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METHOD FOR MAKING BANDAGE MATERIAL FOR ORTHOPEDIC CASTS AND PRODUCT THEREOF

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This invention relates to cast-forming elements designed to be used for immobilizing or supporting parts of the body.

In conventional practice cast-forming elements composed of plaster of Paris or other settable material supported on suitable backing material are utilized in making casts that fit closely to the part of the body requiring immobilizing or support. The backing material is most usually in strip form wound into a roll or suitably pre-cut to the desired shape as, for instance, in manufacture of arm splints. The backing material may be woven gauze or crinoline of suitable mesh, or may be of knitted construction. In use, the cast-forming element, such as a bandage, may be immersed in water, excess water squeezed out by hand pressure, and the bandage then applied to the body in spiral fashion until enough thickness has been built up to provide the cast strength needed.

One technique of applying the plaster of Paris to the backing involves passing the backing fabric through a chamber in which the plaster of Paris, in the form of a fine powder, is dusted or otherwise coated on the backing. This is a dry operation, and the product is commonly known as "loose plaster bandage." The loose plaster bandage has marked disadvantages. The plaster is not firmly secured to the backing and tends to drop off in handling and wash off during immersion of the bandage prior to application by the physician. This loss of plaster results in the production of casts of non-uniform and generally low strength.

The patent faults of the loose plaster bandage gave rise to investigation into ways of improving adherence and minimizing loss of plaster of Paris from the backing material. The result of these developments was the hard-coated bandage in which the plaster of Paris is mixed with a liquid-dispersing medium into the paste or slurry, and this paste is employed to impregnate the backing sheet. Upon drying of the plaste-impregnated backing one obtains a plaster of Paris bandage in which the plaster of Paris is bonded to the fabric, i. e. a hard-coated bandage. In procedures utilizing water or aqueous liquids as dispersing medium for the paste it has been a problem to inhibit setting of the plaster of Paris, i. e. conversion of the hemihydrate to the dihydrate of calcium sulfate, between the time the paste is first prepared and the time the bandage is dried to produce the finished product. For this purpose, the use of various retarders such as ammonium borate (disclosed in U. S. P. 2,557,083), or acetic acid has been proposed, or bandages have been prepared by the so-called "hot water process" in which setting of the plaster of Paris was prevented or minimized by keeping the paste hot during the critical period between initial wetting of the plaster and final drying of the bandage.

Plaster of Paris bandages have always had certain inherent disadvantages which have long been well recognized by the profession and by the trade. In the first place, plaster of Paris has by nature a high density

and is, therefore, a heavy material, which is a considerable disadvantage for ambulatory patients. Further, in order to assure adequate cast strength, it has been deemed advisable to employ plaster of Paris bandages in considerable thickness, which not only aggravates the weight disadvantage, but also decreases X-ray transparency. It would be desirable, if possible, to make a cast so thin that it would be permeable to X-rays, thereby making possible taking of X-ray pictures while the cast is still in place on the body of the patient. Set plaster of Paris casts are also notably susceptible to deterioration upon contact with water. Improvement in water resistance would be of particular advantage in cases of incontinent patients, or in the case of arm casts which are apt to become wetted with water when the hands are being washed.

Ordinary plaster of Paris bandages have no inherent resistance to growth or reproduction of microbes. Growth of micro-organisms between the skin and the cast, or within the cast itself, has in many cases created serious problems, particularly in cases of large body casts or body jackets which remain in place for weeks or even months. Growth of micro-organisms within the cast may be even more serious in cases where casts are placed over open wounds or points of irritation. Hence, it would be desirable, if feasible, to prepare a cast which possesses inherent anti-microbial properties so as to eliminate or minimize the tendency of microbes to live and reproduce within the cast.

Objects of the invention include improving the strength, lightness and X-ray transparency characteristics of plaster of Paris bandage casts. Another object is to incorporate a strengthening agent in hard-coated plaster of Paris bandages so as to improve the strength of the cast prepared therefrom. Still other objects comprise improving the early strength, resistance to deterioration from exposure to water after setting, and anti-microbial action of casts prepared from plaster of Paris bandages.

