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(71) Applicant: **UNION CARBIDE CORPORATION, Old Ridgebury Road, Danbury Connecticut 06817 (US)**

(72) Inventor: **Totten, George Edward, 47 Hillside Avenue, West Haverstraw (US)**
Inventor: **Sabia, Angelo James, 1370 Edcris Road, Yorktown (US)**
Inventor: **Greene, George Homer, Baltic Place, Croton-on-Hudson (US)**

(74) Representative: **Wuesthoff, Franz, Dr.-Ing. et al,**
Patentanwälte Wuesthoff -v. Pechmann-Behrens-Goetz
Schweigerstrasse 2, D-8000 München 90 (DE)

(54) Process for imparting lubricity and hydrophilicity to synthetic fibers and fabrics.

(57) Process for imparting lubricity and hydrophilicity to synthetic fibers and fabrics which comprises applying a graft copolymer of an N-(oxymethyl)-acrylamide and a poly-(oxyalkylene) to the surface of the fiber or fabric and cross-linking the graft copolymer on said surface in the presence of an acid catalyst.

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PROCESS FOR IMPARTING LUBRICITY AND HYDROPHILICITY TO SYNTHETIC FIBERS AND FABRICS

Technical Field

This invention pertains to the art of applying polymeric finishes to textile fibers and fabrics.

Background of the Invention

Unfinished polyester fiberfill fibers exhibit fiber scroop and a rough hand due to high interfiber friction. It is known in the art that a silicone finish will lower interfiber friction and thereby make polyester fiberfill fibers acceptable for commercial uses where fiber scroop can be a problem. For example, Dacron® Hollofil II, available from E. I. du Pont de Nemours, is finished with a silicone which lowers the interfiber friction associated with fiberfill fibers and thereby imparts a soft, down-like hand. However, silicone finishes adversely affect the flammability and latex bondability of polyester fiberfill fibers.

The unblended polyester fabrics produced for the garment industry are hydrophobic. This leads to two problems in the use of a polyester fabric. Hydrophobic fabrics are not easily treated in an aqueous medium unless a surfactant is added to aid in wetting the fabric. Even more importantly, garments made from a polyester fabric do not readily absorb perspiration from the skin of the wearer. This imparts a hot or clammy feel to the polyester garment which leads to consumer discomfort and in turn to consumer resistance of polyester fabrics.

It would be advantageous to develop a durable hydrophilic finish for a polyester fabric.

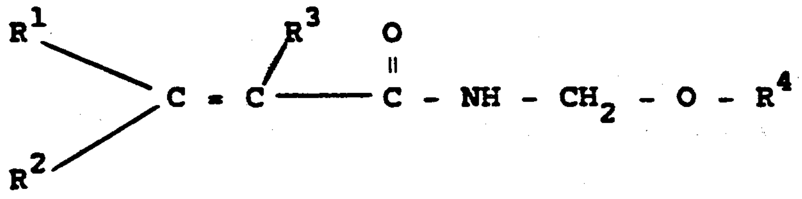
It is also known in the art of fabric finishing that a crosslinkable organic polymer, when applied to a synthetic fabric, will provide various useful properties, e.g., reduction of the static electricity associated with such fabrics. For example, U.S. Patent 3,213,053 to Kendrick discloses that an antistatic composition of a crosslinkable terpolymer of: (1) 5% to 10% of glycidyl methacrylate; (2) 35% to 55% of an alkali metal salt of a styrene sulfonate; and (3) 35% to 60% of methoxypoly(ethylene glycol) methacrylate wherein the poly(ethylene glycol) chain has a molecular weight from 250 to 500, will reduce the static electricity of a synthetic fabric when applied as a finish. French Patent No. 1,427,787 discloses that a copolymer of: (1) from 2% to 20% of an ethylenically unsaturated epoxide or a corresponding methylol compound; with (2) from 98% to 80% of an ester of an ethylenically unsaturated carboxylic acid and an alkylphenoxy polyethylene glycol, will reduce the static electricity or synthetic fabrics when applied to said fabrics as a fabric finish. Swiss Patent No. 513,282 discloses that a copolymer composed of: (1) from 80% to 90% of an ester of an alkyl polyethylene glycol having an alkyl residue with 1 to 3 carbon atoms and an average molecular weight of from 300 to 1000 and an ethylenically unsaturated polmerizable carboxylic acid; (2) 5% to 10% of a etherified N-methylolamide of an ethylenically unsaturated polymerizable carboxylic acid; and (3) 5% to 10% of an ethylenically unsaturated polymerizable compound containing at least one acid group capable of imparting solubility in water, e.g. acrylic acid, will reduce the static electricity associated with a synthetic fabric and enhance the soil release properties of such a fabric.

