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COMPOSITES FROM LEATHER INDUSTRY BUFFING DUST: A REVIEW

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Abstract: *Leather buffing dust is a fine powder of collagen fibril waste from milling and buffing operations and constitutes an important part of solid wastes generated from chrome tanned leather production processes. It is one of the difficult tannery wastes to manage and current practice of its disposal includes its incineration and disposal in landfill. The scientific literature reports numerous studies on its utilization in composites formulations. Chrome tanned buffing dust has been used as filler for various polymeric matrices with the aim of producing leather-like composites for potential applications such as hand bags, wallets, key chain holder and purses and footwear products such as shoe soles, insole, heels etc. This paper compiles different research works done by researchers regarding composites made from leather industry buffing dust. The characteristics of composites are also presented by making use of previously published studies carried out with different polymer matrices. Reviewed studies reveal that fiber-reinforced composites utilizing buffing dust provide landfill avoidance, energy conservation, decrease depletion of virgin raw material, enable production of low cost composites with improved mechanical properties that can be used for multifunctional applications and moreover they provide solution to the environmental problems associated with the waste management of the leather industry.*

Key words: *leather industry waste, composites, recycling, buffing dust*

1. INTRODUCTION

Leather industry is responsible for generation of large amount of solid tanned waste throughout tanning process, which converts raw skins/hides into leather. These solid wastes can be generally classified as untanned hides/skins, tanned leather and wastes from finished leather [1]. The transformation of 1000 kg of rawhide into leather provides only 200 kg of leather final product, along with 250 kg of non-tanned and 200 kg of tanned waste [2]. Among the tanned wastes solid waste from chromium-tanned leather, which includes shavings and buffing dust (BF), constitutes an important part and its disposal cause serious environmental problems.

Buffing dust is a fine powder of collagen fibril, which is generated when the finished leather is subjected to abrasion process in order to get a smooth and fine feel. For every tone of skin or hide processed, about 2–6 kg of buffing dust is generated as a solid waste. The characteristics of buffing dust are listed in Table 1.

Table 1: *Characteristics of buffing dust [3]*

Parameter	**Value**
Humidity (wt%)	7.92
Ash (wt%)	12.86
Chrome oxide (wt%)	3.41
pH	4.15
Nitrogen (wt%)	9.71
Protein (wt%)	54.58
Decomposition temperature °C	323
Diameter average (μm)	4.52
Length average (μm)	258.5

Management of buffing dust from chrome-tanned leather is difficult, and current practice of its disposal includes its incineration and land codisposal. However incineration causes serious air pollution problems because of the release of toxic gases, and on the other hand land disposal method poses a threat to groundwater resources [4]. Therefore various attempts have been made for finding beneficial uses of this waste and numerous researchers reported alternative processes to recycle and utilize buffing dust waste as fillers in a polymer matrix to produce composites, instead of landfilling or incineration in the literature. The aim of this study is to present an overview of the previous researches carried out on the reuse of buffing dust as filler in composites, in order to propose potential application areas and overcome environmental issues associated with its disposal.

2. UTILIZATION OF BUFFING DUST AS REINFORCING FILLER FOR COMPOSITES

In the literature there are numerous leather fiber composite studies, which utilize chrome tanned leather wastes in the form of both chromium shavings, and buffing dust. However in case of chromium shavings, wastes have to be subjected to grinding or milling procedure, prior to incorporation into the composite blend. Therefore in this paper, studies handling exclusively buffing dust as filler were reviewed.

2.1. Literature survey on leather fiber composites from buffing dust

Rubber matrices such as natural rubber, scrap rubber, carboxylated butadiene acrylonitrile rubber, various polymers such as poliamide, poly vinyl butryral are used as matrix where leather-buffing dust was utilized to prepare leather fiber composites. And more recently due to the increasing demand of the eco-biocomposites made from the natural biodegradable material to replace conventional composites naturally-derived polymers such as Polylactic Acid (PLA) [3] and Polycaprolactone (PCL) [5] have been investigated with attempt of replacing nonbiodegradable polymeric materials with biodegradable polymers. Table 2 summarises the studies conducted on composites from leather industry buffing dust, the polymer matrices, mixing ratios and methods for preparing composites, and analysis performed for the characterization of composites for each study were also presented.

