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GLASS FIBER FILAMENT STRAND AND METHOD OF MANUFACTURING GLASS FABRIC

Lawrence P. Biefeld, Granville, Ohio, assignor to Owens-Corning Fiberglas Corporation, a corporation of Delaware

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This invention relates to the treatment of glass fibers and it relates more particularly to the application of a new and improved size to glass fiber filaments to improve the physical and electrical properties of strands, yarns and fabrics formed thereof and to increase their chemical and heat resistance.

In order to improve the characteristics and properties of strands, yarns and fabrics of glass fibers, numerous attempts have been made to coat the strands, yarns and fabrics with polytetrafluoroethylene, a resinous material having a self lubricating slippery surface and characterized by chemical resistance, excellent physical properties and resistance to deterioration at high surface temperatures. Because of the physical nature of the polytetrafluoroethylene resinous material, application has been limited while in the form of fine particles dispersed in aqueous medium. It has been found that the particles of polytetrafluoroethylene are unable to penetrate satisfactorily into the yarns sufficient to achieve the desired coverage and bonding relation and that the dispersion of polytetrafluoroethylene resinous material is incapable of developing a bonding relation unless fused "in situ" on the glass fiber surfaces. As a result, attempts heretofore made to use polytetrafluoroethylene in the treatment of glass fibers have failed.

In accordance with the practice of this invention, glass fibers in filament, strand, yarn or textile form have been successfully coated with polytetrafluoroethylene resinous material to produce a new and improved glass fiber product by treatment of the fibers in filament form with a dispersion of polytetrafluoroethylene resinous material in particle form and a fugitive binder which functions to hold the filaments together in strand or yarn form capable of removal from the forming package onto which it is formed, twisted into cones or multiple wound upon new packages for braiding onto wire or the like, or woven into tapes and cloth, or formed into other fibrous fabrics. When in position of use, the fiber sized with the polytetrafluoroethylene particles and fugitive binder are heated to a temperature in excess of that necessary to effect coalescence of the particles of polytetrafluoroethylene to form a substantially uniform coating thereof on the glass fiber surfaces. At the temperature of coalescence, the fugitive binder is substantially disposed of such that the polytetrafluoroethylene coating is relied upon thereafter for bonding the filaments in their bundle arrangement.

The polytetrfluoroethylene particles and fugitive binder are preferably applied as a size to the glass fiber filaments in forming, as in the manner described in my Patent No. 2,392,805, which issued on January 15, 1946 for a "Glass Fiber Strand." As described therein, a plurality of streams of molten glass issuing from a melting bushing are rapidly attenuated by a winding drum into very fine filaments which are brought together at a roll applicator where size may be applied to coat the individual glass filaments. The sized filaments in bundle form are wound upon the attenuating drum and subsequently removed therefrom for packaging or the like.

In the practice of this invention it is preferred separately to apply the dispersion of polytetrafluoroethylene resinous material in particle form and the fugitive binder and for such purpose two roll applicators may be used for application of the dispersion of the polytetrafluoroethylene from the first followed by application of fugitive binder by the second. In the alternative, the dispersion of polytetrafluoroethylene may be applied by the roll applicator and the fugitive binder later applied by a graphite wheel or else wiped upon the filaments by a wiping pad.

By way of further modification, application of the polytetrafluoroethylene and fugitive binder may be made by way of a single composition containing the fugitive binder in solution or dispersion with the particles of polytetrafluoroethylene dispersed therewith. Where the fugitive binder may be applied as a hot melt, the particles of polytetrafluoroethylene may be dispersed therein as the temperature of the melt is below that capable of fusing the particles. For example, particles of polytetrafluoroethylene in the desired concentration may be dispersed in wax or paraffin heated to a temperature insufficient to fuse the polytetrafluoroethylene but sufficient to reduce the wax or paraffin to molten condition (300–400° F.) for application as a hot melt onto the glass fibers or filaments.

