac Content of Varnish	*Scratch Hardness* g.	*Flexibility : No : 9 Mandrel (diam .0.28cm : elongation for 30 SWG = 10%).*
0	Film too easilydetached for measurements to be taken	—
10	,,	Cracked
20	300	,,
30	2,200	Film does not crack or peel.
40	2,300	
50	2,300	
60	2,300	

From these results it appeared that 30% was the minimum addition of phosphoric acid for satisfactory film forming properties and good adhesion. All compositions containing less than this figure were, therefore, discarded in the subsequent examination. The remaining primers, as films on clean degreased aluminium panels, after drying and ageing for 24 hours, were immersed in cold water for 24 hours. Films of the primers containing 30 and 40% phosphoric acid were substantially unaffected in the test but those containing higher figures had blushed progressively with increase in acid content.

Thus it appeared that the fully constituted shellac primers *should preferably contain between* 30% *and* 40% *phosphoric acid* (85%).

A series of experiments was therefore made at this range of acidity in which measurements were made of scratch hardness of films spread at different times from the pot, i.e. immediately after mixing and up to 24 hours and more after mixing. The respective values for the 30% and 40% primers ranged from 2,300g. to 500g. indicating that pot life for best results using modified shellac and zinc tetroxychromate was definitely less than 24 hours but fairly within one working day. Clearly excellent as this result was on a 2-pack primer basis it gave no indication of one-pack quality.

Concurrently, however, an etch primer based on modified shellac was used to determine the adhesion of etch primers to various metals even when the coating with shellac was substantially thicker than with p.v.b. This shellac primer had the following composition :—

modified shellac solution	105g. (Containing 30g. modified shellac)
zinc tetroxychromate	30g.
phosphoric acid (85%)	10g.

After two hours' grinding the primer was brushed on freshly cleaned and degreased panels (area $5^1/_2'' \times 4''$) of aluminium, brass, copper, duralumin, magnesium, mild steel and stainless steel. The dry film weight per panel was between 0.5-0.6g. In the case of the non-ferrous metals the scratch hardness after 3 days was 2000g. which was much higher than the comparison tests made with the control commercial 2-pack primer based on polyvinyl butyral (Table II).

TABLE II : Adhesion of Shellac Etch Primer on Various Metals

Metal Panel size $5^1/_2'' \times 4''$	*Scratch Hardness*	
	Modified Shellac Primer Dry Weight 0.5 to 0. 6g.	*Commercial "Control" Primer Dry Weight* 0.16 *to* 0.17*g.*
Aluminium	2,200	1,200
Copper	2,200	500
Duralumin	2,000	750
Galvanised Iron	2,200	250
Steel	450	250

Besides scratch hardness, tests were also made for durability, both as to general weathering and salt spray.

Durability tests were also made on a paint system; thus primed panels of each metal were coated after 24 hours with a white paint based upon a long oil glycerol alkyd. After ageing for one week under conditions of constant temperature and humidity (25°C; 65%RH), the panels were exposed to salt spray and accelerated weathering tests. The results after 1000 hours' exposure to the test conditions are also given in Table III.

Continuing with the idea of a 2-pack system the stumbling block is the difficulty of bringing zinc tetroxychromate and shellac together unless the shellac is neutralised or "modified" by treatment with magnesium oxide as a separate and tiresome process. The only alternative form of assembling the components is to grind zinc tetroxychromate in butyl alcohol to form the pigment base and to combine the shellac solution with the phosphoric acid as the second component thus :

Table III : *Resistance of Modified Shellac Etch Primers to Salt Spray and Accelerated Weathering*