Summary of the Invention

In accordance with the present invention, it has been found that the process which comprises (a) treating fibers and fabrics with a neat composition, solution or dispersion containing:

(i) at least 0.001% by solution weight or neat composition weight of an acid catalyst, and

(ii) from 0.1% to 15% by solution weight or neat composition weight of a graft copolymer prepared by grafting to a poly(oxyalkylene) from 0.5% to 50% by graft copolymer weight of an N-(oxymethyl)-acrylamide having the formula:



$$R^1R^2C=C(R^3)-\overset{O}{\overset{\|}{C}}-NH-CH_2-O-R^4$$

wherein R^1, R^2, R^3, and R^4 are hydrogen or monovalent hydrocarbon radicals containing from 1 to 6 carbon atoms each and may be the same or different, and a poly(oxyalkylene) of the formula:

$$R^5[(OC_nH_{2n})_zXR^6]_a$$

wherein R^5 is a hydrocarbon radical having a valence of a and containing up to 21 carbon atoms, <u>a</u> is an integer having values between 1 and 4, X is an oxygen, nitrogen or sulfur atom, R^6 is a hydrogen atom or hydrocarbon radical containing up to 6 carbon atoms and may contain hydroxyl, amino or mercaptyl groups, <u>n</u> is an integer from 2 to 4, and <u>z</u> is an integer having a value from 2 to 800, and

(b) drying and curing said treated fiber at between 100°C and 170°C, which imparts to the fiber a durable finish which increases the lubricity of the fiber manifested by a lowering of interfiber friction without adversely affecting the flammability or the latex bondability of the fiber.

In a particular embodiment of the invention, the poly(oxyalkylene) preferably has the formula:

$$R^5[(OC_2H_4)_x(OC_3H_6)_yOR^6]_a$$

wherein y is an integer from 2 to 5000, and the other designations are as above. The graft copolymer produced from such poly(oxyalkylenes) imparts the property of hydrophilicity to the fabric as manifested by a decrease in the time necessary to wet the fabric.

The graft copolymers useful in the present invention may be prepared as described in copending U.S. application Serial No. 307,211 filed September 30, 1981.

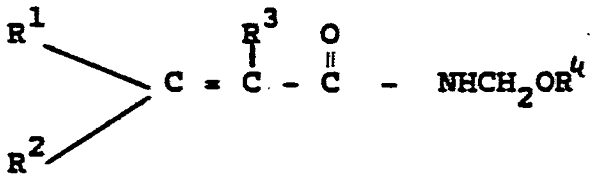
Details of the Invention

Graft copolymers useful in the present invention having an N-(oxymethyl) acrylamide grafted onto a poly(oxyalkylene) compound are prepared by a method which comprises adding an N-(oxymethyl) derivative of acrylamide monomer as hereinafter more fully described and a suitable catalyst to an agitated bath of the poly(oxyalkylene), whereby all of said components are intimately admixed at a temperature at which reaction occurs, and maintaining said temperature until said graft copolymer of acrylamide derivative on poly(alkylene oxide) is obtained.

In general, the poly(oxyalkylene) compounds of this invention contain oxyethylene, oxypropylene, oxybutylene groups or both oxyethylene groups and higher oxyalkylene groups such as oxypropylene and oxybutylene groups, either in random or block distribution in their molecules, and have molecular weights (number average) in the range of 100 to 35,000, and, preferably, in the range of 1,500 to 4,000. These poly(oxyalkylene) compounds may be made by processes well known in the art by reacting an alkylene oxide or mixtures of alkylene oxides with an aliphatic compound, which may be saturated or contain some aliphatic unsaturation, having from one up to as many as four active hydrogen atoms, such as water, monohydroxylic alcohols such as ethanol, propanol, and allyl alcohol; dihydroxylic alcohols such as ethylene glycol and monoethylether of glycerine; trihydroxylic alcohols such as glycerine and trimethylolpropane; and tetrahydroxylic alcohols such as sorbitol. Especially preferred active hydrogen compounds are allyl alcohol and glycerine.

