The present invention relates to the treatment of fabrics or textile material consisting wholly or partly of wool or other animal fiber in order to reduce their usual tendency to felt when washed or during wear with aqueous liquor and to control this anti-felting treatment so as to avoid undue chemical attack of the wool substance.

According to the present invention animal fibers, yarns or fabrics alone or in admixture with other fibers are caused to be impregnated with a resist and the impregnated material is then treated with an anti-felting reagent. Thus the material may be treated with a solution or dispersion of a resist or a potential resist, subjected to an insolubilising treatment, and then treated with an agent known to cause diminution in the felting properties of wool. A class of resist which we prefer is that which after application of a solution or dispersion of it to the wool may be caused to become water-insoluble, and this class may also be described as belonging to the class of high polymers generally known as synthetic resins.

By the term "potential resist" I mean a solution or dispersion of an inorganic or organic substance capable of being partially or wholly insolubilised which may be applied to the material containing wool and which may then be converted into the actual resist if necessary by some insolubilisation treatment which may include a heating step at a temperature above 100°C. Examples of such potential resists are molecular weight condensation products of one or more of the following: urea, thiourea, cyanamide, melamine, ammonium cyanate, dicyanamide, phenol, combined with formaldehyde, which are characterised by the low viscosity of their aqueous solutions in high concentrations. As examples of resists, in addition to the resists formed from the potential resists above mention may be made of dispersions of urea and formaldehyde resins unmodified or suitably modified, dispersions of esters of acrylic or methacrylic acid and other rubber-like compounds and indeed natural rubber latex have been employed with success. These lists are illustrative and not intended to be exhaustive. The resist need not be wholly organic, for it may be composed of an organic and an inorganic constituent, as for example the resins obtained by mixing together ammonium salts of salicylic acid and boric acids. Again the resist may be wholly inorganic, such as the inorganic synthetic resin known as phosphonitrilic chloride (PNCI)₂. The insolubilisation treatment need not necessarily be heat treatment, although it may include this step. An example of this kind is the treatment of material containing wool with a low molecular weight condensation product of urea and formaldehyde containing an acid or potential acid precipitant in which the production of a methylene urea is caused to take place in or on the textile material at ordinary temperature.

As examples of anti-felting reagents to which the textile material containing wool may be subjected, the following may be mentioned used independently or in sequence, or simultaneously where compatible: gaseous chlorine or bromine, solutions of hypochlorites or hypobromites, solutions of chlorine or bromine or alkyl hypochlorites in organic solvents, aqueous solutions of nitrogen-chloro derivatives, aqueous and non-aqueous solutions of caustic alkalis, sodium peroxide, strong organic bases, sodium sulphide, oxidising and reducing agents or enzymic preparations. By the use of non-aqueous solutions of these anti-felting agents, there is afforded a double protection to the wool, and it may be found necessary to increase the time of action in order to produce the desired effect.

In a preferred form of the invention, an internal potential resist is applied under such conditions that it penetrates within the fibers by impregnating the textile material containing wool with a low viscosity, low molecular weight initial condensation product of a synthetic resin, the material being then dried and subjected to a heat treatment to convert the potential resist into the insoluble actual resist. The theory of the process is not essential to the invention, but it is thought that the interior of the fiber is thus protected while the surface is still susceptible to attack by the known felting agent. The internal resist is thus believed to be much more effective than the external resist since the internal resist is deposited in the very parts of the fiber which it is desired to protect. It may be that the action of the potential resist or the actual resist (according to the preferred method in which the potential resist is rendered less soluble in the particular liquor to be subsequently used as anti-felting agent) is to prevent swelling and of diffusion of the reagents into the interior of the wool fiber and substance but the scope of the invention is not limited by this possible explanation of its mechanism. The term "internal resist" is used to describe impregnation within the fibers while the term "external resist" applies to less intimate impregnation which may be more superficial in character. The observed result is that the resist, be it internal or external, decreases or retards the destructive ac-
tion of the anti-felting reagent. The resist may be removed from the treated material as a final operation. This removal of the resist is not in all cases desired or necessary. When the resist is applied in the initial stages of manufacture of the wool, if its presence might interfere with the operations of dyeing subsequent to the anti-felting treatment, it may be removed after such treatment to avoid this difficulty. On the other hand, the resist may be applied to the dyed or printed product and allowed to remain as a means of improving the physical properties of the material.