The strength-giving material incorporated in the paste which is employed to impregnate the backing must, of course, be refractory to the retardant employed in cases where an aqueous liquid is utilized in the paste, and must in any case resist the effect of the plaster of Paris itself. It must resist deterioration under conditions necessary to effect removal of liquid, i. e. elevated temperature. The finished bandage also must have stability so that it may be stored on the shelf of the wholesaler and retailer for a reasonable length of time without excessive decrease in strength-producing properties. A further object of the invention, therefore, is to incorporate a strengthening agent in a hard-coated plaster of Paris bandage, the desired strengthening agent being refractory to the conditions to which it is subject, and the finished bandage having a suitable storage life.

The foregoing objects are realized according to the invention in the form of a cast-producing element comprising a supporting fabric having bonded thereto a composition comprising 5 to 30% by weight of an aldehyde-triazine resin, and 95–70% by weight of plaster of Paris based on the total weight of resin and plaster of Paris. The invention bandage is prepared by making a paste or slurry of a dispersing liquid, plaster of Paris and the uncured aldehyde-triazine resin, plus a suitable amount of retarder if required, the amount of resin and plaster of Paris being in the ranges aforesaid, impregnating the backing with the paste, and drying the impregnated backing in a time short enough to prevent substantial curing of the resin and at a temperature high enough to effect drying of the bandage within the time requirement, but below temperature at which substantial curing of the resin would take place. Advantageous properties of the invention bandage include greater cast strength (including superior early strength), resistance to water after setting of

the cast, resistance to micro-organisms, and other advantages suggested by the foregoing recitation of objects. Other features of the invention and its preferred embodiments are set forth hereinafter.

The triazine-aldehyde resin, the use of which is contemplated according to the present invention, is preferably the one prepared from melamine, a species of triazines, with formaldehyde, a particular aldehyde. The condensation product of about 1 mol of melamine with about 3 or more mols of formaldehyde is suitable. However, the invention is not limited to a particular ratio of triazine to aldehyde, nor is it limited to a particular triazine, melamine, nor the particular aldehyde, formaldehyde. It is, however, preferred according to the invention that the triazine-aldehyde resin be water-dispersible, and be capable of being cured to a hard-set water-insoluble state. The resins are of the type which are now commercially available, and which are described in United States Patent 2,260,239 issued October 21, 1941 to Talbott and United States Patent 2,310,004 issued February 2, 1943 to Widmer et al. Alternatively, a suitable resin may be made by mixing about 1 mol of melamine with 4 mols of formaldehyde in the form of a 37% aqueous solution (formalin). The formaldehyde is preferably first brought to a pH of 8.84 by addition of 3% aqueous solution of sodium hydroxide. The mixture of melamine and alkalinized formaldehyde is preferably heated under a reflux condenser for about 15 minutes, after which time water is removed overhead from the reaction vessel as the reaction proceeds. Removal of distillate is continued for about 15 minutes and until the temperature of the reactor charge is about 105° C. At this point the operation is interrupted and the batch cooled to about 60° C. as rapidly as possible. The product is a clear, slightly viscous oily-appearing syrup having a pH of about 8.1 and a resin content of about 50%. It may be used in preparing pastes of resin—plaster of Paris for impregnating fabrics to make plaster of Paris bandages according to the present invention.

The plaster of Paris used for purposes of present invention may be ordinary plaster of Paris of the type conventionally incorporated in plaster of Paris bandages, or may be the high strength type plaster of Paris commonly known as "alpha gypsum." The latter material is disclosed and described in U. S. P. 1,901,051, issued March 14, 1933 to Randel and Dailey. This high strength gypsum is manufactured by calcination of gypsum rock in contact with steam at 17 to 20 lbs. gauge pressure, followed by drying and grinding. Alpha gypsum differs from ordinary plaster of Paris in that its compressive strength will range from 5000 lbs. per square inch on upward. Alpha gypsum is further differentiated from ordinary plaster of Paris or hemihydrate in the physical nature of individual crystal fragments composing the finely ground product. Its properties and methods employed in production are fully disclosed in the above-mentioned Randel et al. patent.