The poly(oxyalkylene) products of such reactions will have linear or branched oxyalkylene or mixed oxyalkylene chains, and such chains will terminate with hydroxyl groups. Although the poly(oxyalkylenes) may be hydroxyl terminated, some or all of these hydroxyl groups may be etherified by reaction with a dialkyl sulfate such as diethyl sulfate or an alkyl halide such as ethyl chloride. These terminal hydroxyl groups may also be etherified with alkyl-halohydrins such as 2-chloro ethanol. This will yield a poly(oxyalkylene) that has a terminal hydroxyl group, which is preferred because of its ability to condense with the N-(oxymethyl) functionality that is introduced into the poly(oxyalkylene) to facilitate crosslinking of the poly(oxyalkylene) chains.

The grafting monomers employed in preparing the copolymers useful in the present invention are substituted acrylamide monomers having the formula



wherein R^1, R^2, R^3 and R^4 may be the same or different and are hydrogen atoms or a monovalent hydrocarbon radicals containing from 1 to 6 carbon atoms. These acrylamide derivative monomers are generally homopolymerizable monomers with a reactive, cross-linkable pendent group or groups. Illustrative suitable monomers are methoxymethyl acrylamide, ethyoxymethyl acrylamide, N-butoxymethyl acrylamide, allyloxymethyl acrylamide, N-butoxymethacrylamide and preferably, N-methylolacrylamide and N-(iso-butoxymethyl)-acrylamide.

A grafting catalyst is employed which is a free-radical initiator. The choice of such initiator is not narrowly critical, as any one of a wide variety of known inorganic or organic initiators of free-radical polymerization may be used. The choice of initiator will generally depend on the particular combination of reactants from which the graft copolymer will be prepared. For example, if a given grafting monomer will self-condense at the grafting reaction temperature necessary for a given catalyst, then the reaction mixture will form an undesireable gel; i.e. the graft copolymer will cure before application to the fiber. Therefore, a catalyst must be chosen such that the grafting reaction temperature will not cause the grafting momomer self-condense. Exemplary of suitable initiators are azobisisobutyronitrile; hydroperoxides such as t-butyl peroxypivalate, di-t-butyl peroxide, and t-butyl perbenzoate; peroxycarbonates such as diethyl peroxydicarbonate and diisopropyl peroxycarbonate; and persulfates such as potassium and sodium persulfates.

Homogeneous graft copolymers useful in the present invention which are substantially free (contain less than 2 percent by weight) of insoluble homopolymerized acrylamide derivative may be prepared by methods known in the art but preferably are prepared by charging the reactants in two separate feed streams, advantageously in gradual and/or incremental amounts, one of which consists of the grafting monomer and a second consisting of the free-radical grafting initiator. Either of the reactants may be mixed with a portion of the poly(oxyalkylene) compound prior to feeding them to the reaction zone when doing so facilitates the gradual or incremental feeding thereof to the reaction mixture. The amount of acrylamide derivative added to the polymerization reactor zone is not critical and may be varied over a wide range. The preferred range is from 6% to 12% by weight of poly(oxyalkylene). In general, however, up to about 70 percent by weight, and preferably from 0.5 percent by weight to 50 percent by weight based on the total weight of poly(alkylene oxide) compound, is charged.

The temperatures at which the graft reaction may be carried out may vary over a wide range and depend, in general, upon the combination of reactants to be used in the reaction and the catalyst chosen to catalyze the graft reaction. For example, when organic free-radical grafting initiators are employed, a temperature sufficient to activate the initiator, to about 160°C, can be used in the grafting reacting, and preferably, a temperature in the range from 70°C to 100°C. Where employing inorganic free-radical initiators, a temperature from about above the freezing point of the solvent to about 65°C may be employed. Reaction temperatures above 160°C lead to gelling of the reaction mixture, and should be avoided.

Incremental and/or gradual addition of the two separate reactant feed streams coupled with efficient agitation of the poly(oxyalkylene) compound in the reaction zone constitutes the most important technique for producing the graft copolymers useful in the present invention. This method is particularly important in large scale or commercial operations, not only for preparing the desired homogenous graft compolymer, but also to facilitate handling and storage of the monomer and the free radical initiator.

The grafting reaction is preferably carried out in bulk without the use of a solvent. If desired, however, a solvent may be used which is inert to the reactants. Suitable solvents include benzene, toluene, tertiary-butylbenzene, heptane, hexane, or octane, and mixtures thereof, and water.

