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PHYSICO-CHEMICAL PROPERTIES OF RECONSTITUTED FIBERS COMPOSITE PREPARED FROM LEATHER WASTE

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ABSTRACT

The reconstituted fiber composite materials (RFCMs) were prepared by leather fibers (LF), Textile fibers (TF) viz., cotton fibers (CF)/polyester fibers (PF) and natural rubber latex (NRL).The objective of this composite material in boardformwas developed using finished leather waste (FLW), as a solid waste from the leather industry. Different concentrations of these natural polymers were used to find out the optimum concentration which gave better mechanical properties.RFCMswere characterized usingscanning electron microscopy (SEM) etc and biodegradation properties. Leather composites prepared using100 mL of natural rubber latex (NRL)possessed better mechanical properties viz., tensile strength, elongation at break (%), flexural strength, tearing strengthetc. Hence, the study focuses on the conversion of leather industry solid waste into value added products.

KEY WORDS: **leather waste, leather fibers, textilesfibers, natural polymer, recycling**

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INTRODUCTION

The leather industry is an age-old industry and has been serving the society as an important customer industry by providing a wide range of consumer leather goods such as shoes, garments,bags, etc.[1] According to the latest estimates, 20-30% leather discarded as waste during foot wear production. Also, enormous amount of used leather products viz., chappal, shoes, bags etc and end products of leather industry constitutes to major solid wastes.[2]The weak capacity combined with the low level of public awareness and the lack of knowledge on environmental impacts has led to uncontrolled solid waste disposal. Leather solid waste management is an increasingly pressing matter in many developing countries due to the growing volume of the waste and the associated negative impacts on the environment, health and safety of the population.[3] The proposed technological solution to the problem of waste shavings utilization is the production of secondary or artificial leathers designed for footwear elements, fancy goods ornon-woven fabrics as substrates for leather-like materials.[4]Leather like material prepared using chrome shavings leather waste is reported.[5]Utilization of buffing dust as a potential source of composite filler materials is also proposed.[6]The leatherwaste utilization is also reviewed.[7]The decreases in the waste generation and to the development of a product that causes a reduced environmental impact throughout its life cycle.[8] Currently, there is growing interest to polymer and leather waste matrix composites, reinforced by natural and synthetic textile. Such materials exhibit attractive mechanical properties including tensile strength, tearing strength and flexing endurance.[9]Leather waste were taken up for this study owing to their inherent eco-friendly nature, low cost, low density, biodegradability, recyclability and significant processing advantages, in particular equipment abrasion, energy consumption, pollutant emission, dermal and respiratory irritation are all reduced..[1] The textile industry uses different types of natural and synthetic fibers in the clothing manufacturing. Textile fibers are manufactured from a unique type of fiber or from a combination of several fibers, natural or synthetic, providing a huge variety of final products.[10]Cotton fibers consist of 95% cellulose I (β-1,4-D-anhydroglycopyranose).[11]The natural fibers used in construction of fiber-reinforced concrete (FRC) have improved significantly during the past five decades, and their employment have been on the rise.[12] Synthetic fibers account for about half of all fiber usage, with applications in every field of fiber and textile technology.It is this superior performance that makes synthetic fibers so important in consumer goods today,especially polyester, now the most-used synthetic. The polyester fibers to act as a good suture material should possess inertness, adequate tensile strength and strength retention in the body's environment, and good healing characteristics. Furthermore, the fibres must be biologically compatible with the surrounding body tissue.[13]Natural polymeric materials such as shellac, amber and natural rubber have been in use for centuries. Particularly, natural polymers exhibitchemical, physical formability, and biodegradabilityproperties.[14] The objective of the presentstudy uses environmentally friendlier technology process to prepare the composites based on leather fibers, natural/synthetic fibers and natural rubber latex (NRL).The production of reconstituted leather composite materials (RLCMs) to enhance its mechanical properties.RLCMs prepared using different textile fibers were characterized for its physico-chemical properties using FTIR, TGA and SEM. Mechanical properties such as tensile strength, elongation at break, flexing index, water absorption and water desorption properties were also assessed.