Triazine-aldehyde resin is incorporated in the paste or slurry, and eventually in the completed plaster of Paris bandage, in amount sufficient to impart to the final product a substantial increase in strength and substantial improvement in properties from the standpoints mentioned in the statement of objects above. Generally, appreciable improvement in properties may be noted if the amount of resin is at least about 5% of the total combined weights of resin and plaster of Paris, i. e. 5% resin and 95% plaster of Paris. Optimum properties from the standpoint of final cast strength, early strength, resistance to water, etc., are noted within the preferred composition 10 to 15% resin, 90 to 85% plaster of Paris by weight. At resin compositions substantially above 15% advantages of the invention will still be notable. However, as resin concentration increases above this value there may be a corresponding increase in difficulty of preparing and impregnating the paste on the backing fabric, and particularly where aqueous pastes are utilized there may be increased difficulty in removing water from the impregnated fabric to produce the desired dry finished bandage. Accordingly, resin concentrations are generally maintained below about 30% by weight based on the combined weights of resin and plaster of Paris.

From the standpoint of simplicity of operation and required apparatus it is preferable to employ water as liquid dispersant for the paste or slurry. However, the invention is not limited to a particular paste-forming liquid. Certain advantages of the invention inhere by use of organic nonaqueous liquids such as isopropyl alcohol, 75% aqueous alcohol, or methylene chloride. In these cases, use of a retarder may be dispensed with since there is not sufficient water in the system to set the plaster of Paris in the slurry.

As indicated above, the period between paste formation and the final drying of the bandage is a critical one in that the plaster of Paris and resin are subjected to conditions which tend to destroy or derogate from the sought-for properties of the bandage. Hence, control of operating variables in this period is important. One variable to be controlled is the pH of the paste. pH is maintained above about 7.0, and preferably in the approximate range 7.0 to 10.0, in order to minimize curing of the triazine-aldehyde resin. pH may be controlled by incorporating suitable amounts of alkalizing material and by eliminating any ingredients which would tend to lower the pH. Retarders other than the ammonium borate mentioned specifically may be employed providing they do not produce undesirably low pH so as to effect advancement or curing of the resin.

Drying, i. e. removal of liquid from the impregnated bandage, whether it be aqueous or nonaqueous liquid as described above, is carried out at temperature and other conditions which minimize tendency of the resin to advance or cure. Removal of liquid should be brought about in the minimum time and at the minimum temperature feasible. That is, the drying conditions should be maintained so that the time required to effect desired degree of removal of liquid is short enough so that curing of the resin is not excessive. Furthermore, during this drying period temperature is maintained below a level at which appreciable curing will take place, but sufficiently high to effect removal of water within the time limits specified above. Most preferably, temperatures are maintained at not greater than about 300° F. A suitable operating range of temperature for drying aqueous pastes may be found between 200 and 300° F.

The reason for the critical nature of the drying period is that liquid, particularly water, tends to promote or catalyze not only setting of the plaster of Paris, i. e. conversion to the dihydrate or gypsum, but also tends to catalyze advancement or curing of the resin. The resin once cured, of course, can impart no strengthening characteristics to the cast-forming bandage and, in fact, materially detracts from the strength properties that the plaster of Paris would have in the absence of any resin. Accordingly, drying conditions described above are maintained until free (volatile) water content of the bandage has been reduced to below 0.3% based on the weight of resin. Pursuant to maintaining desired low water content of the bandage and preventing the bandage, once dried, from absorbing water from the atmosphere, the bandage is most preferably wrapped in a sealed substantially water vapor-impermeable wrapper or container promptly after leaving the drying operation. If the bandage material is to be slit into widths narrower than the web coated and dried in the bandage-making operation, such slitting will preferably be carried out after drying and before packaging so that the packaged bandage, once sealed, may be maintained intact until finally used by the consumer.

The resin—plaster of Paris bandages of the invention

may contain conventional amounts of plasticizer such as glycerols, glycols, polyglycols, etc. Setting time of the bandage may be controlled by addition of accelerators or retarders known in the art to be effective for controlling the setting time of the plaster of Paris. Retarders include soluble citrates, phosphates, acetates, or other organic retarders. These ingredients, when used, are generally incorporated into the plaster of Paris—resin paste described above.

