A Scientific Study on Sāncipāt Manuscript and Hengul-Hāitāl Painting Traditions of Early and Medieval Assam

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4. Conclusions and Future Scopes

The present study of *Sāncipāt*, a popular manuscript writing-base of early and medieval Assam and a painting tradition of medieval Assam, popularly known as *Hengul-Hāitāl* has revealed some intriguing novel information regarding the traditional science and technology including preparation, conservation and restoration of centuries old *Sāncipāt* manuscripts and woodcarvings found in ordinary open conditions at villages and Vaishnavite monasteries of Assam. The present study also revealed some structural and morphological features of the cellulose and lignin extracted from both new and old *Sānci* bark, while also examining how cellulose and lignin modified with zirconium oxychloride influence the same. These have been summarized below:

4.1. Conclusions

4.1.1. Structure and properties of Sāncipāt

(a) The present study reveals some interesting traditional knowledges associated with preparation of *Sāncipāt* related to their attractive look, physical properties, composition, adhesion of the ink on it and longevity of the manuscript in harsh climate. Raw *Sānci* bark consists of native cellulose together with some hemicellulose and lignin devoid of nitrogenous compounds. The traditional degumming process is less drastic than common alkaline degumming which partially removes the unwanted hemicellulose and lignin leaving mostly the fibrous cellulosic part. The amount of carbon and oxygen in freshly prepared *Sāncipāt* as slightly higher than that of raw *Sānci* bark. The smoothness of surface, tensile strength and gloss index are increased during the preparation of *Sāncipāt*.

(b) Antimicrobial test shows that raw *Sānci* bark has no antifungal properties but the *Sānci* bark after degumming in the presence of $CuSO_4$, and after application of a coating of *Hāitāl* and *Hengul* shows remarkable inhibition towards fungi. The antifungal property of *Sāncipāt* manuscript have been attributed to a synergistic effect of $CuSO_4$ used during degumming and due to application of *Hāitāl* and *Hengul*. Application of a thin layer of *Hāitāl* and *Hengul* in the empty spaces of cleaned folios can be used as a method of conservation of *Sāncipāt* manuscript to protect them from insect and fungus.

(c) Cellulose and lignin were extracted from century old and new *Sānci* bark using alkaline and peroxide treatments for cellulose and acidic treatments for lignin. The cellulose and

lignin extracted from new *Sānci* bark were embedded with $ZrO_2.nH_2O$ nanoparticles using zirconium oxychloride. Old cellulose (OC) and old lignin (OL) were found to show a higher moisture content percentage compared to new cellulose (NC) and new lignin (NL), reducing mechanical properties in both OC and OL. The structural and chemical compositions were nearly identical, indicating only a minor degradation of intricate structure. The complex composition and structure of lignin results in a slower thermal decomposition rate. It can withstand a more comprehensive range of temperatures compared to cellulose because the different oxygen functional groups that make up its structure have different thermal stabilities and scission temperatures. The cellulose samples were found to have a high carbon content, which is an excellent property because of its good chemical and weathering resistance. The carbon content is marginally higher for both OC and OL than for NC and NL. Heterogeneous deposition of $ZrO_2.nH_2O$ nanoparticles on cellulose and lignin was observed. Better mechanical properties of NC have been observed. A lower level of mechanical strength for OC is seen because of aging and degradation.

(d) The amorphous nature of $ZrO_2.nH_2O$ may cause the gradual reduction in XRD peak intensity observed for MC and ML. OL particles had the least average diameter among NL, OL, and ML particles. The P-XRD of OL confirmed that as particle size decreases, mechanical strength also decreases. The apparent decrease in tensile strength of PVA-OC and PVA-OL films was noticed. This finding could be related to decrease in mechanical strength and higher moisture content found in OC and OL. Zirconium oxychloride modifications in case of NC and NL should not have a significant impact on the conservation of these manuscripts.