The preferred graft copolymers are made from a poly(oxyethylene-co-oxypropylene) copolymer of molecular weight in the range of 350 g/mol to 4000 g/mol and which are at least about 40% ethylene oxide monomer by weight of the polymer. The upper limit is not critical as longer chain polymers have been found to impart better lubricity; however, the high viscosity of very high molecular weight poly(oxyalkylenes) may make the use of such polymers difficult. The preferred poly(oxyalkylenes) have been treated with a sufficient amount of N-methylol-acrylamide or N-(isobutoxymethyl)-acrylamide in a grafting reaction such that at least an average of 1,5 N-(oxymethyl)-acrylamides molecules are grafted onto each poly(oxyalkylene) molecule and most preferably an average of from 3 to 6 N-(oxymethyl)-acrylamide molecules per poly(oxyalkylene) molecule.

An optional component of the treating solution is an antioxidant that will inhibit the degradation of the poly(oxyalkylene) polymer thereby improving the durability of the "fiber finish ". Such antioxidants are well known in the art of stabilizing poly(oxyalkylenes) and may include any number of antioxidant compounds. Especially suitable are hindered phenolic compounds such as Bisphenol A, BHA and BHT. The amount of such an antioxidant is not critical and generally ranges from 1% to 3% by weight of the treating composition or solution.

The graft copolymer is then mixed with an acid catalyst and applied to the fiber or fabric to be treated.

Although the various examples given herein are directed to the practice of the instant invention with fiberfill fibers, it is believed that the instant invention will impart lubricity to any synthetic fiber, e.g., a textile fiber. It is to be understood that the phrase "fiberfill fiber" is intended to mean any non-woven bating or fiber mat. Although all the examples shown herein are directed to carded polyester fibers, it is to be expected that non-carded, non-polyester fibers will exhibit similar properties when treated by the process of the instant invention. In addition to the Hollofil-808 fibers available from E. I. du Pont de Nemours that are exemplified herein, other fiberfill fibers, such as the round, solid fiber available from Hoechst, are useful in the instant invention.

Similarly, the process of the instant invention is exemplified hereinafter by the application of the graft copolymer to 100% polyester fabrics made from polyethylene terephthalate. Examples of suitable polyester fabrics are Kodel, a registered trademark of Eastman Kodak, and Dacron, a registered trademark of E.I. du Pont de Nemours. However, it is to be understood that the process of the instant invention is not limited to polyester fabrics. It is believed that substantial hydrophilicity would be imparted to other textile fabrics, e.g. nylon, synthetic/natural fiber blends, etc.

The choice of acid catalyst suitable for use in the invention is not critical and may depend on such considerations as economic or toxicological factors. Any acid that will lower the pH sufficiently to make the solution weakly acidic will catalyze the crosslinking of the graft copolymer on the fabric surface. Examples of acid catalysts include inorganic acids such as hydrochloric, hydrobromic, sulfuric and nitric acids; organic acids such as carboxylic acids, phenols, alkyl and aryl sulfonic acids, Lewis acids, such as zinc fluoroborate, will also catalyze the graft copolymer cross-linking on the surface of the fabric. An acid catalyst that is particularly suitable for use in the instant invention is citric acid because of its commercial availability and non-toxicity. In a most preferred embodiment, the acid catalyst chosen is water soluble because an aqueous solution is a convenient medium with which to apply the graft copolymer to the fiber.

The graft copolymer and acid catalyst may be applied as a neat composition or a solution. Any solvent which will dissolve the graft copolymer may be used. Suitable solvents include water, alcohols, ketones, esters or mixtures thereof that will dissolve the graft copolymer and the acid catalyst. When water is used as the solvent, a functional additive such as an anionic or nonionic surfactant may be added to facilitate the initial wetting of the fiber. In a highly preferred embodiment, the graft copolymer and acid catalyst are added to water to form a treatment solution that is from 1/2% to 15% by solution weight of graft copolymer and 0.001% to 2% by solution weight of an acid catalyst.

