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手工紙之製造

Preparation of Handmade Paper

行政院農業委員會林業試驗所 發行

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造紙術是我國偉大的發明之一，對文化傳播及促進人類文明的進步與發展有著極大的貢獻，對知識傳遞、文化傳承及性靈陶冶有其重要的意義。

時至今日，因科技進步，人類多使用機器紙，加上市場競爭，使得前述傳統技藝生存不易並逐漸式微中。因此民間願投入研究者幾希；但也由於其量少、質精且多樣化，增加其研究及發展空間。林業試驗所為國內林業相關研究之專責機關，責無旁貸的投入相關研究工作，相繼於民國 73 年及 96 年成立手工造紙實驗室及紙質文物維護實驗室，致力於手工紙及書畫文物保存等相關主題之研究，使這些看似沒落的傳統產業得以重新展現其在時代演進潮流中可扮演的角色及歷史新意，並開創承先啟後之功。

本手冊謹就手工紙製作過程相關知識闡述說明，圖文並重，以期各界對此固有之傳統技藝有更深廣之認識。

林業試驗所所長

黃裕星 謹識

Preface

The art of papermaking was a great invention of the Chinese. It has profoundly contributed to the spread of culture and advancement of human civilization and development. The art of papermaking has great significance in the passing on of knowledge, cultural instilment, and sustenance of our spiritual lives.

At present, the advancement of science and technology has shifted paper use toward machine-made materials. Coupled with the disadvantages of labor intensiveness and poor market competitiveness, the traditional art is in a bind and gradually declining. As a consequence, very little interest has been shown by the private sector for researching such arts. However, the rareness, purer stock, and diversity also presented an expanding horizon for research and development. In 1984 and 2007, the Taiwan Forestry Research Institute (TFRI) respectively established handmade paper and restoration of paper-based cultural relics laboratories. The labs endeavor to work on the creation and revamping of the art of handmade papers and preservation of artwork based on these papers. The TFRI is the only domestic organization with a forestry-related research mission, and it is our solemn duty to endeavor to conduct pertinent research in a bid to infuse new life into seemingly fading traditional crafts and to endow new roles and historical meaning to them in the torrents of changing time. Thus a function based on old traditions may find new followings after all.

In this book, we have compiled knowledge pertaining to the preparation of handmade paper with detailed explanations of each using photos and written words. We hope the reader can gain a deeper understanding of this aspect of our traditional culture.

Y. Stan Huang

Director General, Taiwan Forestry Research Institute

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1. 手工紙之製造—原料處理

選取低年生韌皮纖維植物枝條如構樹、三桠等予以砍除，因韌皮部分木質素含量較低，纖維較長，故取其韌皮部分作為造紙原料。砍伐後的植株可再萌芽生長。如在植物生長季節砍除，因樹液流通，可以直接剝皮，是為生皮。如在冬季砍伐，則砍下之枝條須先以蒸汽蒸 2-3 小時以利剝皮，謂之熟皮。如要將樹皮處理成白皮，則需將外層之黑皮及中層之青皮刮除。

1. Preparation of handmade paper—raw material treatments

The tender young shoots of bast fiber plants such as paper mulberry, mitsumata, etc. are selected for harvest. Because the bark often has a relatively low lignin content and long fibers, the phloem parts are ideal papermaking raw materials. Harvested individuals will resprout new shoots for sustainable harvesting. If the harvest takes place in the growing season, the flowing sap renders debarking easy and produces green bast. If, however, the harvest takes place in winter time, then the branches must be steamed for 2~3 h before peeling. The bast thus obtained is called ripened bast. To obtain white bast fibers, the outer black bark and the mid-layer green bark must be scraped off.



剝皮
Peeling bast fiber.



剝下之構樹皮（上為黑皮，下為白皮）
Peeled paper mulberry bark (top, black bast; bottom, white bast).



成捆之樹皮
Bast fiber bales.



原料蒸煮前浸泡處理
Soaking of the raw materials before digestion.

