Historical and Scientific Analysis on Sizing Materials Used in Iranian Manuscripts and Miniature Paintings

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ABSTRACT

The present study aims to investigate historical and scientific analysis of sizing material used in Iranian manuscripts and miniature paintings. A large number of sizing materials has been introduced according to historical treatises from the Timurid (fifteenth century), Safavid (sixteenth century), and Qajar (nineteenth century) periods. In order to investigate the presence of sizing materials mentioned in historical literary references, sample analysis was conducted on the sizing materials of eleven historical Persian and Indian miniature paintings and illuminated manuscripts from sixteenth to eighteenth century.

Out of the twelve sizing materials that were recommended by masters based on the historical survey, the mucilage of cucumber seeds was the most common sizing material on the paper samples as identified by the FT-IR (Fourier-transform infrared spectroscopy) method.

The present historical and scientific survey suggests a wide range of natural sizing materials that can be used as tools for conservation and restoration of paper documents where the sizing of paper is required.

INTRODUCTION

Sizing paper is the process of preparing the surface suitable for writing, illuminating, and painting. After the sheet is formed and dried, the cellulose fiber in paper can continue to absorb water unless it has been sized or impregnated with some substance such as starch, glue, or wax to prevent penetration (Bloom 2001). Different techniques have been applied for sizing paper depending on requirements, such as soaking or applying one or a number of layers of sizing material on the paper surface with the help of a soft brush.

Specimens from the third century indicate that paper-makers had a range of sizing techniques, from coating the surface with gypsum to treating with gum, glue, or starch, to prevent the ink from spreading (Bloom 2001).

According to Dard Hunter one of the earliest methods of sizing paper consisted in covering the surface of the sheets with a thin coating of gypsum. The next improvement (Hunter 1957) was to render the body of the paper, as well as the surface, impermeable to ink by the use of lichen, starch, or rice flour. In Iran, according to Sheila Canby, once the paper was dried it was sized by soaking it in albumen or a starchly solution to fill in and even out the surface for painting (Canby 1993).

Some scientific investigation has also revealed valuable information on materials used in the sizing process. According to H. E. Wolf, based on chemical investigation, the Iranian papermakers at Samarkand have made an important contribution to paper technology by introducing sizing of paper to make it more suitable for writing with ink and a reed pen. According to him wheat starch and later gum tragacanth or the boiled bulbs of asphodel were used as the sizing substances.

There are a number of sizing materials, revealed by masters in Iranian treatises belonging to the Timurid, Safavid, and Qajar periods, which have been overlooked by scientists and conservators. Studying these historical references not only gives a new chapter to identification of materials used in manuscripts and miniature paintings during the Safavid period, but also helps conservators and restorers to develop new methods and techniques for sizing processes based on traditional materials. Our analytical study on sizing material used in Persian manuscripts and miniature paintings was based on two phases: historical analysis and scientific analysis.

In the first phase we collected information and studied Persian historical treatises from the Timurid and Safavid to Qajar period (fifteenth to nineteenth century). In the second phase sizing materials of original samples from the Iran Bastan Museum collection as well as from some pri-
HISTORICAL ANALYSIS

During the Sassanian period (fifth to sixth centuries CE), before the Islamic era, Iranians used sizing materials on cloth to prepare the surface for writing and painting (Heravi 1993). After learning the process of papermaking from the Chinese, Iranians continued the sizing process tradition on paper to prepare a suitable surface for writing and painting. The chief contribution of Iranian paper makers working under Arab rule was the perfection of rag paper through improved techniques for beating the fibers and by preparing the surface for writing by sizing it with starch (Bloom 2001).

Referring to Persian historical treatises, use of a sizing layer has been recommended by Iranian masters many times. Soltan Alimad Majnoon Rafiqi Heravi advises in his book "Adab al-Mashaq" to use soft, smooth, and even paper to write or to draw. Also in the book "Favayed al-Khotoot" is the recommendation to apply sizing materials to make fragile papers strong enough and to reduce the fluffiness of paper fibers as well as to make them smooth for writing.

