Basic Knowledge about Animal Glue

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for animal glues/
Animal glue today and tomorrow

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Fig.1 Various animal glues

- Industrial animal glues (洋膠/yo-nikawa/yo-ko): **a**. Banshu Pellet Nikawa 播州粒膠 (Terawaki Sangyo Co., etc. 寺脇産業㈱ 他); **b**. Nanjin Shika Nikawa 軟靭鹿膠 (Tsumaya Nikawa Laboratory, Inc. 妻屋膠研究所㈱); **c**. Pearl Nikawa Daio パール膠大王 (Sun-Oriento Chemicals, Inc. サンオリエント化学㈱; no longer produced); **d**. Ita Nikawa Tengu板膠天狗 (*Ibid*)
- Domestic animal glues (和廖/wa-nikawa/wa-ko): e. Sanzenbon Nikawa 三千本膠 (Seikei Shoten 清惠商店; no longer produced); f. Kyojo Nikawa 京上膠 (Ibid); g. Sanzenbon Nikawa Asuka 三千本膠飛鳥 (Asahi Gelatine Industrial Co., Ltd 旭陽化学工業㈱)
- Classical animal glues (古典的廖/koten-teki nikawa): h. Shaved Raw Cattle Hide Animal Glue, Third Extraction by Soft Water 牛剃毛生皮軟水三番抽出廖 (General Incorporated Foundations, World Paper Heritage Support Foundation KAMIMORI 财世界紙文化遺產支援財団紙守); i. Gyuhi Wako Aoi t Foundation KAMIMORI 时间,以下野山文化遗产研究所(他);j. Deer Hide Animal Glue, First Extraction鹿皮廖一番抽出(Ibid)
- Prototypes by UDAKA Kentaro (classical animal glues): k. Shaved raw deer hide animal glue, first extraction by hard water; l. Carp scale animal glue, first extraction by soft water; m. Deer antler animal glue, second extraction by soft water



What is animal glue?

Animal glue (/ nikawa) is traditional material produced from animal hide, bones or other materials. It has been used widely from ancient days in the creation of art, calligraphic work and craftwork as well as in conservation. Its main constituent is gelatin (polypeptide, straight-chain polymer formed from amino acids). Other ingredients include fats, salts and minute amounts of other impurities. In the production of Japanese-style paintings, animal glue is first used as a dispersant (surfactant) when dispersing pigments in water. Then, as drying and lowering of temperature progress, intermolecular hydrogen bonding progresses until animal glue hardens into a gel form (gelation) and holds pigment particles to the support (base). Finally,

after animal glue has dried, it functions as an <u>adhesive</u> to fix pigments to the support. The fluidity, rigidity, and flexibility of animal glue greatly influence workability and the stability of the paint layer after completion of the artwork (decreasing pigment flaking as well as increasing water-resistance).

In Edo period (1603-1867) Japan, production of leather and that of animal glue were undertaken by people of special villages. As a result, few referential documents remain and, even though animal glue has always been an extremely important material, knowledge concerning its production has not been correctly made known to the general public for a long time.

Raw materials of and production methods for animal glues

1. Raw materials

Various raw materials are used to produce animal glues, including animal hide, bones, antlers and fish scales¹⁻¹⁰⁾. In this leaflet the most common type of animal glue, that produced from animal hide, will be introduced. In order to produce high quality animal glue, it is necessary to epilate the hide before extraction^{1-4,11)}. There are many contaminants such as dirt and dung attached to animal hair and the surface of the hide. Thus, if animal glue is extracted from

hide with hair remaining, the product will contain a great amount of impurities. To epilate, the hide may be soaked in natural river water or treated with lime, etc. (either to pull out or dissolve hair) or physically shaved 1-4,6,7,12-14). Today, to economize and preserve resources, pieces of epilated hide produced in the process of leather production or scraps of tanned leather are commonly used as raw material for animal glue 10,15).

Table 1 shows the outline of the typical processes

involved in the technique of leather production today and in the pre-modern period (pre-1868). Of the classical techniques of producing leather employed in the pre-modern period, that of vegetable-tanning is comparatively widely used even now. However, it seems that the processes of epilation and deliming are the same as those used in the production of chrome-tanned leather since the modern period (about 1868 to 1945) to the present. Today cattle hide is usually preserved in salt by hide distributors immediately after cattle have been slaughtered and decorticated. Then it is delivered to tanners, desalinated with water (antibacterial agents and degreasing agent are added as necessary), fleshed to remove subcutaneous fat and pieces of flesh, epilated, and in some cases tanned and/or dried. After these processes, parts of hide that would not be used for leather products are delivered to animal glue producers to be used as raw material for animal glue. In this way, there is a close connection between animal glue and the leather, meat, livestock, and hunting industries.

Common raw materials for animal glue today are: 3 for industrial animal glue, 1 and 2 for domestic animal glue^{10,15)} (cf. Table 1). On the other hand, raw materials such as 4, 5 and 6 are thought to have been commonly used as raw materials for classical animal glue in the pre-modern period 1-7,12-14) while materials such as 7 were more commonly used in the West 12,17).