MATERIALS AND METHODS

Leather wastes were collected from leather industry Chennai (Tamilnadu, India). Textile fibers were collected from Textile technology Department, Anna University (Chennai, India). All chemicals used were of analytical grade.

Preparation of leather fibre (LF)

The leather portion of these waste were cleaned and it was dried under sunlight for 2 h These leather wastes (Figure.1a) were cut into small pieces(Figure.1b)using Swing ARM Clicker (Porielli S.20, VIGEVANO-ITALIA) (Figure. 1c).The cut leather wastewas converted into leather fibre (LF) with the help of fibrizer machine (SDL868, USA)(Figure. 1d).The fibre size is in the range of 1.0 cm in length and 0.3mm in diameter (Figure. 1e).[14]

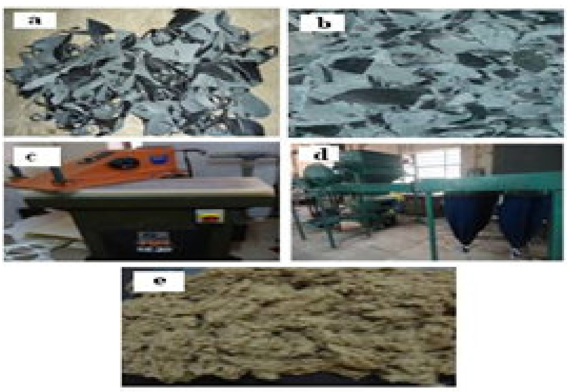

Figure 1
Photographic images of (a) Leather waste (b) Cut leather waste (c)Swing ARM Clicker (d) fibrizer machine (e) Leather fibre

Preparation of textile fibre (TFs)

The raw cotton fibers (Figure.2a) and polyester fibers(Figure.2b) were cut into small size using cutting machine(Figure.2c).The process is done to obtain fiber sizelength 15 mm and 12µmdiameters and uniformity of fiber quality(Figure.2d&e).

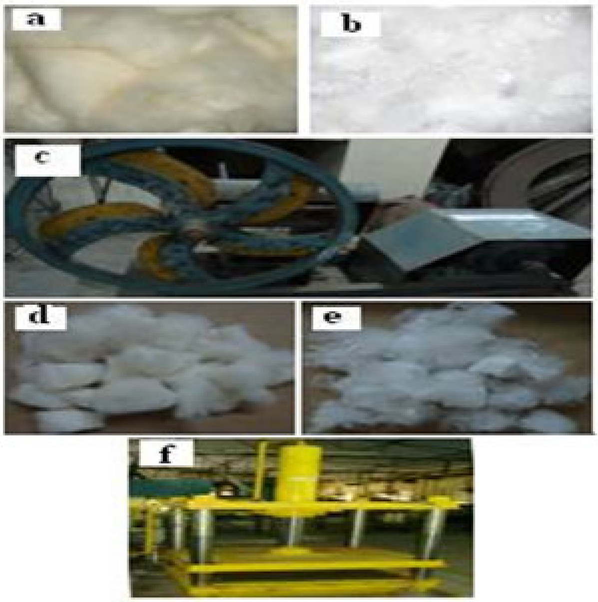

Figure 2
Photographic images of(a) raw cotton fiber (b) raw polyester fiber (c) Cutting machine (d) length of cotton fibers (e) length of polyester fibers (f) hydraulic press

Characterization of LF and TFs

LF and TFswere characterized for their mechanical properties and surface morphology. Mechanical properties such as tensile strength (MPa) and percentage of elongation at break were measured using Universal testing machine (INSTRON model 1405) at an extension rate of 5 mm/min.Scanning electron microscopic (SEM) analysis was carried out on Model LEICA stereo scan 440 instrument. The samples were coated with gold ions using an ion coating unit. The micrographs for LF and TFs were taken by operating the instrument at 15 kV accelerating voltage.

