Sāncipāt: A Popular Writing-base of Manuscript of Early Assam

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Sāncipāt was a popular manuscript writing-base of early and medieval Assam. Tens of thousands of *Sāncipāt* manuscripts still exist in Assam, some of them centuries old, without fading of ink and miniature painting in spite of its harsh hot and humid climate. Traditionally, *Sāncipāt* was made of bark of *Sānci* tree through an arduous procedure. Here we report a scientific study of physicochemical properties of traditionally prepared model and old *Sāncipāt* folios at different stages of preparation using FT-IR, XRD and SEM-EDX spectra, weight loss during degumming, tensile strength, gloss index and antifungal properties. Comparison of data with freshly prepared *Sāncipāt* showed intact internal structure and strength in the old *Sāncipāt*. An antifungal property observed in *Sāncipāt* is attributed to *Tutia* used during degumming of the bark, and two pigments, *viz.*, *Hengul* and *Hāitāl* applied as thin coating and border, respectively. Partial degumming, coating with fatty pulse, application of *Hāitāl* and *Hengul,* and repeated pressing, smoothening and drying together impart strength and glossiness to *Sāncipāt*.

Keywords: *Sāncipāt* manuscripts, *Hengul-Hāitāl*, medieval writing-base, antifungal activity, degumming

Introduction

India possesses more than five million ancient manuscripts, making it the largest repository of manuscript wealth in the world[1,2]. These manuscripts are treasures of information for research of Indian intellectual heritage and need adequate conservation[3]. Scientific study of manuscripts and manuscript-making traditions may unravel interesting traditional knowledge and immensely help in their conservation. Different types of writing-bases were used in ancient and medieval world[4-7], such as papyrus in ancient Egypt and medieval Europe, animal skin in medieval Europe, hand-made paper in China. *Tālpatra* (Palm leaf) in south and southeast Asia including and *Bhurjapatra* (bark of Betula utilis, Himalayan Birch) in north India. Interestingly, Assam, a northeastern state of India, had a rich heritage of manuscript writing on a unique type of writing base, *Sāncipāt,* made of bark of *Sānci* tree (*Aquilaria malaccensis* Lamk. syn. *A. agallocha* Roxb.), during early and medieval period (Figure 1)[8-10]. Tens of thousands of *Sāncipāt* manuscripts still exist in Assam, most of them without losing their herbal ink and luster for centuries in a harsh and humid climate of Assam[11]. The first record of *Sāncipāt* manuscript is in *Harshacharitam* by Banabhatta, a biography of king *Harshavardhana* (606-647AD) of Kanouj, now in North India[12,13]. A bundle of manuscripts, made of *Sāncipāt* with a reddish yellow color of *Hāitāl* (yellow orpiment), was gifted to *Harshavardhana* by king *Kumar Bhaskaravarman* (595-650AD) of Kamrupa, then Assam. This unique tradition of writing *Sāncipāt* manuscript, started by 7th century which is assumed to be continued till the early 20th century[14,15], predominated over other contemporary writing bases like *Tulāpāt* (hand-made paper) and *Tālapatra*, but now is almost extinct[16]. The tradition gained a new momentum during the Vaishnavite movement of Assam lead by the Vaishnavite Saint Srimanta Sankardev during the fifteenth century, carried forward to a great popularity by Vaishnavite Satras of Assam, and also patronized by Ahom and Koch kingdom [16,17].

