

Dec. 14, 1943.

R. W. MAXWELL

2,336,797

FELTED PRODUCT

Filed June 19, 1939

Fig. 1.

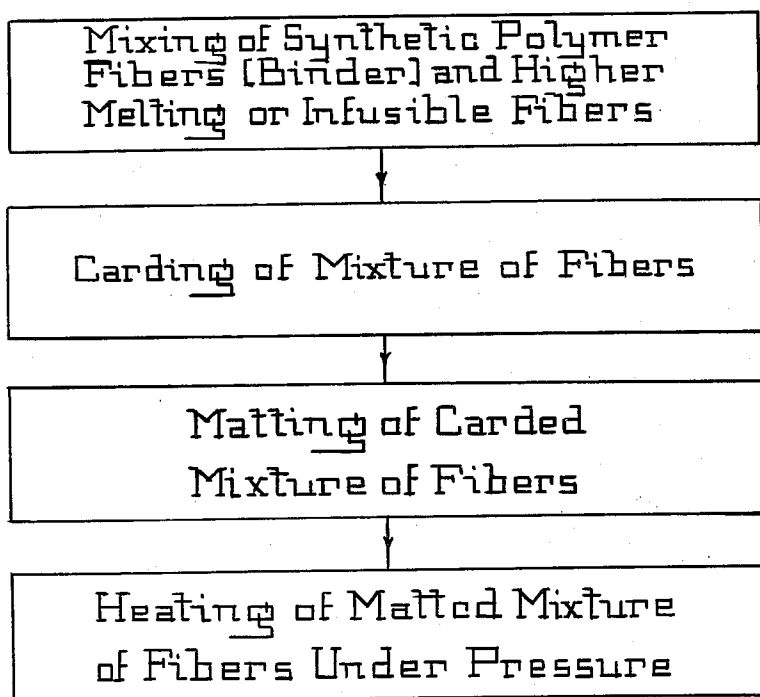


Fig. 2.

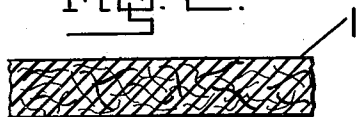
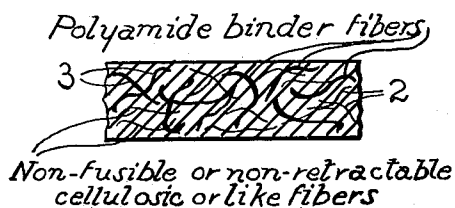


Fig. 3.



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UNITED STATES PATENT OFFICE

2,336,797

FELTED PRODUCT

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Application June 19, 1939, Serial No. 280,016

6 Claims. (Cl. 154—33)

This invention relates to fibrous materials, and more particularly to improved felted products.

This invention has as its object the preparation of new felt compositions having improved physical properties. A further object is the economical manufacture of new and valuable felted products. Other objects will appear hereinafter.

These objects are accomplished by the production of a felted material comprising a binder of synthetic linear polymer and filaments which are substantially unaltered at the softening point of said polymer. A convenient method of obtaining my new products comprises the preparation of a felt by forming a sheet or mat containing a uniform mixture of fusible or heat retractable staple binding filaments prepared from synthetic linear superpolymers and non-fusible staple filaments or staple filaments which soften or retract at temperatures appreciably higher than that of the synthetic binding filaments, and then heating the preformed sheet or mat under pressure at a temperature sufficient to cause the softening or retraction of the binding filaments without appreciably softening or harming the other filaments. The non-fusible or non-retractable filaments may be cellulosic, wool, hair, glass, etc. In place of the non-fusible filaments it is possible to use filaments of considerably higher melting point than the fusible filaments which are made to soften or retract during the felting operation.

The above mentioned synthetic filaments forming the binding material are those prepared from the synthetic linear superpolymers which are obtainable from bifunctional reactants as described in Patents 2,071,250, 2,071,251 and 2,130,948. These polymers are capable of being formed by extrusion from melt into filaments which upon cold drawing show molecular orientation along the fiber axis.

Fig. 1 represents a flow sheet which indicates the steps used in making my felted product;

Fig. 2 is a sectional view of my new felt; and

Fig. 3 is a similar view showing a greater magnification of the fibrous structure.

In the embodiment shown in the drawing the felt comprises a compressed mixture of polyamide binder fibers 3 and cellulosic fibers 2.

