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Valorisation of Human Hair for Packaging Material

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Abstract

The building block of life is Protein, which contains amino acids. The hair and nails of human being and the hoofs and horns of animal is made up of Keratin which is a structural protein. This natural and abundantly available compound is generally discarded, and it takes years to completely biodegrade. Valorisation of such bio-waste into a polymeric material for various end use applications including eco-friendly packaging as a technical textile component is a novel way of converting waste to value. The Keratin extracted from the human hair after alkaline dissolution and lyophilisation is used for making biofilms for packaging application.

The fast-growing human population, enhanced life expectancy and the increased frequency of hair cutting by both men and women has resulted in generation of huge amount of human hair as a bio- waste. Although, it is a biological component of human body, it is one of the slowest parts to biodegrade as it takes years to decompose. Moreover, biodegradation is delayed depending on the type and the amount of oil, colour and cosmetic chemicals applied on the hair. Thus, the annual generation and accumulation of human hair has become a major eco-concern (Figure 1).

Introduction

The hair is made up of keratin, which contains various amino acids including Cysteine. It provides the essential ability to form cluster of fibers and the individual strands within the bundles further crosslink through the sulphur-sulphur (S-S) bonds of cysteine. This bonding imparts characteristic strength and makes the Keratin a natural super strong material. The other component of keratin is Chitin, a high molecular weight tissue which helps enhance the toughness of hair. Thus, the combination of cysteine and chitin makes the Keratin a hard, strong, tough part of the animal body and provides natural protection.

Therefore, such human hair when cut and thrown as a waste material gets accumulated in land mass as well as water streams and having relatively slow biodegradability, causes huge environmental concerns. Even the incineration method of disposal is not advisable as the burnt hair releases environmental harmful toxic gases such as ammonia, carbonyl sulphides, hydrogen sulphides, sulphur dioxide, phenols, etc. Thus, preventing waste of such material requires both addressing the problems in the current usage and developing ways for its utilization [1].

The best way to address such problems is to develop systems which utilize the waste material as a bio-resource. As a potential material resource, human hair has the advantage that it is natural, renewable, economical and available in every locality. Developing appropriate utilization for human hair waste in a context therefore requires considering all possible uses and technologies along with their socioeconomic and environmental impacts. While there is abundant literature on the chemistry and biology of human hair, there is very little research literature on systematic environmentally safe management of human hair waste. Hair keratin, being one the difficult proteins to be solubilised or digested using commonplace technique, needs special methods of hydrolysis based on acidic, alkaline, and enzymatic treatments. A precise solvent system directly attacks the disulphide bonds among cysteine and hydrates the shaft. Eventually, the hard biomass of hair turns into a soft jelly-like material and after further processing it can be converted into powdered form [2].

Chemically, hair keratin consists of about 70-98% protein, 6% lipids, melanin pigment (natural colourant), small quantities of polysaccharides and 2-4% water. The elemental composition contains about 45% carbon, 28% oxygen, 15% nitrogen, 7% hydrogen and 5% sulphur. The shape of this protein's molecule is lengthy and stringy having extended chains of polypeptide along one axis. Appropriate methods of chemical hydrolysis and use of sophisticated mechanical devise can help extract, remove, and isolate the essential chemical components from hair for use in various end use applications. The effective utilisation in some cosmetic products and medical effects has been researched extensively and products developed. Earlier research revealed that keratin powders may be mixed with other compounds, this brought about the emergence of new studies. The use of keratin-based products in wound healing, drug delivery, tissue engineering, cosmetics, etc is widely studied [3-7].

The present area of research is aimed at synthesising a bioplastic for food packaging and technical textile application. The Keratin purification and extraction from human hair as a waste biomass followed by its characterisation using various sophisticated instrumental evaluation techniques and then preparing a biofilm for the intended end use application is being investigated.

It has been reported that 100% biodegradable packaging materials can be produced from renewable sources such as starch, proteins, and lipids. Keratins are desirable proteins due to their environmental stability and biocompatibility characteristics. The abundant cysteine amino acids in keratin are oxidised to give inter- and intra-molecular disulphide bonds, and they form a three-dimensional crosslinked network that results in high mechanically strength, hydrophobicity, and thermal stability. Thus, these qualities could lead to development of biodegradable materials from waste human hair such as films, sponges, self-assemble structures, hydrogels for compostable packaging products, tissue engineering, wound healing and drug delivery systems. One of the renewable sources of keratin is waste human hair which has about 17.5% cysteine content. Therefore, it can be adequately utilised for making biofilms for various technical textile

applications.

Conclusion

The procedure of growing extra efficient techniques for the production and detection of keratin will quicken its utility to industries and environmental waste management. It is noticed that in recent years, a wide range of advancements have taken place in the field of the keratin research area. Thus, human hair keratin finds a wide range of applications in varied disciplines including technical textiles.

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