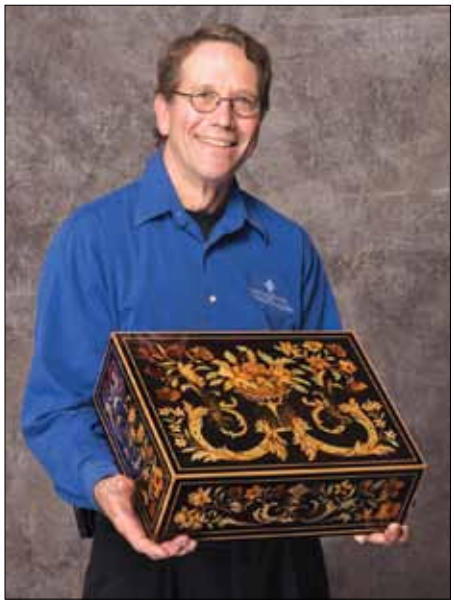
Tools & Techniques

Why Not Animal Glue

by W. Patrick Edwards



W. Patrick Edwards has operated Antique Refinishers in San Diego, CA, since 1969. Begun as a means to augment his income as a physics lab technician, he found restoring antique furniture extremely lucrative and decided to work full time in the conservation and restoration of pre-industrial furniture.

To expand his knowledge of marquetry, he studied under **Dr. Pierre Ramond** at the Ecole Boulle in Paris, and his San Diego studio became the only workshop in North America to be accredited by the Ecole Boulle to receive their students for extended study. He opened the American School of French Marquetry, in 2000, to teach the French methods, and the school has received hundreds of students over the years, from many countries.

In 1992, Patrick was invited to join the newly created international group of marquetry conservation professionals, ADEN, in Paris. As a member, he participated in research on various problems encountered during conservation and restoration of complex decorative surfaces on furniture. One such area of study was to investigate the modification of protein glues, with the goal of extending the open time and reducing the gel point. After several years of experimentation, the result was the product *Old Brown Glue,* which is distributed across North America and internationally. In the field of animal protein glues, Patrick is considered the "glue guru."

In 2014, Patrick was awarded the *Cartouche Award* by the **Society of American Period Furniture Makers,** in recognition of achievement and contributions to the field.

For more info about Patrick, the American School of French Marquetry, and Old Brown Glue, visit his website: *www.wpatrickedwards.com*.

My first woodworking project was a failure. I thought that I would make a backgammon board with veneer. I carefully cut all the elements out of Rosewood and Satinwood, making a nice veneer assembly held together with veneer tape.

I selected a piece of MDF, applied white glue to the surface, and pressed the veneer in place. The next day, when I removed it from the press, I was very upset that the entire surface was wrinkled. Nothing I could do would fix it, and the piece ended up in the trash. After some reflection, I realized that the problem was with the glue, so I started over with animal hide glue. The results were wonderful, and I decided immediately that I would only use protein glues after that. That was over 45 years ago, and I have never questioned the wisdom of my decision.

PROBLEMS WITH SYNTHETIC GLUES

There are several problems associated with synthetic (white and yellow) glues, which make them unattractive to furnituremakers. These problems are often overlooked in favor of the generally perceived "easy to use" features that make a ready-to-use product handy around the shop.

One of the most overlooked problems is the most obvious: lack of reversibility. Most furniture makers today do not consider the future problems synthetic glues create when it comes time to repair their creations. However, all furniture is subject to use and damage, and all furniture needs to be repairable if it is to survive the generations. Synthetic glues cure by a catalytic conversion from one chemical to another and are irreversible. This means to take apart furniture made with synthetic glues requires destructive intervention and physical removal of all glue prior to repair.

Modern glues have a mechanical bond only and require tight fitting joints and even clamping. They do not bond to themselves and set up unevenly, remaining wet in one area of the joint while setting dry in another. These glues seal the wood surface and prevent stains and finishes from penetrating evenly. They are difficult to sand and remove from the surface when set. One of the greatest problems is the lack of resistance to sheer forces, which allow the wood to "creep" along the glue joint. This "creep" allows veneer joints to open up, and solid wood joints to move over time as wood movement occurs relative to humidity and temperature fluctuations, as well as wood shrinkage due to aging.

A more serious consideration when using synthetic glues is the toxic nature of the solvents, which are included in their formulation. This represents, in some cases, immediate health concerns for the woodworker, who might be constantly exposed to these solvents on a daily basis, and requires informed decision making as to what kinds of protection are required for their safe use.