The following examples, in which the parts are by weight, are illustrative of the practice of this invention:

Example I

Filaments were prepared from an amide-ester interpolymer consisting of 15% polyhexamethylene adipamide-85% polyethylene adipate and cut into staple of $1\frac{1}{4}$ to $1\frac{1}{2}$ inch length. After this staple filament was opened 18 parts

of it was mixed thoroughly with 82 parts of cotton fiber by tumbling. This mixture was then carded and matted in the fashion customarily employed in the felting industry. The mat of fibers was placed between two pieces of canvas and the entire assembly pressed for 90 seconds between the platens of an hydraulic press at a temperature of about 140° C. and at a pressure of about 1500 lbs. per sq. in. The felt produced by this method had good strength and was suitable for use in various applications as described later.

Example II

Filaments were spun from an interpolyamide derived from 40 parts of hexamethylenediammonium adipate and 60 parts of caprolactam. These filaments were cold drawn about 400% and then cut into staple fiber of about $1\frac{1}{2}$ inch length. This staple fiber was then mixed with cotton fiber in the same proportions and in the same manner as described in Example I. This mixture of fusible and non-fusible fibers was then carded and felted in the same manner as described above.

Another interpolyamide of this type which is especially useful in making the felted products of this invention is that obtainable from hexamethylenediamine, sebacic acid, and 6-amino-caproic acid.

Example III

A synthetic fiber spun from polyhexamethylene adipamide was cut into $\frac{1}{2}$ to $\frac{3}{4}$ inch lengths and dispersed in water in a paper beater with the roll at "heavy brush" for 15 minutes. Twenty-five parts of these beaten fibers (dry basis) were then mixed with 75 parts of kraft fiber and formed into sheets by standard paper-making practice. The sheets were preheated for one minute at 177° C. and then pressed for 30 seconds at a temperature of 177° C. and a pressure of 1700 lbs. per sq. in. The pressed sheets had a higher tearing strength than sheets containing kraft fibers only.

The presence of water in the polyamide fibers lower the temperature at which felting occurs. Water is particularly effective in this connection in the case of the interpolyamide of Example II.

Example IV

Similar results were obtained when sheets were prepared in the same manner as described in Example III with the exception that 75 parts of polyhexamethylene adipamide fibers were used with 25 parts of kraft wood pulp fibers.

Example V

A mixture of equal parts of polyhexamethylene adipamide fibers about $\frac{1}{2}$ to $\frac{3}{4}$ inch long with the crinkled kraft fibers obtained by the process

of Patent 1,857,100 was prepared and formed into sheets by the procedure described above in Example III. The resulting sheets also had a higher tearing strength than corresponding sheets containing only the crinkled kraft fibers.

Example VI

Filaments spun from an interpolymer obtained from equimolecular parts of hexamethylenediammonium adipate and decamethylenediammonium sebacate were cold drawn 450% and then cut into lengths of $\frac{1}{8}$ to $\frac{1}{4}$ inch. Twenty parts of these fibers were then beaten in 10 kg. of water with 40 parts of kraft wood pulp in a paper beater. When the fibers were dispersed sheets were prepared in the usual manner and dried at 90° C. After drying the sheets were subjected to a pressure of 6000 lbs. on an 8 inch square area for 1 minute at a temperature of 160° C. These pressed sheets were tough and pliable and had a tearing strength about three times that of sheets made from kraft fiber alone. This type of polyamide fiber softens over a fairly wide temperature range and is particularly desirable for use in this process because compression of the fibrous mass at the softening temperature is sufficient to cause adhesion between the various fibers without causing the polyamide to liquefy and fill the interstices. This imparts toughness to the sheet without lowering the pliability of the material.

Example VII

A mixed fabric containing 25% wool and 75% crimped polyhexamethylene adipamide fiber was subjected to heat and pressure to felt the fibers in this fabric. The fabric responded to this treatment in substantially the same manner as fabric made entirely of wool.

The heat retractable filaments may be made from synthetic linear polymers other than the polyamides and ester-amide interpolymers. Other examples are the polyesters derived from hydroxy acids such as omega-hydroxydecanoic acid, omega-hydroxycaproic acid, or from appropriate derivatives of these acids. Polyesters may also be obtained by reacting dibasic acids and glycols or suitable derivatives of these reactants. As acids may be mentioned carbonic, oxalic, succinic, glutaric, adipic, pimelic, sebacic, hexadecamethylenedicarboxylic, phthalic, etc., and as glycols may be mentioned ethylene glycol, propylene glycol, dimethylene glycol, hexamethylene glycol, decamethylene glycol, etc.

