Animal glues used in painting

Properties of animal glues and their use in traditional painting

mgr Marta Hirschfeld

Art conservator

Krakow, 03/2024

Glutin glues

Animal glues are a group of natural polymers that are derived from collagen, the main structural protein found in the skin, connective tissue, cartilage and bones of mammals and fish. Due to the variety of substances and preparation methods, these adhesives have different physical, chemical and mechanical properties[1]. Animal glue has many advantages, such as high strength, reversibility, the ability to produce thin joints, quick setting time and wide range of applications. There is probably no other glue that is as effective and proven as animal glue. It is especially very useful in traditional carpentry and as a binder in some technological layers in easel painting[2]. One of the most important features of animal glue is the reversibility of dissolution under the influence of moisture and elevated temperature. The biggest disadvantage of animal glues is that they are an excellent breeding ground for microorganisms.

Animal glue is made by processing various raw materials of animal origin, such as animal skins, tendons, cartilage, bones and horn core. These raw materials are exposed to high temperatures. This process evaporates the water and thus thickens the glue, which is then poured into molds and dried[3]. In this way, the adhesive can be obtained in various solid forms, which becomes liquid again when exposed to water and temperature again.

The first batch of glue is of the highest quality, and subsequent batches are produced from reused animal raw materials. The choice of appropriate ingredients affects the quality and type of glue that can be obtained[4]. Animal glue is available in various forms such as blocks, flakes, and pearls. The shape of dry glue does not affect its properties, only crushed glue swells faster under the influence of water because its surface is larger.

1. Collagen – an ingredient responsible for the adhesive mechanism

Glutin adhesives rely mainly on collagen as the adhesive ingredient. Collagen does not dissolve in cold water, but when heated in water it denatures, transforming into dissolved gelatin. The denaturation process is necessary to turn the collagen into gelatin, which has adhesive properties[5]. During gluing, individual protein folds rearrange themselves, creating more ordered structures. The properties of the formed film depend on the number of newly formed hydrogen bonds between the adhesive molecules.

[1]Schellmann, N.C., "Animal glues: a review of their key properties relevant to conservation", Reviews in Conservation, no. 8, 2007, s. 55.

[2]Truax, T.R. "The Gluing of Wood", Department Bulletin No. 150, Forest Products Laboratory, Branch of Research, Forest Service, United States Department of Agriculture, Washington, D.C., June 1929, s. 5.

[3]Truax, T.R. "The Gluing of Wood", Department Bulletin No. 150, Forest Products Laboratory, Branch of Research, Forest Service, United States Department of Agriculture, Washington, D.C., June 1929, s. 5.

[4]Ibid.

[5]Schellmann N. C., "Animal glues: a review of their key properties relevant to conservation"Conservation, no. 8, 2007, s. 56.

Collagen-based adhesives have the unique ability to gel when cooled and repeatedly liquefy when reheated, even after very long periods of time[6]. Although these adhesives may swell when exposed to water and dissolve when heated, their properties are not significantly impaired unless modified by the addition of tannins, which make them more water-resistant[7].

Collagen, due to its three-dimensional structure and the presence of many functional groups susceptible to ionization and polarization, forms characteristic three-stranded spiral coils.[8]. The temperature at which collagen denatures varies and depends on its chemical structure and spatial. Collagen found in mammals has a higher denaturation temperature (approx. 40-41°C), while collagen obtained from deep-sea or cold-water fish (e.g. cod) denatures at temperature approx. 15°C[9].

2. The influence of moisture on the properties of glutin adhesives

Air humidity affects the physical properties of glutin adhesives. Glutin adhesives have the ability to absorb moisture from the air. Low moisture adhesive films are very brittle, regardless of the collagen source and molecular structure. Even with standard water content (12-14%), adhesive films crack easily under pressure[10]. Traditionally, honey was a common addition to glutinous adhesives to obtain flexible and elastic adhesive layers[11]. Sugars have hygroscopic properties, so they stabilize collagen molecules by creating additional hydrogen bonds[12]. A high fat content also affects the elasticity of the adhesive, but at the same time reduces the adhesive's gelling strength and final strength.

Higher water content or an excess of hygroscopic additives lowers the glass transition temperature of the adhesive, so low percentage adhesive often remains liquid despite the low temperature. At very high relative air humidity values (above 85%), the collagen in the adhesive is reorganized into spiral structures[13]. This leads to the formation of new hydrogen bonds, making the bond stronger again when the air humidity returns to lower values[14]. These properties of glutin adhesives can have both positive and negative effects on the object.

3. Raw material

Types of glutin adhesives depending on the raw material:

[6]Schellmann N. C., "Animal glues: a review of their key properties relevant to conservation"Conservation, no. 8, 2007, s. 56.

[7]Rivers, S., Umney N,. "Conservation of Furniture", Butterworths-Heinemann, Oxford/Auckland, 2003, s. 156-173.