Application of polytetrafluoroethylene may be made with dispersions containing 1–10 percent by weight of the resinous material in particle form. It is preferred, however, to apply dispersions or suspensions containing 2–5 percent by weight of polytetrafluoroethylene so as to secure about 1–3 percent by weight of the resinous material on the glass fibers in final form. The particles may be coalesced in situ on the glass fiber surfaces by heating at a temperature in the range of 650–900° F. for a time depending upon the particular polymer and temperature employed. For example, one minute at 700° F. is sufficient but 4–5 minutes is often used and still less time may be employed at higher temperatures, although longer time may be used, if permissible, to achieve more complete removal of the fugitive binder and more complete fusion and coalescence of the polytetrafluoroethylene on the glass fiber surfaces. When so fused in situ on the glass fibers, the polytetrafluoroethylene resinous material coats the fibers and functions as a binder to impart the desired improvement in strands, yarns and fabrics formed therewith.

As the fugitive binder which functions to hold the fibers together until the polytetrafluorethylene is heated for coalescence, use may be made of wax, paraffin, gelatin, starch, glucose and other binder substances, alone or in various combinations. These binder substances are suitable for glass or mineral fibers and capable of removal in substantial amounts when heated to temperatures in the range of 650–900° F. Such binders, capable of solution in aqueous medium, such as gelatin, starch, glucose and the like, may be applied in solutions containing from 5–20 percent by weight of the binder solids and preferably formulated with a lubricant in amounts ranging from 0.5–4 percent by weight. Suitable lubricants include oils, such as vegetable oils of the type cocoanut oil, soybean oil, peanut oil and hydrogenated oils of the type described and mixtures thereof, and fatty acid esters of the type butyl stearate and polyglycol esters of fatty acids. Further improvement is secured by the use of a small amount, such as from 0.1–1.0 percent by weight, surface active agent or wetting agent such as a long chain fatty acid amine salt, cationic fatty acid amine or fatty acid quaternary ammonium compound represented by lauryl amine acetate, stearyl amine chloride and the like, or a condensation product of amines and acids such as formed from tetraethylene pentamine

with a fatty acid neutralized with acetic acid. Water insoluble binders, which include waxes, paraffins and the like may be applied from aqueous dispersions containing from 3–30 percent by weight of the binder or else they may be heated to molten temperature and wiped onto the glass fibers as a hot melt. When applied as an emulsion, it is preferred to embody a small amount, such as 0.05–1.0 percent by weight of a non-ionic emulsifying agent such as polyoxyalkalene derivatives of sorbitan salts of fatty acids, such as sorbitan monopalmitate polyoxyethylene derivative, sorbitan monostearate or sorbitan monolaurate polyoxyethylene derivatives; sorbitan monolaurate, stearate, oleate, trioleate, sesquioleate, or alkylated aryl polyether alcohols or alkyl aryl polyethylene glycol ethers and the like.

EXAMPLE 1

Composition A

5 percent by weight polytetrafluoroethylene
94.5 percent by weight water
0.5 percent by weight wetting agent

Composition B

10 percent by weight paraffin
89.8 percent by weight water
0.2 percent by weight emulsifying agent

In Composition A, the wetting agent may be selected of anionic compounds such as the sodium salts of a sulphated acid ester represented by the dioctyl ester of sodium sulfosuccinate, sodium salt of sulphated lorol and myristyl colomide, sodium alkyl aryl sulfonate, sodium salt of alkyl naphthalene sulphonic acid, fatty alcohol sulphates, sodium oleyl methyl laurate, sodium di(2-ethyl hexyl) phosphate and the like, or other suitable wetting agents well known in the industry.

Composition A is applied to the glass fiber filaments in forming, as by a roll applicator, and Composition B is applied onto the glass fiber filaments after the first roll applicator by a wiper pad or the like. About 1½ percent by weight polytetrafluoroethylene based upon the weight of the glass fibers is deposited on the glass fiber surfaces.

The paraffin of Composition B functions to bind the filaments in bundle form and functions as a temporary binder while the bundle is formed into strands and twisted into yarns, wound upon packages or cones for use as braiding upon wires, or for use in the fabrication of woven or unwoven textiles or fibrous structures. When in position of use or even in advance thereof while in yarn or strand form, the fibers are heated for 1–4 minutes at 700° F. whereby the fugitive binder is substantially eliminated or inactivated and the polytetrafluoroethylene particles are coalesced to coat the glass fibers substantially throughout their lengths and assume the function of the binder to hold the filaments together. Thus the fugitive binder functions to secure the fibers together until the polytetrafluoroethylene is able to function as the binder component in the fibrous structure.

