Studies on the Correlation between Surface and Sewability Properties of Crust Leather

by

Niklesh C.,[1,4] Jayakumar G.C.[1,4] and Phebe Aaron K*[2,3,4]

[1]*Centre for Academic and Research Excellence (CARE)*

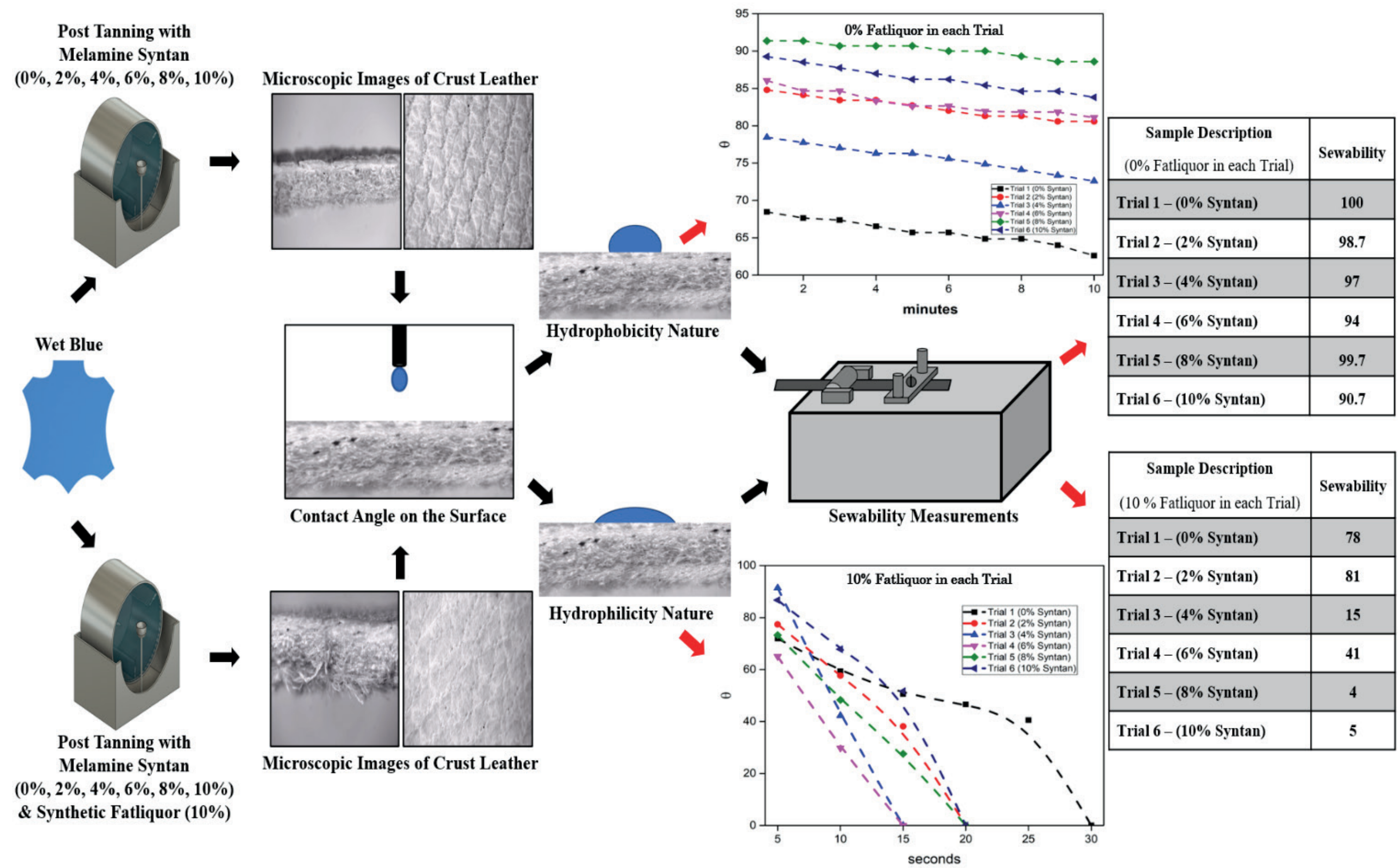
[2]*Project Planning, Monitoring and Evaluation (PPME)*

[3]*Shoe & Product Design Centre (SPDC)*

CSIR-Central Leather Research Institute, Adyar Chennai, India

[4]*Department of Leather Technology, Alagappa College of Technology, Anna University,* Chennai

Graphical Abstract



Abstract

The surface properties of leather are critical factors that influence the aesthetic quality of the leather. Commonly, organoleptic properties are evaluated for leathers to ascertain the bulk properties such as compactness, smoothness, softness and general grain appearance. Though these parameters are very subjective, still these properties are essential for leather product manufacture. In the current research, we discuss the correlation between the surface parameters and sewability of the leathers. In our earlier studies, we discussed the influence of syntans and fatliquors on sewability. In aligning to a similar subject, the impact of surface properties has been evaluated through contact angle measurements and correlated with the sewability properties of the leather. From the spread ability measurements, it can be inferred that the sewability properties are better towards the surface of the leather, which is more hydrophilic. This result agrees that the fatliquoring of leathers has enhanced the stitch ability; moreover, the studies provide biophysical parameter importance for qualifying leather sewability.

