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FIBROUS ABSORBENT BODY AND METHOD OF MAKING SAME

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This invention relates to fibrous bodies of various forms, such as pads, sheet materials, and others. The invention will be herein disclosed in connection with the manufacture of surgical sponges, dressings, bandages, and the like, in all of which absorbency is a highly important property, but the invention is equally useful as applied to other fibrous bodies in which this characteristic is not important.

In the manufacture of the various surgical absorbent materials above mentioned, gauze is extensively used. For example, in making surgical sponges, as much as a square yard of gauze often is folded to make a single sponge. The chief reason for using gauze is to avoid the presence of loose fibers and to obviate the liability of these fine particles getting into the incision or the wound and remaining there. While it has been proposed to combine gauze with loose cotton or other loose absorbent fibers and thus to reduce the proportion of the gauze used in a sponge or dressing, and such a product has been used to a limited extent, it is necessary in such cases to completely enclose the cotton and to adopt measures to prevent the presence of fibers so short that they cannot be controlled by the gauze. The more common practice still is to use gauze exclusively for surgical purposes.

It is evident, however, that cotton or other absorbent fibers, when once spun, are not in a form suitable for producing maximum absorbency. In other words, the ability of fibrous bodies to absorb liquids is chiefly a surface phenomenon, the liquid being held between the fibers largely by capillarity. The spinning of the fibers into threads and the subsequent weaving of these threads into a fabric therefore greatly reduces the water-holding or absorbing capacity of a given amount of fiber. Or, to state the matter differently, the same weight of identical fiber in a loose, free, and fluffy condition could hold a much greater quantity of water.

The present invention aims to device a fibrous structure in which the necessity for spinning, weaving, and other fabricating processes will be eliminated. As applied to surgical materials, it aims to utilize the greater absorbency of the fiber in a loose and unwoven or unorganized condition and thus to produce surgical sponges, dressings, and the like, in which the benefit of this more efficient utilization of the fiber will be obtained, while at the same time making such a body equally as safe as the gauze sponges and dressings heretofore used.

To these ends one phase or aspect of the present invention involves the steps of producing a fibrous body of approximately the desired shape and size and subjecting all or a portion of the surface of said body, as desired, to a treatment which will bind the surface fibers together and thereby produce a superficial web-like structure having substantially the same porosity and permeability to the passage of air and water as did the untreated surface but which will confine the underlying fibers and keep them under control. Whether such a surface treatment completely encloses the fibrous body, or covers only a portion of it, depends entirely upon the use for which the fibrous body is intended. A typical procedure consists in making a fibrous bat, as for example by the methods heretofore used in making cotton batting, dividing such a bat into pads, sponges, or dressings of the desired size and shape, and then surface treating them.

This treatment or unification of the surface can be successfully accomplished in several ways. For instance, the body of cotton, or other equivalent fibrous material, may be sprayed, or superficially wetted in any convenient manner, with a liquid binder such as nitro-cellulose, cellulose acetate, or some of the other cellulose derivatives dispersed in a suitable solvent, or with rubber latex, either vulcanized or unvulcanized. If such a spray is made rather fine and mist-like, and the fibrous mass has a density suitable for use as a surgical sponge, no substantial penetration of the spray into the body of the fiber will be produced, but the particles of binder will be caught and held by the surface fibers. Upon the evaporation of the solvent, or the other dispersing liquid, it will be found that the surface fibers are bonded together, forming a strong foraminous surface structure which effectually prevents the interior fibers from sifting through when the body is either wet or dry. At the same time the absorbency of the entire mass is not materially affected.

While a wide variety of binders can be used in this process, it is desirable in making products designed for surgical use, to employ a binder that is not dissolved, softened, or adversely affected by the presence of water or blood, it being understood that the terms "dissolved", "soluble", and the like, are herein used in their common meanings, instead of in accordance with their strictly scientific definitions. In some cases, also, binders which would be substantially affected by alcohol, ether, or chloroform should be avoided. Bakelite binders are satisfactory for this purpose. Some of the cellulose derivatives, such as cellulose

acetate, answer these requirements as to water or blood, as do also resins of the urea-formaldehyde type, "glyptols" (glycerol-phthalic anhydride), and the condensation products of formaldehyde with aromatic sulfonamides. The last mentioned materials are known in the trade as "Santolites."

