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Introduction

In traditional Japanese mounting, several different methods are used for drying following processes that use water, such as cleaning, pasting and lining. An appropriate method is selected depending on the aims of the treatment and the materials involved. The *karibari* technique, which is a method of drying with restraint, is also used for conditioning objects for the purpose of achieving flatness and greater stability after conservation.

We sometimes receive questions concerning *karibari*, such as 'How is *karibari* made?', 'How is *karibari* maintained?', 'Where can I buy *karibari*?', 'What does the brown colour of *karibari* come from?' and so on. Workshops and training courses on the conservation-restoration of *washi* have been held, one of which is ICCROM's JPC that has been taking place for more than 20 years. We sometimes receive requests, asking why we do not hold *karibari* workshops on these courses. This has led us to ponder on the level of interest in *karibari* among Western conservators.

Even in Japan, some people see *karibari* as a custom, or as one of the traditional processes of Japanese mounting. But we know that sometimes 'tradition' involves risk. Even though a method itself is traditional, materials and environment may change day by day. Furthermore, we must consider the risk when *karibari* is used for cultural objects other than East Asian paper or silk, because this technique started in China and has been modified as a drying or conditioning technique during mounting and restoration for East Asian paintings and calligraphic works.

In this paper, we will discuss two aspects of *karibari*: first, the function and characteristics of *karibari*, and, secondly, conditions such as temperature, humidity and duration of treatment for *karibari*.

1 What is *karibari*?

Karibari is a term in the field of Japanese traditional mounting, called *hyōgu*, *hyoso* or *soko* (these three words have almost same meaning in dictionaries). *Karibari* means pasting temporarily. There are several drying or conditioning techniques used in Japanese traditional mounting; *karibari* is one of them, and is a method that utilises restraint. It gives tension to an object during drying and conditioning to achieve a flat and stable result. It is carried out several times after processes using water such as cleaning, pasting, lining and flattening during restoring and mounting. Sometimes, the panel or board used for *karibari* has been also called *karibari*. However, in this paper, *karibari* is used only for the technique, in order to distinguish it from the panel or board to which objects are pasted.

Karibari originally came from China to Japan. In China, they paste objects on walls for *karibari*; ancient Japanese mounters and restorers probably tried to do the same as the Chinese masters did when the technique was introduced to Japan. But there was one big problem: traditional Japanese architecture has few walls, and Japanese mounters could not find enough walls to use for *karibari* in their buildings. Instead of walls, we can instead find many *fusuma*, or sliding doors, in Japanese traditional architecture and it is conceivable that the mounters decided to use those sliding doors for

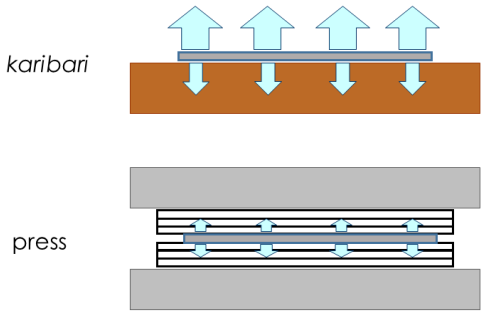

Fig. 1 Illustration of migration of water during drying. Light blue arrows mean water migration. Their sizes indicate speed of drying.

karibari and in fact, *fusuma* and *karibari-ita* (*ita* means a panel or board) have similar structures. Panels are made by pasting many sheets of paper on a wooden frame with a wooden lattice. *Karakami* (decorated paper) is applied to the surfaces of a panel for a sliding door, while paper coated by *kakishibu* (fermented persimmon juice) is applied to that of a *karibari*-panel. Paper coated with fermented persimmon juice has a similar function to Gore-Tex®, water vapour can pass through the sheet but liquid water is repelled from the surface of the sheet. At the same time, the coating of fermented persimmon juice reinforces the paper surfaces of the *karibari*-panel. These characteristics make it possible to paste something on to a *karibari*-panel using starch paste and later remove it.