The product hereof has markedly improved chemical resistance, excellent electrical properties, good weather resistance, high strength and is able to withstand variable and extended temperatures ranging from —70° C. to 250° C.

EXAMPLE 2

Composition C

3 percent by weight polytetrafluoroethylene
96 percent by weight water
1 percent by weight wetting agent

Composition D

10 percent by weight partially dextrinized starch (15 percent soluble)
2 percent by weight hydrogenated vegetable oil
0.5 percent by weight cationic wetting agent
0.3 percent by weight non-ionic emulsifying agent
87.2 percent by weight water

Composition C is applied to the glass fibers in forming as the fibers are brought together over the roll applicator and then Composition D is applied by a graphite wheel. The compositions are allowed to air dry on the fibers while arranged in bundle form and wound about an attenuating drum. About 1 percent by weight of the polytetrafluoroethylene, based upon the weight of glass fibers, is deposited on the surfaces of the glass fiber filaments.

After the bundles of sized fibers are formed into yarns, tape, fabric, or braided about wire or the like, the glass fibers are heated for 1–2 minutes at a temperature of about 800° F. whereby the temporary starch binder is replaced as the binding element by the polytetrafluoroethylene which is coalesced to provide a coating on the glass fiber filaments.

EXAMPLE 3

Composition E

2 percent by weight polytetrafluoroethylene in particle form
97.5 percent by weight water
0.5 percent by weight wetting agent

Composition F

10 percent by weight paraffin
89 percent by weight water
1 percent by weight dispersing agent

Composition F is in the form of a dispersion which is applied by roll applicator to the glass fiber filaments after Composition E has been applied by a first roll applicator in accordance with the procedures outlined in Examples 1 and 2.

When in position of use, the fibers are heated for 1–10 minutes at 650–900° F. whereby the particles of polytetrafluoroethylene are coalesced in situ on the glass fiber surfaces to coat the fibers and bind them together and replace the paraffin as the operative binder for the glass fibers.

EXAMPLE 4

5 percent by weight polytetrafluoroethylene in particle form
10 percent by weight wax
83.8 percent by weight water
0.2 percent by weight dispersing agent

The size of Example 4 is applied by a single treatment at the roll applicator as the fibers are gathered together and then wound upon the attenuating roll. When in the desired strand, yarn or fabric form, the fibers are heated to a temperature of 750° F. for 2–3 minutes to fuse and coalesce the polytetrafluoroethylene which thereafter coats the fibers substantially throughout their lengths and functions as the binder.

EXAMPLE 5

4 percent by weight polytetrafluoroethylene in particle form
8 percent by weight gelatin
0.2 percent by weight wetting agent
1 percent by weight oil
86 percent by weight water
0.3 percent by weight non-ionic dispersing or emulsifying agent

In this formulation a single composition is formed in which the polytetrafluoroethylene is dispersed in the aqueous solution of gelatin. The composition is applied at the roll applicator and the yarns or fabrics treated as previously described in Examples 1–4.

EXAMPLE 6

10 percent by weight polytetrafluoroethylene is dispersed in particle form in paraffin reduced to molten condition at 350° F. for application as a hot melt onto the glass fiber filaments as they are drawn together over a graphite wheel. The paraffin functions temporarily to hold the fibers together in bundle form until the polytetrafluoroethylene is coalesced by heating the glass fibers at a temperature of 750° F. for 5 minutes.

Though not equivalent in the sense of chemical composition and properties, use may be made of other polymeric materials, such as polytrichlorofluoroethylene and copolymers of tetrafluoroethylene and trichlorofluoroethylene with one or more polymerizable organic compounds containing an ethylene group for addition polymerization, such as vinyl chloride, vinylidene chloride, acrylic esters and alkyl arcylic esters, such as methyl methacrylate. With such copolymers, fusion or coalescence may be achieved at lower temperature than that previously set forth for polytetrafluoroethylene, but in any event, it is desirable to make use of temperatures in excess of 600° F. for substantial elimination or inactivation of the fugitive binder.