ANIMAL AND VEGETABLE GLUES

The use of animal collagen glue by man has been traced back over 8,000 years. Artifacts discovered in caves near the Dead Sea were found to contain this material as adhesives. Large specialized glue factories emerged in Europe at the end of the 17th century and in America at the beginning of the 19th century. Furnituremakers used hot glue exclusively until the start of the 20th century, when the development of synthetic glues began to change the market for this product.

American furnituremakers were some of the first to abandon the use of animal glues in favor of these new synthetic products, while in England and Europe the use of traditional glues continued until well after the second World War. Today, traditional animal glues are still generally used in America by antique restorers, museum conservators, and musical instrument makers and restorers.

Animal glues are adhesives, which are essentially high polymer proteins derived from hydrolyzed collagen. These organic colloids are comprised of complex proteins found in animal hides, connective tissues, and bones. This protein has two elements that define its characteristics: chondrin, which gives it adhesive strength, and gluten, which gives it gel strength (gelatin).

These glues are made using a rather simple process, which hasn't changed much over the ages. The raw material is first conditioned in a water solution with lime (calcium hydroxide), and the pH value is adjusted by adding a dilute mineral acid and rinsed in water. Then, the process of cooking begins, and while the material is cooked the water/protein solution is extracted and filtered. The protein, which is collected by the filters, is dried and ground up as a final product.

The resulting glue is then tested as to viscosity (fluidity) and gel strength (stiffness of gel formation), and graded on a scale from 50 to 512. Lower grades dry slower and are more flexible, and higher grades dry faster and harder. Glue chip glass is made using hide glue with a 135 gram strength, which allows the glue to actually tear off the surface of the glass as it sets. Woodworkers can choose between 164, 192, and 251 gram strengths, which have slightly different working characteristics. 192 gram strength is the most popular and allows hammer veneering, "rubbed" joints, and adequate working times when the wood is preheated.

The strength of animal glues are through "mechanical bonding"—meaning that the surfaces are held together by an adhesive that has penetrated the porous surface, while it is liquid, then anchored itself during solidification—as well as "specific adhesion"—whereby intermolecular attraction forces form bonds between the adhesive polymer and the molecular structure of the wood itself. Water has a strong molecular attraction to wood, primarily through hydrogen bonding with hydroxyl groups of the cellulose that is in the wood. Since protein glues are carried by hot water, it's understandable that they would have excellent penetration into the wood surface and form specific adhesion with the molecules of the wood itself.

BASIC ADVANTAGES OF PROTEIN GLUES OVER SYNTHETIC GLUES:

- ✓ Protein glues can be reversed, and the viscosity can be manipulated by adjusting the ratio of water or heat as variables.
- ✓ Protein glues penetrate deeply into wood fibers since they are carried by water.
- ✓ Protein glues are very slippery when hot and provide lubrication for tight wood joints.
- ✓ Protein glues have a longer working time, which makes them perfect for lamination.
- ✓ Protein glues are transparent to oils and finishes and do not stain the wood.
- ✓ Protein glues easily clean up with water.
- ✓ Some protein glues have a fast tack, which makes them perfect for rubbed joints and hammer veneering, including marquetry fabrication.
- ✓ Protein glues have a very high sheer resistance to creep.
- ✓ Protein glues can be used to size wood and sand easily.
- ✓ Protein glues bond with both mechanical adhesion and molecular attraction.
- ✓ Protein glues bond to themselves.
- ✓ Protein glues are the only glues that are appropriate for traditional furniture construction.
- ✓ Protein glues are not damaged by freezing.

DISADVANTAGES OF SYNTHETIC GLUES:

- ✓ Synthetic glues are not reversible.
- ✓ Synthetic glues are not easy to remove from wood surfaces without damage to the wood.
- ✓ Synthetic glues creep under stress.
- ✓ Synthetic glues do not bond to themselves.
- ✓ Synthetic glues are damaged by freezing.
- ✓ Synthetic glues stain the wood and are difficult to clean up.
- ✓ Synthetic glues are difficult to sand properly.
- ✓ Synthetic glues do not penetrate deeply into wood fibers.
- ✓ It is difficult to adjust the viscosity of synthetic glues.