<Figure 1>

Due to its hot and humid climate, Assam is a hub of fungi and insects which feed on cellulosic materials. Interestingly, it is a general observation that the survival ability of properly made *Sāncipāt* manuscript is greater than other types of manuscript found in Assam where fungi and insects easily destroy manuscripts. Thus, although the choice of a writing base usually depends on availability of the material, the unique writing base of *Sāncipāt* seems to have been chosen due to its greater survival ability over others in its harsh hot and humid climate in addition to availability of *Sānci* tree in Assam[8,17]. The preparation of *Sāncipāt* from *Sānci* bark involves repeated smoothening, pressing and drying; partial degumming; polishing with fatty pulse paste; application of yellowish coating with *Hāitāl* (HgS, *Cinnabar*) and a border with *Hengul* (As_2S_3, *Yellow Orpiment*), and punching a hole at the center for tying bundles of *Sāncipāt* which have been reported on several historical and cultural contexts[17,18]. This arduous process of preparation of *Sāncipāt* through several steps involving some interesting ingredients thought to be responsible for its special properties, viz., strength, glaze, durability and ability to retain ink and pigment. There are well-researched methods for conservation of manuscripts made of papyrus[19], paper[20], parchment[21] and *Tālpatra*[22] but absolutely no scientific method is available for conservation of *Sāncipāt*, which is different from other cellulose based writing bases. Thus, a customized scientific method of conservation is urgently needed to protect tens of thousands of *Sāncipāt* manuscripts.

A scientific study of the traditional knowledge involved in the recipe and the characteristics of *Sāncipāt* may unravel the secrets of using the unique writing base in preference to others or the secrets behind its survival for centuries with undiminished glaze in an unfavorable climate. The study may also help in deeper understanding of the craftsmanship and technology that was used and provide clues for its appropriate method for conservation of *Sāncipāt* manuscripts for which there does not exist any specific conservation method. The present work was aimed at carrying out a systematic scientific study of the traditional knowledge involved in *Sāncipāt* manuscript through characterization of the folio at various stages of preparation by the traditional recipe through physicochemical and biochemical analysis with a focus on the possible factors of its survival for centuries retaining the ink and glaze in a hot and humid climate. In order to avoid destructive method, we prepared fresh model *Sāncipāt* by the traditional method under supervision of one of a few traditional practitioners. We also had it in our mind to find some clues for customized conservation of *Sāncipāt* manuscripts.

Experimental

Sānci bark was obtained from Debajit Gogoi from Golaghat, Assam, who grows *Sānci* tree crop for extracting a valuable perfume oil from its stem. The *Sānci* bark strips of about 2m long, 15cm wide and 3mm thick were collected from a 17-years old *Sānci* tree (Figure 2). The mineral pigments, *viz*., *Hāitāl, Hengul* and *Tutia* (blue vitriol, $CuSO_4.5H_2O$) were obtained from Kamakhya Bhandar, Nagaon, Assam (Figure 2). XRD spectra of *Hāitāl, Hengul* and *Tutia* indicates them to be As_2S_3, HgS and $CuSO_4.5H_2O$, respectively. Potato dextrose broth (PDB) and Agar were purchased from Himedia, Mumbai. Distilled water was used to prepare solutions used in degumming process.

<Figure 2>

Scanning electron micrograph (SEM) and energy dispersive X-ray (EDX) spectra were recorded on a Jeol machine, JSM 6390LV. Fourier transform-infrared (FT-IR) spectra were recorded on a Perkin Elmer spectrophotometer, (Frontier MIR FIR). X-ray diffraction (XRD) spectra were recorded on a D8 FOCUS (Software: XRD COMMANDER 2, DIFFRAC.EVA.)

spectroscope and PCPDF-WIN software was used to analyze them. Tensile strength was measured using a universal testing machine, Zwick-Z010. Glossiness of surface was measured with digital glossmeter (S.C. Dey & Co., Kolkata).