2. Production methods

In present-day Japan, animal glues are classified into industrial animal glue (洋膠/yo-nikawa/yo-ko) and domestic animal glue(和膠/wa-nikawa/wa-ko). Production methods for industrial animal glue using modern techniques like decompressing-concentration were introduced to Japan in the early Taisho period (1912-1926), and chrome-tanned leather chips (Table 1 3) began to be used as a raw material from the early Showa period (1926-1989)^{10,15)}. On the other hand, from about this time, products made primarily by heating-concentration from untanned, epilated hide began to be called "wa-nikawa" or "wa-ko". Included among these are Sanzenbon Nikawa(三千本膠)10). For epilating and treating the raw material before extraction, modern methods introduced from the West using lime and sulfur-containing compounds^{10,12,13)} became common (Table 1 1), 2). After extraction, de-foaming agents, preservatives, and bleach were added as necessary. This type of animal glue differs greatly from classical animal glue in both raw materials and production methods. As with Japanese-style painting (日本画 / nihonga) domestic animal glue and its terminology are actually new, having been created since the modern period. Thus, domestic animal glue should be clearly distinguished from classical animal glue of the pre-modern period.

The representative raw material of classical animal glue is hide that has been shaved or epilated by washing it in

Table 1 Typical methods for leather production today and in the pre-modern period in Japan 10,12-14,16)

Most common method for leather production today use Chrome tanning (introduced since the end of the Meiji period [1868-1912]) 1. Wash rawhide in water with antibacterial agent and degreasing agent added. 2. Epilate by lime, sodium sulfide, and sodium hydrosulfide. Classical methods for leather production in the pre-modern period used Japanese white tanning (existed from before the Heian period [794-1185] but declined since the modern period) 2. Tan by extensive rubbing with a small amount of rapeseed oil and sodium chloride. · · · · · · (5) Brain fluid tanning (existed from before the Heian period but declined since the modern period) 2. Remove grain. 3. Soak in brain fluid that has been kept for a long time and thus has fermented; then tan by rubbing. Vegetable tanning (classical method in the West; introduced into Japan after the beginning of the Meiji period) 1. Epilate rawhide by extended soaking in lime. 3. Tan by extended soaking in vegetable-based tannin solution.

^{*}These are representative methods. A combination of methods may be used in some cases.

river water 1-7,12-14) (Table 1 (4), (5), (6)), and documents suggest that light-colored animal glue were produced without using chemical additives^{6,7,18,19)}. In addition, judging from the condition of extant cultural properties, it is thought that these products were also outstandingly stable. Table 2 shows the classification of animal glue and an outline of the general processes of their production.

In the past, it was said that treatment with lime and sulfuric acid was very important for the production of high quality animal glue^{14,15,20,21)}. However, results of recent studies show that it is possible to produce light-colored, flexible animal glue having diverse characteristics by classical methods without the use of lime or other chemical additives^{1-5,22-25)}. In these studies, various types of classical animal glue have been approximately reproduced by employing processes (4), (5) and (6) of Table 1 or by using raw materials like deer antlers and carp scales (cf. Fig.1).

Temperature and time necessary to extract animal glue depends largely on the preparatory treatment of the raw materials¹⁻⁵⁾. When hide has been epilated by washing it in natural river water or by using lime, extraction is possible at comparatively low temperature and in a short time, but if extraction is done with hide that has been shaved or by using a bone-type raw material, a greater amount of heat is required. Moreover, since properties of animal glues depend on the combination of raw materials, method of pre-treatment and conditions of extraction, it is possible to produce animal glue of one's desire by adjusting these factors. For example, there is a correlation between the viscosity of animal glue and molecular weight; this is strongly influenced by the method of epilation of the rawhide and the temperature and duration of extraction^{1-3,23,25)}. Harder the water in which animal glue is extracted, slightly lower its viscosity will tend to be and less oil and fat content it will have, resulting in a more translucent and lustrous glue1-3,22). Gel-strength of animal glue has strong negative correlation with the temperature and duration of heat treatment and may be related to the functional side chains and electric charge tendency of gelatin molecules in the animal glue^{1-4,23,25)}. The melting point and gelating point of animal glue are said to be related to both viscosity and gel-strength. Furthermore, surface-tension, which may be related with workability and how it fits with the base material, is in negative correlation with the temperature and duration of heat treatment at the time of extraction and is also influenced by the method of epilation of the raw material^{2,3,24)}.

Animal glue today and tomorrow

The production of Sanzenbon Nikawa (Fig.1 e), which had been most widely used until recently in Japanese-style painting²⁶⁾, has been terminated with the last production having been in fiscal year 2009. Many artists of Japanese-style painting experienced a great sense of crisis in securing materials necessary for their work. Even a feeling that the existence of Japanese-style painting itself was endangered pervaded among some, and there were cases in which they vied to buy what was available at retail shops and wholesale dealers. From then until now, various products have been sold and the use of substitutes employing industrial animal glues and synthetic resins has been attempted. However, it is clear that unless we, the users ourselves, know correctly what animal glue is and what its actual situation is and embark on a fundamental measure to ensure its continuation on a long term, similar crisis will arise if one of the remaining producers decide to terminate production.