Another ingredient employed in preferred embodiments of the invention is a binder which serves the purpose of effecting maximum adhesion of the plaster of Paris and resin to the bandage backing material. Suitable binders are polyvinyl acetate emulsions, described in U. S. P. 2,655,148. Other usable binders include emulsions or solutions of polymers of vinyl chloride, vinyl acetate, acrylates, methacrylates, or butadiene; or copolymers, interpolymers or polymeric mixtures thereof. The binder is preferably mixed into the paste just as are the other components of the bandage.

To produce a cast of the invention bandage, the bandage is immersed in water according to the usual procedure. Further, the resin in the bandage is optionally treated with a catalyst to produce curing of the resin as rapidly as possible. This catalyst is conveniently added to the water in which the bandage is immersed. Catalyst concentrations in the water are maintained at a value sufficient to produce in the resin the desired degree of cure in the desired interval of time. Catalyst concentrations of 0.5 to 6.0% may be found to produce the desired effect. One indicia of satisfactory environment for proper resin cure is pH, which is preferably maintained at about 6 or below in order to effect proper resin cure within a short period of time at the relatively low temperature which will prevail. Acidity control may be produced by use of the resin-curing catalysts, for example ammonium chloride or other acid salts or weak acids such as zinc sulfate, zinc chloride, aluminum sulfate, etc.

The following examples, in which parts are on a weight basis unless otherwise specifically indicated, are presented not in a limiting sense but as illustrating the invention.

Example I

With 10 parts of uncured water-soluble melamine-formaldehyde resin prepared from a mixture of 1 mol melamine and 4 mols formaldehyde according to the foregoing procedure, there were mixed 90 parts of alpha gypsum prepared substantially according to the procedure of U. S. P. 1,901,051, and 40 parts water containing 0.5 part borax and 1.2 parts of polyvinyl acetate emulsion containing 55% polyvinyl acetate. The mixture had the consistency of a thin paste. It was coated on gauze and dried for about two minutes at 275° F. A strip of the dried bandage material 4 inches wide by 5 yards long was dipped into a 1½% aqueous solution of ammonium chloride and wrapped around a cylindrical member to prepare a cast. The cast was made of about 25 laminations of the gauze as measured through its thickness. The cast was allowed to set for 24 hours at room temperature after which time it was tested for cast strength according to Federal specification GG–B–107, June 21, 1951, section 4.3.6 (except that setting time was 24 hours instead of 1 hour as called for by the specification). Strength tests were also made on similar casts after 7 days setting time. The result obtained is presented in the table below.

Example II

A homogeneous mixture was prepared of 15 parts of melamine-formaldehyde resin substantially the same as that employed in Example I, 85 parts of alpha gypsum and 35 parts water containing 0.4 part boric acid, 0.8 parts 28% aqueous ammonia solution and 0.6 part polyvinyl acetate emulsion containing 55% polyvinyl acetate. The paste was coated on gauze backing and dried. After preparing a cast according to the procedure described in Example I, strength tests were carried out as described above. The results of tests for cast strength are presented in the table below.

Example III

A paste similar to that described in Examples I and II was prepared using 25 parts aldehyde-triazine resin, 75 parts alpha gypsum and 45 parts water containing 0.6 part polyvinyl acetate emulsion, 0.4 part boric acid and 0.8 part of 28% aqueous ammonia. The mixture was coated on gauze and dried at 250° F. for about 3 minutes. A cast was prepared as in Example I and tested as described in that example. Results are presented in the table below.

Example IV

A paste similar to that described in the foregoing examples was prepared from 90 parts alpha gypsum, 10 parts of the same resin and 50 parts of 95% aqueous ethyl alcohol containing 1 part of polyvinyl acetate emulsion. The mixture was coated on ordinary gauze and dried at 170° F. for 2 minutes. The cast was tested as in Example I, the results being presented in the table below.

Example V

The slurry in this example was composed of 85 parts alpha gypsum, 15 parts of the same resin and 2 parts of ammonium chloride, mixed with 60 parts of anhydrous methylene chloride containing 1 part of polyvinyl acetate emulsion. The mixture was spread on gauze using a knife coater, and dried at 100° F. for five minutes. A strip of the material 4 inches wide by 5 yards long was immersed in water, and a cast was prepared. The cast was tested according to the procedure described above with the results presented in the table below. For purpose of comparison the table also includes strength tests on a commercially available 4 inches wide by 5 yards long bandage made into a cast, the bandage being formed of alpha gypsum coated on and bonded to gauze, and having composition similar to invention bandages except that there was no aldehyde-triazine resin present.