In the sizing process three basic elements are involved. Size (kaheim), burnishing tools (mohreh), and a base surface (takhete). Several sizing materials have been used according to the historical treatises, which is the particular concern of this paper. According to these sources the materials can generally be categorized as proteinaceous materials, including: animal glue; starches from rice or wheat; vegetable gums; mucilage of plants and seeds; and fruits and sugar. A number of burnishing materials also have been used such as agate stone (aqiq), jade (yashm), glass (zejaj), crystal (bollou), and shell (jis). Sometimes hands alone also have been used to smooth the surface. A hard and smooth surface made of flint stone (chamag) and a wooden board was also used as the base for burnishing and sizing the paper (Heravi 1993).

SIZING MATERIALS

Our historical analysis was based on nine treatises from the fifteenth to the eighteenth century. Some of these historical treatises are by known authors and some are anonymous. In table 1 the titles of the treatises along with the date and the name of the author have been listed. Twelve sizing materials in six general categories have been identified in the historical analysis and are listed in table 2. These sizing materials have been described in historical treatises basically from the Taimurid (fifteenth century), Safawid (sixteenth century), to Qajar (nineteenth century) periods as follows:

Starch (neshaste)

A general term for starch (neshaste) has been mentioned in five treatises; we believe that when the nature of starch has not been specified it refers to rice starch. In these

<table>
<thead>
<tr>
<th>No.</th>
<th>Title of the Treatise</th>
<th>Author</th>
<th>Date</th>
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<tbody>
<tr>
<td>1</td>
<td>Dar Bayazeh, Morakab va Tahl Aliati</td>
<td>Anonymous</td>
<td>9th AH (c. 15th CE)</td>
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<tr>
<td>2</td>
<td>Serat al-Soltan</td>
<td>Soltan Ali Mashhad</td>
<td>920 AH / 1512 CE</td>
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<td>3</td>
<td>Golzari Safa</td>
<td>Ali Syafi</td>
<td>950 AH / 1552 CE</td>
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<td>4</td>
<td>Favayyal al-Khotoot</td>
<td>Mohammad Ibn Doust Mohammad Bokhari</td>
<td>975 AH / 1617 CE</td>
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<td>5</td>
<td>Adab al-Mashaq</td>
<td>Babh Shahi Isfahani</td>
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<td>6</td>
<td>Khut va Morakab</td>
<td>Hossein Aqili Rozandari</td>
<td>930-964 AH / 1552-1606 CE</td>
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<tr>
<td>7</td>
<td>Nusheh Dar Bayazeh Takkirah Soltani Morakab Ali Younghzayi Ali</td>
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<td>8</td>
<td>Dar Bayazeh Khat, Morakab Va Kaghaz Va Soltani Randi</td>
<td>Anonymous</td>
<td>10th 11th AH (c. 17th-18th CE)</td>
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<td>9</td>
<td>Halat al-Khat</td>
<td>Anonymous</td>
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Table 1. Historical analysis of Persian treatises
sources (1, 2, 4, 8, and 9) the process of sizing by starch (nezhašt) has been discussed in detail. For example the eminent calligrapher Soltan Ali Mashhadi devoted several couplets of his treatise “Serat al-Sotour” on calligraphy to sizing and glazing paper by hand (Bloom 2001). The process of sizing has been described as follows:

Prepare the size (ahar) from starch
Learn these words from an old man,
First make a paste, then pour in water,
Then boil this for a moment on a hot fire;
Then add to thin starch some glue (serish);
Strain so that it is neither too thin nor too thick,
Spread it on paper and see
That the paper should not move from its place;
When you are applying size to your paper
Moisten the paper slightly with water, carefully
It is worth mentioning that in sources nos. 2 and 4 it has been specifically advised to mix serish gum with the starch paste.

Wheat Starch
Wheat starch (nezhašt-e gandom) has been specified in two sources, “Golzari Safa” by Seyrafi and “Khat va Morakab” by Hossein Aqili Rostamdari, as follows:

For sizing paper make some wheat starch paste, filter it followed by cooking. Then take a wooden board and cover it with felt (nâmâd) or a muslin cloth. Take two bowls; pour the starch in one and some water in the other.