The preferred synthetic linear polymer filaments are, however, those which contain groups of formula $-\text{NHCO}-$ or its sulfur analog as an integral part of the polymer chain. These polymers include the polyamides, the ester-amide interpolymers, the polyurethanes, and their sulfur analogs. Important polyamides in the practice of this invention are those obtained by reacting one or more diamines with one or more dicarboxylic acids or amide-forming derivatives of dibasic acids. On hydrolysis with hydrochloric acid these polyamides yield a mixture comprising a diamine hydrochloride and a dibasic carboxylic acid. Examples of these polyamides are polytetramethylene sebacamide, polypentamethylene adipamide, polypentamethylene sebacamide, polyhexamethylene suberamide, polyhexamethylene sebacamide, polyoctamethylene sebacamide, polydecamethylene carbamide, polyparaxylylene sebacamide, polyhexamethylene phenylenediacetamide and the polyamide derived from 3,3'-diaminodipropyl ether and adipic acid. The inter-

polyamides, e. g. of the general types used in Examples II and VI are especially useful. Another type of polyamides are those obtainable from polymerizable amino acids, as for instance 6-aminocaproic acid, 9-aminononanoic acid, and from amide-forming derivatives of these acids, e. g. lactams. On hydrolysis with hydrochloric acid these polyamides yield an amino acid, as the hydrochloride. The ester-amide interpolymers are obtained by heating a mixture of polyamide-forming and polyester-forming compositions, e. g. a mixture of a dibasic acid, a glycol, and a diamine, or a mixture containing an hydroxy acid and an amino acid. The polyurethanes are obtained by reacting a glycol, diphenol, or a dithiol with a diisocyanate or with a diisothiocyanate. Suitable reactants of this kind include decamethylene glycol, resorcinol, or decamethylene dithiol, and decamethylene diisocyanate or hexamethylene diisothiocyanate.

The above mentioned synthetic filaments are preferably cold drawn, that is permanently elongated by tensile stress, in order to orient them since the oriented filaments have greater strength and elasticity. Furthermore, the oriented filaments in many cases, and particularly in the case of the interpolymers retract at temperatures considerably below their softening points and are therefore particularly suitable for making a soft-flexible felt. The unoriented or but slightly oriented filaments obtained by spinning under little or no stress, are, however, also useful in the present process.

The various synthetic polymer filaments used to form the felt may be either plasticized or unplasticized. If a softer or lower softening filament is desired it may be plasticized with an aryl sulfonamide such as a toluene sulfonamide or amylbenzene-sulfonamide. Other plasticizers which may be used are salicylic acid, amylphenol, camphor, dibutyl phthalate and tricresyl phosphate.

The cotton mentioned in Examples I and II may be replaced with various other non-fusible filaments, such as wood, kapok, glass fibers, hair, jute, etc. or even with the higher melting synthetic polymers, e. g. polytetramethylene adipamide or polyhexamethylene adipamide. The proportion of fusible or heat retractable filament used in the mentioned examples as binding agent in the felting composition may be varied from as low as 5 to 10% of the total composition up to 50 or even 75% of the total composition. The time, temperature and pressure used in processes indicated in these examples will vary depending upon the nature of the fusible or heat retractable filament, particularly its softening or retracting point, and on the nature of the other ingredients of the composition. For example, if a high melting filament is used as the binding agent in the felt a relatively higher temperature and pressure will be required than if a low melting filament is used. Likewise, if a soft felt is desired a lower pressure or temperature will be used than if a hard felt is desired. It is not necessary to heat the formed sheet to the melting point of the filament used as the binding agent in the composition. It was quite unexpected to find that heating to a temperature sufficient to cause retraction of the binding filament, a temperature considerably below its melting point, produced a felt of good quality. The felting action is facilitated if the heating is done in the presence of water, alcohol or other vapor or liquid which will have a soften-

ing effect on the fibers, particularly under pressure.

The felt obtained by this invention can be dyed by usual methods either by application of the dye to the felt or to the fibers separately before being mixed.

The physical properties of the felt such as, for example, its tackiness, feel, etc., may be altered to a considerable extent, if desired, by subjecting the felt to fluffing and steaming treatments.