Preparation of Sāncipāt by traditional method

The major steps traditional method of preparation of a Sāncipāt folio, in brief, involves removal of a strip of bark of several feet length and several inches width from a mature Sānci tree, drying in sunlight the strip rolled inside out, smoothening, cutting into size of folios, partia degumming using tutia, drying and smoothening again, application of a primer of a paste fatty pulse, and application of a coating of Hāitāl and a boarder of Hengul before writing. [17,18,19]*Sāncipāt* folios were prepared for this study under supervision of a practicing expert of the tradition following traditional procedure as briefed below. *Sāncipāt* at various stages of preparation can be seen in Figure 3. The outer scale of the *Sānci* bark was cleaned using a knife, rolled inside out and is dried in the sunlight for 10 days. The strip was dampened, cleaned, smoothened and then dried again. Then the strips were cut into pieces of about 12 inches long and 4 inches wide. These pieces were analyzed as raw *Sānci* bark. The pieces were soaked in 500 ml water in a plastic tray in presence of 0.1M *Tutia* ($CuSO_4$), 10 crushed seeds of *Konibih* (*Croton Triglium*) and 30g of crushed leaves of *Chalkuwari* (*Aloe Barbadensis)* (Figure 2) for 12h for partial degumming. These materials were collected locally. Both surfaces of the strip were again scrapped with a small knife and smoothened by rubbing with a *Ghila,* a hard seed with red color, nicker bean, *Entada scandens* Benth (Figure 2). Then, a thin coat of a fine paste of a skinned fatty pulse, called *Matimah* (*Phaseolus radiatus* Linn.), was applied on the strip to fill up any cracks or wrinkles on the surface of the strip and then sundried. The dry strips were smoothened again by rubbing with a *Ghila*. Then, a thin coating of yellow *Hāitāl* pigment was applied on both sides of the strip. For this, the paint is prepared by mixing powdered *Hāitāl* in water using an herbal gum obtained from fruit of *Bel* (Stone apple, *Aegle Marmelos*). The pieces are again sundried and smoothened with a *Ghila*. A red boarder of about 1 cm width of red *Hengul* pigment is also applied along the boundaries on both sides of the strip which is ready for manuscript writing and illustration. The freshly prepared *Sāncipāt* was found to be physically strong, smooth, and glazing. The samples were powdered and dried in desiccator for 7 days prior to physicochemical analysis.

<Figure 3>

Physicochemical characterization at various stages of preparation of Sāncipāt

In each step of preparation of *Sāncipāt* from a raw *Sānci* bark, changes in physical and chemical properties have been analyzed through various techniques. The effect of smoothening of fibrous lignocellulose structure is apparent from SEM images (Figure 4). The EDX analysis showed the atomic percentage of carbon, nitrogen, and oxygen in cleaned raw *Sānci* bark as 44.66%, 10.87%, 43.15%, respectively, commensurate with its lignocellulosic composition[24] (Figure 4). The ratio changed to 54.08%, 10.20% and 34.90%, respectively, in freshly prepared *Sāncipāt* due to removal of some lignin during degumming and addition of proteins and fats in the coating of fatty pulse. The atomic percentage of carbon, nitrogen, and oxygen obtained for an old damaged *Sāncipāt* were 46.69%, 8.16% and 44.06%, respectively. The elements of Mg, Si, S, Cl, K, Ca, As, Pb were detected in trace amounts in all three samples. The amount of arsenic was found to be highest in the freshly prepared *Sāncipāt* which probably comes from *Hāitāl*. Cu was absent in the raw *Sānci* bark but observed in the freshly prepared *Sāncipāt* and the old *Sāncipāt* which can be attributed to *Tutia* used during partial degumming.

<Figure 4>

FT-IR spectra of raw *Sānci* bark and *Sānci* barks at three stages of preparation also indicated presence of lignin, cellulose and hemicellulose (Figure 5). In traditional method of preparation of *Sāncipāt*, only a partial degumming is done retaining the fibrous cellulosic part in order to retain the basic structure and shape of the bark. As expected, the FT-IR spectra of the old manuscript folio was also found to be similar to that of the freshly prepared one.

<Figure 5>

Similar largely amorphous XRD patterns were obtained for both freshly prepared *Sāncipāt* and old *Sāncipāt* samples (Figure 5). However, characteristic peaks observed at 14.1^{o} (-1 0 1) and 22.8^{o} (0 0 2) and 41.6^{o} (2 4 0),[25] suggest them to be native cellulose, $(C_6H_{12}O_6)_x$, system-monoclinic,[21](PDF no. 030289; ID:03-0289)[25]. A broad peak observed in the range between 21.90^{o} to 22.80^{o} for freshly prepared *Sāncipāt* which was flattened in old *Sāncipāt* may be attributed to a slight change in cellulose structure.