Rice Starch
Rice has been specified in one source, “Haliat al-Ketab” by an anonymous author. In this source the process of making starch paste for sizing material out of rice has been explained as follows:

Take the best quality of white rice, rub it with salt, wash it until it becomes clean and the taste of salt disappears. Then add some water and keep it for one full day till it becomes soft and it dissolves by rubbing. Place it in a mortar (havan) and bray it with water till it becomes very soft. Boil it on a slow fire; stir it with a wooden stick until it becomes pasty. Let it get cold. Spread a piece of cloth in the sun and put the paper over it till it dries up. Finally burnish the paper till it becomes very smooth. Dyes can be added to the paste to get colored paper. By this method nobody can distinguish this paper from Baghdadi paper.

Plant Mucilage (loat)
Mucilage is a gummy or gelatinous substance produced in certain plants by the action of water or the cell wall. In four sources (1, 3, 6, and 7) a number of sizing materials out of plant mucilage are named. However, the descriptions are not as detailed as the descriptions on starch.

Table 2. Identification of sizing materials based on historical analysis

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Mucilage of Rice (loabi berenj)
Rice mucilage is named in three historical treatises (1, 3, and 6) as follows: "Cook rice on fire until its mucilage is obtained. Make sure the rice and vessels used are free of oil. Then size the paper with it."

Fleawort Seed (ispaghol, esfarzeh, quitona)
In all three sources (1, 3, and 6) the techniques explained are the same; however, the duration of dipping the paper in mucilage is different.
In sources nos. 3 and 6 the term quitona has been used for fleawort seed and the process explained as follows: "Pour some fleawort seed until you get its mucilage. Leave the paper in the mucilage for one hour and then take it out."
In source no. 1 the advised duration for dipping the paper in fleawort seed is shorter. The description is as follows: "Size the paper sheet with mucilage of fleawort (esfarzeh, spaghol) at one time. Then let it dry."

Cucumber Seeds (tokhmi khiar)
Another sizing material is cucumber seed, which is cited in the same three sources (1, 3, and 6). The description on preparing mucilage from cucumber seed is quite brief. "Keep cucumber seeds in water until its mucilage is obtained. Dip the paper into it for some time and then take it out."

Mucilage of Marshmallow (loabi khatmi)
Mucilage out of marshmallow is mentioned in only two sources (1 and 7) as follows: "Keep marshmallow in some water for one night and one day. Heat it over fire until you get the mucilage. Dip the paper into it for some time and then take it out."

Fruit Juice/Syrup
It is very interesting to know that in the historical treatises two types of fruits, melon and grape, have been introduced for use as sizing materials.

Grape Syrup (shireh-e- angoor)
Grape syrup is mentioned as a sizing material in three sources (1, 3, and 6). Seyrafi in "Golzari Safa," in part of his couplets on sizing materials, names grape syrup as the fourth material for sizing. In source no. 1 the technique is explained as follows: "Filter grape syrup. Apply it on paper as a sizing material. Let it dry in the sun carefully."

Serish
Serish is a very well-known vegetable glue, which traditionally is used for binding books in Iran. As mentioned before, two sources (2 and 4) advise mixing serish with starch to thin the paste: "... then add some glue (serish), to thin starch."

Mixed Sizes
In one source, "Resaleh dar Bayani Tariqeh Sakhtani Morakabi Alvan va Kaghazhayi Alvan" (7), myrtle extract and sugar syrup are introduced as the materials to be added to a plant mucilage for sizing paper as follows:

Vegetable Glue
The next category that has been identified as sizing material in the historical treatises is vegetable glue.

Gum arabic (Samqi arabi)
Gum arabic is named in four sources (1, 3, 6, and 7). According to the above-mentioned historical reference gum arabic is a very good sizing material and it is suitable for writing. The description (6) reads: "... and furthermore melt gum arabic and size the paper with it."

Animal Glue
The next category that can be identified in the historical sources is animal glue.

Fish glue (sirishumi mahi)
Fish glue as one of the sizing materials used by the masters is mentioned in four sources (1, 3, 6, and 7) in a quite similar way as follows:

Serish
Serish is a very well-known vegetable glue, which traditionally is used for binding books in Iran. As mentioned before, two sources (2 and 4) advise mixing serish with starch to thin the paste: "... then add some glue (serish), to thin starch."