In the preferred form of the invention the wool material or textile material containing wool is impregnated with aqueous solutions of a urea-formaldehyde low molecular weight low viscosity condensation product by suitable mechanical assistance such as by squeezing between the bowls of a mangle, or by centrifugal action, so as to ensure thorough penetration of the material by the solution and also to remove the surface liquid. The low viscosity low molecular weight solution containing synthetic resin components contains suitable catalysts, well-known in the art by means of which the final insolubilisation is effected. After insolubilisation of the resist in the known manner by drying and heating the material is treated with an anti-felting reagent which modifies the unprotected surface with the minimum of damage to the fibers of the material.

**Example 1**

The following example is given to illustrate the extraordinary protective action of urea formaldehyde resin towards chlorine when applied to wool: it is not suggested that this is the best example for the production of non-felting wool.

100 g. of urea is dissolved in 200 cc. of 40% neutralised formaldehyde. This neutral solution is allowed to condense for from 3–6 hours at ordinary temperature and is then diluted to 60% concentration and 2–3% ammonium dihydrogen phosphate added (estimated on the concentrated liquor).

A fabric consisting of a mixture of cotton and wool fibers is impregnated with this solution and squeezed between the bowls of a mangle. The fabric is then dried at least at 110° C. after which it is heated for 3 minutes at 150° C. The material was then immersed in an aqueous solution of bleaching powder 3° Tw. for 10 minutes, squeezed between the rubber bowls of the mangle and the resist removed by steeping in aqueous decinormal hydrochloric acid at 60° C. for 20 minutes followed by washing and drying.

The finished fabric showed resistance to felting and in a number of cases there was an appreciable improvement in the resistance to abrasion. It will be noted that the amount of chlorine is very much greater than that usually employed for the chlorination of wool and that the acidity is uncontrolled; nevertheless, the cloth is not damaged in these circumstances.

**Example 2**

The fabric consisting of a mixture of cotton and wool fibers was impregnated with a urea formaldehyde condensate as outlined in Example 1, and heated in the same manner. The increase in weight due to the formation of the resist was 12%.

The cloth was then wetted with a dilute solution of sulphated oleyl alcohol or Turkey red oil on a jig equipped with a box of large capacity. Hypochlorite solution was then added so that the amount of chlorine was 5% on the weight of the wool and the volume of liquor was 50 times that of the wool. On this basis 100 lbs. of a mixed fabric containing 50% wool and 50% cotton require 250 gallons of 0.5° Tw. calcium hypochlorite solution acidified with hydrochloric acid so that the liquor shows a hydrogen ion concentration corresponding to a pH 4.5. The cloth was then given four passages through the liquor, after which it was squeezed and the resist removed by working in decinormal hydrochloric acid at 60° C. for 60 minutes, followed by washing, drying and finishing in the usual manner.

Alternatively the resin treated cloth may be impregnated in 125 gallons of the sodium hypochlorite solution by two passages through the liquor after which a further 125 gallons may be added and two more passages given through the liquor. The remainder of the treatment is as outlined above.

Cloth treated in this manner showed an area shrinkage of 0% when washed in circumstances under which the untreated material showed an area shrinkage of 28%. The handle of the treated fabric was good and its resistance to abrasion was unimpaired.

**Example 3**

The following example illustrates the use of an alkaline anti-felting reagent for wool according to the present invention. 100 g. of urea is dissolved in 200 cc. of 40% formaldehyde solution (previously neutralised), 9 parts of concentrated ammonium hydroxide solution (density .88) is added to this mixture and the mixture refluxed for three minutes, after which this is rapidly cooled. It is then diluted (every 60 parts of concentrated solution is mixed with 40 parts of water) and to the diluted liquor 2 to 3% of ammonium di-hydrogen phosphate added (estimated on the concentrated solution).

A knitted wool fabric which had been previously lightly scoured and dried was impregnated with this mixture and centrifuged in a hydroextractor. The material was then dried and passed through a heating chamber so that the time of passage was three minutes and the temperature 130 to 150° C. This fabric contained in one experiment 12% of synthetic resin. It was wetted out in water, hydroextracted and immersed in caustic soda solution 98° Tw. for 20 minutes at ordinary temperature (20° C.). At the end of this time it was passed through a mangle having a light nip and thoroughly washed off in water, again mangled and dried. It showed good anti-shrink and anti-felting properties when washed with soap solution together with an untreated sample of the same knitted wool fabric.