Example	Cast Strength Pounds	
	After 1 Day	After 7 Days
1	882	1,250
2	1,027	1,290
3	867	1,190
4	940	
5	822	
Control	450	894

The invention is not limited to the foregoing examples and description since there are many modifications and equivalents within the scope of the invention.

The claims are:

1. A bandage for producing an immobilizing cast comprising a fabric backing and bonded to said fabric a substantially dry composition comprising about 5–30% by weight of uncured aldehyde-triazine resin and about 95–70% by weight of plaster of Paris based on the total weight of resin and plaster of Paris, and sufficient adhesive to bond said composition to said backing.

2. A bandage for producing an immobilizing cast comprising a fabric backing and bonded to said fabric a substantially dry composition comprising about 5–30% by weight of uncured melamine-formaldehyde resin and about 95–70% by weight of plaster of Paris based on the total weight of resin and plaster of Paris, and sufficient adhesive to bond said composition to said backing.

3. A bandage for producing an immobilizing cast comprising a woven fabric backing and bonded to said fabric a substantially dry composition comprising about 10–

15% by weight of uncured melamine-formaldehyde resin and about 90–85% by weight of plaster of Paris based on the total weight of resin and plaster of Paris, sufficient adhesive to bond said composition to said backing, and plasticizer for said composition.

4. The method of producing a plaster of Paris bandage which comprises preparing a paste of a liquid, plaster of Paris, and an uncured aldehyde-triazine resin, the amount of resin being about 5–30% and the amount of plaster of Paris being about 95–70% of the combined weights of resin and plaster of Paris, and sufficient adhesive to bond said resin and plaster of Paris to a web, impregnating a web with said paste, and drying the impregnated web under conditions to prevent substantial hydration of said plaster of Paris and to prevent substantial curing of said resin.

5. The method of claim 4 for producing a plaster of Paris bandage which comprises preparing a paste of a liquid, plaster of Paris, an uncured aldehyde-triazine resin, the amount of resin being about 10–15% and the amount of plaster of Paris being about 90–85% of the combined weights of resin and plaster of Paris, impregnating a fibrous web with said paste, and drying the impregnated web under conditions to prevent substantial hydration of said plaster of Paris and to prevent substantial curing of said resin, and sealing the dried material in a substantially water-impervious wrapper promptly after said drying operation.

6. The method of claim 4 for producing a plaster of Paris bandage which comprises preparing a paste of an aqueous liquid, plaster of Paris, an uncured melamine-formaldehyde resin, and retarder, the amount of resin being about 5–30% and the amount of plaster of Paris being about 95–70% of the combined weights of resin and plaster of Paris, impregnating a fibrous web with said paste, and drying the impregnated web under conditions to prevent substantial hydration of said plaster of Paris and to prevent substantial curing of said resin.

7. The method of claim 4 for producing a plaster of Paris bandage which comprises preparing a paste of an aqueous liquid, plaster of Paris, an uncured melamine-formaldehyde resin, retarder and plasticizer, the amount of resin being about 10–15% and the amount of plaster of Paris being about 90–85% of the combined weights of resin and plaster of Paris, impregnating a woven fibrous web with said paste, drying the impregnated web at temperature not above 300° F. for time short enough and under conditions to prevent substantial curing of said resin, and controlling the pH of said bandage in the approximate range 7.0 to 10.0 during said drying operation.

8. The method of claim 4 for producing a plaster of Paris bandage which comprises preparing a paste of an aqueous liquid, plaster of Paris, an uncured melamine-formaldehyde resin, retarder and plasticizer, the amount of resin being about 10–15% and the amount of plaster of Paris being about 90–85% of the combined weights of resin and plaster of Paris, impregnating a woven fibrous web with said paste, drying the impregnated web at temperature not above 300° F. for time short enough to prevent substantial curing of said resin to volatile water content below about 0.3% based on the weight of said resin, controlling the pH of said bandage in the approximate range 7 to 10 during said drying operation, and sealing the dried material in a substantially water-impervious wrapper promptly after said drying operation.

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