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UV protection ability of silver coated coir fabric by magnetron sputtering

KEYWORDS

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ABSTRACT *This research mainly focuses on the UV- protection for natural ligno cellulosic coir fabric using silver coating by magnetron sputtering technique. Recent development in the incorporation silver thin films on natural fibers makes it possible to utilize its excellent physical and chemical properties in the field of textiles. This will help to widen the use of natural coir fibers. The surface morphology of the coated coir fibers are investigated by employing a scanning electron microscope. The results show that the surface functionalization of silver-coated coir fibers is highly versatile, and it possess excellent protection against ultraviolet radiation. This study demonstrates that treatment, which uses silver thin films by magnetron sputtering, is a promising method for achieving multifunctional coir fabrics.*

Introduction

The coir (Cocos nucifera) is an important lignocellulosic hard and stiff fibre obtained from coconut husk, by the process of retting or mechanical combing, which grow extensively

in tropical countries such as India, Sri Lanka, Thailand etc. Because of its hardwearing quality, durability and other advantages, it is used for making a wide variety of floor furnishing materials, yarn, rope etc [1]. However, these traditional coir products consume only a small percentage of the potential total world production of coconut husk and these products are facing stiff completion with the synthetic fiber alternatives. Hence, research and development efforts have been underway to find some diversified application area for coir fibres including utilization of coir fibres as reinforcement in polymer composites [2], desiccant materials [3] geotextiles, and sound absorbents [4].

In recent years, natural fiber industries have been focussing on improving the functional properties of fibers such as ultraviolet (UV) protection, fire retardency, water repellency and antibacterial properties [5]. Ultra violet radiation is a major cause for skin damages. UV exposure to human skin induces skin wrinkling, the degradation of matrix molecules, the development of elastosis, and an increased risk of skin cancer. So it is necessary to improve the UV protection ability of fabrics [6].

Silver thin films are widely used due to their excellent electrical, optical and antimicrobial properties. Traditionally silver is coated on the fabrics using solution treatments. But these processes produce much waste water. But with the advent of vacuum deposition coating, magnetron sputtering coating is widely used to deposit very thin films on various substrates. This technology has many advantages such as environmental friendliness and solvent free process. Recently sputter coating has opened up new possibilities in the surface modification of natural fibers. However, not much study has reported on the surface functionalisation of coir fibers by sputter coated silver particles.

This investigation is directed towards coating of coir fibers with silver by magnetron sputtering technique. Their morphological characterisation is studied by using SEM. Moreover the coated coir fibers are studied to characterise its ultraviolet radiation penetration. It is expected that this study will pave a new way for developing UV protecting coir fabrics.

Experimental

Coir fibers are obtained by courtesy from Centre for Coir Research Institute, Alleppey. In the present study acetone is used for removing the fats and oils on the coir fiber substrates. Prior to deposition, the coir fiber samples are first immersed into an acetone solution for 2 min, and then washed thrice with deionised water. Following that, the coir samples are dried at a temperature of 80 °C for 24 hours.

Silver target with high purity (purity: 99.99%) is used to deposit silver thin films onto coir fiber by using a magnetron sputtering system. The dimensions of the silver target are 50 mm in diameter and 5 mm in thickness.The pressure before evaporation is kept at $2^* 10^{-6}$ Torr and then it is increased to about 7^*10^{-6} Torr when argon is introduced into the vacuum chamber as the bombardment gas. The deposition rate is 1Å/sec for all coating. The thickness of the coating was monitored by using a quartz crystal monitor. The sputtering current and voltage are maintained at .15A and 115V respectively. Since the size and shape of the coir fibers may vary from fiber to fiber, we had taken a set of 20 samples to produce reliable results. The deposition time is 10min and 20 min on the samples.

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The surface morphology and chemical composition analysis of the silver coated coir fibers are performed by a scanning electron microscope (SEM). UV-blocking properties of the silver coated coir fabrics are evaluated according to AATCC test method 183-2004 (transmittance).The ultraviolet protection factor (UPF) rating system measures the UV protection provided by fabric. It is defined as the ratio of the average effective UV irradiance calculated for skin to the average UV irradiance calculated for skin protected by the test fabric. The higher the value, the longer a person can stay in the sun until the area of skin under the fabric become red. This can be calculated by the equation[7]

$$UPF = \frac{\sum_{280\,nm}^{400\,nm} E_\lambda \times S_\lambda \times \Delta_\lambda}{\sum_{280\,nm}^{400\,nm} E_\lambda \times S_\lambda \times T_\lambda \times \Delta_\lambda}$$

where E_λ is the relative erythemal spectral effectiveness, S_λ is the solar spectral irradiance, T_λ is the average spectral transmission of the specimen, and Δ_λ is the measured wavelength interval (nm).