The tensile strength (longitudinal) values of cleaned raw *Sānci* bark, traditionally degummed *Sānci* bark and freshly prepared *Sāncipāt* after drying are shown in Figure 6. Elongation at break was same for all three samples and was approximately 7.8%. The ultimate tensile strength of the cleaned raw *Sānci* bark considerably increased from 20MPa to 48MPa and 78MPa in the degummed and freshly prepared *Sāncipāt*, respectively. The Young's modulus (Y/X) calculated from three points on the three curves at (X=3.32, Y=9.97), (X=3.32, Y=28.63) and (X=3.32, Y=48.01) were found to be 3.00, 8.62 and 14.46 for cleaned raw *Sānci* bark, degummed *Sānci* bark and freshly prepared *Sāncipāt*, respectively. Thus, the tensile elasticity of the *Sānci* strip is significantly increased during preparation of *Sāncipāt*. The degumming and application a coating of paste of fatty pulse with stone apple gum have probably contributed to the toughness of *Sāncipāt*.

The averages of glossiness of inner side of the folios at three stages of preparation are shown in Figure 6 along with the average of glossiness of three folios of a damaged old manuscript at three different angles of measurements. It has been observed that the glossiness of the folio is increased with the angle of measurement as expected. It was interesting to note an increase in the glossiness gradually in each stage of the preparation. The improvement in gloss index from stage 1 to 3 may be attributed to increase in reflection due to filling of the pores and cracks on the surface by the coating of fatty pulse and the coating of *Hāitāl*. However, the glossiness of the old manuscript was much lower than stages 2 and 3 of the fresh ones as expected. The gloss index of both inner and outer sides of freshly prepared *Sāncipāt* were also compared to examine if there was any difference between the two sides and found to be almost identical (Figure SI-1). Interestingly, it was not possible to distinguish the inner and outer sides of an old manuscript.

The effect of the duration of soaking of *Sāncipāt* in water presence of 0.1M $CuSO_4$ on weight loss or partial degumming of the *Sāncipāt* was studied by varying the duration up to 24h [figure SI-2]. The weights were recorded before soaking, and after soaking and drying without scrapping with knife. It is interesting to note a linear relation of percent weight loss, calculated as (final weight of strip/initial weight of strip) × 100%, with time (SI-2). The weight loss may be attributed to a gradual loss of hemicellulose and lignin of *Sānci* strip with time during the process.

Antifungal activity:

For testing antifungal activity of *Sānci* bark and *Sāncipāt*, three filamentous fungi, *viz.*, *Aspergillus niger*, *Candida albicans* and *Fusarium oxysporum*, were sub-cultured. A standard procedure was used for antifungal activity test on *Sānci* strip at four different stages of the preparation[26]. The *Sāncī* manuscript was cut into small pieces having the equal surface area for the experiment. For preparation of potato dextrose broth (PDB) solution, 5g of PDB was dissolved in 50 mL distilled water followed by autoclave at 121ºC and 15 pounds for 15 min. Moreover, potato dextrose plates were prepared with PDB and 1.8 g of agar. All the fungal strains were seeded to 50 mL of PDA containing conical flasks and incubated for 7 days at approximately 20ºC. For the antifungal test, 100 µL of fungal inoculums were spread carefully in the PDA plates and placed all small pieces of the samples. The samples along with controls were incubated in static incubator and their growth were monitored systematically. Water was used as a negative control whereas antimycotic solution from Himedia at 10µg/mL were used as a positive control. All the experiments were performed in triplicates.