*Corresponding author email: phebe@clri.res.in

Manuscript received September 7, 2022, accepted for publication October 25, 2022.

Introduction

Leather goods and products gain importance due to their unique properties, such as breathability and comfort.[1-3] During leather manufacture, the post tanning and finishing processes are crucial in imparting bulk and surface properties. In post tanning; retanning and fat liquoring chemicals are used to achieve performance properties such as softness, roundness, pliable, grain compactness, etc.[4,5] Physical characteristics such as tensile, tear, grain crack, fastness, sewability, drape are also crucial properties achieved during the post tanning process. In our earlier studies, we have studied the influence of synthetic fatliquor, melamine and phenolic syntan on the sewability properties of the leather.[6,7] Our research group has been involved in understanding the individual post tanning chemicals to attain better sewability properties for the leathers, an inevitable parameter in manufacturing most leather goods and garments. From the sewability studies, it is understood that melamine syntan behaves similar to phenolic syntan, and the presence of fatliquor is significant to better sewing the leather.[7] However, the surface properties of the leathers also play a significant role in sewing. The needle penetration on the leather is usually disoriented depending on the surface properties.[8]

In our recent research, we have established the correlation between performance chemicals and physical strength characteristics. In continuation with the study, a post-tanning experiment was carried out without offering the fatliquor while just varying the melamine syntan percentage. The experimental leathers were further evaluated for their sewability, grain crack, tensile strength and microscopic images. Also, the coherent relationship between the surface sewability properties of the melamine retanned leathers has been studied. The wettability of the melamine crust leathers has been determined using a contact angle meter. Further, gloss values at 20°, 60° and 85° have also been determined for the crust leather to establish the correlation between the organoleptic properties such as roundness, softness, grain compactness and smoothness. The surface property and physical strength characteristics have been correlated to establish the impact of sewability of the melamine crust leathers.

Materials and Methods

Chrome-tanned goat leather was used as a raw material for the study and commercial-grade chemicals were used for the post-tanning process. Experiments with different concentrations of melamine syntan with 0% fatliquor process are given in Table I and methodology adopted for the study is shown in Figure 1.