Producers of animal glue have, until now, appeared and disappeared with time, and the same is expected to occur in the future. Nevertheless, as long as we can share systematic information, production of animal glue having the same properties that it has today even one thousand years from now should be possible as long as animals like cattle and deer do not become extinct.

Today, not only animal glue but also various other traditional materials that support Japanese-style painting and craftwork, such as paper, silk, brushes and some coloring materials, are at risk either of their quality decreasing or of their disappearing all together. It is time for users of animal glue and educators who speak about it or are involved in some traditional art to assume the responsibility of preserving and disseminating information about animal glue as common knowledge rather than leaving it all to the producers.

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Animal glue is indispensable material for those involved in some traditional art or craftwork. However, it is hard to say that its actual substance has been well known until now. This leaflet summarizes the knowledge about animal glue based on recent studies. The authors hope that it will help various activities of the readers and the continuance of traditional culture.

Table 2 Classification and an outline of industrial, domestic and classical animal glue^{1-7,10,14,15)}

Table 2 Classification	
Indus anima (洋膠/yo-nik	l glue
Dome anima ^{(和膠/wa-nik}	l glue
Class anima (古典的膠/koter	l glue

... Introduced in the modern period.

Production Chrome-tanned leather or others (Table 1 ③) → Liming → Pickling (de-chroming) → Adding lime → Extracting in hot water → Advanced filtration → Decompressing-concentration → Gelating → Cutting → Drying (de-foaming agent and preservatives generally added)

: Chrome-tanned leather chips are used as raw materials; animal glue is extracted as a result of liming and de-chroming treatment by sulfuric acid. The finished product is generally lightcolored and clear because of advanced filtration. Low in cost; not much difference in quality from lot to lot; mostly for industrial use.

In Japan industrial animal glue is called *yo-nikawa* or *yo-ko*; literally, these terms mean 'westernized animal glue', since it is produced by modern western (European) method.

(Product examples in Japan: Banshu Pellet Nikawa 播州粒膠 (Terawaki Sangyo Co., etc. 寺脇産業㈱他); Nanjin Shika Nikawa 軟靭鹿膠 (Tsumaya Nikawa Laboratory, Inc. 妻屋膠研究所㈱); Pearl Nikawa Daio パール膠大王 (Sun-Oriento Chemicals, Inc. サンオリエント化学㈱; no longer produced); Ita Nikawa Tengu 板膠天狗 (Ibid))

... Derived in the modern period as an eclectic product of industrial and classical animal glues.

Production Hide epilated by using lime (Table 1 ①, ②) → Liming → Adding sulfuric acid → Extracting in hot water → Heating-concentration → Optional filtering → Gelating → Cutting → Drying (defoaming agent and preservatives generally added)

Features : Raw material is epilated by liming; animal glue is extracted after soaking the hide in lime. Generally, the finished product is brown and non-translucent to semi-translucent and somewhat fatty. Because an eclectic method between industrial and classical animal glue is used for its production, this type of animal glue is comparatively low in cost and has been used widely in the production of modern Japanese-style painting.

> In Japan domestic animal glue is called wa-nikawa or wa-ko; literally, these terms mean 'Japanese animal glue'. Until recently, it was often inaccurately thought of as a classical material

(Product examples in Japan: Sanzenbon Nikawa 三千本髎 (Seikei Shoten 清恵商店; no longer produced); Kyojo Nikawa 京上髎 (*Ibid*); Sanzenbon Nikawa Asuka 三千本膠飛鳥 (Asahi Gelatine Industrial Co., Ltd 加陽化学工業級))

... Existed in the pre-modern period but declined afterward; sometimes included in the category of domestic animal glue in the broad sense of the word but there is a great difference between the two in reality.

Production . Hide that has been shaved or epilated by washing it in a river, or other materials (Table 1 4), 5, (6) → Extracting in hot water → Optional heating-concentration → Filtering in some case → Gelating → Cutting → Drying

Features : Hide that has been shaved or epilated by washing it in natural river water is used as raw material and animal glue is extracted without the use of chemical additives. In the past, there were light-colored and flexible products. Because much of the work, including the treatment of raw materials, is done by hand, it is high in cost. Since the modern period, cases of product circulation have not been known until quite recently.

In Europe it was often produced from hide epilated by lime even in the pre-modern period. However, the recent lime-epilating method has generally quite changed since the modern period.

(Product examples in Japan: Shaved Raw Cattle Hide Animal Glues 牛剃毛生皮膠 (General Incorporated Foundations. World Paper Heritage Support . Foundation KAMIMORI 劇世界紙文化遺産支援財団紙守);Shaved Raw Deer Hide Animal Glues 鹿剃毛生皮膠(*lbid*);Gyuhi Wako Aoi 牛皮和膠葵 (Amanosan Cultural Heritages Research Institute, etc. (社)天野山文化遺産研究所 他))

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^{*}This is the general outline of each class of animal glue in Japan. There are cases in which part of the process may be different, as when an eclectic method is taken or some features are not fulfilled

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