***Table 2**: Studies conducted on buffing dust composites*

Polymer matrix	Method	Mixing ratios	Analysis performed for composites	Authors
Carboxylated butadiene-acrylonitrile rubber (XNBR); butadiene-acrylonitrile rubber (NBR)	Vulcanized	100phr XNBR: 5phr ZnO: 5phr BF	Hardness, elasticity, shock absorbing capacity, electrical conductivity, SEM, mechanical properties, resistance to thermal ageing	Chronska et al., 2008 [6]
Poly vinyl butryral (PVB)	Extruded and compression molded	30-50-70% BF	Mechanical properties, hardness, abrasion resistance	Ambrosio et al., 2011 [7]
Natural rubber latex (NRL)	Compounded and hydraulic pressed	400g BF: 150, 300, 450 mL NRL	FTIR, TGA, SEM, mechanical properties, water absorption	Senthil et al., 2015[8]
Polycaprolactone (PCL)	Extruded and compression molded	2-5-10-20-30-40% BF	DSC, mechanical properties, XRD, SEM, TGA, water absorption	Joseph et al., 2015 [5]
Natural rubber (NR)	Vulcanized	100phr NR: 15phr ZnO: 2phr Stearic acid: 10, 20, 30phr BF	Rheometric characteristics	Cardona et al., 2016 [9]
Polylactic Acid (PLA)	Extruded and compression molded	2-5-10-20-30% BF	Mechanical properties, SEM, DSC, water absorption, contact angle, TGA	Ambone et al., 2016 [3]
Epoxy polymer; Titanium dioxide	Mixed and cured	10% BF	SEM, Hhardness, DSC, TGA, FTIR, mechanical properties, chemical resistance test	Sivakumar et al., 2015 [10]

***Phr**: Parts per hundred rubbers*

Authors carried out the structural characterization of the composites using Fourier-transformed infrared (FTIR) spectroscopy and X-ray diffraction spectroscopy (XRD). Scanning Electron Microscopy (SEM) was used to analyze morphological structure and distribution of BF in the matrix. Differential Scannig colorimetry (DSC) and thermogravimetric analysis (TGA) were used for investigation of thermal properties of composites. And in some researches biological stability [8], and chemical resistance of compositeswere also analyzed [10].

2.2. Characteristics of leather fiber composites from buffing dust

Table 3 provides the general characteristics of leather fiber-reinforced composites developed by researchers. Utilization of BF in rubber mixes improved processibility and mechanical properties of composites. Chronska and Przepiorkowska (2008) reported that incorporation of BF as filler for rubbers such as carboxylated butadiene-acrylonitrile rubber (XNBR) and butadiene-acrylonitrile rubber (NBR) has improved their mechanical properties, increased thermal aging, provided higher cross-linking density, and higher hardness. Cardona et al. (2016), observed that incorporation of BF into natural rubber formulations improved processibility and facilitated the vulcanization process during mixing, diminishing the viscosity and vulcanization time. Senthil et al., (2015), developed a composite material in board form from buffing dust using different concentration of natural rubber latex. Among the different concentrations of NRL used, 450 mL (w/v) provided significant mechanical properties, which may find application in footwear, leather goods, and household interior applications.

Table 3: *Properties of fiber-reinforced composites*

Polymer	Tensile strength (Mpa)		Elongation at break (%)		Shore A hardness (◦Sh)	Water absorption (%)	Reference
	Neat polymer	Composite	Neat polymer	Composite			
XNBR vulcanizates (100phr XNBR: 5phr ZnO: 5phr BF)	8.5	14.88	45	58	355.15	-	[6]
NBR vulcanizates (100phr NBR: 5phr ZnO: 5phr BF)	2.1	3.45	50	46	458.6	-	[6]
Natural rubber latex (NRL) (400gr BF: 450 mL NRL)	-	4.19	-	3.99	-	50	[8]
PLA (90 PLA: 10 BF)	43.15	45.05		-	-	2	[3]
PVB (70 PVB: 30 BF)	21	8	63	75	175	-	[7]
PCL (80 PCL: 20 BF)	15	16	-	-	40	3.8	[5]
Epoxy (10gr Epoxy:0.005 Nano TiO_2:1gr BF)	4.43	15.08	9.44	6.11	-	-	[10]