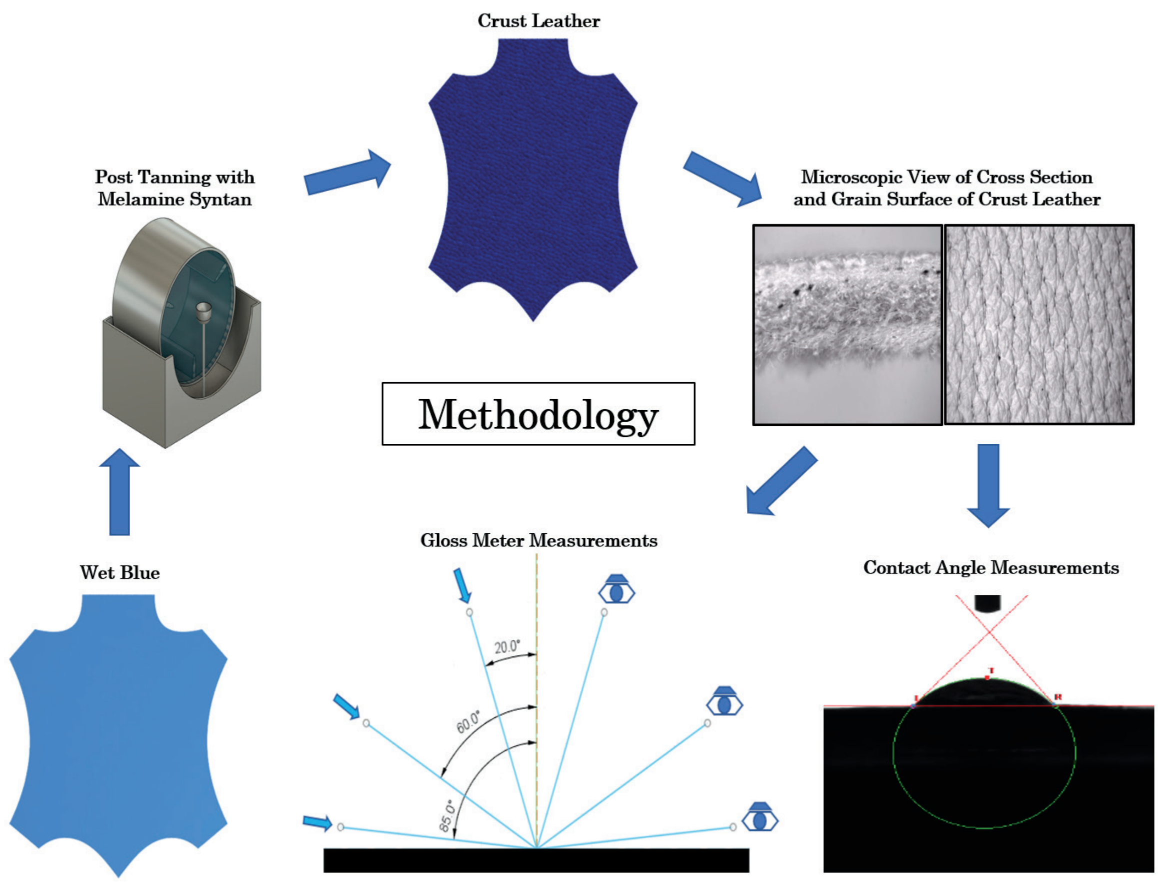


Figure 1. Process Methodology of the present study

Table I
Post tanning process

Process	Percentage	Durations
Neutralization		
Water	150%	60 min
Nutrigan	0.50%	(pH 5.0 to 5.5)
Drain & Wash		
Retanning		
Water	100%	
Syntan Base:	Melamine Base (FB6)	
Trial 1	0%	
Trial 2	2%	
Trial 3	4%	30 min (Each Trial)
Trial 4	6%	
Trial 5	8%	
Trial 6	10%	
Fixing		
Formic Acid	0.50%	30 min (pH 4.0)
Drain & Wash		

Contact Angle Analysis
The contact angle was measured using a drop deposition method wherein a drop of liquid was placed on the crust leather surface and later the same was analyzed using software.[9,10] This experiment was carried out using Apex contact angle meter (ACAM Series – ACAM NSC 17, Contact Angle measurement 0°-180° with an Accuracy of ±0.05°).

Gloss Meter Analysis
A beam of light was projected over the surface of the crust leather and the reflection of that light was measured at an equal but opposite angle.[11,12] This experiment was carried out using 3nh Gloss Meter (YG268 Triangle Gloss Meter, Measuring Angle: 20°, 60°, 85°).

Sewability Analysis
The crust leather was cut into the required dimensions (30 × 350 mm) and then used to determine the sewability values. This experiment was carried out using an L&M tester machine (penetration rate – 100/min, needle number – 90, needle system – 34LR).[7] The sewability property efficiency is determined by the percentage values. The values ranging between 0 to 10% are recommended to have better stitching properties.[13,14]

Physical Testing of the Sample
The control and experimental crust leathers are characterized by their physical strength. Before testing, the leathers were conditioned and tested as per standard norms of Tensile (IUP 6, 2000) and grain crack (IUP 9, 1996).[15,16]

Optical Microscopic Studies
The microscopic images of the control and experimental leathers were captured using an optical microscope connected to a camera.

Results and Discussion

The functional and performance properties of the leather are greatly influenced by choice of post-tanning chemicals. During the post-tanning process, the physical strength characteristics such as tensile, tear, grain crack, fastness and sewability depend on the type and concentration of retanning and fatliquoring chemicals.[17] Our research group focuses on the ongoing evidence-based symbiotic relationship between syntan and fatliquor for the sewability properties of leather. Phenolic and melamine syntans behave similarly on the sewing properties.[6,7] In the present study, the surface properties of the melamine syntan retanned crust leathers have been evaluated for their hydrophobic-hydrophilic nature and gloss values.

Table II shows the sewability measurements of the melamine retanned crust leather without fatliquor trials. By observing the trend of the obtained sewability values, it is clearly understandable that the values obtained in each trial are very high (above 90%), which makes it unsuitable for stitching. The grain crack values

Table II

Sewability Measurements

Sample Description	Standard Threshold	Sewability (High)
TRIAL 1 – (0% Fatliquor; 0% Syntan)	417	100.0
TRIAL 2 – (0% Fatliquor; 2% Syntan)	450	98.7
TRIAL 3 – (0% Fatliquor; 4% Syntan)	400	97.0
TRIAL 4 – (0% Fatliquor; 6% Syntan)	450	94.0
TRIAL 5 – (0% Fatliquor; 8% Syntan)	450	99.7
TRIAL 6 – (0% Fatliquor; 10% Syntan)	425	90.7

Table III

Lastometer Ball Burst Test - Grain Crack

Sample Description	Measurement	Value
TRIAL 1 (0% Fat-Liquor; 0% Syntan)	Load at Grain Crack (Kg)	25.5
	Distention at Grain Crack (mm)	9.2
TRIAL 2 (0% Fat-Liquor; 2% Syntan)	Load at Grain Crack (Kg)	26.5
	Distention at Grain Crack (mm)	9.2
TRIAL 3 (0% Fat-Liquor; 4% Syntan)	Load at Grain Crack (Kg)	27.3
	Distention at Grain Crack (mm)	9.2
TRIAL 4 (0% Fat-Liquor; 6% Syntan)	Load at Grain Crack (Kg)	24.8
	Distention at Grain Crack (mm)	9.1
TRIAL 5 (0% Fat-Liquor; 8% Syntan)	Load at Grain Crack (Kg)	23.2
	Distention at Grain Crack (mm)	9.2
TRIAL 6 (0% Fat-Liquor; 10% Syntan)	Load at Grain Crack (Kg)	23.5
	Distention at Grain Crack (mm)	9.1

