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THERAPEUTIC SPONGE AND METHOD OF MAKING

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This invention relates to a liquid-permeable, water-insoluble, gelatin sponge having the general physical characteristics of a sponge but being absorbable by animal bodies.

In various aspects of the practice of medicine and surgery it is desirable to insert into various portions of the body a porous substance. This may carry a therapeutic agent and hold such therapeutic agent in contact with certain tissues or organs. This porous substance should be reasonably soft when wet, have many fine interstices in order to hold a quantity of the therapeutic agent and to discharge it slowly, and/or act as an efficient absorbative agent for free flowing fluids in a wound area such as blood and exudates. It is preferably assimilable by the body in order that the incision into which it is placed need not be kept open. It is also desirable to have such a porous and assimilable substance for use as a surgical sponge in order that absorbative packs may be left, if desired, in situ when closing an operative area, or to remove the danger present when a nonabsorbable sponge is inadvertently left in an incision. It is necessary that this substance be insoluble in water in order that it may be freely soaked in aqueous therapeutic solutions or will absorb blood and other body exudates without being affected thereby and without undue dissolution. It is further desirable that such sponge have physical properties that permit it to be readily cut into pieces which conform in size and shape to the contour of the area being treated.

Accordingly, the principal object of this invention is to provide a sponge-like substance which has large numbers of small interstices that may be cut into convenient swabs or packs and is substantially insoluble in water, but which will be readily absorbable by the human body.

It is a further object of this invention to provide a sponge-like substance of the type mentioned which can be manufactured in an economical manner.

It is a further object of this invention to provide a sponge-like substance of the type mentioned which can be manufactured in an economical manner and which will be sterile upon arriving at the end of its manufacturing process and will not require additional processing to insure a sterile condition.

Among the various problems arising in the field of medicine and surgery, there is particularly the case of minimizing the presence of blood around a surgical incision. The flow of blood is commonly stopped, or slowed by the application

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of a coagulating agent, such as thrombin. However, when the coagulating agent is merely poured into the incision, it impedes surgical operations nearly as much as the blood itself, or, if clotting is produced, the resulting clot quickly washes away. To prevent this, it is commonly applied by soaking small sponges in the coagulating agent and placing them strategically within the incision.

This is effective but it presents the problem that, upon closing the wound, these nonabsorbable sponges must be removed, which usually results in reinstating hemorrhage. There is also the constant danger of inadvertently leaving a sponge within the incision.

It is desired, therefore, to eliminate these hazards by providing a sponge which will be equally effective in the use as described and which will cause no inconvenience or danger if it is not removed from the incision. Also, it is frequently undesirable to remove a sponge because of the danger of starting hemorrhage. Sometimes these new sponges will be deliberately left within an incision in order to keep a constant supply of therapeutic agent at a selected point therein, as well as to preclude hemorrhage due to removal. It might also be desirable to have such a sponge whose rate of absorption into the body will be controllable so that the surgeon can select one which will remain in place the length of time which he desires. The process herein-after disclosed by which my sponges are made can be easily controlled to vary the absorbability of the sponges as desired within considerable limits but without otherwise substantially changing their properties.

In practicing my invention I first prepare an aqueous solution containing 3-10% by weight of gelatin, preferably a skin gelatin, although other types, such as bone gelatin, may be employed, and these need not be highly purified. This is prepared at a relatively warm temperature, such as 80° centigrade, allowed to cool to 35°-40° centigrade. Then I add a small amount of formalin (40% aqueous solution of formaldehyde), between 10.0 and 0.01 per cent based on the gelatin in solution, and incubate the resulting solution at slightly above room temperature (30°-37° centigrade) for approximately two hours. The material is then beaten vigorously for about 5-15 minutes to produce a firm foam of from 4 to 8 times the volume of the original solution. This is placed on a monel wire screen in a drying oven and large quantities of air at about 30 to 33° centigrade and 10% humidity are circulated

through it. This is continued until the foam is dry. When thoroughly dry, the foam is heated to a temperature of approximately 140° centigrade, and allowed to remain there for about three hours. The foam is now dry and firm and may be cut with a knife into convenient sizes and shapes.

As a specific example of the practice of my invention, for illustrative purposes only, I have dissolved 5 grams of gelatin in 100 grams of water at 80° centigrade, and cooled the resulting solution to 35° centigrade. Then I added 0.03 cubic centimeter of 40 per cent formalin and incubated the resulting mixture at 37° centigrade for about 2 hours. The solution was beaten vigorously for about 5 minutes, at which time it had formed a firm foam with a volume of about 600 cubic centimeters. The foam was then placed on screens in a drying oven at 33° centigrade and large quantities of substantially dry air (10% relative humidity) circulated through said oven at the same temperature. This was continued until the foam was thoroughly dry, whereupon it was heated to 140°-145° centigrade and kept at such temperature for three hours. This, for the quantities above mentioned, produced about 500 cubic centimeters of a dry, sterile, liquid-permeable, water insoluble gelatin sponge which was firm when dry but softened without dissolving when saturated with water. The dry material was sufficiently firm to be cut easily by a small knife into whatever shapes and sizes were desired. The final heat treatment may be interrupted for packaging purposes, if desired, without disadvantage.

