# Development of Electrospun Nanofibers Embedded with Activated Carbon derived from Tannery Solid Waste LSTM-Based Deep Learning Framework for Real-Time Water

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Development of Electrospun Nanofibers Embedded with

Activated Carbon Derived from Tannery Solid Waste

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Abstract

Globally, tanneries are producing approximately 6 million tons of solid and liquid waste per year. About 80% of solid wastes produced during leather process are generated from pre-tanning stage, whereas 20% of wastes are generated during post-tanning operation. Fleshing waste is considered to be one of the major solid wastes, which is rich in proteins and fat. The current disposal methods of fleshing wastes have various challenges and limitations. Conversion of fleshing waste into activated carbon and incorporating it into electro spun fibers is one of the sustainable approaches for developing a composite material and waste management strategy.

Converting leather solid waste to activated carbon plays a significant contribution to reduce major landfill burden. Also, the activated carbon produced from leather solid waste shows a large surface area, high porosity, and other physical properties as compared to activated carbon produced from other sources. The process of making activated carbon consists of two phases. The first step involves carbonization of the raw material in the presence of nitrogen or argon atmosphere. The second step is the activation of carbonized material, which can be physical or chemical. The activated carbon prepared is incorporated into PVA solution which was then electro-spun to produce activated carbon embedded PVA nanofibers. These nanofibers were further processed for stability and the nanofibers were tested for the adsorption of organic pollutants.

Keywords: Activated carbon, nanofibers, adsorption, Fleshing waste, waste management

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## 1. Introduction

The leather tanning industry generates millions of tons of solid waste yearly, mainly fleshing waste, the subcutaneous tissue removed during pre-tanning. Traditionally dumped in open sites or landfills, this organic-rich waste causes major environmental issues like health risks, methane emission, groundwater contamination, and odour problems.

Recent advances in circular economy and waste valorisation have focused on converting tannery fleshing waste a proteinaceous, carbon & nitrogen-rich by product into high-value activated carbon (AC). These ACs show excellent adsorption properties due to high surface area, developed porosity, abundant functional groups, and natural nitrogen doping. These characteristics arise naturally due to the biochemical composition of the raw material and can be further optimized through controlled pyrolysis/carbonization followed by physical (e.g., $CO_2$ or steam) or chemical (e.g., KOH, $H_3PO_4$, $ZnCl_2$) activation processes.1

Organic pollutants such as synthetic dyes (e.g., azo, cationic, and anionic types), phenolic compounds, pharmaceuticals, and pesticides—pose persistent threats to aquatic ecosystems and human health, as they are often toxic, carcinogenic, mutagenic, and resistant to conventional biological treatment. Adsorption onto AC offers a cost-effective, efficient, and sludge-free alternative for their removal, particularly in industrial wastewater from textile, pharmaceutical, tanneries and chemical manufacturing sectors2.

Activated carbon is widely recognized as one of the most effective adsorbents for removing organic pollutants from aqueous environments due to its large specific surface

area and reusability by simple regeneration. Despite these advantages, powdered or granular activated carbon from fleshing waste faces practical limitations in real-world water treatment applications, such as difficulties in

separation/recovery from treated effluents, potential secondary pollution from fine particle dispersion, and reduced accessibility of internal pores in flow-through systems. To address these challenges, integrating activated carbon into polymeric nanofibrous composites via electrospinning offers a transformative approach. Electrospinning enables the fabrication of highly porous, non-woven nanofiber mats with large surface-to-volume ratios, tuneable fiber diameters, and excellent mechanical integrity, facilitating easy handling, filtration, and reusability.

This study focuses on the preparation of activated carbon from tannery fleshing waste and its subsequent incorporation into a composite material designed for the efficient adsorption of organic pollutants from aqueous solutions. By utilizing a low-cost, abundantly available industrial waste as the primary precursor, this approach not only addresses solid waste management in the leather industry but also contributes to sustainable wastewater treatment technologies.

2. Methodology

The fleshing waste (FW) from tannery were delimed to neutral pH using weak acid like ammonium chloride or sulphate followed by washing with distilled water to remove

(a) (b)

Fig. (a) AC- nanofiber before crosslinking Fig. (b) AC- nanofiber after crosslinking

excess residues then dehydrated using Acetone and dried in sunlight. The dried fleshing waste (DFW) were grounded into fine powder mechanically. The powdered DFW were pyrolysed in inert atmosphere about 400ºC to get carbon powder which was then activated chemically using KOH at 800ºC and washed with dil. HCl followed by distilled water and dried at 80ºC and stored for further usage 1. The electrospinning solution is prepared as follows, PVA solution of 7-8 wt % was prepared and the activated carbon prepared was added to the solution and stirred vigorously and sonicated to get a fine dispersed solution2.

The solution is then transferred into a 10mL syringe and electro spun into AC incorporated nanofiber (ACnanofibers). The nanofiber is crosslinked to improve its stability3 ; the stabilized nanofibers were characterised and examined for its ability towards adsorption of organic pollutants.

3. Result & Discussion

The structure morphology of the nanofiber was studied using FE-SEM shows that fiber morphology of nanofiber is highly retained after crosslinking and EDAX conforms the presence of carbon incorporated inside the fiber matrices. The adsorption study of the activated carbon incorporated nanofiber towards organic dyes was tested using UV absorbance spectrometer against PVA nanofiber as control.

4. Conclusion / Inference

In the current study, activated carbon derived from fleshing waste and PVA nanofiber composite were successfully prepared by electrospinning technique. Activated carbon enhanced thermal stability of PVA nanofiber composite, the AC incorporated PVA nanofiber showed better absorption of dyes compared to PVA nanofibers, thus this sustainable technology might help to develop filters to capture organic pollutants and volatile organic compounds.

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