Sustainable Conversion of Tannery Hair Waste into Electrospun Nanofibers for Transdermal Drug Delivery

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Sustainable Conversion of Tannery Hair Waste into Electrospun

Nanofibers for Transdermal Drug Delivery

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Abstract

Waste from leather industries poses a significant challenge to the environment. Research towards reducing this waste will have an additional significance if it leads to the production of value-added product(s). Hair waste derived from animal skin act as a valuable source of protein namely keratin; which has a great potential to serve in biomedical, textile and cosmetic applications. This hair waste is currently used as fertilizers or disposed as a landfill or incinerated.

In this work, we extracted keratin, while retaining its secondary structural and functional properties, using protease thus enabling a greener way of extraction. The structural integrity of keratin was evaluated using Fourier transform infrared (FTIR) and Circular Dichroism (CD) spectroscopy. Thermal and morphological characteristics were also analyzed to confirm the property. The extracted keratin was electrospun into nanofibers, which acts as a support for transdermal applications.

For conditions such as osteoarthritis and rheumatoid arthritis, different rates of controlled drug release are desirable to treat patients via non-invasive therapy. This keratin-based polymer matrix is expected to help in consistent drug release. The total system with the characteristics of biocompatibility, biodegradability, anti-bacterial behavior can be disposed off without causing harm to the environment. This work maximizes the goal of achieving circular economy by utilizing the waste of one industry and converting it into a potential candidate for the other industry.

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1. Introduction

Solid waste management is one of the emergences in our world, but the production of goods cannot be reduced due to the consistent population growth. The best way to address this issue is to plan a circular economy and reusing the waste of one industry as raw material for other. Leather industries during processing of skin/hide through soaking, liming, dehairing and tanning, produces several solid wastes like hair, fleshing, trimming, and shaving residues. On considering the hair wastes, it has been estimated that nearly 143 thousand tons of hair waste are generated annually from leather industries worldwide1.

Most of this waste is disposed of by landfilling or incineration, which contributes to soil and water pollution. In alteration these can be used to extract rich source of protein – keratin. It is a fibrous, high-sulphur protein primarily composed of cysteine amino acids, forms the essential framework of animal hair, wool, nails, feathers, and horn. It exists in two different secondary structures: á-helical keratin and â-sheet keratin. It shows unique properties like strength, flexibility, self-assembly due to the disulphide linkages and inter-molecular hydrogen bonds2. The enzymatic extraction of keratin offers a sustainable and selective alternative to traditional chemical methods by preserving the structural integrity.

Arthritis and its treatment should be addressed, as the population affected with different types of arthritis was

increasing in various age groups particularly above 503. The preliminary and continuous joint pains can be treated using transdermal patches which can monitor the drug release periodically. Polymer matrix along with keratin can serve as a integrate material for controlled drug delivery. This study aims to develop a keratin incorporated polymer matrix suitable for controlled drug delivery, which can serve to huge population worldwide.

2. Methodology

Goat hair was used as a source of keratin. The sample was washed, cleaned, and stored at 4oC for further reactions. Hair sample was taken in the ratio of 1/10 (w/ v) with enzyme allowed to react with 10ml of water was added. Mixture was stirred @ 55oC for 24 hours followed by filtration and dialysis. The dialyzed solution was lyophilized to obtain keratin powder. Different polymers like Polyvinyl alcohol, chitosan was electro-spun with

Ftir of keratin

3370 Amide A (N-H stretching vibrations)

2361,2316 C-H Stretching

1651 Amide I (C=O Stretching)

1552 Amide II (N-H bending and C-N stretching vibrations)

FT-IR Spectroscopy-

characteristic peaks

1404 C=O Stretching

1327,1240,1150 Amide III (C-N stretching and N-H bending vibrations)

650-600 C-S stretching

keratin to optimize its mechanical strength, water absorption, and drug release. Finalized matrix will be studied along with extracted keratin.

3. Result and discussion

The structural confirmation of extracted keratin was analyzed using Fourier transform infrared spectroscopy and CD spectrum. The peaks in the region of 1650 to 1655 cm-1 and 1552 cm-1 responsible for the carbonyl group of Amide I and C-N/N-H stretching of Amide II, these bands corresponded to features typically associated with αhelical conformation. In CD spectrum, the positive to negative hump peak and the broad W shaped peak was obtained which ensures the retention of α-helical structure.

The polymer matrix was electrospun using different weight percentages, needles, and concentration to obtain various size of the fibers, which need to be evaluated.

4. Conclusion:

Goat hair was utilized to extract protein with potential properties. The extracted keratin was analyzed for its structural information using spectroscopic techniques. The polymer matrix and keratin incorporated matrix will be analyzed for its features that would facilitate the controlled drug release.

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