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## ISOCYANATE-POLYVINYL FORMAL RESIN COMPOSITION AND COATED WIRE

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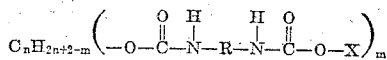
This invention relates, to resinous compositions especially adapted to serve as electrical insulation for metals. More particularly, the invention relates to compositions of polyvinyl acetals reacted with certain polyurethanes and to wires coated with these compositions.

A number of important uses have developed for polyvinyl acetals since their discovery over twenty years ago. The insulation of electrical conductors with polyvinyl formals modified with phenol-aldehyde resins is one of the major commercial applications. These insulating coatings are used for approximately 70% of the magnet wires manufactured in this country. Nonetheless in certain applications a need exists for a wire enamel possessing greater dielectric breakdown strength in the presence of moisture, greater resistance to the solvent action of certain refrigerants such as chlorodifluoromethane (CHClF<sub>2</sub>), and one which will permit the ready soldering of coated wires at temperatures below 500° C.

An object of this invention is to provide resinous compositions of urethane modified polyvinyl acetals. Another object is to provide a wire coated with such compositions.

A further object of this invention is to provide in one system a new insulating enamel which has the desirable properties of the present polyvinyl formal-phenolic compositions and in addition possesses the desired characteristics referred to above.

These and other objects are attained by reacting polyvinyl acetals with a polyurethane represented by the general formula



where R represents a member of the class consisting of phenylene, methyl phenylene, naphthylene and methyl naphthylene groups, X represents a member of the class consisting of phenyl and alkyl phenyl groups, said alkyl groups containing 1-6 carbon atoms, m is an integer greater than 1 but not greater than n, and n is an integer from 2-10. These particular polyurethanes are aliphatic, aromatic polyesters of aromatic dicarbamic acids.

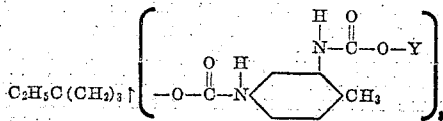
This invention is illustrated but not limited by the following examples in which the parts are by weight.

### EXAMPLE I

A polyvinyl formal resin was used having the following analysis:

10.5% acetate groups calculated as polyvinyl acetate  
6.0% hydroxyl groups calculated as polyvinyl alcohol  
83.5% formal groups calculated as polyvinyl formal (by difference)

One hundred parts of this resin and 133 parts of a polyurethane represented by the formula



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where Y is a methyl phenyl group, were dissolved in a mixture of 440 parts of high solvency petroleum hydrocarbon (B.P. 150-184° C., composed principally of alkyl benzenes) and 258 parts of a commercial cresylic acid (B.P. 207-223° C.). The solution was amber colored and had a viscosity of about 80 poises at 20° C.

Six coats of this enamel were applied to 0.05 inch diameter annealed bright copper wire by running the wire through the solution and then through spring clip dies. After each coating, the wire was passed through a vertical oven 12 feet high at a speed of 8 ft./min., the hottest portion being approximately four feet long and having a temperature of about 335° C. The enamelled wire so produced is classified by the National Electrical Manufacturers' Association as HF wire, the increase in diameter due to coating being within the range of 2.6 to 3.5 mils.

Enamelled wires were prepared in a like manner using the formulae shown in Examples II-IX (Table 1).

Table 1

	Examples							
	II	III	IV	V	VI	VII	VIII	IX
Polyvinyl formal of Ex. I	100	100	100	100	100	100	100	100
Polyvinyl formal "A"					100		100	
Polyurethane of Ex. I	45	22	266	33	43			
Polyester resin			67					
Phenolic resin				25				100
High solvency petroleum hydrocarbon	273	230	635	440	480	374	391	440
Commercial cresylic acid	167	135	324	302	252	219	229	258

The polyvinyl formal "A" resin had an analysis of 13.0% acetate groups and 7.6% alcohol groups, the balance being formal groups.

The polyester resin was a liquid, low molecular weight alkyd, highly branched and having several OH groups per molecule.

The phenolic resin was a soluble, fusible, heat-hardenable phenol-formaldehyde reaction product dissolved in an equal weight of cresylic acid.

Example IX illustrates the commercially available high quality insulated magnet wires of the present time.

The enamelled wires of Examples I-IX passed the standards of the National Electrical Manufacturers' Association (NEMA) for vinyl acetal magnet wire as to flexibility and adhesion. Results of other standard tests on these coated wires are shown in Tables 2 and 3.

Table 2

Ex. No.	Build (mils)	Dielectric Strength, dry	(volts/mil) wet	CHClF <sub>2</sub> Blistering Test	Tinning Time seconds at 450° C.
I	2.9	2,700	2,300	1	6
II	2.8	2,900	2,400	1	25
III	2.7	2,900	1,800	1	20
IV	3.2	2,700	2,700	1-2	10
V	2.8			1	45
VI	2.6	2,900	2,300	1	11
VII	3.3	2,300	1,800	2	15
VIII	2.2	2,300	1,400	4	40
IX	2.7	2,500	1,400	4	60

**Build.**—The addition to the diameter of the bare wire, in thousandths of an inch, is measured by means of a micrometer caliper.

**Dielectric strength, dry.**—Pairs of wires were twisted together 9 turns over a distance of 4.75" under a tension