4.1.2. Restoration and conservation of Sāncipāt manuscripts

(a) This first study on conservation of *Sāncipāt* manuscripts reveals some interesting traditional knowledge which contributed to longevity of the manuscripts. Treatment of old partially damaged *Sāncipāt* with some commonly used solvent and chemicals, *viz.*, isopropyl alcohol, thymol and cetrimide, has shown marked changes in physicochemical properties, structure and mechanical strength of lignocellulosic

Sāncipāt. Even a prolonged exposure to water also causes such changes in *Sāncipāt.* On the other hand, some treatments of *Sānci* bark during the traditional preparation of *Sāncipāt, viz.,* partial de-gumming in presence of *Tutia* and application of a thin coating of antifungal and insect repellant *Hengul-Hāitāl* pigments protect the folios from fungi and insects. *Lā-charowā,* a traditional way of varnishing, finally imparts physical strength and water resistance to the folios in addition to protecting the readers from exposure to *Hāitāl* and *Hengul*. *Bael* gum used in mending of *Sāncipāt* does not leave any stain on the folio unlike many other traditional natural gums. Though *Mahī,* a unique traditional herbal ink used in writing *Sāncipāt,* is prepared in water and is as such water soluble, the ink has a strong adhesion on the folio and is hardly affected by water. Preservation of *Sāncipāt* manuscript between two flat wooden plates coated with *Hāitāl* avoids kinking or bending of the folios.

(b) A novel method of restoration and conservation of Sāncipāt manuscripts, based on the traditional method of their preparation avoiding harmful chemicals and with minimum exposure to water. The method involves mild physical cleaning, mending with freshly prepared *Sāncipāt* using *Beal* gum, application of *Hāitāl-Hengul* with matched color, application of *Lā* and keeping the manuscript between two flat wooden plates coated with *Hāitāl* and rapping with red cotton cloth. Results of piloting of the proposed method of conservation on eleven *Sāncipāt* manuscripts show that the method can be employed to save tens of thousands of precious *Sāncipāt* manuscripts existing in museums, Satras and villages in Assam from natural damage.

(c) In addition of, the present study reveals some interesting effects of the four common conservative chemicals, namely, water, thymol, isopropyl alcohol and cetrimide on fresh *Sāncipāt* also. The UV-visible spectra of water after soaking of fresh *Sāncipāt* has shown a weaker peak compared to other solvents indicating that less cellulose and hemicellulose were leached into water compared to the other solvents. The FTIR spectra of *Sāncipāt* samples recorded after treatment with the solvents suggest that thymol, a commonly used conservative chemical, causes the maximum damage to the *Sāncipāt* among all four solvents which have been studied. Treatment with isopropyl alcohol, and thymol increases the tensile strength of freshly prepared *Sāncipāt* but reduces the toughness. Weight loss of *Sāncipāt* after treatment indicates leaching of lignin and hemicellulose from freshly prepared manuscripts. *However, this weight loss decreases after application of Hengul-Hāitāl indicating a positive effect of Hengul-Hāitāl to the Sāncipāt.* Thus, the present study reveals that treatment of fresh *Sāncipāt*

with the common conservative chemicals causes physicochemical and mechanical changes to *Sāncipāt* such as destruction of lignocellulosic properties, fluctuation of crystallinity, weight loss and reduction of toughness.

4.1.3. Traditional Science in pigments and recipe of *Hengul*-Hāitāl painting

(a) The present scientific study of the ingredients, the properties and application of traditional *Hengul-Hāitāl* paints has revealed some interesting traditional knowledge related to the pigments and their application. Mineral pigments of *Hengul* (mercuric sulfide, HgS), *Hāitāl* (Arsenic sulfide, As_2S_3) and Kharimāti (calcium aluminum silicate clay) were used for red, yellow, and white, respectively. However, though a natural dye, Indigo, was traditionally used as blue color, it is now replaced by synthetic Prussian blue.

(b) The physicochemical analyses of the pigments have shown that while *Hengul* and *Hāitāl* samples showed some natural oxide and carbonate impurities. On the other hand, the sample of Nīl (Prussian blue) was found to be adulterated with hematite. The sample of *Hāitāl* snowed 38% crystallinity, which was higher than 28% observed for *Hengul*. The particles of *Hengul*, *Hāitāl* and Nīl, after grinding, have been found to be distinctly distributed while that of the particles of Kharimāti have been found to be spread smoothly. The average particle sizes of the pigments were between 4 to 10μm. Measured low zeta potentials of the pigments indicated rapid agglomeration which was in fact observed in practice requiring complete use of the paints within 4-5 hours of preparation. The use of three primary colors, viz., red, yellow, and blue in the tradition for preparing any desired shades is noteworthy.