Incorporation of buffing dust into polymer matrices resulted in increase in mechanical properties and hardness. This increase in hardness derived from higher hardness of tanned leather fibers than the plasticized polymer matrices. Ambrosio et al., (2011) reported that increasing the incorporated buffing dust leather content in the poly (vinylbutyral)–leather fiber composites led to a significant increase in the elastic modulus and shore hardness of the composites, whereas tensile strength and abrasion resistance decreased [7] .

Joseph et al (2015), developed Polycaprolactone (PCL) biocomposites filled with waste leather buffing dust, which could be used to produce low cost materials suitable for applications in footwear industry, for making bags and suitcases [5]. Incorporation of BF with increasing concentrations into PCL resulted in improvement of tensile modulus, increase in percentage of water uptake and reduction in percentage crystallinity of PCL matrix. Similarly Ambone et al., (2016) also reported that addition of BF in increasing contents improved tensile properties of biodegradable polymer based biocomposites and led to a reduction in percentage crystallinity of PLA matrix [3]. BF/PLA biocomposite showed increase in water absorption with BF addition.

2.3. Application areas of leather fiber composites from buffing dust

Numerous application areas and benefits for utilization of buffing dust for the production of leather fiber-reinforced composites were listed in Table 4.

Properties of composites studied here varied with the type of polymer matrix and content of leather wastes. Type of polymer matrices must be selected according to the desired final properties of the material to be manufactured. For instance mechanical properties and water absorption capacity of a composite material play a major role in deciding its use in footwear and leather goods manufacture. Comfort footwear could be made from leather boards with tensile strength of 5.5 Mpa while inexpensive and light foot wears could be made from leather boards with tensile strength of 4.0 Mpa and the water absorption (%) should be minimum of 35% [8]. On the other hand composites with high chemical resistance and hardness can be required for construction materials and mechanical automobile body parts.

Table 4: *Application areas of fiber-reinforced composites*

Application areas of composites	Benefits of utilization of buffing dust as a filler in composites
•Footwear,	✓ Decrease depletion of virgin raw material
•Handbag,	✓ Landfill avoidance
•Suitcase,	✓ Energy conservation
•Shoe sole shoe last, shoe heel,	✓ Low cost composite production
•Clothing	✓ Reduction of waste volume
•Household interior	✓ Reuse waste
•Construction materials	✓ Improve/increase of mechanical properties of composition
•Automobile interior moldings	✓ Profitable use of waste
•Heat-sound insulating boards	✓ Air permeability
•Flooring materials	

Utilization of buffing dust enables saving of depletion of virgin raw materials avoids landfilling of wastes and reduces waste volume. Due to environmental issues arising from tanned leather wastes the demand for cost effective, environmental friendly materials continues to increase. The driving forces behind the utilization of the leather industry buffing waste are environmental benefits, cost, and renewable resource utilization.

3. CONCLUSIONS

Incineration and landfill of chrome tanned leather wastes pose significant environmental problems. Numerous studies have been carried out on utilization of buffing dust as filler for fiber-reinforced composites. Various polymeric matrices have been usedwith the aim of producing leather-like composites, which may find application in footwear, leather goods, and household interior applications.

This paper presents an overview of the previous researches carried out on the reuse of buffing dust as filler in composites, in order to overcome environmental issues associated with its disposal and propose a profitable use of chromium tanned leather waste. Studies reveal that fiber-reinforced composites utilizing buffing dust have good mechanical properties, acceptable water absorption values which can used for multifunctional applications. The developed composites also provide solution to the environmental problems associated with the waste management of the leather industry. Leather wastes composites exhibited a homogeneous distribution within the polymer matrix, which makes it feasible to develop low cost eco-friendly composites for shoes, bags and upholstery manufacturing.

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