[8]Schellmann, N.C., "Animal Glues – their adhesive properties, longevity and suggested use for repairing taxidermy specimens", s. 36.

[9]Ibid..

[10]Ibidem, s. 61.

[11]Ibidem, s. 36.

[12]Ibid.

[13]Ibidem, s. 62.

[14]Ibid.

- **Leather glues** are produced using mammalian hides, usually bovine hides. They typically have higher cohesive strength than bone adhesives, which results in lower tensile strength and greater brittleness.

- **Bone glues** are primarily prepared from the bones of freshly slaughtered animals. Some bone glues are made only from ossein, which is an organic intercellular substance found in bone tissue[15].

- **Skin-bone adhesives**

- **Gelatine** is a purified adhesive ingredient, which is pure collagen. It can be obtained from animal skin or bones. Pure gelatin is actually denatured collagen in its pure form. Glutin adhesives contain many impurities, which affects their color, making them yellow or brown[16]. Gelatin becomes stiffer and more brittle under the influence of time, UV radiation, changes in humidity and temperature.

- **Rabbit glue** it is made exclusively from rabbit skins[17]. It is characterized by high strength, but has a lower bond strength compared to other leather adhesives. This is due to the high fat content in the glue, the fat allows it to remain more stable conditions with variable humidity[18].

- **Fish glues are** made from fish skins and bones, primarily beluga, cod and sturgeon. They are available in liquid form. The complicated production process and specific raw material contribute to the high price of this product. They are characterized by high viscosity and elasticity[19]. IN compared toglues fish glues of mammalian origin show lower stiffness[20].

- **Karuk** is an adhesive made from the swim bladders of various fish species. It takes the form of completely dried blisters, thin plaques or strips. The isinglass production process involves extracting the swim bladder from the fish, placing it in hot water, cleaning it from veins and muscles and then drying[21]. Isinglass is a very pure, natural source of collagen. Research has shown that isinglass obtained from sturgeon retains its mechanical properties best under the influence of time, light, temperature and

[15]Kremer-Pigmente, "Bone glue (63000)", Safety Data Sheet, Technical Data, Germany (2020), available at: https://www.kremer-pigmente.com/elements/resources/products/files/63000_SDS.pdf , accessed: 10/02/2023.

[16]Schellmann, N. C., "Animal glues: a review of their key properties relevant to conservation", NatSCA News, Issue 16, 2009, s. 6.

[17]Kremer-Pigmente, Bone glue (63000), hide glue (63010–63020), rabbit skin glue (63025, 63028, 23052), gelatin (63040), isinglass (63100), salianski-isinglass 63110, fish glue (63550), Franklin Hyde Glue (63500–63512)", Safety Data Sheet, Technical Data, dostępne na: https://www.kremer-pigmente.com/en/, dostęp: 10.02.2023.

[18]Dorner M., "Malmaterial and its use inPicture", 18th ed., Enke Verlag, Stuttgart, 1994, p. 98.

[19]Kremer-Pigmente, Fish Glue (63550), 2019, available at:
https://www.kremer-pigmente.com/elements/resources/products/files/63550_SDS.pdf, accessed: 10/02/2023.

[20]Coerdt A., "To be used for sizing – studies on cold liquid glutin glues", Restauro 113, 2007,s. 191-197.

[21]Schellmann N.C., "Animal glues: a review of their key properties relevant to conservation", s. 63.

humidity changes compared to other glutin adhesives.[22]. Isinglass is also characterized by very little color and produces slightly yellow or whitish solutions[23].

4. Preparing the glue

Preparation of the glue begins by mixing it with water in the appropriate weight ratio. The glue should be immersed in cold water until it swells completely. Depending on the form of glue, its swelling time varies. Glue in the form of small particles will soften within several dozen minutes, glue in lumps will take several hours, and glue in the form of a block may swell for up to several hours[24].

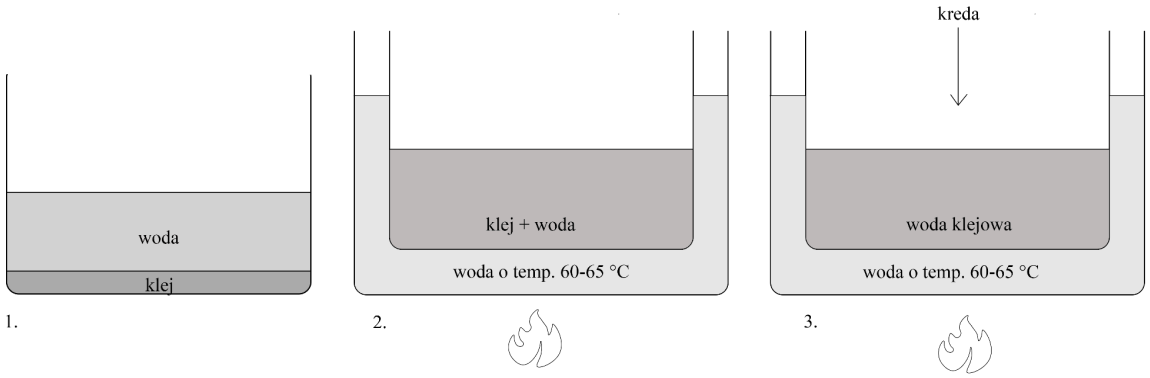

Fig. Diagram of a water bath. Drawing by Marta Hirschfeld.