Preparation of reconstituted fiber composite materials (RFCMs)

Preparation ofRFCMswas done using leather fiber waste, Textilefibersand NRL. Leather fiber, Textile fiber viz. cotton fibers, polyester fibers, NRL and water were mixed in 100g:50g: 100mL: 50mL ratio. Two different concentrations (50 and 100 w/v) of natural and synthetic fiberswere used as textile fibers. To this leather fiber, cotton fiber/polyester fiber, water and binder slurry, 1 % ethylene glycol was added. The prepared paste was poured into steel plate (size 3×2 feet) and the pH was adjusted to 5 by spraying 1N H_2SO_4. The surface was covered with another steel plate. The prepared sheet was pressed using hydraulic press(polyhydron4DL10SG S-10)(Figure.2f)to remove water using pressure (1000 psi for 5 s). The resultant leathercomposite materials were dried in sunlight for 8 h and further pressed at 50°C for 10 s at 2000 psi.[14]

Characterization of RLCMs

Characterization of RFCMs samples were subjected toSEM analysis as described in earlier section

Mechanical properties

Mechanical properties were studied using dumbbell shaped specimens of 4 mm wide and 10 mm length prepared from RFCMs.Tensile strength (MPa), percentage of elongation at break (%) and tearing strength (N/mm) were measured using Universal testing machine (INSTRON model 1405) at an extension rate of 5 mm/min. Flexing endurance strength was also assessed using Fibre board flexing (TER 74)machine according to STM 129 test method. Water absorption and desorption (%)capacities of different LBs prepared were also determined.

Enzymatic biodegradation method of RFCMs

The composites materials to assess the biological stability of the material and its level of degradation. Known weight of each sample was taken and they were air dried overnight at room temperature. Composites sample was added into a small vial containing 30 mL acetate buffer (pH 4.5) with cellulose or collagenase enzyme (concentration of 2g/L). The mixture was then incubated at 55 ^{o}C in water bath. After every 48 h, composites sample was washed with distilled water, and then dried in a vacuum at 45^{o}C for 24 h. The immersion media were refreshed daily to maintain enzymatic activity. The extent of biodegradation was estimated for composites sample based on weight loss.[15].

Statistical analysis

Results are presented as mean ± standard deviation (SD) of three individual experiments (n = 3). ANOVA (Analysis of variance) and Duncan's multiple range analysis were done to determine the significant differences among the groups. *P* values of $p < 0.05$ were considered significant.

RESULTS AND DISCUSSION

Presently, finished cutting leathers scarps are being discarded as waste material inmost of the leather goods and footwear industry. Composites prepared from leather waste and textile fibers possessed better properties, which could be used for the manufacture of footwear, leather goods products etc.

Characterization of LF and TFs

The mechanical properties of leather fibre (LF), cotton fibre (CF) and polyester fibre (PF) are given in Table 1**.**Collagen constitutes the major portion of leather fibre. Cellulose, hemicelluloses and lignin constitutes the major portion of cotton fibers. Polyester fibres have the shape of liquid resin with styrene monomer.[16]However, the use of LF, CF and PF as reinforcement for natural rubber latex has not been investigated.The use of CF has several advantages, which include low cost and low weight.

Table 1
Mechanical properties of LF, CF and PF

Sample	Tensile strength (Mpa)	Elongation at break (%)
Leather fiber	0.38±0.01	0.38±0.04
Cotton fiber	0.66±0.06	0.72±0.03
Polyester fiber	0.96±0.01	0.95±0.04

The surface morphology of LF, CF and PFwas studied using SEM (Figure.3(a-c))**.**In LF, individual collagen fibres were clearly observed. CF was flat with twisted ribbon-like structure caused by spiraling of cellulose fibrils.[17]PF was perfectly smooth, with the exception of perturbed surface which might present several morphologies.