2. 手工紙之製造—原料蒸煮

蒸煮目的主要在去除纖維素以外之不純物，並使原料易於解纖。古代常用草灰或石灰蒸煮，現代則以氫氧化鈉及碳酸鈉為主要蒸煮藥品。依原料種類及所製紙漿性質決定所使用藥品及用量。例如黑皮含不純物多，雁皮木質素含量高，其用藥量就必須多一點。蒸煮前先泡水，以利樹皮膨潤及溶去水溶性物質，蒸煮時間隨種類及用鹼量多寡而定。通常煮沸 1-3 小時，蒸煮完畢後原料須充分洗淨，否則影響後續之漂白作業及紙張品質。

2. Preparation of handmade paper—digestion of raw materials

The purpose of digestion is to remove impurities other than cellulosic fibers and make the material easily defibrillate. In ancient times, grass ash or lime was often used for digestion. Presently, sodium hydroxide and sodium carbonate are the main chemicals used for digestion. The chemicals and dosages are dependent on the kinds of raw materials used. For instance, the higher lignin content of gampi and greater amounts of impurities in the black bark require higher chemical dosages. Before cooking, the materials are soaked in water to make the bark swell and remove water-soluble substances. The cooking time depends on the material and alkali charge, and usually takes 1 to 3 h. After cooking, the material must be fully rinsed to avoid affecting the subsequent bleaching operation and paper quality.



原料蒸煮

Digestion (cooking) of the raw materials.



蒸煮完畢倒出之原料

Poured raw materials after cooking.



原料清洗
Washing of the cooked raw materials.



原料清洗完畢
Raw materials after washing.

3. 手工紙之製造—漂洗選料

如為製作本色紙，原料經揀選剔除雜質即可使用。若製造白紙，尚需將原料漂白。因為手工紙原料木質素含量較木漿低，故漂白方法及設備較簡單，通常以次氯酸鈉進行單段漂白。漂白條件需嚴格控制，否則易對纖維造成極大之損傷，且漂白後需充分洗淨漿料，否則殘留漂白劑會影響紙張之保存性。無論是原色漿料或漂白漿料，皆需大量人工剔除漿料中之雜質。

3. Preparation of handmade paper—bleaching, washing, and sorting

To make a native-colored (yellowish-buff colored) paper, the raw materials need only to be inspected, the visible impurities picked off, and then the pulp is ready for production. To make a white paper, however, bleaching is required. Because most handmade paper stocks have lower lignin contents than the corresponding wood pulps, the bleaching method and facility requirements are simpler. A single-stage hyperchlorite bleaching process is often sufficient. Conditions of bleaching need to be carefully controlled, otherwise, the fiber may be severely degraded. A post-bleaching rinse to remove any residual chemicals is also important, lest the preservability of the paper is harmed. For both native-colored and white papers, the labor-intensive removal of impurity specks is generally necessary.



原料揀選

Sorting and washing of the washed raw materials.



原料漂白

Bleaching of the raw materials.



漂白洗淨之原料
Raw materials after bleaching.

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4. 手工紙之製造—春搗解纖

蒸煮及漂白後樹皮大部分仍保持原有之條狀型態，為使纖維充分解離，必須打漿或春搗。打漿之目的不僅要使纖維分離而且希望纖維產生帚化起毛，增加纖維接觸面積，提高紙力。古代打漿係將樹皮置於木板或石板上以木棒或木槌敲打原料，或以獸力拉石碾進行輾料解纖。近代則以機械方式打漿。

4. Preparation of handmade paper—beating to defibrillate the fibers

After digestion and bleaching, most bast materials still retain the original stripped form. In order to liberate the fibers, beating or repeated hitting with a pestle is necessary. The purpose of beating is not only to separate individual fibers from the bundles but to cause the fibers to be fibrillated like a broom. Through the action of beating, contact areas between the fibers are increased which helps increase the paper strength. In ancient times, cooked bark strips were placed on a wooden plank or stone slab, then a wood pestle or mallet was used to hit the material repeatedly, or a beast-driven grinding stone was mulled over the bark to achieve the necessary action. In recent times, mechanical beating is utilized.



舂搗解纖

Pestle ramming to defibrate the raw materials.



打散之紙漿

Pulp after beating in a Hollander beater.



古代獸力碾料圖

Draft animal milling of fiber stocks in ancient time.



古代用於分離纖維之石碾

A stone grinder used to defibrate fiber in ancient time.