(c) It was also interesting to note the selection of a non-staining robust natural gum, viz., Bael gum, to prepare the paints. However, there was hardly any change in the color properties of paint samples of different colors on replacing the Bael gum with a starch-based commercial gum. While all shades obtained from *Hengul*, *Hāitāl* and Nīl have shown very good hiding power, all shades containing *Hengul* and *Hāitāl* have shown high brightness. It is also interesting to note the use of either *Hengul* or *Hāitāl* or both for preparation of any of the shades except white probably to repel termites and fungi. It was also a practice to mix a little of antifungal and insecticide Tutia with Kharimāti for white color. Application of a primer coat of Kharimāti mixed with Tutia is indicative of the traditional knowledge of use of primer as well as preservation of woodcarvings from fungi and insects. On the other hand, application of Lā coating finally is indicative of traditional knowledge of stopping natural erosion of the paints

and avoiding toxic *Hāitāl* by devotees of idols and utility items by users upon touching. The unraveled traditional knowledge pertaining to glaze and durability applied in the preparation of woodcarvings and *Hengul-Hāitāl* painting tradition of Assam is helpful in developing a customized method for restoration of worn-out woodcarvings for preservation in open ordinary environment in villages and Satras.

4.1.4. Restoration of heritage woodcarving with *Hengul*-Hāitāl painting

(a) A scientific traditional restoration method has been proposed for restoration of some old partially damaged woodcarvings due to natural weathering or woodcarvings which had lost the antique look due to application of enamel paints have shown good results receiving appreciation form local people. Revelation of ivory in nails and figure and use of precious pigments indicates an economically strong patronage of the woodcarvings.

(b) The restoration has imparted new but traditional look with enhanced glossiness and thermal stability to the woodcarving enabling preservation of the woodcarvings at least for another century in the open public places like Namghars in an as is where is way.

(c) The media coverage and satisfaction of local people indicate people's acceptability and appeal of the restoration method based on traditional *Hengul-Hāitāl* paints. Two important aspects of the present restoration method are that the woodcarvings placed at public place like places of worship do not contaminate the hands of people if they touch them due to the Lā-coating and the restoration allows preserving the woodcarvings at ordinary rural set up, bereft of passive conservative condition, in as is where is way.

4.2. Final Statement

The current investigation discloses several intriguing traditional knowledge about the preparation of manuscripts that are related to their appealing appearance, physical characteristics, composition, inks adhesion to it, and the manuscripts durability in adverse weather. By altering the conventional procedure with the aid of contemporary scientific techniques, the preparation of *Sāncipāt* will be scaled up without compromising the *Sāncipāt* qualities. It will also be looked at what causes distinct *Sāncipāt* manuscripts to deteriorate over time. The structural and morphological study of both cellulose and lignin extracted from Sānci bark has revealed some important physiochemical and mechanical

properties. Based on this knowledge, a novel method of restoration and conservation of *Sāncipāt* manuscripts: a unique type of traditional manuscripts written on *Sānci* bark in medieval Assam is proposed. A painting tradition of medieval Assam, popularly known as *Hengul-Hāitāl*, has been studied with an aim of restoring and conserving centuries-old woodcarvings and *Sāncipāt* manuscripts for preserving in ordinary open conditions at villages and Vaishnavite monasteries.

4.3. Future Scope

Following the completion of the work outlined in this thesis, further intriguing issues that are linked and need to be addressed are as follows:

(a) We can conserve the ancient dilapidated *Sāncipāt* manuscripts in different parts of India, including Assam, with the help of our proposed method by us.

(b) It can be studied whether *Hengul Hāitāl* can be used in other writing bases in addition to *Sāncipāt* manuscripts.

(c) To investigate whether woodcarvings from Indian cultural societies other than those from the Satria community in Assam may be kept and restored using the traditional natural pigments known as *Hengul* and *Hāitāl*.

(d) There is a scope for further research and development for reviving these unique traditions for tourism commerce.

(e) To study whether cellulose and lignin extracted from Bhola Sānci tree can be used for various tasks such as heavy metal adsorption, biomedical application, etc.

(f) Catalytic activity of modified cellulose and lignin of Sānci bark may also be explored.