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Electrophoretic Coatings based on Phenolic Resins

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Conventional organic coatings use a lot of organic solvents which are costly, scarce, toxic, pollutant and inflammable. Authors have developed oil-soluble phenolic dispersions in water thus avoiding organic solvents to a great extent. The colloidal dispersion of the resin can be coated on a metal surface by normal conventional methods or they can be electrocoated by making metal as anode.

INTRODUCTION

Normal phenolic resins made by reacting a phenol with formaldehyde are not suitable for surface coating applications as they are brittle[1–3]. To impart flexibility, normal phenolic resins are reacted with vegetable oils under specified conditions to get oil-soluble phenolic resins which find extensive use in surface coating industry. In normal use, adjustment of viscosity of resin solution consumes a lot of organic solvents which are costly, scarce, toxic, pollutant and inflammable. The authors have converted oil-soluble resins into colloidal water dispersions thus avoiding organic solvents to a great extent. The colloidal dispersions of the resin can be surface coated by normal methods or they can be electrocoated on a metal surface. This paper describes the dispersions obtained without using any emulsifier and which are suitable for electrocoating on an anode.

EXPERIMENTAL

Initially oil-soluble flexible phenolic resins with high acid value were prepared and then high acid value was neutralised with ammonia or amines to get water dispersions. Typical preparations are described below:

Rosin modified phenolic resins: Straight phenolic resins are not soluble in oils[1–3]. Hence to make them soluble, 10 to 20 parts of straight phenolic resin was heated with 80 parts of rosin at 180°–200°C when brisk reaction and frothing took place and a product of acid value 130 to 140 was obtained which was oil-soluble. Then polyol such as glycerol (8 parts by weight) was added and esterification was carried out at 200°–250°C to get an acid value around 70 to 80. Finally 60 parts by weight of linseed oil was added and heating continued with stirring till resin got completely dispersed in the oil and acid value of 40–50 was obtained. Acid value was further reduced with ammonia solution at 50°–60°C and the product was water-dispersable at a pH of 7.5–8.

Para-substituted phenolic resins[2,3]: *Para* substituted phenolic resins do not require treatment with resin as they are directly soluble in vegetable oils. For instance 30 parts of *para*-substituted phenolic resin (obtained by reacting *para* substituted phenol with formaldehyde in acid medium) was directly cooked with 65 parts of linseed oil fatty acids at 210°C to get a product of acid value around 130–140. The acid value of the product was further reduced to 40–50 by reacting the product with 8 parts of glycerine at 180°–200°C for 4–5 hrs. To get water emulsion of the resin, small quantity of water-soluble solvent such as diacetone alcohol or butanol was added and acid value was neutralised by adding ammonia to get pH value 7.5–8.5.

Cashew nutshell liquid (C.N.S.L.) resin[4,5]: 300 Parts of C.N.S.L and 24 parts of hexamine were taken in a round-bottomed flask fitted with stirrer and condenser. The material was heated at 130°–140°C for 10–20 min. Then 150 parts of linseed oil fatty acid and 18 parts of glycerine was taken in and temperature was raised to 200°–230°C and heating continued till acid value of 40–50 was obtained. To make the resin water-dispersible it was neutralised with ammonia to a pH value 7.5–8.

Alkyd modified C.N.S.L phenolic-resin[4,5]: In another experiment 300 parts of C.N.S.L was reacted with 24 parts of hexamine. Phenolic resin thus obtained was reacted with 100 parts of alkyd resin (based on phthalic anhydride linseed oil fatty acids and glycerine of acid value 60–70) at 200°–250°C till final acid value of 40–50 was obtained. Further neutralisation was done with ammonia to get pH value 7–8 when resin became water-dispersible.

Experimental set up

For electrocoating, a conventional D.C. source with voltage ranging from 0 to 150 volts and current ranging from 0 to 100 milliamperes plugged on to the 220 volts mains was used. The electrolyte bath was 250 ml pyrex breaker. Counter-electrode was a thin perforated aluminium foil made into a cylinder which was snugly fitted inside the beaker touching the outer walls of the beaker.

