Effects of mixed solvents on the film properties of lac

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USE of lac in the field of surface coating is known from very early times. In this field it is mostly used in the form of spirit solution which when applied properly produces a hard, smooth, glossy and attractive finish on wood and other substrates. Shellac films are particularly noted for their toughness, transparency and high brilliance. The performance of these films, however, depend to a very great extent upon the quality of lac used, the solvent used for preparation of the varnish and other experimental conditions such as humidity and temperature etc.

Though a good amount of work has been done on the use of lac in surface coating, very little information is available on the performance of shellac films[1-3] from different solvents and solvent mixtures.

In view of the importance of the above work in the field of surface coating especially in printing ink industry, the present study was initiated by Ghosh and Kumar[4] who found that amongst the individual solvents used for the preparation of shellac varnishes, ethanol (spirit) and isopropanol serve the best. Since it is reported that mixed solvents give better performance[5], the present study was undertaken to find out the best mixture for lac.

Experimental

Varnishes containing 25% non-volatiles were prepared by dissolving 100 gms of dewaxed lac in 300 g of the solvent mixtures chosen for the experiment. After complete dissolution of lac, the varnishes were filtered over No. 1 filter paper to remove any suspended impurities. Care was taken to avoid any appreciable loss of solvent during filtration.

Clear, transparent solutions were invariably obtained. These varnishes were then tested for viscosity, specific gravity etc. Standard methods[6] of testing the above properties were followed. The data obtained are brought out in table 2.

Thereafter films were prepared on tin and glass panels by flowing and on wood by French polishing technique. One set of film was air-dried for seven days while the other set of films on tin and glass panels was baked at 100°C for one hour. Both air-dried as well as baked films were then tested for their mechanical and other properties such as water, solvent, heat and chemical resistance, etc.

The third set of films for determining the rate of solvent release was prepared by flowing on the panels, an accurately weighed quantity of each varnish from a weighing pipette and allowing the film to air dry under similar conditions i.e. temperature humidity and air-current.

The amount of solvent released from the films was determined by accurately weighing the panels at regular intervals of time till constant weight was obtained. The difference in weight obtained in each case denoted the amount of solvent evaporated during that period of air-drying. From these data, the percentage of solvent evaporated at each step was calculated and the data are presented graphically in graphs 1 and 2.

RESULTS AND DISCUSSIONS

Film properties

The films obtained from different varnishes were hard, smooth and uniform. It may be seen from Table 1 that there is no appreciable difference in the scratch hardness of these films. However, the films obtained from varnishes, 6 and 7 showed some better flexibility as compared to other films. This is possibly due to retained solvent/solvents which do not completely go off from the film in seven days and act as plasticizer and thus improves the flexibility.

Water resistance

In regard to this property films obtained from varnishes 1, 2 and 3 showed better resistance as compared to others. These films did not blush up to 72 hours continuous immersion in water. However the films obtained from varnishes 6 and 7 showed blushing within 24 hours. This is again due to retained solvent in the film which due to hydrophellic character attracts water molecules rapidly and thus show quick blushing.

Heat resistance

It may be seen from table 1 that the films obtained from varnishes 1 and 2 showed slightly better resistance to heat as compared to other films.

These data also support, the previous finding that the greater the retained solvent in the film the poorer is the heat resistance.

TABLE I

Film properties of lac varnishes with different solvent mixtures (25% solid/Wt) (Films tested after 7 days air-drying or after 24 hours of baking at 100°C for one hour)