WORKING WITH PROTEIN GLUES

Working with traditional animal glues is a simple process. The glue in dry form has an unlimited shelf life, stored in a dry container and kept away from heat. To prepare the glue for use, just add cold water and let sit overnight. It is not really important how much water you add, as long as it completely covers the glue. If you mix by weight, use 1.8 parts of water to 1 part of glue. If you mix by volume, just cover the dry glue with more water than glue. Once all the water has been absorbed, put the gelled glue into a double boiler and cook it on a low heat. A variety of materials can be used for the double boiler, such as copper, iron enamel, glass, stainless steel, or aluminum. Use a stainless steel meat thermometer to monitor the glue temperature. Keep it constantly at 145° F (60° C), and add more water, as needed, to replace that lost to evaporation. A foil cover can be kept loosely over the top of the glue pot while cooking, to reduce evaporation. A good quality round bristle brush is best as an applicator.

Traditional woodworkers used subjective tests to monitor the hot glue as it cooked. The odor should be pleasant if the glue is good, and smell bad if the glue is overheated or has been damaged by mold. The viscosity is measured by lifting the glue brush about a foot over the pot, and letting the glue drip back down. It should be thin and liquid, with no lumps.

You can test the strength by putting a small amount of hot glue between your finger and thumb, and rubbing together until it cools. The strength is then measured by pulling the finger and thumb apart several inches and looking at the protein strands, which appear like spider webs. The longer the strands, the stronger the glue. The color of protein glue when freshly cooked is light amber, and it continues to darken as it is cooked. As long as it is not overheated, it remains quite strong. If the glue temperature reaches 212°, it is ruined. If there is mold in the glue, it can be very hard to see, but the glue will remain lumpy at operating temperature, and should be discarded. Then, glue pot and brushes must be cleaned by boiling in water before a fresh batch is made.

A glue pot, with brushes and a thermometer

Animal hide and bone glues set in a 2-part process, which first begins by cooling from 145° to room temperature, and then completely drying by evaporation during the next 12 to 24 hours. This allows the traditional woodworker to use this glue to his advantage, since hammer veneering and "rubbed" joints both require glue with a rapid initial grab as it cools. In addition, the strong initial hold of these glues allows clamps to be removed and reused on another job, while the first project dries overnight.

Hide glue can be heated and cooled as many times as you like without any problems. I cook it all day long and turn it off when I go home. The only consideration in cooking hide glue is that it will attract mold if it is not heated on a regular basis. Therefore, if I am not using the glue for some period of time, I pour it out on a piece of heavy plastic, wait an hour for it to gel and then place the glue sheet on a screen to dry. Once dry, it will last forever. To reuse it, just break it up into pieces and soak in cold water as usual before heating once again in the glue pot.

Protein glues can be easily modified with a wide variety of additives to change the working characteristics of the glue. I have used urea to reduce the gel point of the hide glue to manufacture "Old Brown Glue," which has become a recognized liquid protein glue. It is in the form of a gel in the bottle at room temperature and needs to be heated up for use. It can be frozen, refrigerated, or kept at room temperature and has a guaranteed shelf life of 18 months, regardless of storage conditions. It has a much longer working time than the hot glue, is just as strong, and is easier to clean up.

There are other proteins used to make glues, and each type has its historic application. Rabbit skin glues are diluted quite thin with water (16:1) and work under the gold leaf and gesso quite well. Fish glues are a different animal. They are normally liquid at room temperature and are generally used to adhere a variety of materials that are not wood to a substrate. Materials used in marquetry, such as ivory, bone, horn, shell, and metals all expand and contract as a function of humidity and temperature in opposite directions to wood. Therefore, fish glues are used to hold them in place, since these glues allow a certain movement of elements during environmental fluctuations.

Historically, woodworkers have used glues made of either bone or hide or a mixture of both. Bone glues have

slightly different characteristics than hide glues and are essentially more rigid after curing. The most common mixture of these glues is 1/3 bone and 2/3 hide. Hide glues are usually made from the skins and tendons of cows, and in the past, there were specific uses for each part of the animal. The last American manufacturer of hide glues is Milligan & Higgins, in New York. More information on the properties of hide glues can be found by contacting **Jay Utzig** at *www.Milligan1868.com*, as he is their chief chemist and is always willing to share his insights with interested parties.

THE IMPORTANCE OF REVERSIBILITY

Animal protein glues are the only easily reversible glues available to woodworkers. All modern synthetic glues convert from one chemical form to another by using a catalyst. Once converted, these synthetic glues are difficult or impossible to undo. Since protein glues react to heat and moisture, they can be easily converted from liquid to solid and back again, even after a century or more of time.