Results and Discussion

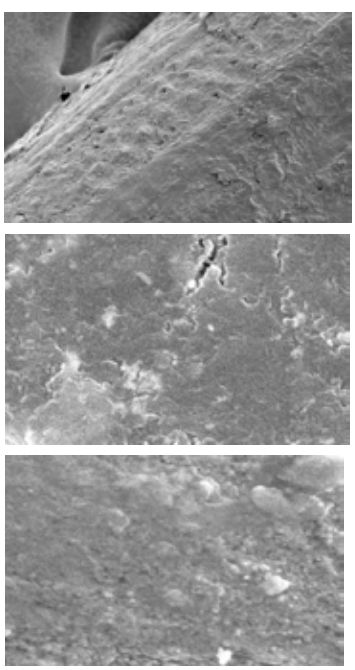

Fig 1 SEM images of a) uncoated coir fiber b) Ag coated (10min) c) Ag coated (20min)

The surface morphologies of the fabrics before and after sputter coating are studied by using SEM and are shown in Fig. 1. The surface of uncoated coir fiber shows the presence of micro pores. The results indicate that the silver particles are well dispersed onto the fibre surface and cover up the uneven surface of the original fibre. The fibre is uniformly covered with the dense silver particles (Fig. 1b). With an increase in the sputtering time homogenous depositions of silver particles on the coir fibers are observed.

3.2 Ultraviolet Radiation Penetration

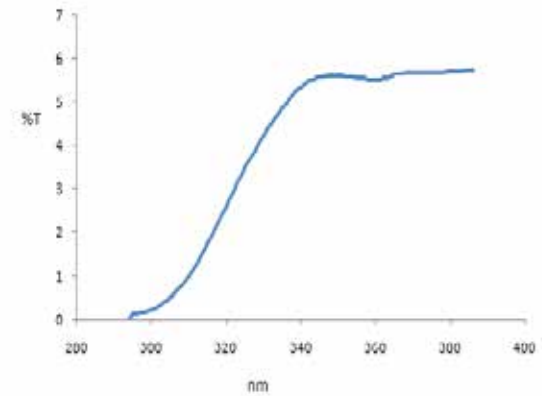

Fig 2 UV transmittance spectra of uncoated coir fiber

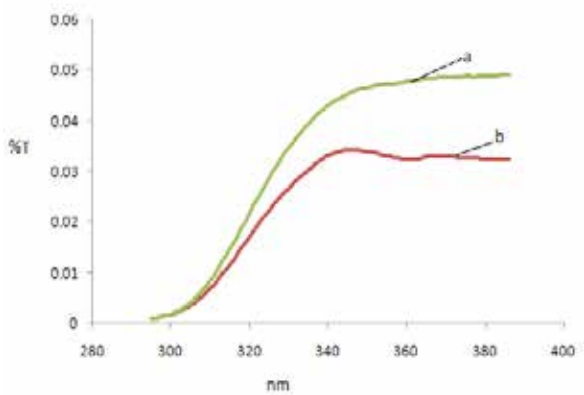

Fig 3 UV transmittance spectra of a) Ag coated (10 min) b) Ag coated (20min)

For investigating the UV-protective ability of silver coated coir fabrics, the ultraviolet transmittance spectra of the uncoated coir fabrics are compared with those of the coated fabrics. As revealed in Fig. 2 and Fig 3, there is an appreciable difference between the coated fabrics and the uncoated fabrics in terms of ultraviolet transmittance spectra. Even though the ultraviolet transmittance in the UV-B band (280-315nm) of the uncoated fabric is less, it has a higher UV transmittance, which is above 5% in the UV-A band. This is an indication of less resistance of uncoated fabrics to UV rays. UV transmittance curve of silver coated coir fabrics indicates that it can block a high percentage of both UV-B and UV-A radiations. It is observed that more than 99.5% of the radiation is absorbed by silver coated coir fabric over the entire UV region. Therefore it is evident from the transmittance spectra that silver coating can provide excellent UV-blocking to the coir fabrics in the complete UV region.

In comparison with untreated polyester, the calculated UPF increases from 56.7 for untreated coir fabric to 390.12 for the silver sputter coated coir fabric after sputtering for 20 min. The result confirms that silver coated coir fabric offers excellent protection from UV radiation as indicated by a UPF rating of 50+. UV transmission is found to be very much reduced in silver coated coir fabric. The deposition of silver on the fiber surface found to enhances the light

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reflection. This reflection will reduce the absorption of UV radiation during outdoor activities. Then it can be concluded that the silver particles are deposited not only on the fiber surface, but also the spaces between the single yarns in the coir fabric. This in turn will prevent the penetration of the ultraviolet radiation through the fabric. The effect of deposition time on the UV-blocking performance is significant because more silver particles are deposited on the coir fabric and give more coverage on the fabric with better ultraviolet radiation protection.

4. Conclusions

Silver coated coir fabrics are fabricated via sputtering method. SEM study reveals that a layer of fine silver particles is evenly distributed on the fabric surface. When compared to the uncoated coir fabrics, the average UPF factor of the silver coated coir fabrics increases significantly. There it can be concluded that the silver coated coir fabrics could therefore be used in outdoor UV shielding applications.

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