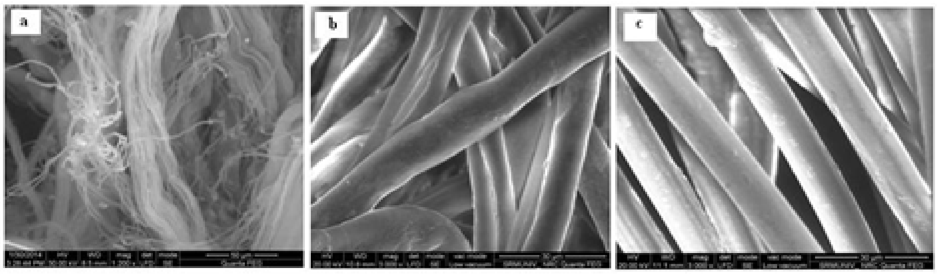

Figure 3
Scanning electron microscopic images of leather fibres and Textile fibres (a) Leather fibre (b) Cotton fibre (c) Polyester fibre

Preparation of Reconstituted fiber composite (RFCMs)

Reconstituted leather boards(RL) prepared using leather fibers are shown in (Figure.4a). Final surface finish was done with binders and pigments (Figure.4b).RFCMsprepared from LF,CF, PF and natural binders, denoted as RFCM1 (LF: CF) and RFCM2 (LF: PF) are shown in Figure.4 (c & d**).**RFCMs were more suitable to make leather goods and footwear consumer items such as purses, bags, keychain holders, shoe upper, shoe insole, slipper etc. The reconstitutedfiber composite materials were produced different pigment and dying operation, obtained were of good quality and smooth finish(Figure. 4 e & f).

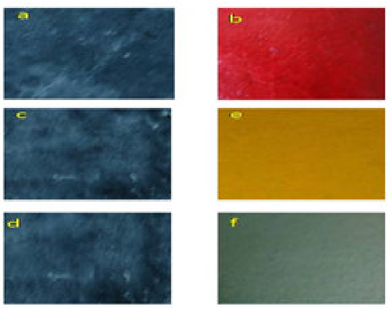

Figure 4
Photographic images of (a)RL (b) Pigmented RL (c) RFCM1 (d) RFCM2 (e) Pigmented RFCM1 (f) Pigmented RFCM2

Characterization of RFCMs

The surface morphology of RFCMs, were revealed by scanning electron microscopy. In RFCMs **(**Figure.5a&b),individual collagen fibres were clearly observed and showed smooth surface, which could be due to the blending of leather fibers and textile fibers.

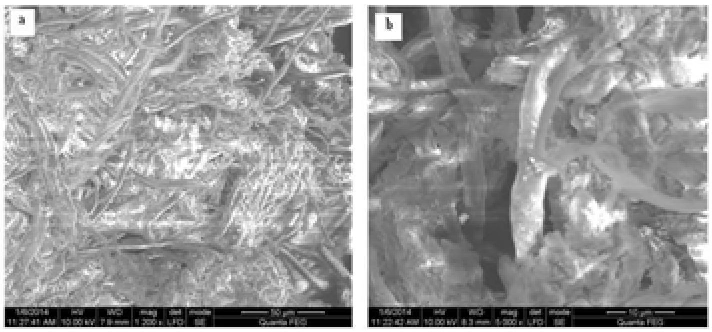

Figure 5
SEM analysis of RFCMs prepared using (a) Cotton fibre (b) Polyester fibre

Mechanical properties such as tensile strength, elongation at break, tearing strength, water absorption etc were studied (Table 2).In RFCMs, proportions of (100g LF: 50g CF: 100 mL NRL: 50mL H_20,100g LF: 50g PF: 100 mL NRL: 50mL H_20) ratio exhibited significantly ($p<0.05$) higher values compared to other proportions.Water absorption and desorption capacity of a composite material play a major role in deciding its use in footwear and leather goods manufacture. Since, maintaining a dry product surface is essential to prevent slipperiness and microbial growth. Water absorption can lead to swelling of the fibre, forming voids and micro-cracks at the fibre matrix interface region which may result in a reduction of the mechanical properties and dimensional stability of composites[18] Figure.6 RFCMs water desorption and desorption values compared to RL.Ethylene glycol was used to increase the flexibility of the composite material.