Table IV

Tensile Strength and Elongation Measurements

Sample Description	Direction	Tensile Strength (MPa)	Elongation at Break %
TRIAL 1 (0% Fat-Liquor; 0% Syntan)	1	13.2	77.3
	2	23.7	33.8
TRIAL 2 (0% Fat-Liquor; 2% Syntan)	1	12.2	73.0
	2	21.3	34.1
TRIAL 3 (0% Fat-Liquor; 4% Syntan)	1	14.9	80.4
	2	26.6	34.3
TRIAL 4 (0% Fat-Liquor; 6% Syntan)	1	10.7	94.0
	2	24.8	35.0
TRIAL 5 (0% Fat-Liquor; 8% Syntan)	1	12.7	68.1
	2	20.5	33.0
TRIAL 6 (0% Fat-Liquor; 10% Syntan)	1	12.5	85.2
	2	24.2	34.6

of experimental leathers without fatliquor are given in Table III, which are found to be comparatively lesser than those offered with 10% fatliquor. A similar trend is inferred in Table IV for tensile strength and elongation measurements. The values obtained for the experimental melamine retanned leathers with the offer of 10% fatliquor have been found to improve strength properties, as reported in our previous study.[7]

All these experiments (Tables II, III & IV) were carried out to support our earlier reported experiments on melamine retanned leather with 10% fatliquor trials. In the previous work, we reported that the crust leathers with 8% melamine syntan and 10% fatliquor exhibited better sewability properties.[7] Similar trend in the properties has been achieved for the grain crack and tensile strength properties. The present study summarizes a holistic understanding of the symbiotic relationship between surface and sewability properties.

Contact Angle Evaluation

From the sewability studies, 0% fatliquor with various concentrations of syntan, showed higher sewability values, indicating that the leathers were stiffer. The contact angle measurement results inferred that the control leather trials are more toward hydrophobicity in nature. The trend of contact angle measurements of various concentrations of syntan with 0% fatliquor retanned crust leather is shown in Figure 2. Also, the contact angle values of leathers retanned with 10% fatliquor and various concentrations of melamine syntan are shown in Figure 3. The results show that these leathers are found to be more hydrophilic, and the sewability value is found to be higher. This is in accordance with the organoleptic property of the 0% fatliquor and 10% fatliquor offering with melamine syntan leather (Figure 2 and 3).

Significance of Hydrophobicity - Hydrophilicity on Sewability Property

Hydrophobicity – hydrophilicity nature of the leather is conventionally tunable using performance chemicals during the post-tanning and finishing steps.[18] Fatliquoring process is the significant step which provides hydrophobic nature to the leathers.[19-22] However, when fatliquor is less and dried, leathers tend to show a hydrophobicity nature. This is primarily due to the coalescence of collagen fibers and the removal of water molecules from the leathers. The softness of the leather depends on the fatliquoring, which provides pliability

