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COTTON FABRIC AND PROCESS

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The present invention relates to a novel cotton fabric and to the process of producing the same, and comprises a self-sustaining mass of cotton fibre in sheet or strip form, the individual fibres of which are bonded by reason of an artificially-induced mutual adhesion of the fibres. This product, the form, inherent stability and strength of which are due to the fact that the fibres are crushed together at points of crossing and thus provide an artificial, pressure-induced fibre-to-fibre adherence, is to be distinguished from cotton fabrics which depend for their strength and stability upon the customary weaving or knitting of pre-formed threads.

Physically, carded cotton comprises a disorganized mass of fibres, which lacks identity as a fabric distinct from the aggregation of fibres. While the carding operation has some tendency to arrange the fibres in a more or less parallel relationship, these fibres will be found to extend in practically all directions. We have herein employed the term "unorganized" to refer to this miscellaneous or heterogeneous tangled arrangement of the fibres as distinguished from the generally parallel arrangement in such cotton products as woven or knitted cloth.

Cotton fibres, lacking the horny projections found in wool and other fibres, normally have little or no tendency to adhere together. Whatever mutual attachment of the fibres exists in an unorganized, carded mass is entirely fortuitous and arises from the fact that the fibres are tangled to a certain extent. The carded mass is light and fluffy and not at all coherent. Individual fibres or groups of fibres will separate readily at any point.

We have discovered that cotton fibres may be made to adhere and stick to one another, and we have developed a method by which we are able to produce from a mass of unorganized cotton fibre a novel cotton product in the form of a self-sustaining strip of fibre. Our novel product may be extremely tenuous and yet possess sufficient strength to be self-sustaining and capable of being rolled, unrolled without peeling and used in industrial processes in automatic machines, whereas in an ordinary carded roll of similarly light weight, peeling will occur upon unrolling, the layers losing their identity and part of one layer sticking to another. Our product is admirably suited to a variety of uses, among which may be mentioned its use in combination with gauze in surgical and catamenial bandages.

Raw cotton fibre consists essentially of cellulose, with which are associated certain natural

waxes, oils, pectins, etc. We have found that our artificially-induced mutual adhesion of the fibres cannot be produced by applying pressure to such raw cotton. We therefore subject the raw fibre to treatment for the removal of the waxes, oils, pectins and like materials which in the cotton fibre occur naturally with cellulose, the major constituent. The removal of these undesirable constituents may conveniently be accomplished by treatment similar to the customary chemical boil.

The chemical boil is usually an extended treatment with a hot solution of caustic soda, ash, soap and often other ingredients. The further bleaching treatment is usually a prolonged immersion in a dilute solution of sodium hypochlorite. In textile finishing the requirements of chemical treatment are usually to obtain whiteness, absorbency and "hand"; a great deal of tolerance is permitted in the amount of impurities still remaining on the cotton after its chemical processing and, in fact, in many cases impurities such as starch, oil, wax, soap, etc. may be added.

Since our preparation of the cotton for our pressing treatment involves the attainment of a high standard of cleanliness (by which we mean freedom, as a practical and commercial matter, from waxes and oils), both the conduct of our chemical processing and the degree to which it is carried may differ widely from ordinary textile or absorbent cotton finishing. Various lubricants which have been used to assist in the carding of absorbent cotton we have found to be serious deterrents to proper pressability.

The bleaching process is a process of oxidation. Cellulose is itself, to a small extent, susceptible to oxidation. If the bleaching operation is carefully controlled it is possible to obtain a very satisfactory product from the point of view of whiteness and absorbency without getting more than a negligible amount of oxidation of the cellulose itself. The intention in conventional chemical processing of cotton and cotton goods is to obtain satisfactory whiteness and absorbency with a minimum of oxidation of the cellulose. We have found, however, that for our purposes the cellulose of the fibre may advantageously be subjected to oxidation or "degradation". We therefore find it advantageous to carry the bleaching somewhat beyond the point dictated by the requirements of whiteness and absorbency, so that the treatment may attack and degrade the cellulose itself. Since conditions of bleaching vary a great deal with concentration of the bleach, temperature of the bath, its pH, efficiency of the previous boil,

etc., we have found that various bleaching conditions will give various ratios of oxycellulose production to decolorization of the cotton. This chemical treatment of the cotton, if employed, must be carefully controlled in order that the cellulose molecule shall not be too far degraded. While on one hand the treatment may advantageously go beyond the point of bleaching and the cellulose itself be attacked, on the other hand the degradation must not be carried so far as to interfere with the carding or strength of the treated fibres.

While the reaction or reactions involved in this chemical degradation are not fully understood, we suggest the following explanation which is not, of course, to be taken in a limiting sense.