5. 手工紙之製造—打槽抄紙

將配料打漿好之漿料加入紙槽中並加入分散劑(古代稱紙藥)，以木竹棍攪拌謂之打槽。其目的是使漿料分散均勻不致結團。加入分散劑則可減緩濾水速度及防止漿槽中之纖維沉澱，使漿料在抄紙時有足夠時間留置在竹簾上，利於抄造均勻之薄紙。東方通常用竹簾抄紙，抄好的紙張於一側放置一條尼龍線，以利工人計算工資及烘乾時揭紙用。分散劑可大分二類，一為植物性分散劑，如黃蜀葵根、馬拉巴栗根；一為合成之分散劑，如聚環氧乙烷 (Polyethyleneoxide) 或聚丙烯醯胺 (Polyacrylamide)。

5. Preparation of handmade paper—agitating pulp stock and forming webs

The beaten pulp stock is placed in a vat, and a dispersant (called a paper medicine) is added. Then a wood or bamboo stick is used to stir the stock, the purpose being to disperse the fibers homogeneously without forming big clumps or flocs. Adding a dispersant can reduce the drainage rate and prevent the fibers from settling. Thus, fibers in suspension have sufficient time to be retained on the screen, facilitating the formation of a homogeneous thin layer. In the Orient, screens are often formed of thin bamboo sticks tied together with string. The formed sheets are interleaved with a nylon string for ease of counting production and separating individual sheets after drying. The dispersants are of 2 categories. One is plant mucilage such as root fluids of yellow hollyhock (*Abelmoschus manihot*) or Pachira-nut (*Pachira macrocarpa*). The other one consists of synthetic chemicals such as polyethyleneoxide and polyacrylamide.



分散劑過濾
Filtering dispersant to remove lumps.



抄紙
Forming a paper sheet.



放尼龍線

A nylon string is placed along the edge of formed sheet.



覆簾 (1)

Covering sheets with the forming screen and a wet web attached to it (1).



覆簾 (2)

Covering sheets with the forming screen and a wet web attached to it (2).



揭簾

Peel up and remove the screen.

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6. 手工紙之製造—壓榨去水

抄好的紙一疊數百張如同豆腐一樣脆弱，無法一張一張揭起乾燥。通常先靜置過夜，令其自然滴水，次日再以機械方式壓榨。壓榨時需緩慢增壓，如增壓過快，就如同壓豆腐一樣，易使紙堆中央壓潰，造成紙張破損。當紙堆不滴水時可再增加壓力，直到紙堆不再滴水為止。此時紙堆含水率較低，如同一塊豆乾。通常壓榨時間長達數小時。

6. Preparation of handmade paper—pressing dewatering

A stack of formed wet sheets numbering several hundred is often as tender as a piece of tofu, and cannot be individually separated to dry. Usually the stack is allowed to sit overnight to drip. Then mechanical pressing is applied. Pressure is applied slowly, lest the sheets are crushed, mostly at the center. When the pressed stack ceases to drip, additional pressure gradients can be applied, until the stack no longer visibly expels water. At this time, the stack of sheets is dewatered, much like a piece of pressed bean curd. The entire procedure can take several hours.



記數尼龍線

Counting the number of nylon strings.



待壓榨之紙堆

Paper stack waiting to be pressed.



壓榨去水
Pressing dewatering.



壓榨完成之紙堆
Paper stack after pressing.

7. 手工紙之製造—紙張乾燥

經壓榨完成之紙堆尚含有多量水分，無法直接取用，需經乾燥後始可使用。常見乾燥方式有日光乾燥及加熱板乾燥。前者多用於高級紙張或厚質不適加熱板乾燥之紙張，此法費時且易受天氣影響，但所乾燥之紙張不易因受光照而變色。後者常見於一般紙廠。將紙堆逐張揭起平置於加熱板上，刷平紙張，令其乾燥。如一次揭起二張濕紙乾燥，即一般所稱之雙宣或夾宣。通常緊貼加熱板的紙面較光滑稱之正面，另一面因有刷痕較粗糙稱為反面。

7. Preparation of handmade paper—drying of the paper

The pressed paper stack still holds a substantial amount of water, and cannot be put to use directly. Drying is necessary. Afterward, the paper can be put in service. Common drying methods include sunlight drying and heated-platen drying. The former is often seen in the preparation of higher-grade products or thicker papers. The method is time-consuming and weather dependent, but the resulting paper is often immune to discoloration by light. The latter method is widely used in many paper mills, where individual sheets are picked up one by one and laid on a heated metal platen, the sheet is brushed smooth, and the water contained therein is quickly evaporated. If 2 sheets are dried at once, the paper is called double Shuan or plied Shuan. Often the side in contact with the platen turns out to be smoother, and is called the front side; the other side, often with brush marks, is coarser and is referred to as the back side.



紙張烘乾 (1)
Drying by a large heated platen (1).



紙張烘乾 (2)
Drying by a large heated platen (2).



紙張烘乾 (3)
Drying by a large heated platen(3).



日光乾燥 (張豐吉先生提供)
Solar drying (photo credit: Prof. Feng-Jyi Chang).



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