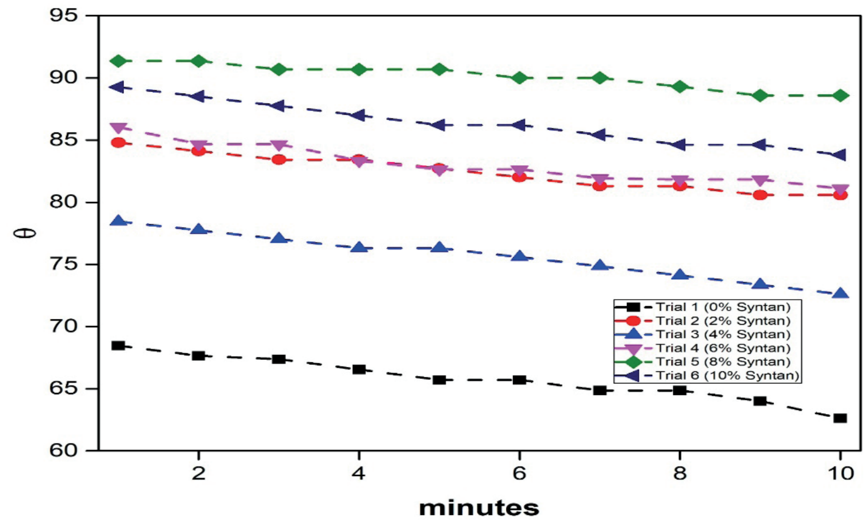


Figure 2. Graph for Contact Angle Values of Leathers with 0% Fatliquor

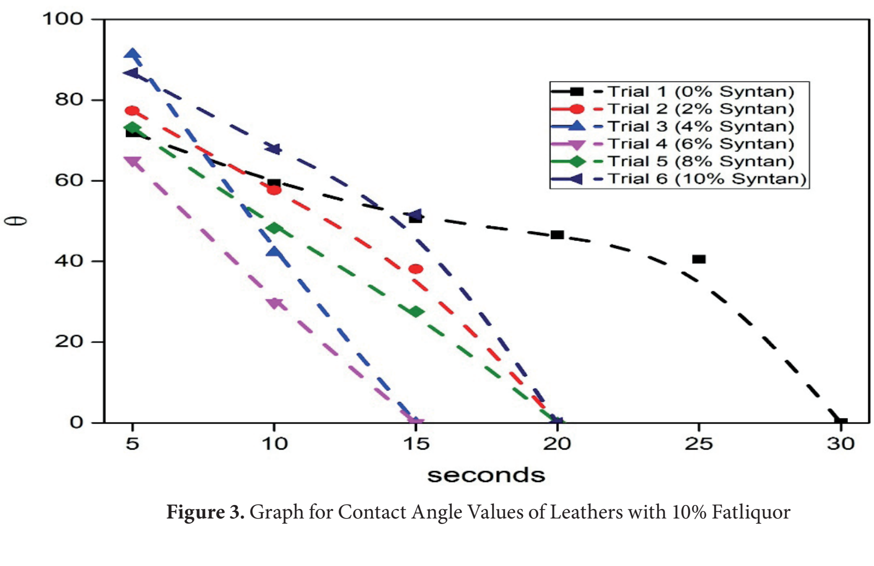


Figure 3. Graph for Contact Angle Values of Leathers with 10% Fatliquor

and eases the stitching properties. From our earlier studies, it can be inferred that the leathers' stiffness is higher for the leathers with less offer of fatliquor, which shows that the stiffness property is inversely proportional to the sewability properties.[6,7] In the present study, the similar synergistic effect of fatliquor on spread ability values has been determined using a contact angle meter. It was found that the leathers retanned without the fatliquor showed more hydrophobicity which results in less sewability property. Sewability values imply the importance of fatliquoring for the stitching of leathers. Moreover, the studies also establish that the absence of fatliquor leads to higher leather stiffness and a reduced sewability property.

Gloss Meter Evaluation

The glossiness of leather is one of the significant properties of leather products. The glossiness of the leather surface is influenced by choice of post-tanning chemical and finishing operations.[12] The glossiness effect on the crust leather has been studied using a gloss meter. The gloss values of control and experimental leathers are shown in Figures 4 and 5. The gloss values at 20° for both types of leathers are found to be similar, which is between 0.5 to 1.0. The difference in gloss values is probably due to no significant glossiness on the leather. However, the gloss value at 60° and 85° varied for the control and experimental leathers. The experimental leathers showed higher glossiness compared to control leathers which are post-tanned without the offer of fatliquor. The presence of fatliquor has enhanced the glossiness property of the leather. From the gloss values, it can be inferred that the high glossiness of the crust leather is attributed to better sewability of the leather, which is similar to the contact angle measurement observations.

Microscopic Evaluation

The optical images of the leathers are shown in Figures 6 and 7 where it can be observed that the leathers are stiff in the case of 0% fatliquor offered compared to 10% fatliquor offered melamine retanned leathers.