Metal	*System*	*Salt Spray 1000 Hours*		*Accelerated Weathering 1000 Hours*	
		Modified Shellac	*Commercial "Control"*	*Modified Shellac*	*Commercial "Control"*
Aluminium	Etch Primer	No visible damage	No visible damage	No visible damage	No visible damage
	with Finishing Coat	,,	,,	,,	,,
Copper	Etch Primer	Severe flaking at top & bottom of panel	Severe flaking but less than with shellac	,,	,,
	with Finishing Coat	No visible damage	No visible damage	,,	,,
Duralumin	Etch Primer	No visible damage	No visible damage	,,	,,
	with Finishing Coat	,,	,,	,,	,,
Galvanised Iron	Etch Primer	No visible damage	,,	,,	,,
	with Finishing Coat	Film easily scratched. No visible damage.	,,	,,	,,
Mild Steel	Etch Primer	Some damage to film; Light under-rusting.	Film destroyed. Severe rusting.	,,	,,
	with Finishing Coat	No visible damage	Lower part damaged. No other change.	,,	,,

GENERAL NOTE : With the exception of the films on copper, the shellac primer generally preserved the panels in a slightly better condition than the controls.

A.	shellac ...	10g.
	ethyl alcohol ...	19.5g.
	n-butyl alcohol ...	2.0g.
	phosphoric acid (85%)	3.5g.
B.	zinc tetroxychromate	10g.
	n-butyl alcohol	25g.

To use mix equal weights of A and B.

This etch primer called a "reversed" primer was applied to clean degreased aluminium panels at intervals of 10 minutes and 1, 2, 4, 7 and 24 hours after mixing to examine the storage stability of the material. The films, after 24 hours' drying, were tested for scratch hardness and the results are given in Table IV.

Table IV : Film Properties of "Reversed" Shellac Etch Primer.

Interval after Mixing A & B.	*Scratch Hardness (g.) of Film after 24 hrs.*	*Weight (g.) of dry Film on $5\frac{1}{2}'' \times 4''$ Panels*
10 minutes	1200	0.2133
1 hour	1200	0.2362
2 hours	1000	0.2409
4 hours	300	0.2531
7 hours	300	0.2501
24 hours	300	0.2418

It was clear from these results that the film properties of this type of 2-pack etch primer were somewhat inferior to those of the modified shellac type, and that its pot life was very short—between 1 and 2 hours—for optimum properties.

One-Pack Etch Primer Based on Shellac

The encouraging results obtained by generally substituting shellac for polyvinyl butyral in the more or less conventional 2-pack type of etch primers led to the conclusion that if zinc tetroxychromate was not used there would be no need to modify or neutralise the shellac. Experiments soon showed that this was so, namely that compositions based on ordinary zinc chrome and shellac were less reactive and, therefore, had a longer life than the corresponding products made with zinc tetroxychromate. So much was this the fact that it was no longer necessary to first treat the lac with magnesium oxide and further that the components could all be ground together in a ball mill. The following composition is a type indication of suitable etch primer having a pot life measured in days rather than hours :—

shellac	...	20g.
ethyl alcohol	...	26g.
butyl alcohol	...	26g.
zinc chrome (DTD 377a)		20g.
phosphoric acid (85%)		8g.

The manner of mixing was as follows : The powdered lac was dissolved in the ethyl alcohol in the cold, the remainder of the components added and the whole ground in a ball mill for 2 hours.

It was established in the manner already described that the optimum content of phosphoric acid is between 30% and 40% on the weight of the shellac. The optimum pigment concentration is still being studied but indications are that it is unlikely to be different from the proportion given above.

The application of the primer to metal surfaces and the tests made thereon were as already described.

Examination of numerous batches of this type of primer at intervals over a period of 50 days' life showed no appreciable thickening and little loss in film properties as determined by scratch hardness of the films prepared from the stored primer as shown in Table V.

Table V: Storage Properties of One-Pack Primer

Age of Primer (days)	*Scratch Hardness of Films after 24 hours g.*
Freshly made	1500
5	1200—1500
17	1200
50	1000

Two months later the same batch of material (having been stored in the laboratory meanwhile) was found to be still useful in the sense that it could be painted out although it took two or three days to harden off completely as judged by thumb-nail scratching.

Over some considerable part of a year numerous batches of one-pack shellac etch primer have been made and used in England on practical jobs as well as under laboratory test conditions. In most cases the material has been exposed to the air for some hours and the lid then replaced but not always effectively.

