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Synthesis and Characterization of Multifunctional Polymer for

Upscaled Functional Leather Applications

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Abstract

The intricate collagen matrix of leather is continuously explored and experimented to meet the demands for up-scaled functional leather products. Conducting polymers such as polyaniline (PANI), polypyrrole, and polythiophene exhibit excellent stability, processability and compatibility. They are known for their conducting properties & electromagnetic interference (EMI) shielding effects and can be exploited for various applications such as conductivity, enhanced physical strength, antimicrobial capabilities, self-cleaning features, and EMI shielding effects. Herein, we aimed to develop multifunctional polymers, PANI in particular, enabling the production of conductive leathers for operation of touch-sensitive devices. The synthesized polymer was characterized for size, functional group and morphology using techniques like, Dynamic Light Scattering (DLS) FT-IR and FE-SEM. PANI was introduced into the leather in Post Tanning where it was let to penetrate into leather at fixed time intervals and was also applied onto leather skin by spraying it along with base coat formulation. The treated leather was characterised for conductivity and physical testing to assess its performance. The leathers exhibited appreciable conductivity capable of operating touch sensitive devices, which has been validated by the test results .

Keywords: Conducting polymers, polyaniline, touch sensitive devices, conductive leathers

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Introduction

Recent advancements in the field of technology has resulted in the development of gadgets exhibiting improved user interface - touch sensitive operations.1 Touch sensitive operations has become prevalent in automobiles, warfare aircrafts, spacecrafts and biometrics apart from desktop, iPads and smart phones. They are used everywhere irrespective of the topography, climatic conditions, modernisation of the concerned region. However, in places that experience erratic climatic conditions and in scenarios that holds standard dress code, it becomes difficult to use touch sensitive devices with the conventional insulating gloves. In order to meet the need of conductance, wearables with smart properties is to be developed.

Leather, known for its unique features like flexibility, breathability, thermal comfort and aesthetic appeal, forms an integral part of the wearable component in industries and defense. Leather wearables are upgraded according to the requirements and can be incorporated with smart properties like conductivity for operating touch screens. Conducting polymers such as Polyaniline, Polyacetylene, Polyfuran, Polypyrrole, and Polythiophene exhibits conductivity due to their conjugated pi bonds and can be used for developing conductive leathers. They find application in the field of supercapacitors, bio-sensors, catalysis and biomedicine as they exhibit conductive and optical properties.2 Among various conducting polymers, polyaniline – (abbreviated as PANI), is a majorly explored one due to its high stability, processability, tunable conducting properties and optical properties. W. Jima

Demise et. al has produced self-coloured and conducting leathers using Polyaniline.3 Ionic liquid assisted in-situ polymerisation of aniline resulting in leathers with flame retardant property is also reported.4 PANI exists in three different oxidation states, with varied levels of conductivity. The green coloured emeraldine form is partially reduced and exhibits good conductivity.5 Chemical polymerisation is a common method of synthesising conductive emeraldine form of PANI. In-situ polymerisation has been carried out to add PANI into leather. However, challenges like leaching of dopants and presence of unreacted oxidant molecules demands a benign

and safer method of adding PANI into the leather.

In this work, we have synthesized PANI ex-situ and added the same to leather in the post tanning and finishing stages of leather processing. It was characterised by using FT-IR, XRD, DLS and FE-SEM. The PANI treated leathers were characterised for Conductivity, Contact angle and conventional physical properties. Moreover, real time analyses were performed by using touch screen devices. The work provides a simple and eco-friendly means to develop conductive leathers for operating touch screen devices.

2. Methodology

a) Synthesis of Polyaniline: Equimolar concentrations of Aniline hydrochloride salt and

Sl. No. Characterisation Results

1 UV-Visible Spectroscopy ≈450 nm polaron-π*transition of benzenoid rings, 800 to 900 - π-polaron transition

2 FT-IR Spectroscopy 1581 cm-1 C=C stretching of quinoid rings, 1473 cm-1 C=C stretching of benzenoid rings, 1306 cm-1 stretching frequency of C-N of secondary aromatic amine.

3 DLS Analysis Hydrodynamic diameter: ≈200 nm

4 XRD Analysis 2θ=25° d-spacing of phenyl rings of the PANI chain

Table 1: Characterisation of synthesised PANI

ammonium persulphate solutions (aqueous) were prepared and mixed under vigorous stirring. The reaction was maintained under low temperature conditions. The PANI obtained thereof was filtered, washed and dried before use.

b) PANI coating on leather: The synthesized PANI

was coated on defined sizes of leather pieces by dispersing it in DMF-Water mixture. A lacquer top coat followed by plating was carried out. The treated leather was tested for conductivity.

c) PANI addition in Retanning process: The

synthesised PANI was further treated with Surfactant and Acrylics for size modification. The resultant thereof was added to leather in fixed weight percentages at retanning stage, adjusting the pH accordingly. The leather was tested for conductivity and other physical characteristics.

3. Results and Discussion

The synthesised PANI was characterised by using UVVisible Spectroscopy, IR Spectroscopy, DLS, XRD and SEM. The PANI treated leathers were tested for conductivity, hydrophobicity, and other physical characteristics.

Table 2: Conductivity of PANI treated leathers

The developed leathers were tested for real-time performance by operating touch screens of different mobile phones. The standard physical tests like fastness to light & rub, tensile & tear strength analysis were performed and was found to show the required results.

4. Conclusions:

The work presents the development of conductive leathers with smart properties for glove products that are enabled to perform touch sensitive operations. The use of conducting polymers offers a good choice over other metal – based composites. Moreover, synthesis of PANI in aqueous medium with anilinium salt instead of aniline attributes to eco-friendly methods.

The ex-situ synthesis followed by its addition overcomes the challenges of toxicity and presence of unreacted molecules. The PANI treated leather is found to exhibit appreciable conductivity that can be used for touch screen applications as wearables at extreme climatic conditions.

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