According to the most modern theories of cellulose chemistry, the pure or alpha cellulose molecule consists of a chain of glucose anhydride residues. These chains are grouped together in such a way that the secondary valences are largely satisfied and the result is a structure of low polarity. At the end of each chain or molecule is an aldehyde group which is highly polar, but, being infrequent on account of the great length of the molecule, contributes only a little of its polar character to the molecule.

Our present belief is that in our preferred process, the solution attacks the cellulose molecule in an oxidation reaction. We believe that this oxidation attacks the linkage between adjacent glucose anhydride molecules, whereupon such linkage breaks with the addition of oxygen, leaving new aldehyde ends. These aldehyde ends may be further oxidized to acidic groups. The number of breaks occurring increases with the degree of oxidation. At the same time the polarity of the material increases with the increase in the number of aldehyde (or acidic) end groups and the shortening of the chain of the cellulose molecule. The degree to which the chain of the cellulose molecule is shortened may be measured by observing the viscosity of the degraded cellulose in cuprammonium solution. The shorter the length of the chain, the lower the viscosity of such solution.

We therefore suggest that by oxidation the cellulose may be degraded slightly to produce a more highly polar material which is more amenable to subsequent pressure treatment to form a self-sustaining product. The oxycellulose which is believed to be produced in this treatment is not soluble in water and is entirely distinct from the gelatinous hydrated cellulose which has been used as a binding material.

We have found that a useful assistant to pressability of clean cotton is moistening or humidification. This is not an absolute essential to our process since we have found that cotton which is quite dry is pressable if properly prepared, but the ease of pressing is increased considerably if the cotton is humidified either by suitable humidification of the surrounding air or by treating directly with a water spray.

The cotton fibre, which may advantageously be first subjected to the chemical treatment above described, is carded in the customary manner. Garnetting is of course the equivalent of carding at this point although producing a somewhat inferior product. This preparation of the cotton in relatively thin layer form for our pressure treatment may be accomplished on ordinary cotton machinery including cards in the preferred form, garnets and also even by condensing devices of the general type employed in pickers,

the cotton in any such case being so-to-speak dry-assembled and the required strength for subsequent handling being obtained by pressing as hereinafter described.

As an example of the practice of our process, to produce our novel product in a strip two inches wide, we give the following:

We separate the fluffy mass as it comes from the carding operation into strips approximately ten inches in width. These strips are passed through a trumpet by means of which they are narrowed to the desired two-inch width. The mass of fibre may be treated as by a water spray or by suitable humidification of the surrounding air to make it somewhat moist. We have obtained excellent results with a moisture content of 6 to 8% by weight. Moisture contents up to 25% may be used. The felted mass of fibres, preferably but not necessarily having received this moisture treatment, is subjected to pressure by passing it between steel pressing rolls four inches in diameter and two inches wide.

We find that if too little pressure is applied to the mass the fibres will separate upon release of the pressure and the product will not be self-sustaining. If, on the other hand, the pressure is too heavy, the resulting product will present a glazed appearance, too smooth for many purposes. Since the proper pressure in any particular case will vary with operating conditions with the product desired, it is best defined as a pressure which is sufficiently heavy to produce a self-sustaining strip, yet not so great as to result in an undesirably smooth surface. For example, when operating on a cotton mass or strip two inches wide, 280 yards of which weigh one pound, we have obtained a soft and fluffy but self-sustaining product by applying to each end of a four inch diameter steel roll in contact with a similar roll, a force of between 50 and 100 pounds. Under these conditions, when the cotton has a moisture content in the neighborhood of 5 to 5½% by weight, we have obtained excellent results by applying a force of 85 to 90 pounds to each end of the roll. When operating on the same cotton mass, but with a moisture content of approximately 7%, good results are obtained with a somewhat smaller force,—for example, in the nature of 70 to 75 pounds on each end of the roll. Forces of less than 45 to 50 pounds on each end of the roll are generally not effective in producing the desired fibre-to-fibre bond. It will be noted that in these examples the force given is applied to each end or journal of the roll so that the total resulting force along the nip of the roll will be twice the force given, plus the weight of the roll.

The pressures existing in this example are not known, but we believe them to be high, in excess of 1000 pounds per square inch. This is understandable in view of the fact that hard steel rolls are used of only 4 inch diameter on a web of cotton only 2 inches wide and only about .0035 inch thick. The forces in our example would not be sufficient for softer rolls, larger rolls or a thicker or wider web.

Much higher pressures may be employed, depending on the product desired, the above examples representing pressures suitable for the production of an article of maximum softness but self-sustaining and capable of being unrolled from a compact roll without peeling. Under these conditions a typical product exhibits scattered areas or clusters of "welded" or merged fibre-to-fibre bonds. The carded cotton as it comes to

the nip of the rolls generally contains scattered nibs or "pills", and when the carded web passing between the rolls is sufficiently thin it is believed that at the nip of the roll these scattered nibs have the effect of localizing the pressure to form the above mentioned scattered clusters of fibre-to-fibre bonds, these clusters extending through the cotton web from top to bottom. The formation of a self-sustaining strip is not, however, dependent on the presence of these nibs. In fact, when a sufficiently thick web is used, this phenomenon appears to a less extent, if at all.