When the non-fusible fibers are paper-making fibers, as in Examples III to VI, these fibers may be any of the wood pulp fibers such as kraft, sulfite, sulfate, etc., as well as any other cellulosic fiber of similar properties such as bagasse fibers. The proportions of the fusible filament may vary from as low as 5%-10% up to as high as 75 to 85% of the mixture. The conditions of time, temperature and pressure used in preparing the felted sheet will vary depending on the softening point of the particular filaments being used. A higher temperature and pressure for longer times will be required to obtain a satisfactory felt in which a filament having a high melting or retracting point is used in comparison with a filament having a low melting or retracting point.

The pressing treatment in the present process softens the fusible filaments so that they will adhere to the non-fusible, or higher fusing, filaments or shrink sufficiently to bind them into a good felt. The resulting felted sheet may be subjected to steaming or fulling to alter the physical appearance or properties of the sheets if desired.

In the preparation of felt from woven fabrics of wool or other animal fibers mixed with the fusible or heat retractable filaments, as described in Example VII, the proportions of the synthetic polymer filaments may vary over rather wide limits depending on the physical properties desired in the final product. For example, the fabric may be composed of as little as 5-10% or up to as much as 75 or 85% of the synthetic linear superpolymers. A mixture of two or more different superpolymers may be used in preparing this type of fabric.

The denier of the filaments which may be used in any of the different methods described herein will vary depending on the type and appearance of felt desired. For some purposes it is preferable to use binding filaments having a denier of 1 to 3. However, a good felt can be obtained by using filaments having a denier of about 70. If an extremely coarse felt is desired, even coarser filaments, for example those having a denier of 100 to 150, may be used with satisfactory results. The binding filaments, as in the case of the non-fusible filaments may be straight or crimped.

The felted products of this invention, depending upon the particular filaments and fibers used and upon the conditions of treatment, possess a wide range of properties which adapt the present product for the different purposes for which felt is now used. As examples of some of these uses may be mentioned the use of soft felt in wadding, slightly harder felt in coat linings and shoe linings, and still harder felt in upholstery, hats and millinery. The felt produced by this invention

may be used as filtering agents for gases or liquids and may also be used for insulation purposes, for example, in the insulation of aircraft. It may also be used as a base to which various coating compositions may be applied to form sheet materials of improved properties.

The present invention permits the substitution of cheaper vegetable fibers such as cotton or wood pulp for the expensive animal fibers such as wool or hair now used in the manufacture of felt which results in a considerable saving in the manufacture of felt for use in a large number of purposes. A valuable advantage of the present invention is also found in the fact that the felted products are more suitable for use in those applications where the felt is in contact with organic solvents such as, for example, its use as a filtering agent.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope thereof, it is to be understood that I do not limit myself to the specific embodiments thereof except as defined in the appended claims.

I claim:

1. A felted product comprising a sheet of compressed filaments composed of a mixture of fusible staple synthetic linear polymer binding filaments, and staple filaments which are substantially unaffected at the softening temperature of said polymer, said synthetic linear polymer filaments being heat retracted in situ within the fabric and holding together said last mentioned staple filaments, said synthetic linear polymer filaments being the interpolymerization product of different polymer-forming compositions one of which is composed of a mixture of a diamine and a dibasic carboxylic acid.

2. The felted product set forth in claim 1 in which one of said polymer-forming compositions is composed of a mixture of hexamethylenediamine and adipic acid.

3. The felted product set forth in claim 1 in which one of said polymer-forming compositions is composed of a mixture of decamethylenediamine and sebacic acid.

4. The felted product set forth in claim 1 in which one of said polymer-forming compositions is caprolactam and another of which is a mixture of hexamethylenediamine and adipic acid.

5. The felted product set forth in claim 1 in which said second mentioned staple filaments are cellulose fibers.

6. A process for preparing felted products which comprises preparing a sheet by matting a mixture of staple synthetic linear polymer filaments which exhibit molecular orientation along the fiber axis and which retract at a temperature substantially below their softening temperature, and staple filaments which are substantially non-fusible and non-retractable at the softening temperature of said polymer, and retracting said synthetic linear polymer filaments by heating said sheet under pressure at a temperature below the melting point of said polymer, said synthetic linear polymer being the interpolymerization product of different polymer-forming compositions one of which is composed of a mixture of diamine and dibasic carboxylic acid.

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