The solution may be applied in any manner that is effective to wet the fiber or fabric with the solution. If the fiber or fabric is deposited in a bath containing the treatment solution, the residence time in the bath need only be so long as to allow substantial wetting by the solution. The addition of wetting agents such as surfactants will reduce the necessary residence time. Other functional additives such as colorants, sizing agents, may also be added to the treating bath along with a surfactant. The temperature of the treatment solution is not critical so long as it is maintained below the temperature that will cross-link the graft copolymer in solution with the acid catalyst. The treated fiber or fabric is then heated at a temperature and for a period of time sufficient to dry it and cure the graft copolymer on the fiber or fabric surface. Generally, a few minutes in an oven at between 100°C and 170°C is sufficient to cure the graft copolymer and remove any excess solvent taken up by the fabric in treatment, but the actual time and temperature necessary will depend primarily upon the catalyst and solvent chosen.

The dried, treated fiber or fabric is then ready for further processing with the graft copolymer cross-linked on the surface of the fiber or fabric as a durable, lubricating and hydrophilic fiber finish. Any residual acid catalyst may be removed by further processing, which may include a simple rinsing procedure.

This invention is further described in the Examples which follow. These examples are intended to be illustrative of specific embodiments of this invention and are not intended in any way to limit the scope of the invention. All parts and percentages are by weight unless otherwise specified.

Examples 1 & 2

Graft Copolymer Preparation

Example 1

A four-neck, round-bottom glass flask, fitted with a mechanical stirrer, thermometer, water condenser, two 250 inch (ml) dropping funnels nitrogen source, and nitrogen outlet, was charged with 184.3 g g of an allyl-started ethylene oxide/propylene oxide copolymer (40/60 by weight) having a viscosity of 450 SUS 96 mm^2/s (Seconds, Universal, Saybolt). One dropping funnel was charged with 64.3 g of N-(isobutoxymethyl)-acrylamide (IBMA) and the other was charged with 20.3 g of ethyl acetate and 1.3 g g of 2,2-azobis-(2-methylpropionitrile). The flask contents were heated to 80°C with an electrical heating mantle and the flask was purged with dry nitrogen. The IBMA and ethylacetate 2,2-azobis-(2-methylpropionitrile) were added simultaneously and dropwise over a period of 1 hour at a rate which kept the reaction mixture between 80° and 83°C. After addition of the IBMA and ethyl acetate/2,2-azobis (2-methylpropionitrile) was completed, the flask and its contents were heated to 80°C for 3 additional hours and then allowed to cool to room temperature. Any remaining unreacted IBMA was removed by vacuum stripping along with the ethyl acetate used to introduce the acid catalyst. The graft copolymer obtained thereby is a clear, pourable liquid that is added to water to make the fabric treating solution or may be applied to the fabric as a neat composition with the acid catalyst.

Example 2

A 250 ml three neck round bottom flask equipped with a stirrer was used in this example. To this reactor was charged 120 g of distilled water, 0.5 g of sodium bicarbonate, 0.5 g of sodium sulfite and 0.5 g of sodium persulfate. After dissolution of the salts was completed by stirring, 15.3 g (0.0059 mole) of the poly(oxyalkylene) polymer used in Example 2 were added and the resulting solution was cooled to 0° to 5°C. A 48 percent aqueous solution of N-methylolacrylamide containing 7.4 g (0.034 mole) (28.6 weight percent of the total charge) with 5.0 g additional water was added dropwise to the reaction mixture over a period of 15 minutes. After addition of all reactants was completed, the reaction mixture was stirred for an additional 45 minutes while maintaining the temperature at 0° to 5°C, and then the reaction mixture was allowed to warm to room temperature.

This crude reaction mixture may then be diluted to form a treating solution upon the addition of a solvent and a suitable acid catalyst.

Lubricity Testing

The samples tested in examples 3-7 were prepared by padding the aqueous finishing composition onto carded Hollofil-808, a round, hollow, polyester fiberfill fiber available from E.I. du Pont de Nemours. The amount of finish taken up was controlled such that the Hollofil-808 takes up its own weight in aqueous finish. This 100% pick-up of finish on the fiberfill translated into a percent by weight of finish on the fiberfill equal to the percent by weight of finish in solution, i.e., a 1% graft copolymer finishing solution yielded a finished Hollofil-808 sample that is 1% by weight of graft copolymer finish.

The finished fibers were then dried at the temperature indicated and for the time indicated in the following examples.

The treated samples were then allowed to condition for three days by maintaining them in a constant environment of 50% relative humidity and 21°C (70°F). The samples were then tested for lubricity according to a "Staple Pad Friction" technique. In this technique, a weighted sled is pulled across a fiber sample by an Instron Model 1000 available from Instron Corp., Canton, MA. The "Staple Pad Friction" is displayed in grams by the Instron and the Staple Pad Friction (hereinafter referred to as SPF) Index is computed by dividing the Staple Pad Friction in grams by the sled weight in grams.