Table 2
Mechanical properties of RL and RLCMs

S.No	Composition (%)	Tensile strength (Mpa)	Elongation at break (%)	Tearing strength (N/mm)	Water Absorption (%)	Water desorption (%)	Flexing Index		Thickness
							Along	Acros	
1	RL	4.60±0.19	3.85±0.14	13.69±0.05	40.81±0.84	51.33±0.30	3.00±0.13	2.75±0.16	0.57±.02
RLCs(LF:Textilefibre)									
2	50:25 (CF)	7.5*±0.43	7.26*±0.17	15.87*±0.17	50.90±0.12	39.88±0.70	3.89*±0.30	3.8*±0.28	0.61±0.01
3	50:50 (CF)	8.08*±0.12	7.92*±0.06	16.74*±0.26	54.84±0.15	38.29±0.30	4.58*±0.23	4.60*±0.11	0.61±0.01
4	50:25 (PF)	6.57*±0.10	6.67*±0.38	14.83*±0.12	42.76*±0.12	33.41±0.25	3.12*±0.20	3.37*±0.26	0.64±0.01
5	50:50 (PF)	6.66*±0.44	5.86*±0.19	15.48*±0.24	45.60*±0.21	35.42*±0.39	3.37*±0.20	3.18*±0.11	0.63±0.01

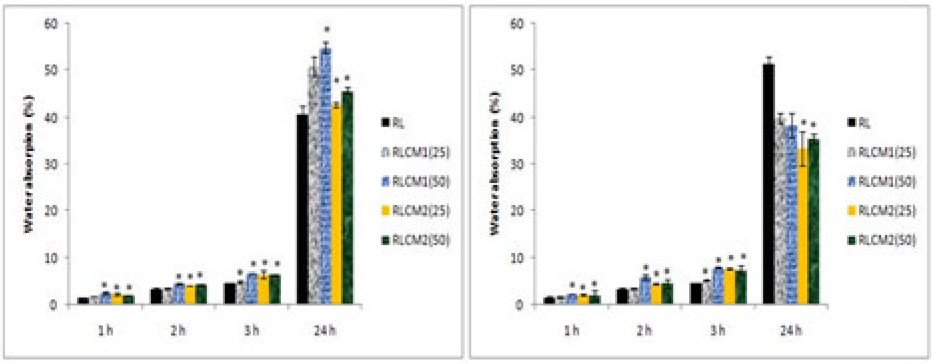

Figure 6
Water absorption and desorption analysis of RFCMs

Enzymatic biodegradation method of RFCMs

The weight loss due by biodegradation by enzymatic treatment is shown in Figure.7.To RLCMs biodegradability under the testing conditions, cellulase and collagenase were used as the testing enzyme. The RLCM2 lowest degradation values with less than around8% weight loss, while RLCM1 had higher biodegradation values around (16% weight loss).The RLCM1 were more significantly degraded in the environment than under the laboratory conditions. The materials confirmed to be biodegradable and hence environmental benefits.

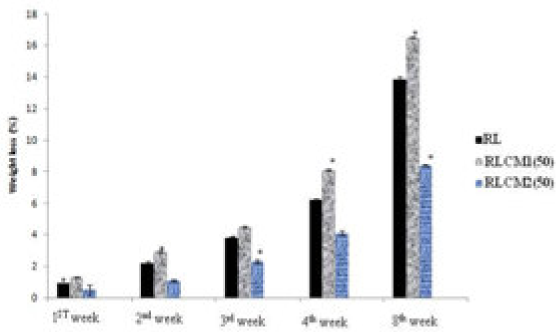

Figure 7
Biodegradation by enzymatic method

CONCLUSIONS

Leather fibres isolated from leather waste were used for the preparation ofreconstituted leather composite materials. The composite materialsprepared,show better or comparable strength properties as compared to reconstituted leather. The composite required mechanical properties for the manufacture of leather goods and footwear consumer materials.Therefore, the present study shows potential use of consumer items bags, keychain holder, purses etc and also production of cost effective composites, as a viable cleaner production option.

CONFLICT OF INTEREST

Conflict of Interest declared None.

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