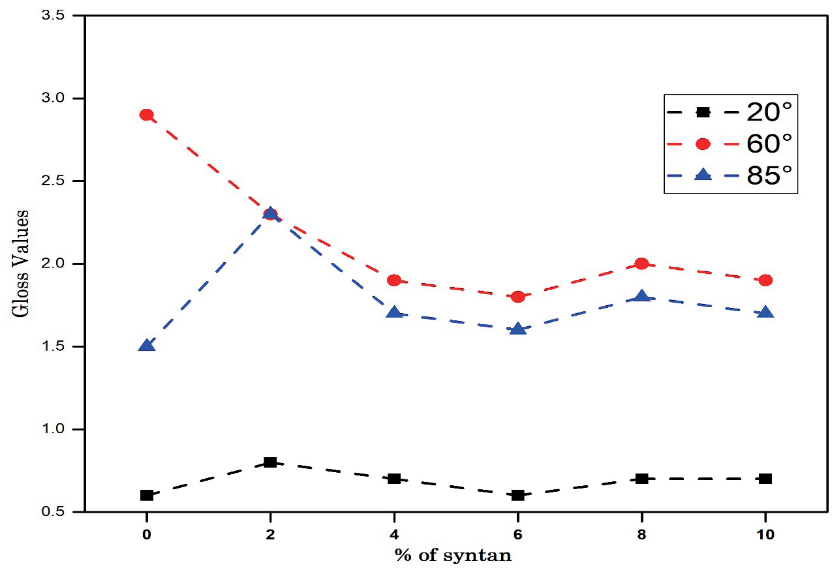


Figure 4. Graph for Gloss Values of Leathers with 0% Fatliquor

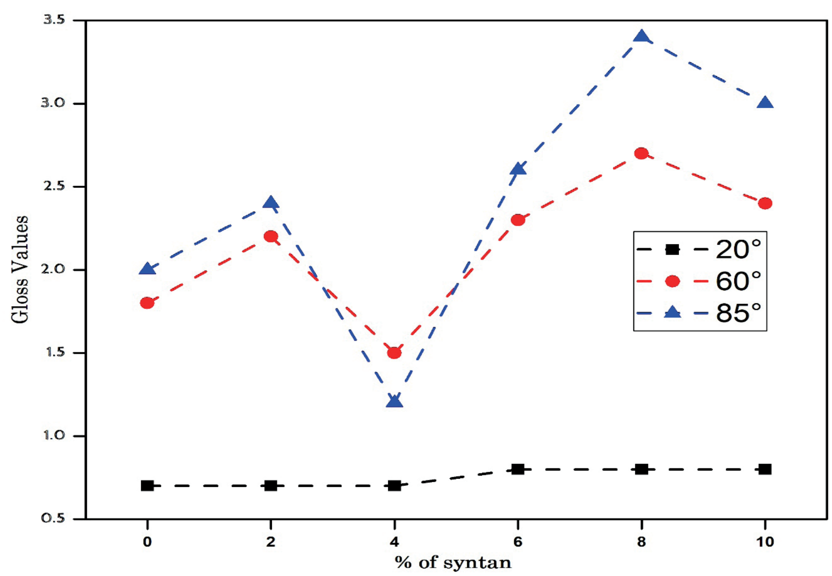
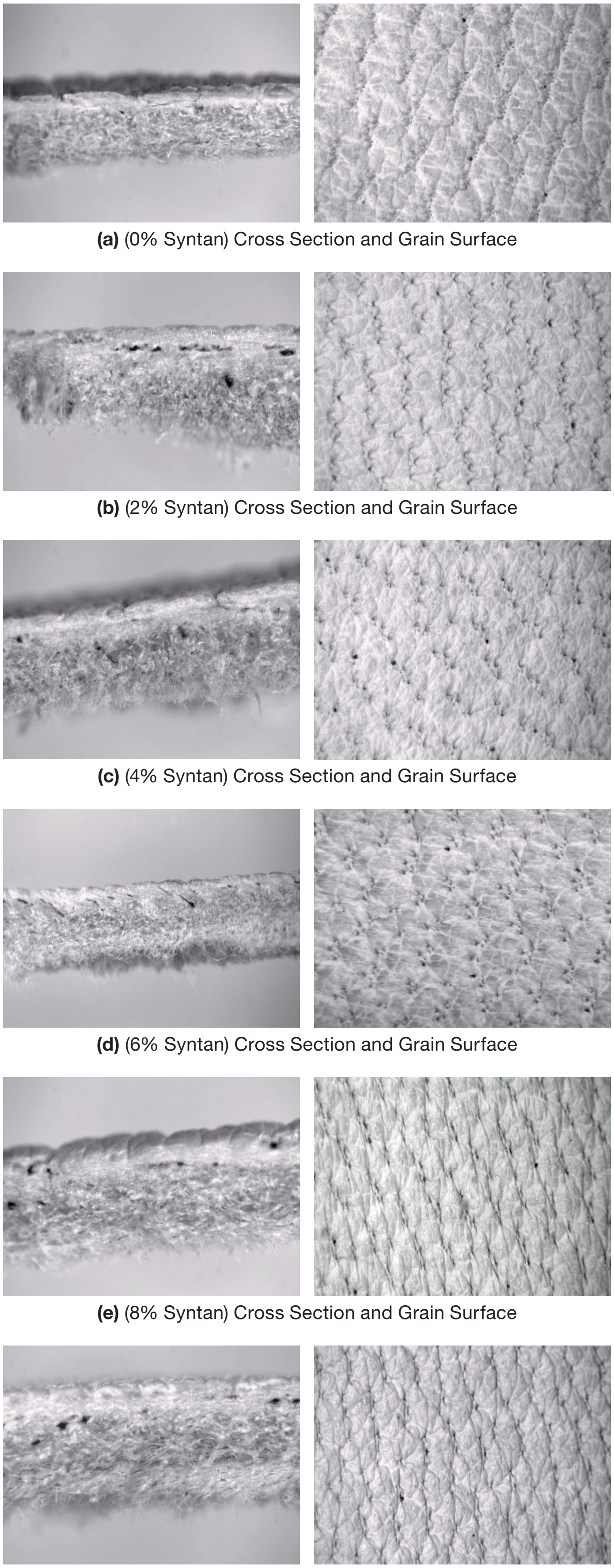