To test the durability of the graft copolymer finish, the samples as indicated were washed for 10 min in a solution of 2.25 g of AATCC Detergent #124 held at 70°C. The samples were then rinsed with deionized water at room temperature and were allowed to recondition in a constant environment as hereinbefore described.

Example 3

This is a control for Examples 4-6 in which untreated Hollofil-808 exhibited an SPF of 0.40. The results of Examples 3-6 are tabulated in Table I.

Example 4

This is a comparative example in which a 1% solution of a ungrafted allyl-started ethylene oxide/propylene oxide (40/60 by weight) with a viscosity of 2700 SUS (~600 mm^2/s) (Seconds, Universal, Saybolt) and an average molecular weight of 3700 g/mol was padded onto a carded Hollofil-808 sample as hereinafter described and tested as herein before described. The SPF for such an ungrafted sample was 0.36 before washing.

Example 5

This is a comparative example wherein no catalyst was used to cure the graft copolymer. The procedure of Example 4 was followed with the exception that the graft copolymer was composed of 26.6 g by weight of N-(isobutoxymethyl)-acrylamide grafted onto an allyl-started ethylene oxide/propylene oxide (40/60 by weight) with a viscosity of 96 mm^2/s (450 SUS) and an average molecular weight of 1400 g/mol. No catalyst was, however, added to the finishing solution. The treated Hollofil-808 fiber exhibited an SPF of 0.30 before washing and and SPF of 0.39 after washing.

Example 6

This is a preferred example wherein 7.5 gms of a graft copolymer composed of 12% by weight of polymer of N-(isobutoxymethyl)-acrylamide grafted onto the poly(oxyalkylene) of Example 4, 7.5 gms of citric acid and .15 g of Bisphenol A were dissolved in enough deionized water to form 750 gms of finishing solution. Samples of Hollofil-808 were treated and tested as hereinbefore described to yield an SPF Index of 0.27 after curing for 10 min at 150°C but before washing, and an SPF of 0.29 after washing as hereinbefore described.

Example 7

This is a preferred example wherein 7.4 g of a graft copolymer composed of 12%

N-(isobutoxymethyl)-acrylamide grafted onto a glycerol-started ethylene oxide/propylene oxide (14/86 by weight) with a viscosity of 78 mm^2/s (360 SUS) and an average molecular weight of 4741 g/mol was dispersed in 750 g of finishing to which was also added 0.75 g of ethoxylated nonyl-phenol, Tergitol NP-40 available from Union Carbide Corporation (as a surfactant to disperse the nearly insoluble graft copolymer), 7.5 g of citric acid and 0.15 g of Bisphenol A. The procedure of application and testing of Example 5 then yield an SPF before washing of 0.26 and an SPF after washing of 0.29.

TABLE I

			SPF	
Example	**EO/PO Copolymer**	**Catalyst**	**Before Washing**	**After Washing**
3	None	None	0.40	0.48
4	EO/PO- 2700 SUS*	None	0.36	-
5	EO/PO- 450 SUS* 26.6 % IBMA	None	0.30	0.39
6	EO/PO- 2700 SUS* 12 % IBMA	Citric Acid	0.27	0.29
7	EO/PO- 360 SUS* 12% IBMA	Citric Acid	0.26	0.29

*As more fully described in the corresponding Example

Table I illustrates that a durable fiberfill finish is obtained by the practice of the present invention which significantly lowers the interfiber friction associated with polyester fiberfill fibers.

Hydrophilicity Testing

The 100% polyester fabric samples tested in the following examples, 8-19, were treated by immersing them in a bath containing a solution of 5% graft copolymers by weight along with 0.1% para-toulene sulfonic acid as a catalyst and 0.1% Tergitol TMN-6, a non-ionic surfactant available from Union Carbide Corporation, to aid wetting in treatment. The fabric was weighed before immersion, immersed, retrieved and then pressed in a Mathis two-bowl Vertical Laboratory Padder, type VF, with a pad pressure of 1 bar and a roller speed of 6 rpm. The resulting weight of the wet, treated fabric indicated a wet pickup of treating solution of 60% to 70% by weight of the fabric. These wet samples were then placed upon a frame and dried in a Mathis Laboratory Drying and Curing Apparatus, type LTF, for 2 minutes at 165°C. The curing of the graft copolymer occurred during this drying cycle.

