BLOOD ALBUMIN GLUES: THEIR MANUFACTURE, PREPARATION, AND APPLICATION

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In Cooperation with the University of Wisconsin
Prior to 1917 a few companies in this country were using blood albumin glue and practically all of these had formulas of their own that were kept secret. About 1917 there began to be a marked demand for water-resistant plywood for military purposes and this created a demand for all of the water-resistant glues that were then available. Following the period of World War I, some foreign plywood manufacturers continued to make use of blood albumin glues but in this country they gained only limited acceptance in industry. The introduction of synthetic resin glues beginning about 1932 served to decrease still further the interest in blood albumin glues because the synthetic resin glues proved more convenient to use and some of them excelled the blood albumin glues in durability under severe service conditions. In recent years, blood albumin has found some use in combination with soybean glues to improve their water resistance and as an extender for synthetic resin glues.

Blood albumin glues are not offered on the market in dry form, as are most adhesives for woodworking, chiefly because of the decrease in solubility of the albumin with age. The materials of which blood glues are made are generally mixed at the time of using. Blood albumin glues may be made either from the fresh blood of slaughtered animals or from the dried soluble blood albumin obtained by processing the fresh blood. To make the use of fresh blood feasible, the supply must be readily accessible to the place of manufacture, inasmuch as rapid decomposition takes place and renders it unsatisfactory for glue purposes. Unless utilized at once, fresh blood must be treated with a preservative or converted into a dried soluble form.

The studies reported here were conducted at the Forest Products Laboratory during the period from 1918 through 1938. The blood product used in these studies was generally referred to at that time as "black soluble blood albumin" or "blood albumin." It was purchased from commercial domestic suppliers and was ordered generally under one of these designations.
actual composition of the products received was not determined. It was assumed at the time that this blood product was produced by subjecting the fresh blood to a process for removing the fibrin and part of the red corpuscles and then evaporating to dryness at a temperature below the coagulating point of the albumin, which is approximately 160°F. It was generally a rather dark, reddish-colored product that dissolved readily in water.

Dry blood albumin is seldom bought under a definite specification. A 90 percent soluble albumin is satisfactory for blood albumin glue and can be readily supplied in this form by the manufacturer. The albumin should be comparatively free from entrained air to avoid a foamy or frothy glue. Color is not important and the cheap dark albumin is as satisfactory as the light-colored albumin. Fat not in excess of 1 percent, ash not more than 10 percent, and a moisture content of about 8 percent are known to be satisfactory limits for these factors. Even with these requirements, however, the albumin must be mixed into glue, and joints made and tested before there is positive assurance that it is of proper quality.

Preparation of Blood Albumin

In order to put the dried albumin into solution, it is necessary to allow it to soak for some time before stirring. It is advisable to add water at about room temperature to the albumin and allow it to stand in a cool place an hour or more before stirring. It should then be stirred until it is of uniform consistency. If particles of insoluble material occur, the mixture may be strained through a screen of about 30 meshes per inch to remove the coarse particles. The dried albumin always contains some insoluble material and becomes more and more insoluble with age. Furthermore, upon long storage the behavior of the albumin and certain chemical reagents appears to change, indicating some aging effect in addition to loss of solubility.

Formulas

A mixture of blood albumin and water alone makes a glue with considerable adhesive properties, but the glue may be improved by the addition of other materials. The original blood albumin glue formula2 for the hot-press

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2Patented in the name of S. B. Henning, Forest Products Laboratory, Feb. 3, 1920 (U. S. Patent No. 1,329,599), and dedicated to the free use of the public.
process worked out at the Forest Products Laboratory is as follows:

100 pounds of black soluble blood albumin (90 percent solubility)
180 pounds of water at about 80° F.
4 pounds of ammonium hydroxide (Sp. gr. 0.90)
3 pounds of hydrated lime.

After the blood has been put in solution, the ammonia is added while the mixture is being stirred slowly. Slow stirring is necessary to prevent foamy glue. The lime is then added in the form of a "milk" and agitation should be continued for a few minutes. The constituents should be weighed carefully inasmuch as a small excess of lime will cause the mixture to thicken and become a jelly-like mass. The glue should be of a moderate consistency when mixed and should remain suitable for use for several hours. The exact proportions of albumin and water may be varied as required to produce a glue of greater or less consistency or to suit an albumin of different solubility from that specified.

Application

The glue may be applied to the wood either with a brush or by means of a mechanical glue spreader. If the spreader is used, it is advisable to run it only when actually coating the wood, as constantly running the spreader is likely to cause the glue to become foamy.

Pressing

To set the glue made by the above formula, a minimum temperature of approximately 160° F. is necessary, which causes the blood to coagulate. When thoroughly coagulated, the glue cannot again be dissolved in water. The heat is conveniently applied to the wood by pressing between the hot platens of a hydraulic press. In order to reduce the time required in the press and thus increase its capacity, it is customary to use temperatures of about 200° to 300° F. Temperatures above 212° F., however, turn the moisture in the glue and wood to steam and are likely to produce steam pockets or blisters between the plies of some woods. Releasing the gluing pressure slowly will often avoid the difficulty, but the safer procedure is to use temperatures just below 212° F.

The amount of pressure required to produce good glue joints depends upon the kind and condition of material, but should be sufficient to insure good contact. Pressures of 100 to 200 pounds per square inch are commonly used at the Forest Products Laboratory, but other pressures can be successfully used.

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The time required for pressing depends upon the thickness of the plies, the number of panels in the press, and the temperature of the platens. With a temperature of 212° F, three minutes are sufficient for one three-ply panel with 1/16-inch face plies. The necessary length of time naturally increases with an increase in thickness of material. Gluing pressures should be applied quickly after loading the press, to prevent coagulating the blood before pressure is secured.