The electrodes to be coated were of mild steel plate (100 mm × 30 mm × 1 mm) and copper panels (100 mm × 10 mm × 2 mm). Some of the panels were butt-welded and bent to study the coating quality at crevasses, weld joints, bends and sharp edges. An electrical conductivity meter was used to check conductivity of the electrocoating bath. The electrodes were cleaned with zero grade emery paper and wiped clean with trichlorethylene solvent and dipped in the electrocoating bath. D.C. voltage used for electrocoating ranged from 20 volts to 130 volts and current in the circuit varied form 5 milliamperes to 100 milliamperes and duration of coating was not more than 2 min. Coating process was terminated when current dropped to a low value of 0–10 milliamperes due to formation of the film and its polarisation effects. Then, coated electrodes were carefully rinsed in clean distilled water to remove loose deposit. The coated panels were air dried or cured in an air circulating oven at specified temperature.

Evaluation of Electrocoated Panels

The quality of the polymer film on the electrodeposited panels was evaluated

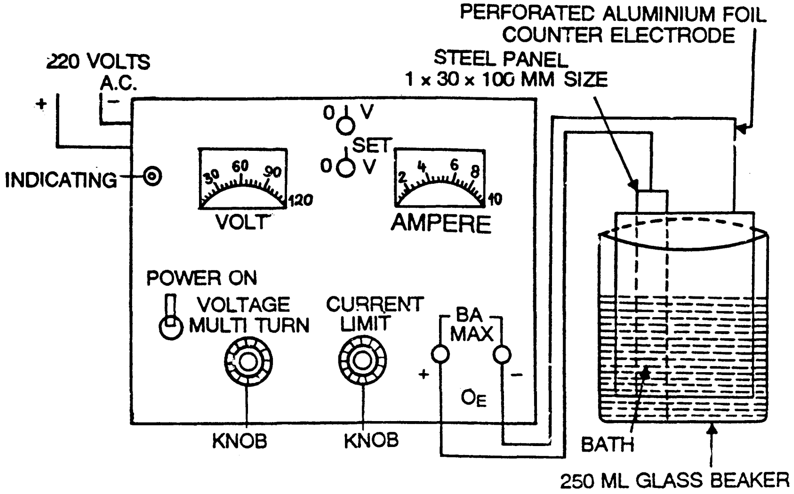

Fig. 1 Regulated D.C. power supply

as prescribed in IS101/1964. Normal parameters observed were thickness, flexibility, electrical breakdown value, gloss, hardness, weather resistance *i.e.*, humidity test and salt spray test. Results are shown in Appendix A.

RESULTS AND DISCUSSION

It is observed that clear coatings obtained are glossy and are similar in appearance to those obtained from organic solvent based coatings their composition was uniform even at crevasses, edges and weld joints and appears to be an advantage over conventional coatings. Electrocoatings were also free from sagging and runs. Air drying and stoving quality of the coating is comparable to conventional coatings. Though clear coatings are not normally used for corrosion protection but results of humidity and salt spray indicate performance to be satisfactory and comparable to conventional varnish coatings. The clear coatings deposited by electrocoating may find application in coatings of coreplate sheets of transformers, electrical motors and generators. They may also find use in coatings on metallic containers for food industry. The electrocoating compositions are deposited only at anode.

As already indicated, electrocoating offers saving in the cost of organic solvents, more uniform coating quality, less consumption of materials, avoids air pollution, health hazard and fire risk. Here, it is recommended that in the production line the use of electrocoating should be adopted.

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APPENIDIX-A

EVALUATION OF WATER DISPERSED POLYMERS COATINGS AS PER IS : 101/1964

Sl. No.	Composition	Viscosity in (P.S. at room temperature)	pH	Finish					Drying Time		Flexibility and adhesion	Scratch hardness	Gloss	Electric strength	Humidity test	Marine test	Thickness (in mm)	Colour	Depositing electrode
				General	At crevasses	At sharp edges	At weld joints	Runs and sags	Air (in hours)	Stoving (in minutes) (150 ± 10°C)									
1.	*Phenolic resins:*													KV/MM	Passes	Passes			
	1. Resin modified	3.2	7.5–8	Smooth & Uniform	OK	OK	OK	Absent	12–18	30	6.5	1200	Glossy	75	7 Days	4 Days	20	Dark brown	Anode
	2. *Para* tertiary butyl phenol	4.5	”	”	OK	OK	OK	”	—	30	6.0	1300	”	86	”	”	23	”	”
	3. C.N.S.L Resin	3.9	”	”	OK	CK	OK	”	16–18	30	7.0	1000	”	72	”	”	21	Golden yellow	”
	4. C.N.S.L. alkyd modified	3.4	”	”	OK	OK	OK	”	18–20	30	7.0	1200	”	66	”	”	19	”	”

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