The samples were then conditioned and tested for wettability in accordance with AATCC Test Method 39-1977 promulgated by the American Association of Textile Chemists and Colorists for the evaluation of wettability of fabric. The readings therefrom are expressed in the average time in seconds needed visibly to wet the tested fabric with a drop of water. The shorter the average wetting time, the more hydrophilic is the fabric. The samples were then laundered in accordance with AATCC Test Method 130-1977 the number of times indicated in Table II.

The AATCC Standard Detergent 124 was used in an amount of about 140 grams in a #4 wash load with a washing temperture of about 120°F and a rinse temperature of about 40°C (105°F). The laundered samples were then reconditioned in accordance with AATCC Test Method 39-1977 for re-testing.

Table II sets forth the nature of the graft copolymer applied to the fabric, the initial wettability of the samples and the wettability after five standard launderings.

TABLE II

Example	Ethylene/ Propylene Oxide Ratio (weight %)	Approximate Molecular Wt. (g/mol)	Amount of IBMA (weight percent)	Amount of NMA	R^5	R^6	Wettability (s)	
							Initial	After 5 Launderings
8	(control)	-	-	-	-	-	> 300	> 300
9	1/0	790	-	28.6	allyl	methyl	21	44
10	0.75/0.25	4000	-	18.8	hydrogen	hydrogen	88	54
11	0.4/0.6	1400	25.9	-	allyl	methyl	4	7
12	0.4/0.6	2600	15.7	-	allyl	methyl	3	7
13	0.4/0.6	3600	11.9	-	allyl	methyl	3	10
14	0.4/0.6	1400	14.0	-	allyl	methyl	3	10
15	0.75/0.25	1400	20.0	-	allyl	methyl	3	4
16	0.75/0.25	1400	25.9	-	allyl	methyl	3	4
17	0.4/0.6	1400	25.9	-	allyl	hydrogen	3	3
18	0.75/0.25	4000	20.0	-	hydrogen	hydrogen	4	13
19	0.75/0.25	4000	6.5	-	hydrogen	hydrogen	4	20

The data show that significant durable hydrophilicity is obtained with N-methylol-acrylamide graft copolymers and that superior durable hydrophilicity is obtained with N-(isobutoxymethyl)-acrylamide graft polymers. The data also show that the structure and functionality of the graft copolymer is not critical within the claimed ranges of structure and functionality of the polyether precursor.

The data in Table III set forth the nature of the graft copolymers applied to the 100% polyester fabric tested in examples 20-24 along with the wettability results after 5, 10, 15 and 20 standard launderings. The treatment process of examples 20-24 is otherwise identical to the treatment process described for examples 8-19.

TABLE III

Example	Ethylene/ Propylene Oxide Ratio	Approximate Molecular Wt. (g/mol)	Amount of IBMA (by weight %)	Amount of NMA	R^5	R^6	Wettability After Laundering (s)			
							5X	10X	15X	20X
20	1/0	350	41.8	-	allyl	hydrogen	22	40	22	27
21	1/0	360	55.5	-	allyl	methyl	22	28	15	32
22	0.4/0.6	1400	14.5	-	allyl	hydrogen	12	32	38	-
23	0.4/0.6	1400	20.5	-	allyl	hydrogen	4	10	10	26
24	0.4/0.6	1400	41.0	-	allyl	hydrogen	9	15	16	17

The data in Table III show that extended durability of hydrophilicity is achieved for the N-(isobutoxymethyl)-acrylamide graft copolymer of the present invention regardless of the structure or functionality of the graft copolymer within those shown in Table III.

The data in Table IV set forth the effect of a catalyst on the cross-linking of the graft copolymer on the surface of the treated fabric. The graft copolymer is the same as that described in Example 23 and the treatment process was identical with the exception of the varied catalyst type and concentration.

TABLE IV

Example	Catalyst	Concentration (wt. %)	Wettability (s) After 5 Launderings
25	None	-	>300
26	para-toluene sulfonic acid	0.2%	4
27	zinc fluoroborate	1.4%	11

The data in Table IV illustrate the need for a Lewis acid catalyst, but that the choice of catalyst is not critical.

The data in Table V illustrate the effect of solution concentration of the graft copolymer of Example 23 in the treatment bath. The other treatment process conditions were identical to those of examples 8-19.