Mixed Sizes
In one source, "Resaleh dar Bayani Tariqeh Sakhtani Morakabi Alvan va Kaghazhayi Alvan" (7), myrtle extract and sugar syrup are introduced as the materials to be added to a plant mucilage for sizing paper as follows:

If a paper has deep turquoise color and it is difficult to write on, the advice is to apply either sweet melon juice (abi karboozeh), or syrup of Egyptian rock sugar (abi nabati mesri), or myrtle extract (abi mord) with mucilage of fleawort seed (ispaghol) and mucilage of oil-free cooked rice (loabi berenj). All these materials make paper strong and if the paper is then burnished it becomes smooth like a mirror.

SCIENTIFIC ANALYSIS
In order to investigate the presence of sizing materials mentioned in historical literary references, sample analyses...
were conducted on the sizing materials of eleven historical Persian and Indian miniature paintings and illuminated manuscripts belonging to the Iran Bastan Museum and private collections dating from the sixteenth (Safawid period) to eighteenth century (Qajar period). The analysis of sizing materials used in the original samples was carried out at the Research Centre for Conservation of Cultural Relics (RCCCR) in Iran. Sizing materials were identified by a staining method and FT-IR (Fourier-transform infrared spectroscopy) analysis.

Starch was detected on paper by formation of the characteristic blue color when a dilute aqueous solution of iodine-potassium iodide was added. A large collection of sizing materials was prepared based on historical recipes for comparison with the spectra of the original samples. FT-IR spectroscopy was carried out with a Nicolet, Model 510 P instrument provided with a microscopic attachment. Sample preparation was done by mixing potassium bromide (KBr) and the unprepared sample 100:1 (Broekman-Bokstijin et al. 1970). Identification of the materials in the samples was obtained by comparing the infrared spectrum with reference spectra via recognition of specific bands. Table 3 provides a complete record of the sizing materials found and indicates the identification methods used in each case.

Out of the six categories of sizing materials recommended by masters in the historical survey, the mucilage of cucumber seeds was the most common sizing material on the paper samples identified by FT-IR. Out of nine Persian miniature paintings and illuminated manuscripts, one was starch, seven were cucumber seed mucilage, and one was a mixture of tragacanth and cucumber seed.

Figures 1–5 show some of the spectra of the sizing materials found in the sample. It can be noticed clearly that in the samples belonging to check list numbers 16, 13, and 18 (figs. 3–5) the spectra exactly match the fingerprints of cucumber seed spectra which were used as reference.

**CONCLUSION**

Unlike many nations that used limited sizing materials to improve the mechanical strength and to smooth paper surfaces, Iranians have used various materials for the sizing process. A large number of sizing materials have been introduced according to historical treatises belonging to Taimurid (fifteenth century), Safawid (sixteenth century), and Qajar (nineteenth century) periods, such as starch (rice and wheat), plant mucilage (fleawort, cucumber seeds, marshmallow), animal glue (fish glue), vegetable glue (serish, gum arabic), fruit juice, and syrup (melon and grape).

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**Table 3. Sizing materials on selected paintings collected from Iran Bastan Museum collection and traditional artists**

<table>
<thead>
<tr>
<th>Origin</th>
<th>Owner</th>
<th>Object</th>
<th>Check List No.</th>
<th>Starch</th>
<th>Fleawort</th>
<th>Cucumber Seeds</th>
<th>Vegetable Glue</th>
<th>Fruit Juice</th>
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Scientific analysis was conducted to identify the nature of the sizing material used in Persian miniature paintings and manuscripts using a stain method and FT-IR analysis.

The findings of the present investigation revealed that cucumber seeds were used extensively in comparison to the other sizing materials under study. Of course further investigation is needed to conclude whether these materials have been used in pure or in mixture form.

The present historical and scientific survey suggests the use of a wide range of natural sizing materials, which can be used as tools for conservation and restoration of paper documents when the sizing of paper is required. The present research is still under investigation. We need to collect more data to conclude which sizing materials were common during specific periods, and which sizing materials were used for specific papers and even for specific requirements.

ACKNOWLEDGEMENTS

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