Figure 5. Graph for Gloss Values of Leathers with 10% Fatliquor



(a) (0% Syntan) Cross Section and Grain Surface

(b) (2% Syntan) Cross Section and Grain Surface

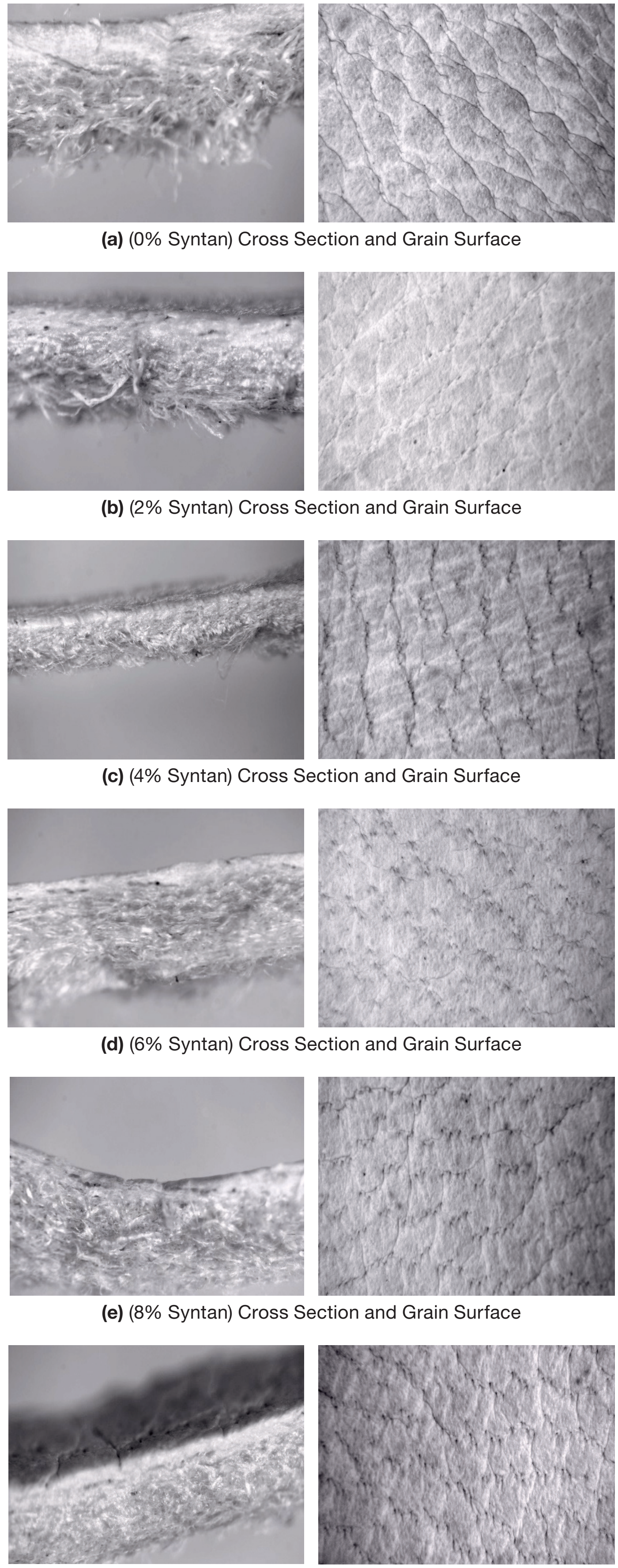
(c) (4% Syntan) Cross Section and Grain Surface

(d) (6% Syntan) Cross Section and Grain Surface

(e) (8% Syntan) Cross Section and Grain Surface

(f) (10% Syntan) Cross Section and Grain Surface

Figure 6. Optical images of leathers with 0% of fatliquor (cross section and grain surface)



(a) (0% Syntan) Cross Section and Grain Surface

(b) (2% Syntan) Cross Section and Grain Surface

(c) (4% Syntan) Cross Section and Grain Surface

(d) (6% Syntan) Cross Section and Grain Surface

(e) (8% Syntan) Cross Section and Grain Surface

(f) (10% Syntan) Cross Section and Grain Surface

Figure 7. Optical images of leathers with 10% of fatliquor (cross section and grain surface)

Conclusion

The chemical and physical characteristics of the leathers are an essential standard norm for varied applications. The choice of leather products desires the specificity of the post-tanning and finishing processes. Stitching is an inevitable mechanical operation required for assembling goods, garment manufacturing, and other leather products through sewing. From our earlier studies, our research group has attempted to cognize the relationship between the sewing operation and post-tanning chemicals. The impact of phenolic and melamine syntans on leather sewability has been studied. In persistence to the recently published research article on *"Physico-Insight on Sewability Properties of Crust Leathers using Melamine Syntan and Synthetic Fatliquor"*, the current article establishes the influence of hydrophilicity-hydrophobicity behavior of leather on sewability. The surface behavior of the leather has been determined using contact angle meter and gloss value measurements and correlated with the sewing values. The θ values obtained for the leathers treated only with varied offers of melamine syntan have shown less sewing performance compared to the leather treated with 10% fatliquor and varied offers of melamine syntan. The disparity in sewing values is mainly attributed to the fatliquoring of leather. Moreover, the leather, which has adequately lubricated fibers, limits the coalescence of collagen fibers, easing the leather's stitchability.

Acknowledgment

The authors acknowledge the support for the testing of leathers at CATERS, CSIR-CLRI and Mr. Ashish Singh, Technical Assistant, SPDC, CSIR-CLRI for the help in measuring sewability. CSIR-CLRI communication number is 1758.