Our product may vary from a relatively soft, fluffy material to a comparatively stiff, thin, glazed product of considerable tensile strength. By using high pressures, a strip two inches wide and weighing 0.8 gram per lineal foot is obtainable, a length of which has supported a weight of more than 1500 grams. Such a product is stronger, stiffer and less cotton-like than will usually be desired, but it illustrates in an exaggerated way the results of our method.

Assuming the tensile strength to increase with increase in weight per unit length, it may be calculated as 2800 times the weight of the strip per centimeter of length.

While we are able to obtain a product of varying thickness, strength and appearance, a typical two-inch strip which finds a wide use will run 280 yards to the pound and will support a weight of about 100 grams. For some purposes we find it desirable to form a considerably thicker, heavier and more compact web.

In the appended claims, by the expression free from natural waxes and oils we mean fibres which as a practical and commercial matter are free from natural waxes and oils even though not strictly and chemically entirely free therefrom, and we have employed the word "normal" to describe the cotton fibre which has received our treatment for the purpose of distinguishing it from fibre which has been gelatinized or mercerized, which latter fibre is harsh and swollen, individual fibres being kinked or curled and the lumens reduced in size.

We claim:

1. As a new article of manufacture, a mass of unorganized, tangled, dry-assembled cotton fibres substantially free from natural waxes and oils but otherwise physically substantially normal, constituent fibres of which are crushed together at points of crossing to produce fibre-to-fibre bonds which unite the mass into a self-sustaining strip.

2. As a new article of manufacture, a mass of unorganized, tangled, dry-assembled cotton fibres substantially free from natural waxes and oils but otherwise physically substantially normal, constituent fibres of which are crushed together at points of crossing to produce fibre-to-fibre bonds which unite the mass into a self-sustaining strip capable of being rolled and unrolled without substantial adherence of one layer to another.

3. As a new article of manufacture, a dry-assembled mass of cotton fibres substantially free from natural waxes and oils but otherwise physically substantially normal, constituent fibres being crushed together at points of cross-

ing to produce a multiplicity of fibre-to-fibre bonds which unite the mass into a self-sustaining strip.

4. As a new article of manufacture, a strip of tangled, dry-assembled cotton fibre substantially free from natural waxes and oils but otherwise physically substantially normal, constituent fibres of said strip being crushed together at points of crossing, said strip being self-sustaining and a length thereof having a tensile strength, measured in grams, of at least 2800 times its weight in grams per centimeter of length.

5. As a new article of manufacture, a strip of tangled, carded cotton fibre substantially free from natural waxes and oils but otherwise physically substantially normal and presenting a multiplicity of crushed fibre-to-fibre bonds, said strip being self-sustaining and a length thereof being capable of supporting a weight of at least 100 grams.

6. As a new article of manufacture, a soft and fluffy, self-sustaining strip of unorganized, dry-assembled cotton fibre substantially free from natural waxes and oils but otherwise physically substantially normal, constituent fibres of said strip being crushed together at points of crossing and presenting fibre-to-fibre bonds, said strip being in roll form and said roll being capable of unwinding without breaking of the strip and without substantial adherence of one layer to another.

7. As a new article of manufacture, a self-sustaining strip of unorganized, compacted, partially degraded, dry-assembled cotton fibre substantially free from natural waxes and oils but otherwise physically substantially normal, the form, inherent stability and strength of said strip being derived from a multiplicity of fibre-to-fibre bonds where fibres are crushed together at points of crossing.

8. As a new article of manufacture, a self-sustaining strip of unorganized, dry-assembled cotton fibre substantially free from natural waxes and oils but otherwise physically substantially normal, said strip presenting scattered adhering areas where fibres are crushed together at points of crossing to form clusters of fibre-to-fibre bonds.

9. The treatment of cotton fibre which comprises treating the same to remove natural waxes and oils, dry-assembling a web of such fibre, passing the web between rotating pressure rolls and applying to the web a pressure such that the fibres are bonded together and a self-sustaining, continuous strip of cotton fibre is formed.

10. The treatment of cotton fibre to produce therefrom a self-sustaining strip of tangled cotton fibres, which comprises as steps treating the fibre to remove natural waxes and oils and partially degrading the cotton by treatment thereof with an oxidizing agent, said degradation being discontinued short of the point at which it interferes with subsequent treatment of the cotton, then dry-assembling the fibres into a web and compacting the resulting cotton mass by pressure to crush constituent fibres thereof together, thereby producing fibre-to-fibre bonds which unite the cotton mass into a self-sustaining strip.

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