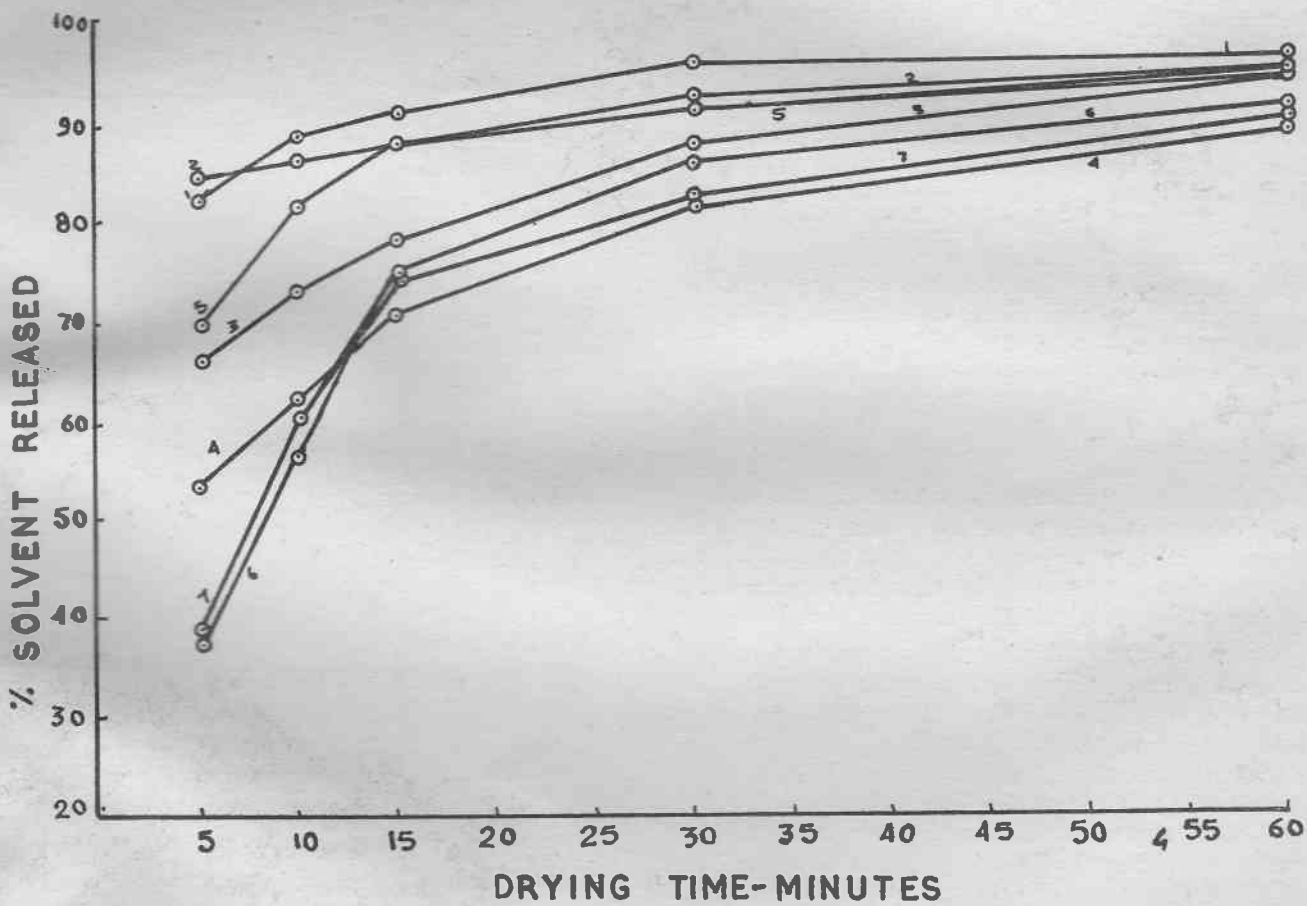
Sl. No.	Solvents used and ratio thereof	Scratch hardness g		Flexibility 1/8"		WATER RESISTANCE					
						Glass panels flow coated				Wooden panels french polished air-dried	
						Time for initial blush hours		Extent of blush after 72 hrs of immersion		Extent of blushing after 48 hours.	Heat resistance temp. of sticking °C
		A.D.	B.	A.D.	B.	A.D.	B.	A.D.	B.		
1	2	3	4	5	6	7	8	9	10	11	12
1.	Spirit, acetone (2:3)	800	800	C	C	72 NB	72 NB	NB	NB	NB	68
2.	Methanol, acetone (3:2)	900	900	C	C	72 NB	72 NB	NB	NB	NB	68
3.	Methanol, spirit (1:1)	800	800	C	C	72 NB	72 NB	NB	NB	NB	66
4.	Spirit, toluene (2:1)	900	800	FC	C	U.F.B. 72	72 NB	FB	NB	NB	66
5.	Ethyl acetate, spirit (3:2)	900	900	FC	FC	U.F.B. 72	72 NB	FB	NB	NB	64
6.	Spirit, butyl acetate (3:1)	800	900	V.F.C.	FC	F.B. in 24 hrs	72 NB	B	NB	60%	64
7.	Spirit (denatured)	800	800	V.F.C.	FC	V.F.B. in 24 hrs	72 NB	B	NB	80%	64