This is a primary reason why these glues have continuously been used in the restoration field. The existing original glue can be softened or cleaned with warm water, and the new application of hot hide glue will completely bond with the previous glue. For example, if you want to repair a rush seat chair, or any joint that can't be fully taken apart, you can drill a small hole into the joint, inject some warm water and then some hot glue using a syringe. Injecting alcohol or vinegar into an old glue joint will dry out the glue and make it more brittle, which can make it easier to take apart. Steam can also be applied to veneers, which make it possible to remove and repair these surfaces.

Reversibility is essential when working with veneers, inlay, and marquetry surfaces. It is necessary to glue and unglue veneers, while building a pattern on the surface. Protein glues allow easy repair and replacement of damaged veneers, by using heat and moisture. The glues are easy to clean off the surface, either with water or sanding, and are not affected by stains, solvents, and finishes. Thinned animal glue mixed with sawdust makes a good mastic for marquetry.

A technique used in conservation of marquetry surfaces for several years demonstrates the advantage of traditional animal protein glue. Since antique veneer and marquetry surfaces in poor condition often have losses in finish, missing elements, loose areas, and cracks, the original animal glue dries out and looses its grip. This original layer of protein glue, often centuries old, can be rejuvenated by a simple process. The surface is first made wet with distilled water and paper towels. Plastic is placed over the towels to keep the water in. Constant observation is necessary to determine when the veneer, mastic, and marquetry elements begin to lift. The surface is then immediately dried off and covered with traditional animal glue modified by urea to make it stay liquid longer.

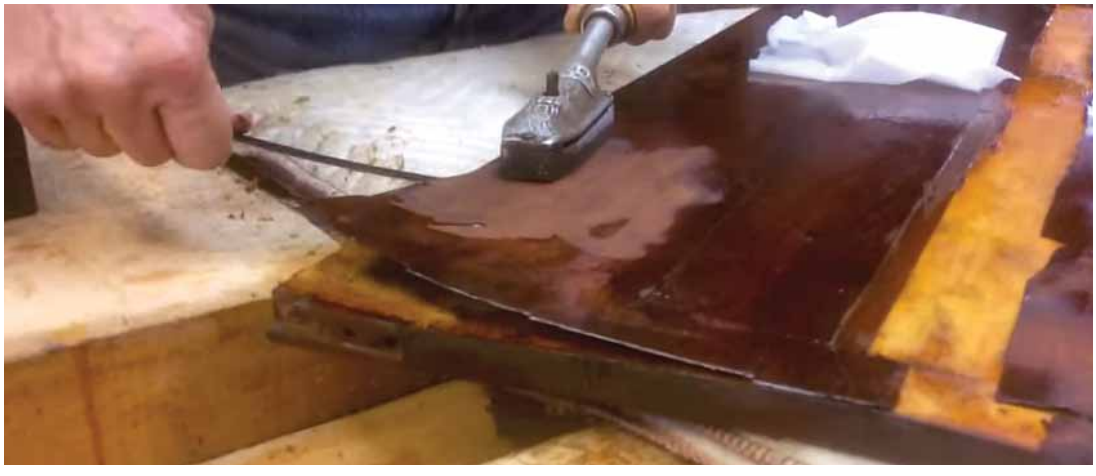
This modified glue is worked into all the cracks and under any loose veneer. Once the glue is rubbed into the surface, it is covered with a thin sheet of Lexan plastic. A heated aluminum plate is then tightly pressed over the Lexan plastic and left in place 24 hours. Once the marquetry is removed from the press and the plastic is removed, the surface glue can be cleaned up with cold water. The new glue "re-activates" the old glue, through the veneer and mastic, and restores the grip of the original glue without any damage to the surface.

These techniques are illustrated in videos on our *YouTube* channel: *www.youtube.com/user/3815utah.*

CONCLUSION

In our efforts to research and understand the furniture of the past, traditional craftsmen are obliged to recreate the process used by pre-industrial cabinetmakers. This implies knowledge of the types of tools and methods used, as well as the materials selected and the reasoning behind their selection. One of the most important elements of all aspects of furnituremaking is the selection of adhesives. If we strive to recreate the period furniture as faithfully, as possible, in the world today, we must adopt the hot glue pot as a permanent fixture in the woodshop.

And for the contemporary maker, these are lessons that should not be dismissed. Their benefits are as applicable to modern techniques. So if your goal is heirloom furniture, you can't argue with the longevity of the past.



Patrick demonstrates the concept of reversibility of animal glue by removing veneer using water and a hot iron from an antique table, constructed in 1840.