Function and characteristics

1 Drying speed

In this section, two drying methods: *karibari* and press drying, both of which employ restraint, are compared (Fig. 1).

During *karibari*, one side of an object is exposed to air and the other faces the *karibari*-panel. The surface of the *karibari*-panel is composed of paper layers coated by fermented persimmon juice, through which air can pass. Water can therefore evaporate from both sides of an object during *karibari* because the surface of the *karibari*-panel acts like Gore-Tex®, as mentioned above.

Alternatively, an object is sandwiched between paper sheets and/or felt during press-drying. Water in the object transfers onto the paper/felt gradually.

Therefore, we can dry the object more rapidly by *karibari* than by press-drying. Of course, this rapid-dry characteristic can cause some problems. Rapid drying means rapid increase in tension and may cause damage to the paper. The restorer has to consider the property of the object and the methodology. During *karibari*, the restorer has to carefully observe the object on the *karibari*-panel, either directly or through a thin paper cover placed over the *karibari*-panel.

2 Distortion after restoration

Between *karibari* and press-drying, the areas of the object placed under restraint are different. With *karibari*, only the edges of an object are fastened by pasting to the panel. During press-drying, the whole area of an object is held under tension by the press. Figures 2 and 3 demonstrate this; the orange material area is different from that of the green area in the figure, showing that the orange material shrinks more than the green material when they are dried.

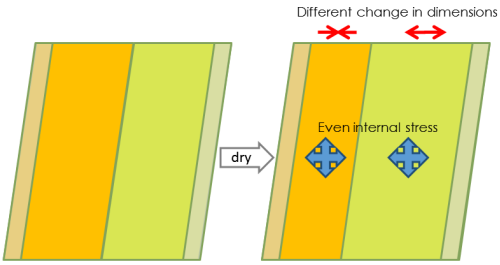

Fig. 2 Dimensional change (red arrows) and internal stress (blue cross arrows) during karibari.

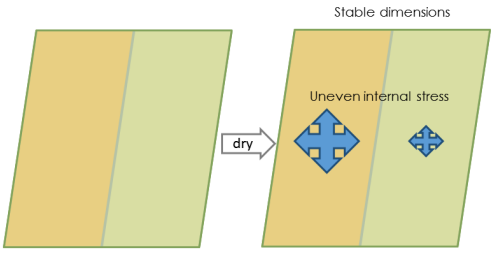

Fig. 3 Dimensional change and internal stress (blue cross arrows) during press-drying. Ideally, there is no dimensional change in this method.

In this model, two sides are fixed to the *karibari*-panel (Fig. 2). When this sample is dried, the orange part shrinks and the green part expands; the total length cannot change, but the length of each part can. However, stored power, called internal stress, is even in both areas.

With press-drying, the whole sample is fixed (Fig. 3). So, when the sample is dried, ideally, both the orange and green parts keep their dimensions. However, the internal stress in the orange part is stronger than that in the green part.

Cross-sections of models are shown in Figure 4. The models consist of three parts, these are lined models of Figures 2 and 3. With *karibari*, the internal stress is the same in every part. When the stress is released by moisture, every part expands similarly. With press-drying, however, stored internal stress is different in each part. When the model is re-moistened and relaxed, each part expands at its own rate. As the results show, in this model, the right side of model goes up, and the left side goes down.

In Japanese artworks which are mounted as *kakejiku*, hanging scrolls, various *washi* and silks are assembled in one hanging scroll. Both *washi* and silk shrink considerably and the rate or strength of change differs in

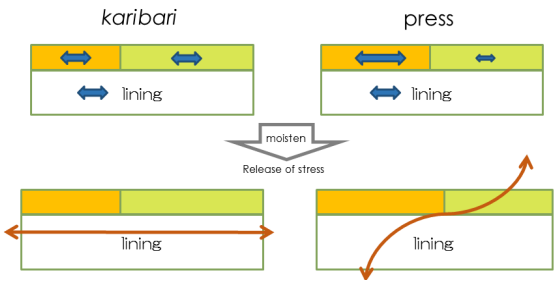

Fig. 4 Influences of dimensional change of each part after moistening of assembled and lined objects. Blue arrows mean internal stress, and their size shows the strength of the stress. Brown arrows show the direction of change in formation.