The results of antifungal test on samples of cleaned raw *Sānci* bark, degummed *Sānci* bark, *Sānci* bark after application of *Hāitāl* and *Sānci* bark after application of both *Hāitāl* and *Hengul* (Figure 6). The growth of the fungi takes place within 48-72h. The observations of antifungal activity in open control, closed negative control and closed positive control were made after 168h (SI-3). After 2h, it was observed that all three fungi grew equally in the open control. *Aspergillus niger*, being the most voracious fungus among the three, grew most rapidly in the negative control. On the other hand, *Candida albicans* grew most rapidly in the positive control. The fungal growths on the open positive and negative control have been observed to increase after one week also. There was no fungus growth on any of the samples before incubation. Interestingly, we observed growth of all three fungi only in the petri plates for cleaned raw *Sānci* bark after one week of incubation [SI-3]. But no growth of any of the fungi was observed on the degummed *Sānci* bark, *Sānci* bark after application of *Hāitāl* and *Sānci* bark after application of both *Hāitāl* and *Hengul*.

<Figure 6>

Fungus feed on cellulosic materials and so *Sāncipāt* is likely to be damaged by fungi in a hot and humid climate that exists during most of the year in Assam. On the other hand, the three minerals, *viz.*, *Tutia*, *Hāitāl* and *Hengul*, are also reported to have antifungal properties[16]. The absence of any growth of all three fungi on the samples of degummed *Sānci* bark, *Sānci* bark after application of *Hāitāl* and *Sānci* bark after application of both *Hāitāl* and *Hengul* is expected to be attributed to antifungal properties of $CuSO_4$ used during degumming of *Sānci* bark and application of coating of *Hāitāl* and *Hangul*. The antifungal property of *Sāncipāt* may be additive, synergistic, or cumulative in nature. Interestingly, the authors have witnessed in various libraries, museums and personal possessions that *Sāncipāt* manuscripts with coating of *Hāitāl* and *Hengul* are never destroyed by fungus or insects while those without the coatings are mostly damaged by fungi or insects (SI-4). It is interesting to note the traditional knowledge of antifungal properties of these minerals and their use for protection of *Sāncipāt* manuscripts from fungus in Assam during the medieval period. This indicates that application of a thin coat of *Hāitāl* on *Sāncipāt* manuscripts on the free spaces of the cleaned manuscript folios to be a good option for conservation of the manuscripts followed by a thin coating of wood sap in a traditional way to avoid future contamination during reading. Though *Hāitāl* is known to be toxic to fungi and insects, it is used traditionally in make-up of dancer in Kathakali dance and for lightening of dark skin. However, its prolific use in cosmetics has been reported to pose risk to human health[27] and care must be taken while handling and applying toxic *Hāitāl* using gloves and masks.

Conclusions:

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 of *Sāncipāt* are increased during the preparation of *Sāncipāt*.

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*. The findings may help in developing a customized method of conservation of old Sancipat manuscripts.

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Figure captions: (main document)

Figure 1. A *Sāncipāt* folio from Adi Dasham, a manuscript dated 1799 AD, preserved at Bengena Ati Satra, Majuli, Assam. The folio is coated with yellow *Hāitāl* with art on a wide boarder of *Hengul* and written with *Mahī*[8-10], a traditional herbal ink of early Assam. The illustrations were drawn with different proportions of *Hengul*, *Hāitāl* and Indigo.

Figure 2. A *Bholā Sānci* tree after removal of bark (a), *Sānci* bark strip rolled inside out for drying (b), *Sānci* bark after degumming (c), after fatty pulse polishing (d), after application of *Hāitāl* (e) and after drawing boarder with *Hengul* and writing with *Mahī* (f).

Figure 3**.** Chalkuwari (Aloe-vera, *Aloe barbadensis*) (a) Koni Bih guti (*Crotton Triglium*) (b) and Ghila (c), Pieces of *Hāitāl* (d) and *Hengul* (e) and fine powder of *Hāitāl* (f) and fine powder of *Hengul* (g) and Tutia (h).

Figure 4. SEM images of raw *Sānci* bark strip (a), freshly prepared *Sāncipāt* (b) and old *Sāncipāt* (c) at a resolution of 100 µm, and EDX analysis of raw *Sānci* bark strip (d), freshly prepared *Sāncipāt* and old *Sāncipāt* (f).