A.D. — air-dried B — baked C — cracks FC — fine cracks VFC — very fine cracks
VFB — very faint blush F.B. — Faint blush N.B. — No blush

TABLE II

Properties of varnishes in different solvent mixtures (25% solid/Wt)

Sl. No.	Solvents used and ratio thereof	Sp. gr. of the varnishes	Viscosity of the varnishes centipoise 27°C	Solvents retained in the film after 7 days of airdrying	Optimum time for air drying of the film-hrs	Percentage of solvent evaporated in the first 5 minutes	Film thickness in mils
1	2	3	4	5	6	7	8
1.	Spirit, acetone (2:3)	0.8784	2.810	0.1%	120	82.1	1-1.3
2.	Methanol, acetone (3:2)	0.8746	1.675	0.1%	120	84:3	1-1.3
3.	Methanol, spirit (1:1)	0.8876	2.430	0.14%	144	66.2	1-1.2
4.	Spirit, toluene (2:1)	0.9077	4.520	0.2%	144	53.3	1-1.2
5.	Ethyl acetate, spirit (3:2)	0.9328	3.900	0.4%	168	69.8	1-1.1
6.	Spirit, butylacetate (3:1)	0.9188	5.281	0.5%	168	37.5	1-1.1
7.	Spirit (denatured)	0.9002	5.981	0.9%	168	39.3	1-1.1



GRAPH No. 1

Rate of solvent release during first 60 minutes

1. Spirit + acetone (2:3)
2. Methanol + acetone (3:2)
3. Methanol + spirit (1:1)
4. Spirit + toluene (2:1)
5. Ethyl acetate + spirit (3:2)
6. Spirit + butylacetate (3:1)
7. Spirit denatured (control)

Resistance to acids and alkalies

Resistance of air-dried as well as baked films to acids and alkalies was studied by the standard methods. It was observed that both air-dried as well as baked films dissolved in 5% $Na_2 Co_3$ solution within 12 minutes and in 2% NaOH within 5 minutes.

These films, however, showed good resistance to acids when immersed in 15% HCl solution. No blushing, lifting or any other type of deterioration could be noticed. It was observed that in general, films from mixed solvents compared favourably with those obtained from spirit varnishes. However, the films from varnishes No. 1 and 2 gave slightly better performance.

released during the first sixty minutes has been plotted. From this graph it may be seen that the rate of evaporation of solvent in the first 60 minutes is very fast and about 83-95 per cent of solvent present in the film is evaporated. However, the fastest

Resistance to solvents

Acetone and alcohol resistance of both air-dried as well as baked films were determined by hard rubbing the films with cotton wool soaked in the respective solvents. Initial damage to the films was noticed within 6-8 rubs in the case of acetone and 5-8 minutes in the case of alcohol. Films obtained from varnishes No. 1 and 2 behaved slightly better as compared to other films. Resistance of films to white spirit and mobil-oil was also determined and it was noted that all the films stood these tests. No softening or lifting of the films was noticed.