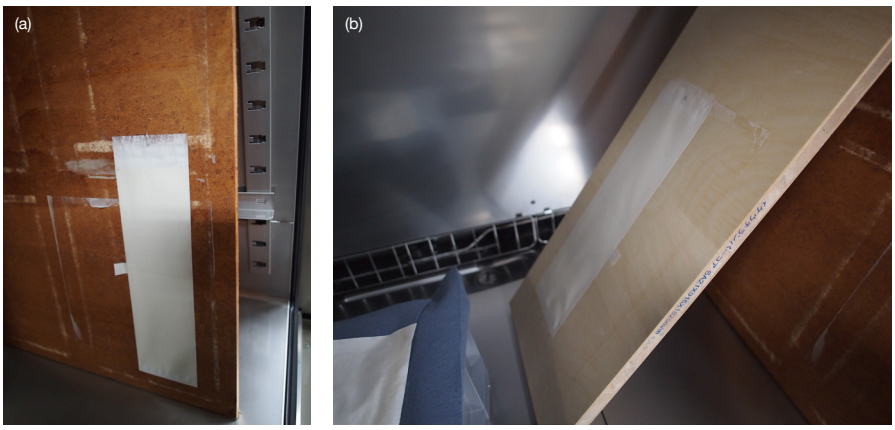

Fig. 5 Photographs of samples, silk lined with paper, under *karibari* on (a) *karibari*-panel and (b) wood-panel.

each material, so distortion caused by those differences appears very easily. But we can solve this problem by using *karibari*. *Karibari* works very well, especially for Japanese mounted objects which consist of several layers and varying ages of parts, with various papers and silks, such as a hanging scroll.

At the same time, it is easy to imagine that the difference in dimensional changes could cause cockling at the interface between different materials. In fact, restorers of Japanese paintings make adjustments when they assemble each part of a scroll in order to avoid such cockling; each part has to be pasted with moderate leeway to allow for shrinkage. This technique requires much experience and great skill. That is the one of reasons why more than 10 years' training is required to become a Japanese traditional restorer.

3 Panel and board for *karibari*

Karibari on a wooden panel and on a *karibari*-panel are compared.

The pictures in Figure 5 (a and b) are taken in the same chamber, with high humidity. Both samples consist of silk as a painting support, with four sheets of paper lining. The sample on the wooden panel was loosened by more moistening than the *karibari*-panel.

The plane of the *karibari*-panel where an object is fixed to paper with a persimmon juice coating is flexible to some extent. When objects which have been wetted through pasting or cleaning are attached to the *karibari*-panel, the plane of the *karibari*-panel immediately expands in response to this moisture. During *karibari*, the plane dries and shrinks as the objects dries and shrinks. As a result, tension is naturally and gently adjusted. As mentioned in the section 'Drying speed', drying by *karibari* is so rapid that it may cause breakage of paper. But this flexibility with the use of water eases the risk.

In Japan, wooden panels are also used for *karibari*, especially when one wants to touch the surface of the work, for example, inpainting on infills, during *karibari*, the flexibility of a *karibari*-panel is not appropriate to those works. In our laboratory, we use plywood or wooden panels. The surface wood is Japanese linden (*Tilia japonica*), Lawson cypress (*Chamaecyparis lawsoniana*) and spruce (*Picea engelmanni*, *Picea glauca*, *Picea sitchensis*). However, it is not the species of wood that is important for *karibari*, but the smoothness of the surface, without resin and without acidic materials.