In India tests have been carried on over a period of 5 months and in England for 3 and 4 months with considerable satisfaction in a practical sense. The results of scratch hardness tests have also remained consistently high even in one case after the batch of material had lost some of its alcohol by evaporation and exposure, it was given a heavier dilution with more alcohol than it had originally, and was still usable as far as one could judge.

Comparative results between this shellac one-pack primer and the control 2-pack primer for film properties on various metals and for resistance to salt spray and accelerated weathering are given in Tables VI and VII. Although the difference in scratch hardness figures should not be taken too literally, perhaps because of the difference in thickness of coating, at least the shellac one-pack primer shows a commendably high standard.

Table VI: Film Properties of Shellac One-Pack Etch Primers on Metals

Metal	*Scratch Hardness (g.) after 24 Hours Drying*		*Scratch Hardness (g.) after 48 Hours Drying*	
	"Control" 2-Pack Primer	*Shellac One-Pack Primer applied 18 days after compounding.*	*Shellac One-Pack Primer applied 100 days after mixing*	
			as it was	*after extra dilution with spirit*
Panels $5\frac{1}{2}'' \times 4''$	*Dry Film Weights* 0. 18-0.20*g.*	*Dry Film Weights* 0.27-0.32*g.*	*Dry Film Weight approx.* 0.35*g.*	*Dry Film Weight approx.* 0.25*g.*
Aluminium	900	1200	2000	1250
Copper	500	1800	500	500
Duralumin	800	1200	1350	850
Steel	300	900	2000	2000
Zinc	600	300	100	100

Table VII. *Resistance to salt spray and accelerated weathering of etch primers as used in table* VI.

Metal	*Paint-System*	*after Salt Spray 500 Hours*		*after Accelerated Weathering 1000 Hours*	
		Shellac One-Pack	*Commercial 2-Pack*	*Shellac One-Pack*	*Commercial 2-Pack*
Aluminium	Etch Primer only	Slight softening	No visible damage	Slight bleaching	Slight bleaching
	with Finishing Coat	No visible damage	No visible damage	Moderate fine blistering (collapsed)	No visible damage
Copper	Etch Primer only	Green discoloration	Green discoloration	Severe water-spotting; bleaching	Bleaching
	with Finishing Coat	No visible damage	No visible damage	Trace of chalking	Trace of chalking. Severe fine blistering
Duralumin	Etch Primer only	No visible damage	No visible damage	Bleaching	Slight water-spotting
	with Finishing Coat	No vissble damage	No visible damage	Severe fine blisters (collapsed & easily broken)	Severe fine blistering
Steel	Etch Primer only	Severe blistering. Moderate rusting.	Superficial rust Staining	Patches of rust, some severe.	General brown discoloration.
Zinc	Etch Primer only	Micro-rust spots	Micro-rust spots	Slight rust	No visible damage
	with Finishing Coat	No visible damage	No visible damage	Severe micro-blistering	Severe micro-blistering.

Again it must be accepted that although these scratch hardness results are erratic, they must be accepted as reasonable if scratch hardness means anything at all. Examination of the surfaces under the optical microscope revealed some differences in the structure of the film notably in the coarseness of the appearance but there has not been time to pursue this aspect of the matter.

Without presuming to suggest that the indicated composition given above for a one-pack wash primer based on shellac, zinc chrome and the right amount of phosphoric acid, is the end of the matter, it seems clear that such primers can be made with a reasonable storage life, adequate for industrial requirements, yet capable of giving results comparable with those obtained from a commercial polyvinyl butyral-based 2-pack primer. The real value of the shellac - based one-pack type is not to be able to keep the material for months as having some facility in use over a matter of a few weeks if necessary and so avoiding waste. If the 2-pack system is followed, it is reasonable to suppose that shellac-based products can be the equal, even if not superior, in some respects at least, to products now commercially available. A further attraction is the distinct possibility of bringing up the film thickness to something like what is expected from a conventional primer.

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