References

1. Virginija Jankauskaitė, Indira Jiyembetova, Ada Gulbinienė, Justa Širvaitytė, Kęstutis Beleška, Virginijus Urbelis; Comparable Evaluation of Leather Waterproofing Behaviour upon Hide Quality. I. Influence of Retanning and Fatliqouring Agents on Leather Structure and Properties. *Materials Science*, Vol. **18**, No. 2. 2012.
2. Krishnaraj, K., Thanikaivelan, P., Chandrasekaran, B.; Relation between drape and mechanical properties of goat suede garment leathers. *J. Soc. Lea. Tech. Chem*. **93**, 1-7, 2000.
3. Phebe, K., Chandrasekaran, B., Mandal, A.B.; Sewability of sheep nappa garment leather. *Res. J. Textile. Apparel*, **18** (2), 49-55, 2014.
4. Kallen Mulilo Nalyanya, Ronald K. Rop, Arthur Onyuka, Zephania Birech, Alvin Sasia; Effect of crusting operations on the physical properties of leather. *Leather and Footwear Journal*, **18**, 4, 2018.
5. Anthony D. Covington, William R. Wise; Current trends in leather science. *Journal of Leather Science and Engineering,* **2**:28, 2020.
6. Jayakumar GC, Phebe Aaron, K., Krishnaraj, K.; A comprehensive understanding on sewability of natural biomaterial: an insight on process optimization during leather manufacture. *JALCA* **116**, 233-238, 2021.
7. Jayakumar GC, Niklesh C, Jeyas Kandhan S, Phebe Aaron K, Krishnaraj K: Physico-Insight on Sewability Properties of Crust Leathers Using Melamine Syntan and Synthetic Fatliquor. *JALCA* **117**(10), 2022.
8. Katarina Zelova, Viera Glombikova, Antonin Havelka; Problems with perfect-looking two-needle decorative seams in the manufacture of leather car seat covers. *Textile Research Journal,* Volume: **90**, Issue: 1, Page(s): 49-62, January 1, 2020.
9. C.A. Papakonstantinou, H. Chen, V. Bertola, A. Amirfazli; Effect of condensation on surface contact angle, *Colloids and Surfaces A: Physicochemical and Engineering Aspects,* Volume **632**, 2 January 2022, 127739.
10. Mamoni Probha Borah, Binita Baishya Kalita; Functional Finishing of eri silk and its union fabrics for hydrophobicity. *International Journal for Modern Trends in Science and Technology*, **6**(9S): 175-182, 2020.
11. M.P.Cook, K.Thomas; Evaluation of gloss meters for measurement of moulded plastics, *Polymer Testing,* Volume **9**, Issue 4, 1990, Pages 233-244.
12. M. Khabir Uddin, Mubarak A. Khan, K. M. Idriss Ali; Development of Polymer Films and Its Application on Leather Surfaces, *Journal of Applied Polymer Science*, Vol. **60**, 887-895 (1996).
13. Gararda, A.; Investigation of the seam performance of pet/nylon-elastane woven fabrics. *Textile Research J*., **78** (21), 21-27, 2008.
14. Phebe, K., Krishnaraj, K., Chandrasekaran, B.; Evaluation of sewability of nappa leathers. *J. Fashion Technol. Textile Eng*., **4**:2, 2016.
15. IUP 6, Measurement of tensile strength and percentage elongation, *J. Soc. Lea. Technol. Chem*., **84**, 317-321, 2000.
16. IUP 9, Measurement of distension and strength of grain by the ball burst test. Official methods of analysis, *J. Soc. Leather Tech. Chem*., 1996.
17. Peter Maina, Moses A Ollengo and Esther W Nthiga; Trends in leather processing: A Review. *International Journal of Scientific and Research Publications*, Volume 9, Issue 12, ISSN 2250-3153, December 2019
18. Danish, P., Kneip, M.; Modern hydrophobic systems: new water repellents and retannages for shoe uppers, *Journal of the American Leather Chemists Association*, 91, 120-125, 1996.
19. Ya-e Feng, Xuepin Liao, Ya-nan Wang, Bi Shi; Improvement in Leather Surface Hydrophobicity through Low-pressure Cold Plasma Polymerization, *Journal of the American Leather Chemists Association*, March 2014.
20. Burçak Karagüzel Kayao lu, Emre Öztürk; Imparting Hydrophobicity to Natural Leather through Plasma Polymerization for Easy Care Effect, *Fibers and Polymers,* 2013, Vol.14, No.10, 1706-1713.
21. Carlos Ruzafa Silvestre, María Pilar Carbonell Blasco, Saray Ricote López, Henoc Pérez Aguilar, María Ángeles Pérez Limiñana, Elena Bañón Gil, Elena Orgilés Calpena and Francisca Arán Ais; Hydrophobic Leather Coating for Footwear Applications by a Low-Pressure Plasma Polymerisation Process, *Polymers*, 2021, 13, 3549.
22. Olga Serenko, Zarina Nizamova, Mikhail Kalinin, Yuri Ostrovsky, Ludmila Polukhina, Aziz Muzafarov; Effect of the Morphology of Leather Surface on the Hydrophobic-Hydrophilic Properties, *Advances in Materials Physics and Chemistry*, 2014, 4, 13-19