Conditions for *karibari*

As we know, unchanging environmental conditions, that is stable temperature and humidity, are needed for preserving works of art of any material. Recently, restoration studios have been equipped with air-conditioning systems for 24 hours a day, 7 days a week. However, although air-conditioning has been introduced of late for preserving cultural properties, traditional restoration/mounting has been practiced under unstable conditions for hundreds of years in Japan. And Japan has preserved many paper cultural properties for hundreds of years. Thus, unstable conditions during restoration do not seem to have such a bad influence on the results of restoration.

Karibari is a traditional technique and has been developed under unstable environmental conditions in Japan. For example, in Tokyo, the climate fluctuates from below 0° C and less than 30% relative humidity in winter, up to about 35° C and about 100% relative humidity in summer. Of course, that is the climate outside; inside, in the restoration studio, it is milder. As well as differences over the year, there are differences of conditions during the day. As mentioned in the introduction, the *karibari* technique itself is traditional but the conditions under which it is carried out have changed considerably. Actually, some Japanese restorers feel the artworks mounted under stable conditions may be spoiled.

Therefore, we must compare the properties of artworks after restoration with *karibari* under stable and unstable conditions.

1 Preparation of samples

Silk was lined with four sheets of Japanese paper, *mino* paper,[1] *misu* paper[2] and *uda* paper[3] using starch paste and *furunori*, aged paste, a standard Japanese mounting technique. Then, the sample was dried and conditioned on a *karibari*-panel at 23° C and 50% relative humidity for more than one month. The samples were fixed to the panel by pasting the edges as usual. After conditioning, the sample was cut and divided into two pieces. Both were fixed on *karibari* panels once more. Then each sample was subjected to different experiences. One was left under stable conditions, 23° C and 50% relative humidity (sample A). Another was put in the climate control apparatus with changing conditions (sample B). Conditions were as follows: a) 23° C and 50% relative humidity, b) 10° C and 30% relative humidity, and c) 35° C and 95% relative humidity. Conditions were changed in the following sequence: a–b–c–b–c–b–c–b–c–a. It took two days to move from one state to another state, according to the previous report[4] which showed that it requires about two days for paper sheets laminated using starch paste to reach an equilibrium of weight. A temperature of 10° C and 30% relative humidity represented the average conditions of winter in Japan, and 35° C and 95% relative humidity represented those of summer. After conditioning, any change in sample weight was recorded, with exposure to high humidity, 23° C and 80% relative humidity.

2 Results and discussion

Figure 6 shows the change in the sample weight over time when samples were exposed to high humidity (23° C and 80% relative humidity). Changes in weight are represented as ratio of weight/initial weight. If the weight does not change, the ratio is 1. So, the value for each sample starts from 1.

Small fluctuations in weight may be due to wind in the chamber from the climate-control system. To keep temperature and humidity stable and even everywhere in the chamber, air is always circulated.

The weight of sample A changed more drastically in a few hours than that of sample B. After drastic change, the slope for sample A was steeper than

1 *Mino* paper is made from *kōzo* fibre only.

2 *Misu* paper is made from *kōzo* fibre with *gofun* (calcium carbonate) as a filler.

3 *Uda* paper is made from *kōzo* fibre with *hakudo* as a filler. *Hakudo* is the term traditionally used by the manufacturer of *uda* paper to describe the white soil used as a filler. The general translation of *hakudo* is 'white clay' which has led some to assume it is a clay such as kaolin, when fact *hakudo* used for *uda* paper is limestone. See: Hisao Mabuchi, 'Elementary analysis of Japanese hand-made paper by radioactivation', in *Conservation Science in 'HYOGU'*, ed. Kyotaro Nishikawa (Tokyo: Tokyo National Research Institute of Cultural Properties, 1977), 73–79.

4 Masato Kato, Takayuki Kimishima, Ryoji Sakai and Wataru Kawanobe, 'Characteristics of Triaxial Woven Fabrics Laminated with Paper and Used for the Lining of Paper or Silk Cultural Properties', *Science for Conservation* 50 (2011): 83–90.