It will be apparent from the description that I have provided means for incorporating polytetrafluoroethylene as a size for glass fibers in a manner to make use of the polytetrafluoroethylene resinous material as a binder and coating for the glass fibers with the result that a new and improved fibrous product is secured having high temperature stability, excellent chemical resistance, good electrical properties, excellent feel, and high strength.

It will be understood that changes may be made in the specific formulations and their method of application and treatment without departing from the spirit of the invention, especially as defined in the following claims.

I claim:

1. In the method of manufacturing a fabric of glass fibers, the steps of sizing the filaments of glass fibers with polytetrafluoroethylene in particle form and a fugitive binder which functions temporarily to bind the fibers together into endless bundles, processing the bundles of glass fibers into a fabric, and heating the fabric to a temperature ranging from 650–900° F. for a time sufficient to coalesce the particles of polytetrafluoroethylene.

2. In the method of manufacturing a fabric of glass fibers, the steps of sizing the fibers with polytetrafluoroethylene in particle form and a fugitive binder characterized by supplying the function of a binder until the fibers are heated to fuse the particles of polytetrafluoroethylene, processing the fibers into a woven fabric and then heating the fibers at a temperature within the range of 650–900° F. until the particles of polytetrafluoroethylene are coalesced.

3. The method as claimed in claim 1 in which the fugitive binder is a material selected from the group consisting of waxes and paraffins applied as an aqueous dispersion in concentrations ranging from 3–30 percent by weight.

4. The method as claimed in claim 1 in which the fugitive binder is a material selected from the group consisting of waxes and paraffins heated to molten condition for application onto the glass fiber filaments as a hot melt.

5. The method as claimed in claim 1 in which the fugitive binder is a water soluble organic material selected from the group consisting of gelatin, starch and glucose present in solution in amounts ranging from 5–20 percent by weight.

6. The method of manufacturing a fabric of glass fibers comprising the steps of sizing the glass fiber filaments with a composition containing 1–10 percent by weight of polytetrafluoroethylene in particle form and a fugitive binder characterized by its function to bind the filaments together into strands until the fibers are heated to an elevated temperature for coalescence of the particles of polytetrafluoroethylene processing the strands of glass fibers into a fabric, and then heating the fibers in the fabric at a temperature within the range of 650–900° F. for a time sufficient to coalesce the particles of polytetrafluoroethylene in situ on the glass fiber surfaces.

7. The method as claimed in claim 6 in which the fugitive binder is a compound selected from the group consisting of waxes and paraffins dispersed with the polytetrafluoroethylene particles in aqueous medium in concentrations ranging from 3–30 percent by weight.

8. The method of treating glass fibers as claimed in claim 6 in which the fugitive binder is a compound selected from the group consisting of waxes and paraffins heated to molten condition for application onto the glass fiber filaments as a hot melt and in which the particles of polytetrafluoroethylene are dispersed.

9. The method as claimed in claim 6 in which the fugitive binder is a compound selected from the group consisting of gelatin, starch and glucose in solution in aqueous medium in concentrations ranging from 5–20 percent by weight and in which the particles of polytetrafluoroethylene are dispersed.

10. Strands formed of a multiplicity of parallel glass fiber filaments each of which is coated with a size consisting of polytetrafluoroethylene in particle form and a fugitive binder which functions temporarily to bond the filaments in the strand and in which the particles of polytetrafluoroethylene function to improve the processing characteristics of the strand of glass fibers.

11. In the method of manufacturing a fabric of glass fibers by sizing glass fibers, forming a strand of the sized glass fibers, processing the strands into a fabric and heating the glass fibers after they have been formed into the fabric to a temperature within the range of 600–900° F., the improvement which employs as the size a composition the solids of which consist essentially of polytetrafluoroethylene in particle form and a fugitive binder which functions temporarily to bond the fibers during fabric formation and in which the particles of polytetrafluoroethylene function in the size to improve the processing characteristics of the glass fibers in fabric formation.

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