As above indicated, an important requirement for the conditions here dealt with is that the binder shall not be continuous but that the gauze-like surface structure produced by the treatment shall be of an open mesh, foraminous and highly porous character. This result is readily obtainable by properly controlling the viscosity or surface tension of the dispersion sprayed upon the fibers. If the binder is used in forms having a high surface tension, the spraying operation may be so performed that the binder will strike the fibrous body in the form of tiny droplets or globules that will not spread easily even on a highly absorbent material, thus depositing the binder in a discontinuous form. Such binders as vulcanized latex and cellulose acetate and others lend themselves readily to control in this manner. When these droplets of liquid binder having a high surface tension strike the fibers, they tend strongly to hold their globular form. If such a droplet happens to contact two or more fibers converging to a common point of intersection, it will try to shift to that point because of the tendency just mentioned. This is a well known phenomena of high surface tension liquids. Such points of convergence and intersection are present at closely spaced intervals throughout the entire body of fiber. Consequently, this phenomena is useful in the present process because it tends to position the discrete particles of binder at the intersections of the fibers where their binding action is most effective.

A further factor demanding attention in the selection of a binder is the wettability of the treated surface with water, blood, or other aqueous fluids. In other words, it is important not only to have a foraminous surface structure or layer, but also to make the unified surface layer easily wettable. The untreated fiber used in these products naturally has a high degree of wettability. If the treatment tends to destroy this property, such a result can be avoided in two ways, first, by including in the binder or unifying material a water soluble plasticizer or wetting agent that will suitably change the properties of this material. Such agents as triacetin, or dimethyl and diethyl phthalates may be used for this purpose with such binders as cellulose acetate or cellulose nitrate. If a binder of the phthalic-glycerol type is used, then suitable plasticizing and wettability agents as succinic, malic or tartaric acids may be employed. Another method is to apply to the unified surface, after the treatment above described has been completed, a molecular layer of a wetting agent such as one of the sulphonated oils, or very small quantities of such substances as "nekal" or "neomurpin." Also, the glycols and fatty alcohols may be used for these purposes, either in combination with the binder as initially applied, or as subsequent surface treating agents.

In making relatively thick fibrous bodies of this nature, the surface treatment alone may not give the desired stability to the structure. Accordingly, another phase of this invention involves the bonding or unification of a fibrous body substantially throughout its mass, while still preserving its porosity, and without substantially altering the nature of its fibrous structure except to bond the fibers together where they come in contact with each other at points so spaced and distributed throughout the mass as to give the entire structure the desired degree of stability. Such a process thus produces a unification of the entire mass. For some purposes it is desirable to use both treatments jointly, or, in other words, to unify the entire mass of the fibrous body in addition to unifying part or all of its surface, as above described.

The unification of the mass involves the serious problem of distributing a unifying material or binder in a finely divided and discontinuous form substantially throughout the fibrous body, and this problem of distribution has proved to be difficult to solve in a practical and satisfactory manner. I have found, however, that this difficulty can be overcome by working the cotton or other fiber into the form of a thin fleece as, for example, by carding it in a commercial cotton carding machine, and while the material is in this condition, dusting the binder in a dry and finely powdered form through the fibers. If the material consists of a shredded wood pulp fiber, or the like, the same result can be produced where the web issues from the shredding machine. Such a web with the particles of binder entangled in the fibers, can then be subjected to heat, if the binder is of a thermo-plastic nature, or, to the action of a solvent in the form of either a liquid, gas or vapor, in the event that the binder is of the solvent sensitive type. Such a binder may consist of a phenol formaldehyde condensation product which is only partly converted. After its application to the fleece or web, it may be subjected to a sufficiently high temperature to complete the conversion. During this process it first becomes plastic and thereupon adheres to the fibers with which it is in contact, but without spreading substantially over the surfaces of the fibers in any manner tending to impair substantially the absorbent properties or wettability of the fibers. If the fibers are in the form of a very thin fleece, the binder could even be applied in minute liquid droplets or globules produced by spraying in the manner previously described.

After the fibrous web has been treated by any of the methods just described, or at any convenient point in the process, as directly after the binder has been sifted into the fleece, it may be folded, plied, or manipulated in any convenient manner to build up a fibrous structure of suitable thickness and these plies may be united to each other either by the application of additional binder, or by a treatment with heat or solvents to render plastic the binder already incorporated in the structure. A surface unifying treatment, such as that previously described, may also be given in the event that such a treatment is desirable.