It will be observed that after the treatment with the caustic soda solution the material is washed in water. It may be pointed out that this illustrates the protective action afforded to the wool by the presence of resin in it but if desired however the caustic soda may be removed by immersing the sample in diluted acids. Diluted caustic alkalis in aqueous solution may be used in place of concentrated solutions as anti-felting agents if the temperature be raised to 90° C. for example, and the passage of the wool through the liquor is made short in time, such as for a few seconds. By the method of Example 3, mixtures of cellulosic and wool materials may be treated. If it is desired to use caustic alkalis dis-
solved in non-aqueous solvents, it is advisable to extend the time of action.

Example 4

A solution was made by adding 40 parts by weight of ammonium salicylate and 20 parts by weight of ammonium borate (NH₄H₂B₄O₇) in 250 parts by weight of water. A knitted wool fabric (previously scoured lightly) was immersed in this solution and run through a mangle, dried at a temperature below 100°C, then heated for 5 minutes at a temperature of 110°C. It was then immersed in a solution of sodium hypochlorite (containing 5% available chlorine on the weight of wool treated) acidified with formic acid to a pH of 3 to 5 at ordinary temperature for 10 minutes. It was then washed in water and given an anti-chlor treatment (a diluted solution of sodium sulphite, well washed and dried). It showed considerable resistance to felting and did not exhibit a sticky handle when wet which was not shown by a controlled sample immersed in sodium hypochlorite and formic acid solution in a parallel experiment. The sample containing the ammonium salicylate and ammonium borate resin was coloured slightly yellowish brown so that this method would probably only be useful in treating wool which would subsequently be dyed in dark shades.

Example 5

A sample of lightly scoured knitted wool fabric was immersed in a 10% solution of monomethylol urea containing 3% of tartaric acid calculated on the total volume of solution. It was mangled and re-immersed in the liquor and mangled again. It was then hung for several hours until the formation of a methylol urea had taken place. The fabric was well washed and mangled and without drying immersed in a solution of sodium hypochlorite acidified with acetic acid to pH 3 to 5 (containing 5% of available chlorine on the weight of wool), for 20 minutes at the ordinary temperature, the ratio of liquor to cloth being 50:1. It was then washed and subjected to treatment of N/10 hydrochloric acid at 60°C. The sample was well washed and dried, when it showed good resistance to felting and shrinking after washing in soap solution.

Example 6

Woven wool cloth was impregnated with a urea formaldehyde condensation product as described in Example 1 and heated; the increase in weight was 12%. The resin treated wool was chlorinated in an aqueous bath containing 7% of chlorine on the weight of the wool, the ratio of liquor to cloth being 50:1. After 30 minutes treatment at room temperatures, the cloth was washed and then treated for 40 minutes in an aqueous solution of sodium bisulphite to remove any chlorine. The cloth was then rinsed, washed and dried.

A washing test on the untreated material gave an area shrinkage of 22% compared with 5% for the treated goods; other anti-chlor reagents may also be used.

Example 7

Woven wool cloth was treated with a casein formaldehyde condensation product so as to increase its weight by 5%; the cloth was then chlorinated in sodium hypochlorite solution containing 7% of chlorine estimated on the weight of the wool, and buffered with sodium dihydrogen phosphate. The ratio of liquor to cloth was 50:1 and the method as outlined in Example 6. Good non-felting results were obtained and the resistance to wear of the treated material was better than that of untreated wool but similarly chlorinated.

Example 8

Woven woolen cloth was impregnated in an aqueous dispersion of an emulsion polymer of ethyl acrylate so as to increase its weight by 5% after drying. The cloth was then chlorinated as described in previous examples, utilising approximately 2% more chlorine than would be required for untreated wool. The cloth was substantially non-felting and showed improved resistance to wear as compared with the unchlorinated untreated product.

If necessary the polymer may be removed by extraction with benzene or other appropriate solvent.

Example 9

The following example relates to the use of a "far-condensed" intermediate condensation product of urea formaldehyde as an "external resist."