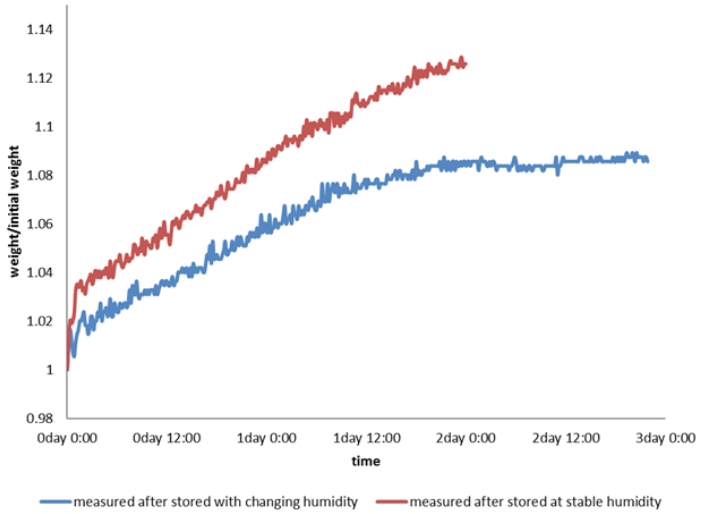

Fig. 6 Influences of conditions during *karibari* on changes in weight of samples which are exposed to high humidity (23 °C and 80% relative humidity).

sample B. These results indicate that sample A absorbed more water per unit of time than sample B. Finally, saturation weight of sample A was higher than that of sample B.

Uesaka showed that the expansion of a single sheet of paper at first humidification after manufacture is higher than after subsequent humidification because internal stress introduced during manufacture was released at the first humidification.[5] He also reported on the relationships between paper and water content. The change of dimensions of paper sheets has a close relationship with water content. More water content means greater change.

In this study, it was shown that silk lined with paper using starch paste behaved similarly to a single sheet of paper in terms of change of weight, which is caused by absorption of water. So, the objects have a higher possibility of distortion occurring at the first increase in humidity after drying and conditioning under stable conditions than they do after drying and conditioning under changing conditions.

In Japan, some Buddhist paintings are still present in temples which are of traditional architecture with low airtightness. Of course, in these cases, stability after restoration under unstable conditions is very important. However, even if the artworks are owned by a museum, it is impossible to escape from a change of conditions entirely. In any case, the higher stability a mounted artwork has, the better it is for preserving the artwork.

Summary and modern modification in Japan

As discussed, *karibari* originated in China and has been modified in Japan. The techniques are optimized for Japanese artworks and Japanese environmental conditions. *Karibari* has been carried out during restoration for artworks in the Japanese climate. Japanese paintings and calligraphic artworks are produced on silk or Japanese paper. Those are stronger than Western papers made from wood pulp. When one tries to apply *karibari* to artworks other than Japanese or East Asian, some modification is needed. Even in Japan, we have recently modified *karibari* techniques.

5 Tetsu Uesaka, 'General formula for hygroexpansivity of paper', *Journal of Material Science* 29 (1994): 2373–2377.

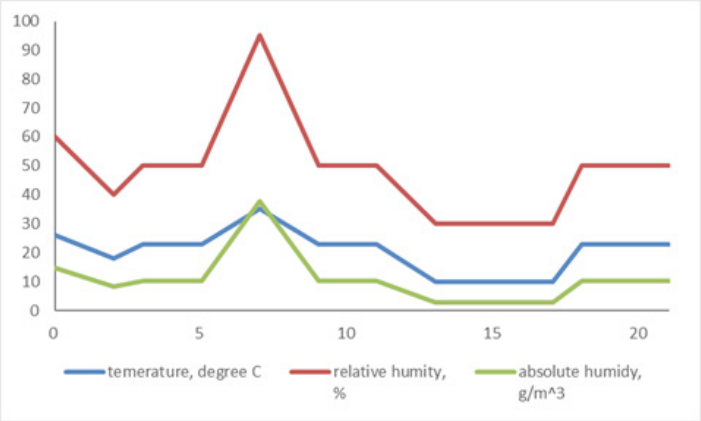

Fig. 7 Schedule of conditions during *karibari*.