A highly effective method of distributing the binder uniformly throughout the fibrous body to be unified, is to apply the binder in a vaporous or gaseous form. This may conveniently be done with a considerable variety of binders such as vinyl alcohol, linseed oil, and others. Usually it is preferable to flow the vapor into and through the fibrous body and to condense it in said body. This can be done while the body of fibers is travelling through a chamber into which the vapors of the binder are conducted. By this process the control of the binder is facilitated, and its positional relationship to the other ele-

ments of the body can be maintained substantially undisturbed while it is carried on through the polymerizing or other curing treatment to which it is to be subjected.

A considerable variety of thermoplastic binders are available which are suitable for use in the process hereinbefore described, including cellulose acetate, cellulose nitrate, phenol-formaldehyde, urea-formaldehyde, glyptol, and others. Also, the plasticity of these products can be varied by incorporating in their composition suitable plasticizers well known to those skilled in this art. Where it is desirable to modify the water wettability of such binding materials, this result may be produced by the addition, either to the binder itself or to the finished product, of any of the wetting agents above mentioned, or such others as triethanolamine, sulphonated fatty alcohols, and others.

It will be noted that this invention produces a fibrous structure from a body of unorganized, heterogeneously disposed fibers intermingled with each other loosely and without spinning, weaving, or other fabricating processes. Consequently, substantially the maximum efficiency of the fiber as an absorbing medium is utilized. In addition, the manufacturing steps involved in making this product are relatively inexpensive.

Furthermore, the surface unification, when used affords a control or restraint of the free fibers below the unified surface which makes such a product fully as safe to use on wounds, incisions, and the like, as are the gauze sponges commonly used heretofore.

The broad claims on the subject matter here disclosed are presented in this application, but those claims on products including the net-like surface structure described in the specification and the methods of producing articles including such a net-like structure, are presented in a divisional application Ser. No. 340,490, filed June 17, 1940.

Having thus described my invention, what I desire to claim as new is:

1. The herein described process, comprising the steps of uniting the fibers of an absorbent body of fibers by applying thereto a liquid binder which does not readily wet the fibers, whereby the binder will remain in droplets on the fibers without covering their surfaces sufficiently to substantially impair the water absorbing properties of said body of fibers.

2. An article of the character described, comprising a body of intermingled, unorganized fibers bonded together in a highly permeable structure by means of a water insoluble adhesive joining said fibers at points where they intersect each other, and a wetting agent carried by said adhesive and serving to render said adhesive water wettable, whereby the water absorbency of said fibrous body is substantially unimpaired by the presence of said water insoluble adhesive.

3. An article of the character described, comprising a water absorbent body of intermingled cotton cellulose fibers, said fibers being adhesively connected, at points where they intersect each other, with discrete particles of a waterproof binder of a cellulosic nature.

4. The process of making a water absorbent mass of loosely intermingled cotton cellulose fibers which comprises treating a body of such fibers with an adhesive by spraying it on said body, said adhesive having sufficient viscosity so that it will remain on the fibers in the form of globules without wetting the absorbent fiber, and subsequently hardening said adhesive.

5. That improvement in methods of making fibrous structures which consists in distributing a polymerizable binder in small discrete particles throughout a water absorbent fibrous body in which the fibers are loosely intermingled, causing the particles of the binder to adhere to the fibers, polymerizing said particles, and so limiting the quantity of said binder that the voids in said body will not be appreciably reduced.

6. An article of the character described, comprising a body of dry assembled, absorbent textile fibers intermingled in a promiscuous manner, said fibers being united into a porous self-sustaining structure by discrete particles of a cellulosic bonding agent, the size of said particles of bonding agent being so small that each particle bonds together only a few fibers.

7. An article of the character described, comprising a body of dry assembled, intermingled, unorganized, absorbent fibers united by small discrete particles of a water-proof bonding agent, said bonding agent containing a sufficient proportion of a wettable plasticizer to substantially enhance the wettability of the bonding agent.

8. That improvement in methods of making fibrous structures, which consists in working a mass of unspun textile fibers into the form of a thin web, and spraying a binder upon said web in such manner that the binder will be distributed in spaced discrete particles susbtantially throughout the web.

9. An article of the character described, comprising a body of intermingled, unorganized, cellulose textile fibers united to each other by water insoluble cellulosic bonds to produce an absorbent structure, said bonds being chiefly confined to the intersections of said fibers with each other and the intervening portions of said fibers being substantially free from adhesive union with each other so that the product has a high degree of porosity.

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