In practicing my invention, certain variations will be found at times convenient. In dissolving the gelatin, any temperature of water will be usable provided only it is somewhat below the boiling point and hot enough to dissolve the gelatin with reasonable rapidity. The gelatin may be swelled with cold water before dissolving, if desired. The temperature to which it is cooled should be in the general region of 35 to 40° centigrade. The amount of formalin added will control the hardness of the sponge and its rate of absorption into the body. The more formalin the harder will be the sponge and the more slowly it will absorb. Also, the higher the temperature employed up to a scorching range, or the longer the heating period employed in the final step of processing the sponge, correspondingly influence the physical properties of the sponge and its rate of physiologic absorption. Optimal ranges for these influencing factors appear to be 0.03 to 0.3 cubic centimeter of formalin per 5 grams of gelatin and 100 grams of water, and heating of the dry sponge at 130 to 150° centigrade for from 2 to 5 hours. In beating the mixture, any time is to be used which is required to secure the foam but this will ordinarily be somewhat less than 15 minutes. In drying the foam, any temperature which will not melt the foam at the particular humidity of the air employed will be acceptable, but I have found that temperatures above 35° centigrade tend to melt the foam and lower temperatures require too much time for drying without providing any noticeable advantage. The relative humidity of the air should not exceed about 15 per cent. The step of heating the dried foam to 140°-145° centigrade increases the water insolubility and this temperature appears to be quite critical. An appreciably higher temperature will scorch the sponge and a temperature much below 130° centigrade will not yield a prod-

uct with satisfactory physical properties. The use of formaldehyde or other hardening agent may be dispensed with and the foam hardened and insolubilized by the heating step alone. This step also makes the sponge sterile.

It is not known exactly how the sponge prepared by the above described method is absorbed by the body, but it is an observed fact that it is so absorbed in from ten to ninety days, depending upon the above-suggested variations in manner of making the sponge, and no trace remains. The sponge is digested in vitro by enzymatic action, as by pepsin trypsin, and other proteolytic enzymes.

Having fully described my invention, I claim:

1. In the preparation of a gelatin sponge, the process: Preparing a 5 per cent by weight aqueous solution of gelatin at a temperature above room temperature but substantially below boiling, cooling same to approximately 35° centigrade, adding an amount of formalin between 0.01 and 10.0 cubic centimeters thereof per 100 cubic centimeters of gelatin in solution, incubating the same at approximately 37° centigrade for about 2 hours, whipping the same until a foam is formed, drying the foam at 33° centigrade and 10 per cent humidity, heating the dry foam for approximately three hours at a temperature of approximately 140° centigrade.

2. In the preparation of a gelatin foam, the process: preparing an aqueous solution of gelatin and bringing same to room temperature, adding formaldehyde thereto in an amount between 0.03 and 0.1 grams of 40% aqueous solution thereof per 5 grams of gelatin, whipping same until foam is formed, passing dry air at a temperature below about 35° centigrade through the foam to remove substantially all water therefrom, and heating the dry foam for approximately three hours at a temperature between 130° and 140° centigrade.

3. In the preparation of a gelatin foam, the process: mixing a limited amount of formaldehyde into an aqueous gelatin solution, beating said mixture until a foam is formed, removing substantially all of the water from said foam at a temperature below about 35° centigrade, and heating said dry foam for a substantial period of time at a temperature of at least about 130° and not substantially exceeding about 145° centigrade.

4. In the preparation of a gelatin foam, the steps which include: forming an aqueous gelatin solution, beating said solution until a foam is formed, removing at a temperature below about 35° centigrade substantially all of the water from said foam, and heating said dry foam for a substantial period of time at a temperature above about 130° centigrade but not sufficiently elevated to cause scorching of the foam.

5. In the preparation of a gelatin sponge, the process which includes: preparing a 5 per cent by weight aqueous solution of gelatin at a temperature above room temperature but substantially below boiling, cooling same to approximately 35° centigrade, adding an amount of formalin between 0.01 and 1.0 cubic centimeter thereof per 100 cubic centimeters of gelatin solution, incubating the same at approximately 37° centigrade for about two hours, whipping the same until a foam is formed, drying the foam at a temperature below about 35° centigrade at about 10 per cent humidity, and heating the dry foam for approximately three hours at a temperature between about 130° and about 145° centigrade.

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6. A water-permeable surgical sponge having a matrix consisting essentially of gelatin sponge hardened to the point of water insolubility and characterized by substantially complete biological absorbability in a living animal body in between about ten and about ninety days.

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