Figure 5. FT-IR spectra of freshly prepared *Sāncipat* (a) and old *Sāncipāt* (b); XRD patterns of freshly prepared *Sāncipāt* (c) and old *Sāncipāt* (d); tensile strength (e) of cleaned raw *Sānci* bark (i), traditionally degummed *Sānci* bark (ii) and freshly prepared *Sāncipāt* (iii); and average gloss index (f) of *Sānci* bark at three stages of preparation: Stage 1 - cleaned raw *Sānci* bark, Stage 2 – after application of fatty pulse-paste, Stage 3 - freshly prepared *Sāncipāt*, and of old *Sāncipāt* measured at 20^o, 60^o and 80^o angles.

Figure 6. Results of antifungal test on samples of cleaned raw *Sānci* bark, degummed *Sānci* bark, *Sānci* bark after application of *Hāitāl* and *Sānci* bark after application of both *Hāitāl* and *Hengul* before (top) and after (bottom) incubation.

Figures:

Figure 1

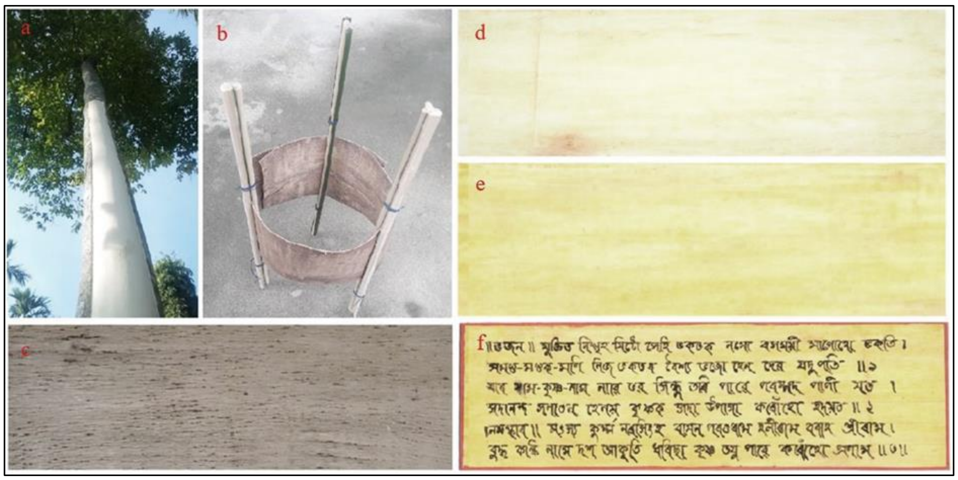


Figure 2

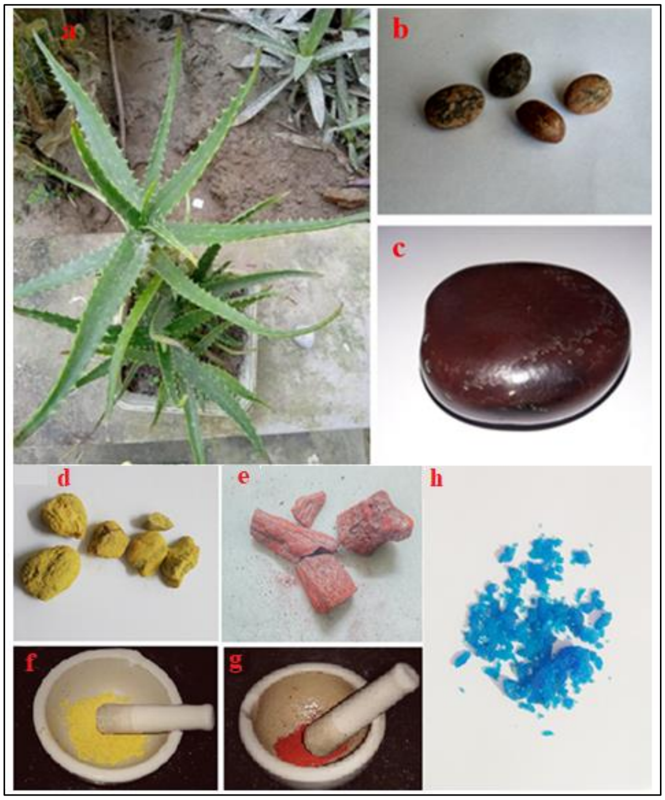
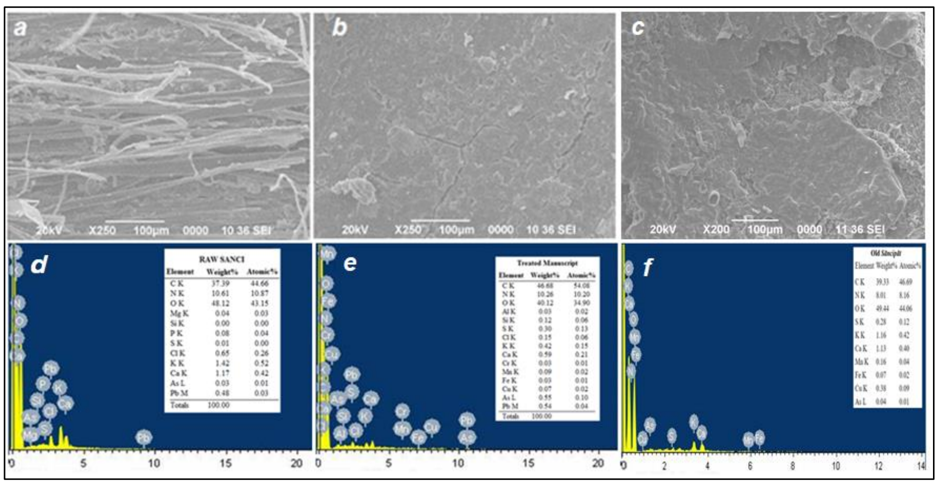


Figure 3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O K 48.12 43.15
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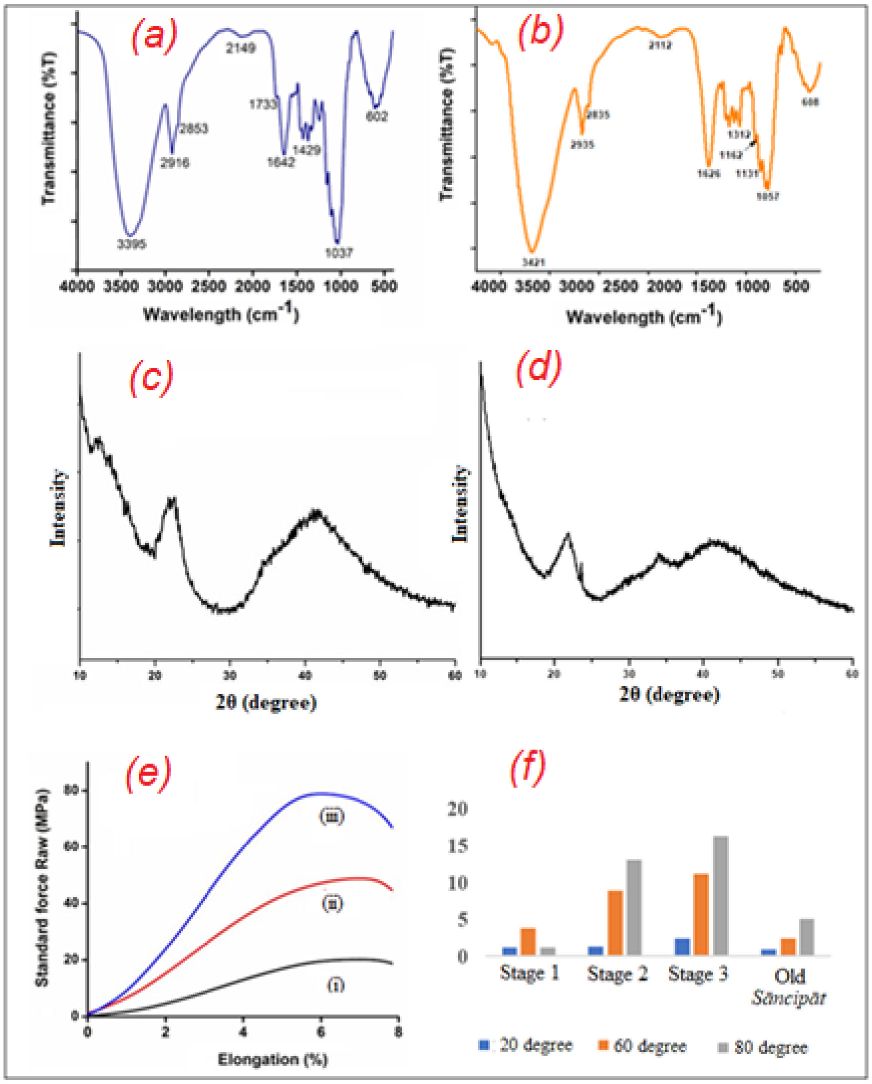
Element Weight% Atomic%
C K 39.33 46.69
N K 8.01 8.16
O K 49.44 44.06
S K 0.28 0.12
K K 1.16 0.42
Ca K 1.13 0.40
Mn K 0.16 0.04
Fe K 0.07 0.02
Cu K 0.38 0.09
As L 0.04 0.01
0 5 10 15 20
0 5 10 15 20
0 2 4 6 8 10 12 14