Solvent release of shellac films

Percentage of solvent evaporated from a film at different intervals of time has been presented in graph 1 and 2. In graph No. 1 the rate of solvent rate of solvent release is in the first five minutes during which time the film becomes touch dry

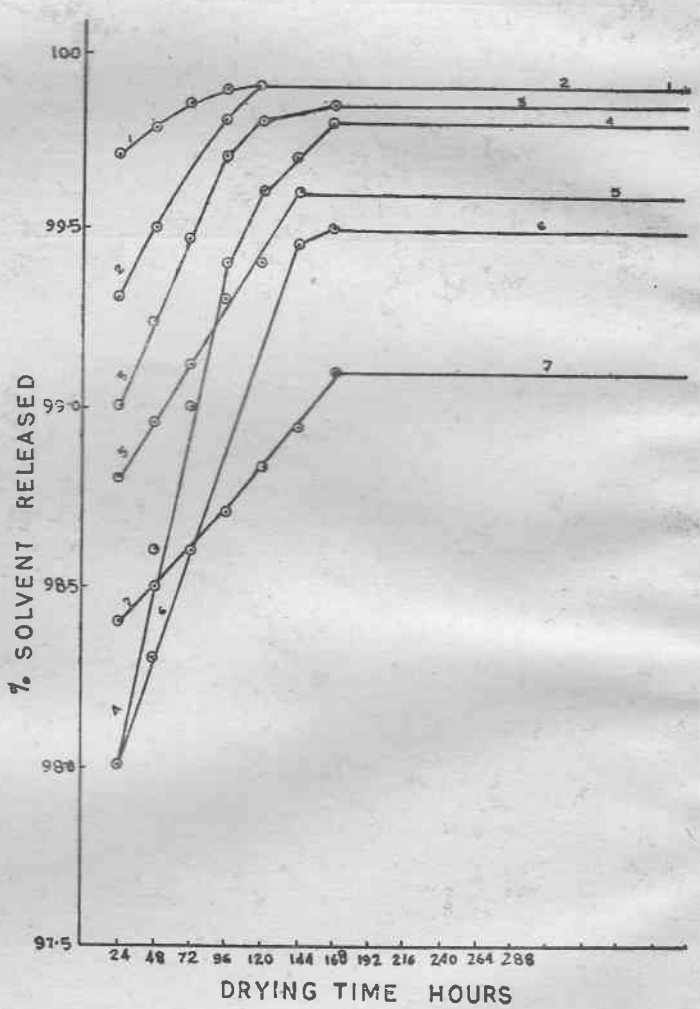
Graph 2 represents the rate of solvent released after 24 hours. It may be seen from this graph that about 98-99 percent of the total solvent present in the film is evaporated within this period, and the remaining solvent i.e. the solvent that is not adhered tenaciously with the resin takes about six days. It may also been seen that in the case of mixed solvents the constant weight is obtained in seven days of air drying showing thereby that the optimum period of testing the films from the mixed solvents is seven days.

Graph 2 further shows that 0.1 to 0.9% of solvent remains tenaciously adhered to the film even after seven days of air drying. In the case of methylated spirit however the retained solvent has been found to vary greatly on the amount of water present in the spirit. **More the water the more the retained solvent.**

Conclusions

From the results it may be concluded that:

1) The mixtures of solvents 1 and 2 are the best as they give varnishes of lower viscosity and produce films of better performance.
2) The presence of tenaciously retained solvent in the film impairs the heat, water and solvent resistance of shellac films.



GRAPH No. 2

Rate of solvent release after 24 hours

1. Spirit + acetone (2:3)
2. Methanol + acetone (3:2)
3. Methanol + spirit (1:1)
4. Spirit + toluene (2:1)
5. Ethyl acetate + spirit (3:2)
6. Spirit + butylacetate (3:1)
7. Spirit denatured (control)

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3) Optimum period of air-drying of the films from mixed solvents is 5-7 days.

4) All the films became touch dry within 5 minutes and tack free in one hour. However, the complete hardness is acquired only after 5-7 days.

Acknowledgements

The authors wish to express their thanks to Dr. S. C. Sengupta, Director for his valuable suggestions.

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