

1

2

3,230,111
POLYESTER-INSULATED MAGNET WIRE AND
METHOD OF MAKING SAME

Ralph W. Hall, Earl L. Smith, and Ernest C. Koerner,
Fort Wayne, Ind., assignors to Phelps Dodge Copper
Products Corporation, Fort Wayne, Ind., a corporation
of Delaware

Filed July 7, 1961, Ser. No. 122,527
15 Claims. (Cl. 117-232)

This application is a continuation-in-part of copending application Serial No. 62,235 filed October 12, 1960, now Patent No. 3,022,200.

This invention relates to the production of magnet wire insulated with a thermosetting polyester resin. It has particular reference to an improved method of curing the polyester resin on the wire and to the product of such method.

During recent years there has been an increasing use of thermosetting polyester resins for magnet wire. These resins are of various forms but commonly consist essentially of the reaction product of a polyhydric alcohol, a glycol and a dicarboxylic acid or a lower alkyl ester of such an acid. These resins have shown remarkable thermal stability and they are readily soluble in organic solvents and thus can be applied to bare copper or aluminum wire by conventional coating methods using wiping dies followed by curing at a high temperature (550 to 1000° F.). The resin solution is generally applied in multiple coats each cured before application of the next.

Examples of polyester resins of the type described, which have been used to advantage for magnet wire insulation, are:

(1) An ester of terephthalic or isophthalic acid reacted with glycerine and/or pentaerythritol plus small quantities of silanes or siloxanes, and

(2) Esters of terephthalic or isophthalic acid reacted with:

(a) glycerine or pentaerythritol and

(b) ethylene glycol or butane diol 1,4 or a mixture thereof.

These various polyesters are disclosed in United States Patents 2,686,739 dated August 17, 1954; 2,686,740 dated August 17, 1954; 2,889,304 dated June 2, 1959; and 2,936,296 dated May 10, 1960.

Certain modified polyester resins of the thermosetting type have also been so used. These are produced by adding to the dihydric and polyhydric alcohol-terephthalic acid polyester in essentially linear form a substantial proportion of another reactant, such as an isocyanate of the more thermally stable type, which serves as the predominant cross-linking agent in curing the resin on the conductor. One such isocyanate commonly used for this purpose is the trimer of a trisubstituted phenol or cresol blocked cyanuric acid (such as Mondur SH, a product of Mobay Chemical Company, Pittsburgh, Pennsylvania) having the following structural formula:

These isocyanate resins, such as Mondur SH, tend to improve thermal stability, slightly reduce heat and solvent shock and, because of their active cross-linking, harden and toughen the finished film as well as improve its electrical properties.

These commonly used prior resins (the curing rates of which, as well as other thermosetting polyesters, are increased according to the present invention) can be described as thermosetting polyesters or modified polyesters which are either (a) the cured reaction product of both di- and polyhydric alcohols and a dicarboxylic acid or its ester (generally an ester of iso or terephthalic acid) or (b) formed by adding to the components included under (a) above, in linear polymer form, a cross-linking reactant such as an isocyanate of the type described above, and curing the resin with this additional reactant. More briefly, they may be described as thermosetting polyester or modified polyester resins of the dihydric alcohol-polyhydric alcohol-dicarboxylic acid type.

While having improved properties, these and other thermosetting polyester resins previously required a high curing temperature and a substantial time for cure. This means high oven temperatures and long residence time, requiring long heating chambers and relatively slow lineal speeds of the coated wire through the heating chamber where the insulating coating is to be cured. Commercially, assuming a fixed size of oven and a fixed oven temperature, any increase in the curing rate means a proportionate increase in the rate at which the insulated wire or conductor can be produced. It is therefore very desirable to find means for reducing the "curing time" (the combination of time and temperature). Efforts have been made to reduce this "curing time" by the addition of metallic catalysts and other agents. However, only minor reductions in curing time are thus obtained and always at the expense of important physical, chemical or thermal properties of the insulation.

According to the present invention, the curing time of thermosetting polyester resins for insulation of electrical conductors is unexpectedly reduced substantially without sacrifice of any of such properties by the addition in combination to the coating solution, prior to cure, of (1) an organic titanium ester and (2) an amino aldehyde resin.

Moreover, these two additives in combination give unexpected improvements in the physical properties of the cured insulation, that is, better adhesion, better abrasion and cut-through resistance, better heat shock and solvent shock resistance, higher dielectric strength and improved hydrolytic stability.

The "organic titanium ester" (which term is used herein in the specification and claims to include any of the following defined titanium esters) capable of use in this invention may be any organic titanium ester in which the titanium is bonded to at least two groups, represented as —O—R and —O—R', in which each of R and R' is an organic radical having less than 16 carbon atoms. Each