150 gms. urea were mixed with 375 cc. of unneutralised formaldehyde (40%) solution and 15 gms. of hexamethylenetetramine; when solution had occurred the mixture was raised to the boil and refluxed until turbidity no longer appeared on cooling, which, in this case, amounted to 25 minutes refluxing. The mixture was rapidly cooled and stabilised by the addition of 0.7% of sodium acetate. The solution was completely miscible with water although its viscosity was considerably higher than that of the condensation product described in Example 1.

This solution contains 66% solid content and was diluted to contain 14%; the dilute solution was used to impregnate the sample of woven wool fabric which had previously been wetted in water; the impregnated material was then dried and heated for 5 minutes at 130°C.

The treated wool was then immersed in sodium hypochlorite solution at pH 3.5 containing 5% of chlorine estimated on the weight of the cloth, the ratio of liquor to cloth being 50:1. After 45 minutes at room temperature the material was washed, rinsed, washed and dried. The increase in weight due to the presence of urea formaldehyde resin was 3.4%. After the chlorination treatment the material no longer felted when washed and rubbed in soap solution.

The resistance to wear of the treated product was superior to that of the original material; chlorination of the original woolen cloth caused a decrease in wear resistance whereas material which had been treated with resin, chlorinated, and the resin removed with N/10 hydrochloric acid showed a resistance to abrasion broadly equal to that of the original untreated cloth.

I declare that what I claim is:

1. The process of treating textile material containing animal hair to reduce its liability to felt which comprises impregnating the material so as to contain from about 3.4 to about 12 per cent on the basis of the weight of the original dry textile material of a synthetical resinous substance as a resist, and then treating the impregnated material with a non-resinious chemical anti-felting reagent.

2. The process of treating material containing animal hair to reduce its liability to felt which comprises impregnating the material with a liquor containing a potential internal resist capable
of forming a synthetic resinous substance so that the material contains an amount of about 3.4 to about 12 per cent on the basis of the weight of the original dry textile material, essentially removing the impregnant liquor from the surface of the hairs, insolubilizing the resist, treating the impregnated material with a non-resinous chemical anti-felting reagent and then removing the resist.

3. The process of treating textile material containing animal hair to reduce its liability to felt, which comprises impregnating the material with an aqueous solution of synthetic resin-forming substance, essentially removing the solution from the surfaces of the hairs, insolubilizing the resinous material whereby to form a resist within the individual hairs, in an amount of about 3.4 to about 12 per cent on the basis of the weight of original dry textile material, and treating the impregnated animal hair with a non-resinous chemical anti-felting reagent whereby the anti-felting reagent is prevented from entering the bodies of the individual hairs by the action of the resist.

4. The process of treating textile material containing animal hair to reduce its liability to felt, which comprises impregnating the material with an aqueous solution of a water-soluble colloidal partial condensation product of urea and formaldehyde, essentially removing the impregnant solution from the surface of the material while leaving the same within the individual fibers in an amount of about 3.4 to about 12 per cent on the basis of the weight of the original dry textile material, drying and heating the impregnated material to condense and insolubilize the synthetic resin, and treating the impregnated animal hair with a non-resinous chemical anti-felting reagent.

5. The process of treating textile material containing animal hair to reduce its liability to felt, which comprises impregnating the material with an aqueous solution of a methyol urea and a condensation catalyst therefor, in an amount of about 3.4 to about 12 per cent on the basis of the weight of the original dry textile material, essentially removing the solution from the surface of the hairs, insolubilizing the impregnant whereby to form within individual hairs a resist of urea-formaldehyde resin, and treating the impregnated animal hairs with an aqueous solution of a non-resinous chemical anti-felting reagent wherewith the anti-felting reagent is prevented from entering the bodies of the individual hairs by the action of the resist.

6. The process of treating textile material containing animal hair to reduce its liability to felt, which comprises impregnating with an aqueous solution containing a water soluble colloidal partial condensation product of urea and formaldehyde, essentially removing the impregnant solution from the surface of the material while leaving the same within the individual fibers in an amount of about 3.4 to about 12 per cent on the basis of the weight of the original dry textile material, drying and heating the impregnated material to condense and insolubilize synthetic urea-formaldehyde resin, and treating the impregnated animal hair with a non-resinous chemical anti-felting reagent.

7. Process as in claim 1 in which the chemical anti-felting reagent is hypochlorite.

8. Process as in claim 1 in which the chemical anti-felting reagent is chlorine.

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