1 Controlling conditions during *karibari*

When Japanese restorers need to achieve higher stability in mounted artworks, *karibari* is carried out for as long as possible. However, it has been shown that *karibari* carried out under changing conditions can achieve a higher stability for mounted artworks than under constant conditions. Recently, we executed *karibari* in a climate-controlled system with changing humidity and temperature, especially useful for artworks that have to be transported abroad after restoration. There is a possibility that these objects will experience climate change during and after transportation. We programmed the schedule of conditions during *karibari* as shown in Figure 7. In this case, the object could experience a hot, highly humid summer day and a cold, dry winter day over the course of three weeks.

2 Control of drying speed and tension

As is already known, Japanese restorers carry out *karibari* on artworks placed both face down and face up. However, because an artwork is dried from both sides during *karibari*, the drying speed is different for each side. Therefore, restorers adjust the speed and extent of drying by changing the face of a *karibari*-panel. It is also possible to slow down drying speed by covering the surface of artworks with paper or other sheets during *karibari*.

When we carry out *karibari* on very weak and fragile artworks, we paste only the covering paper such as rayon to the *karibari*-panel (Fig. 8). By this method, artworks can be conditioned and flattened very gently, because tension as well as drying speed is reduced.

Finally, we would appreciate it if readers would report on how they apply *karibari* in their conservation laboratory, or how they have modified *karibari* for their situation. It can provide clues for the Japanese restorer, too.

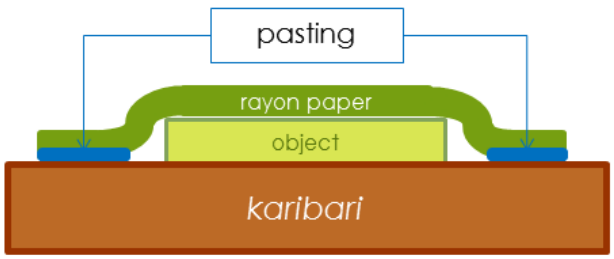

Fig. 8 Gentle *karibari* for a weak and fragile object.

Abstract
In traditional Japanese mounting, several different methods are used for drying following processes that use water, such as cleaning, pasting and lining. An appropriate method is selected, depending on the aims of the treatment and the materials involved. Recently, some Western conservators have used the *karibari* technique, but few papers on how to make the *karibari*-panel discuss the efficiencies of *karibari* and its mechanisms. This paper describes the behaviour of samples lined with *washi* using wheat-starch paste during drying on a *karibari*-panel.

Biographies
Masato Kato has been Head of the Resource and Systems Research Section at the Japan Center for International Cooperation in Conservation, Tokyo National Research Institute for Cultural Properties, National Institutes for Cultural Heritage since 2011, where he promotes the exchange of experience, techniques and materials for conservation between Japan and other countries through workshops and training courses. He gained his PhD in Agriculture from the University of Tokyo in 2001, with the thesis: 'Mechanism of Interaction between Aluminium Compounds and Cellulosic Materials'. He was a Research Fellow, first at the University of Tokyo and later at Ryukoku University, Kyoto from 2000 until 2004. He then joined the National Research Institute for Cultural Properties, Tokyo as a researcher. He is engaged in the study of restoration techniques and materials, mainly for paper cultural properties in Japan but also in overseas collections. He has worked with Japanese conservators, especially Japanese traditional mounting specialists. He has been in charge of the International Course on Conservation of Japanese Paper (JPC) since 2004, co-hosting with ICCROM.
Takayuki Kimishima has been Executive Director and Senior Conservator at Shugo Co., Ltd. since 2013. He joined Oka Bokkodo Co. Ltd. as a Conservator in 1986, becoming Director of Conservation in 2004. From 2007-2011 he was the Director of Conservation Technique and Senior Conservator at Sakata Bokuudo Co. Ltd. before joining Shugo Co. Ltd. as Senior Conservator and Managing Director in 2011.

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