Figure 4



(a)
Transmittance (%T)
3395
2916
2853
2149
1733
1642
1429
1037
602
4000 3500 3000 2500 2000 1500 1000 500
Wavelength (cm-1)
(b)
Transmittance (%T)
3421
2935
2835
2112
1626
1312
1162
1131
1057
608
4000 3500 3000 2500 2000 1500 1000 500
Wavelength (cm-1)
(c)
Intensity
10 20 30 40 50 60
2θ (degree)
(d)
Intensity
10 20 30 40 50 60
2θ (degree)
(e)
Standard force Raw (MPa)
0 20 40 60 80
(iii)
(ii)
(i)
0 2 4 6 8
Elongation (%)
(f)
0 5 10 15 20
Stage 1
Stage 2
Stage 3
Old Sāncipāt
20 degree
60 degree
80 degree

Figure 5

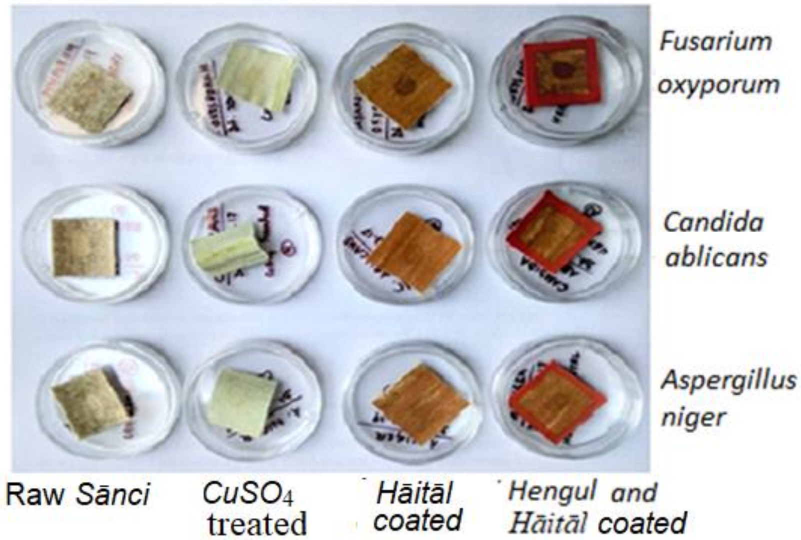

Fusarium oxyporum
Candida ablicans
Aspergillus niger
Raw Sānci
CuSO4 treated
Hāitāl coated
Hengul and Hāitāl coated

Figure 6

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