[22]Schellmann N.C., "Animal glues: a review of their key properties relevant to conservation", s. 63.

[23]Ibid.

[24]Truax, T.R. "The Gluing of Wood", Department Bulletin No. 150, Forest Products Laboratory, Branch of Research, Forest Service, United States Department of Agriculture, Washington, D.C., June 1929, s. 10.

Photo Rabbit glue before and after swelling.

ADHESIVE WATER:

10% glutin glue: 1000 g of water + 100 g of glutin glue (rabbit or leather)
7% glutin glue: 1000 g of water + 70 g of glutin glue (rabbit or leather)

Soak the glue for a few hours so that it swells completely. Then dissolve in a water bath.
An important factor influencing the properties of the adhesive is the dissolution temperature. The optimal temperature is 60°C. However, avoid exceeding the temperature range of 60°C to 65°C. IN temperatures lower than 60°C there is a risk of microorganisms developing in the adhesive at a later time. In turn, temperatures higher than 65°C may lead to accelerated degradation of the adhesive due to

high temperature. Studies have shown that both high temperatures and prolonged heating, even at temperatures lower than 60°C, can significantly reduce the strength of animal glue[25].

Photo Rabbit glue after dissolving in a water bath.

The use of water baths is a common practice to gain greater control over the dissolution temperature of the adhesive. This process is performed by placing a vessel with swollen glue in a second container filled with water. Then the whole thing is slowly heated, thanks to which the temperature of the water bath can be more easily regulated, and the glue gradually dissolves in appropriate conditions. This method of heating the glue makes it easier to avoid accidentally exceeding the permissible temperatures. It is important to adjust the glue viscosity to the type glued surface. If the percentage of prepared adhesive is too low, the adhesive may penetrate too deep into the substrate, leaving the joint without the appropriate amount of adhesive. However, too high a percentage of glue may prevent proper penetration of the glued surfaces. Different types of glutin glues have different viscosities. The viscosity is also influenced by the method of preparing the glue. In order to obtain adhesive solutions with low viscosity, adhesives should not be diluted excessively high viscosity. In such situations, it is better to use a glue with a lower viscosity[26].

[25]Truax, T.R. "The Gluing of Wood", Department Bulletin No. 150, Forest Products Laboratory, Branch of Research, Forest Service, United States Department of Agriculture, Washington, D.C., June 1929, s. 10.

[26]Schellmann, N. C., "Animal glues: a review of their key properties relevant to conservation", NatSCA News, Issue 16, 2009, s. 60.

20%	
15%	
10%	
7%	
5%	
3%	
0%	

Tab. Presentation of the power of gluing linen canvas using rabbit glue with different percentages. The photographs were taken using a digital microscope.

Photo Skin glue.

Photo Rabbit glue.

Bibliography:

- Coerdt, A., "To be used for sizing – studies on cold liquid glutin glues", Restauro 113, 2007.
- Doerner, M., "Painting material and its use in pictures", 18th ed., Enke Verlag, Stuttgart, 1994, p. 98.
- Rivers, S., Umney, N., "Conservation of Furniture", Butterworths-Heinemann, Oxford/Auckland, 2003,.
- Schellmann, N.C., "Animal Glues – their adhesive properties, longevity and suggested use for repairing taxidermy specimens".
- Schellmann, N.C., "Animal glues: a review of their key properties relevant to conservation", Reviews in Conservation, no. 8, 2007.
- Truax, T.R. "The Gluing of Wood", Department Bulletin No. 150, Forest Products Laboratory, Branch of Research, Forest Service, United States Department of Agriculture, Washington, D.C., June 1929.

Websites:

- Kremer-Pigmente, Bone glue (63000), hide glue (63010–63020), rabbit skin glue (63025, 63028, 23052), gelatin (63040), isinglass (63100), salianski-isinglass 63110, fish glue (63550), Franklin Hyde Glue (63500–63512)", Safety Data Sheet, Technical Data, dostępne na: https://www.kremer-pigmente.com/en/, dostęp: 10.02.2023.
- Kremer-Pigmente, "Bone glue (63000)", Safety Data Sheet, Technical Data, Germany (2020), available at: https://www.kremer-pigmente.com/elements/resources/products/files/63000_SDS.pdf , accessed: 10/02/2023.
- Kremer-Pigmente, Fish Glue (63550), 2019, available at: https://www.kremer-pigmente.com/elements/resources/products/files/63550_SDS.pdf, accessed: 10/02/2023.