Paraformaldehyde-Blood Glue

Investigations at the Forest Products Laboratory have also resulted in the development of a blood albumin glue formula which in laboratory tests proved superior in several respects to the formula described above. The formula is as follows:

100 parts by weight of soluble blood albumin
140 parts to 200 parts by weight of water (according to consistency desired)
5-1/2 parts by weight of ammonium hydroxide (Sp. gr. 0.90)
15 parts by weight of paraformaldehyde.

Paraformaldehyde is a polymer of formaldehyde and not a definite chemical compound. Its properties will vary somewhat depending upon details of the manufacturing process. A "slow reacting type" is required for use in this formula. It is advisable, therefore, to purchase the paraformaldehyde directly from the manufacturers and to specify the "slow reacting" type suitable for use in glue formulas.

The blood albumin is covered with the water and the mixture is allowed to stand for an hour or two. Then, when the mixture is stirred, the blood albumin will for the most part go into solution. The ammonium hydroxide is now added with more stirring. The paraformaldehyde may be conveniently added in the form of a suspension in water; just enough water being added to the paraformaldehyde powder to form a "milk." This suspension is poured into the mixing bowl during continued stirring. Preliminary thickening is a characteristic of this type of blood albumin glue and usually takes place within 5 minutes after the paraformaldehyde has been added. The stirring should be continued until the mixture turns to a thick mass, which is then allowed to stand until thinning occurs. The thickened glue ordinarily returns gradually to a good working consistency in about 1 hour. It will

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3 This glue is covered by U. S. Patent No. 1,459,541, granted to A. C. Lindauer of the Forest Products Laboratory and dedicated to the free use of the public.

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remain in this condition for about 6 or 8 hours after which it sets to an insoluble jelly. Care should be taken to remove the glue from the mixer and spreading equipment before final setting takes place, otherwise difficulty in cleaning will be experienced.

Application and Pressing

The glue may be applied by means of a brush or mechanical spreader. It may be used cold on the lighter weight woods or where high strength of joint is not essential, but the application of heat is required to produce joints of uniformly high strength and to develop the full advantages of the glue. When cold pressed the gluing is done in the same manner as with casein or vegetable glue and with the same equipment. Hot pressing, however, improves the joint strength and water resistance and is recommended as a general practice. If the panel is hot pressed, it should be left under pressure sufficient time for all parts of the glue joints to attain a temperature of 160° F. There are indications that higher temperatures (up to 300° F.) and longer periods of pressing (up to 30 minutes) will produce even better joints.

The glue when hot pressed has shown exceptionally good water resistance and durability under extreme exposure in laboratory tests and in this respect is superior to the earlier formula. Equally good results have been obtained by hot pressing promptly after spreading or by pressing cold, allowing the panels to remain under pressure over night, and hot pressing on the following day. The second method reduced to some extent the difficulties from blistering when the platen temperatures are in excess of 212° F.

A Dry-Glue Formula

Another hot press blood glue formula has been developed at the Forest Products Laboratory that offers advantages for certain special uses. The formula is as follows:

100 parts by weight of black soluble blood albumin
190 parts by weight of water
1.5 parts by weight of hydrated lime
10 parts by weight of water
60 to 100 parts by weight of sugar syrup

This glue is covered by U. S. Patent No. 1,336,262 granted to Sponsler, Dunlap, and Henning and dedicated to the free use of the public.
The combination of materials follows the same general procedure as in other formulas used in mixing blood glues for plywood manufacture. The syrup is added to make the glue sufficiently hygroscopic to permit adhesion to the wood if the glue film is dried before pressing. Corn syrup gave good results, but an invert sugar gave even more satisfactory results. The quantity of syrup depends on the kind used. Glycerine may be substituted for the sugar but a smaller quantity is required.

It was originally intended that this glue be spread on both sides of a thin porous paper, dried, and used in the form of a thin film\(^2\) in much the same manner as the more recently developed film glues of artificial resins. The formula lends itself, however, to another technic that might prove useful in certain gluing operations. The crossbands or the crossbanded cores may be spread directly with the adhesive (without employing the paper carrier) and allowed to dry. The coated surfaces should be exposed to a damp atmosphere for a few minutes or otherwise moistened slightly before gluing, the plies laid together, and the assembly hot pressed. Since very little water is present in the glue line at the time of pressing, dangers of blistering are largely eliminated.

United States Department of Agriculture Bulletin 1500 entitled "The Gluing of Wood" contains additional information on blood albumin and other glues for wood working and their application. It may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., for 25¢, cash or money order (stamps not accepted).

The following lists of publications based on research at the Forest Products Laboratory (Madison 5, Wis.) are obtainable on request:

- Boxing and Crating
- Building Construction Subjects
- Chemistry of Wood and Derived Products
- Fungus Defects in Forest Products
- Furniture Manufacturers, Woodworkers, and Teachers of Wood Shop Practice
- Glue and Plywood
- Logging, Manufacture, and Utilization of Timber, Lumber, and Other Wood Products
- Mechanical Properties and Structural Uses of Wood and Wood Products
- Pulp and Paper
- Seasoning of Wood
- Structure and Identification of Wood

Wood Finishing Subjects
Wood Preservation

Since Forest Products Laboratory publications are so varied in subject no single big list is issued. Instead a list is made up for each Laboratory division as shown above. Twice a year, a list is made up showing new reports for the previous 6 months. This is the only item sent regularly to the Laboratory's mailing list. Anyone who has asked for and received the proper subject lists and who has had his name placed on the mailing list can keep up to date on Forest Products Laboratory publications. There is no charge for single copies of any of the reports.