TABLE V

Example	IBMA Graft Copolymer Concentration (wt %)	Wettability after Launderings (s) 5X	10X	15X
28	-	300	300	300
29	1	25	45	48
30	5	2	18	22

The data show that although increasing hydrophilicity is imparted by increased solution concentrations, as little as 1% graft copolymer in solution imparts substantial hydrophilicity to the fabric tested.

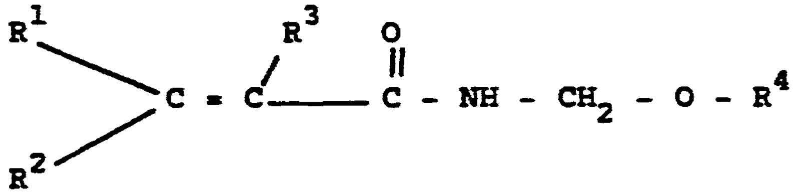
CLAIMS

1. A process to impart lubricity and hydrophilicity to fibers or fabric which comprises:

(a) treating said fibers or fabric with a neat composition, solution or dispersion containing:

(i) at least 0.001% by solution or dispersion weight or neat composition weight of an acid catalyst,

(ii) from 0.1% to 15% by solution or dispersion weight or neat composition weight of a graft copolymer prepared by grafting to a poly(oxyalkylene) from 0.5% to 50% by polymer weight of an N-(oxymethyl) acrylamide of the formula:



wherein one or more R^1, R^2, R^3, and R^4 are hydrogen or monovalent hydrocarbon radicals containing from 1 to 6 carbon atoms each and the poly(oxyalkylene) is of the formula:

$$R^5[(OC_nH_{2n})_zXR^6]_a$$

wherein R^5 is a hydrocarbon radical having a valence of <u>a</u> and containing up to 21 carbon atoms, <u>a</u> is an integers having values between 1 and 4, X is an oxygen, nitrogen or sulfur atom, R^6 is a hydrogen atom or hydrocarbon radical containing up to 6 carbon atoms and may contain hydroxyl, amino or mercaptyl groups, n is an integer from 2 to 4 and z is an integer from 2 to 800, and

(b) drying and curing said treated fiber or fabric.

2. The process of claims 1 wherein the substituted N-methylol derivative of acrylamide is N-(isobutoxymethyl) acrylamide.

3. The process of claims 1 or 2 wherein the poly(oxyalkylene) is made by reacting an alkylene oxide, or mixtures thereof, with an aliphatic compound which is saturated or contains aliphatic unsaturation and which contains from 1 to 4 active hydrogen atoms.

4. The process of claims 1 to 3 wherein the poly(oxyalkylene) is poly(oxyethylene), poly(oxypropylene) or mixtures or copolymers thereof or poly(oxyethylene-co-oxypropylene) monoallyl ether, containing 40 percent oxyethylene/60 percent oxypropylene.

5. The process of claim 1 to 4 wherein the acid catalyst is citric acid or acetic acid.

6. The process of claims 1 to 5 wherein the curing temperature is about 140°C and preferably between 100 and 170°C.

7. The process of claims 1 to 6 wherein the hydrocarbon radical R^5 is selected from the group of allyl, butyl, and glyceryl radicals.

8. The process of claims 1 to 7 wherein R^6 is a hydrogen atom.

9. The process of claims 1 to 8 wherein z is between 40 and 135.

10. The process of claims 1 to 9 wherein bis-phenol is added to the treatment solution.

11. The process of claim 1 to 10 wherein the fiber treated is a fiberfill fiber.

12. The process of claim 1 to 11 wherein the substituents of the N-(oxymethyl) acrylamide R^1, R^2, R^3 and R^4 are hydrogen or monovalent hydrocarbon radicals containing from 1 to 6 carbon atoms each and may be the same or different to the poly(oxyalkylene) of the formula:

$$R^5[(OC_2H_4)_x(OC_3H_6)_yOR^6]_a$$

wherein R^6 is a hydrogen atom or hydrocarbon radical containing up to 6 carbon atoms and x is an integer having a value from 2 to 5000, and y is and integer having a value from zero to 5000.

13. The process of claim 12 wherein the fibers or fabric material is polyester.

14. The process of claim 12 or 13 wherein the acid catalyst is p-toluene sulfonic acid or zinc fluoroborate.