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RESEARCH ARTICLE

THIN FILM ALUMINIUM COATED COIR FIBERS DEPOSITED BY MAGNETRON SPUTTERING

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Abstract

The present paper describes the process of magnetron sputtering of Aluminium on virgin coir fiber materials, analysis of the metal coated coir fibers by SEM. The investigations evince that the coated aluminium particles are crystalline and these particles are physically absorbed onto the coir fiber surface. The physical and chemical properties of the coir fibers are markedly different from those of the uncoated coir fibers. The aluminium coated coir fibers are tested for hydrophobicity and showed a significant water repellent property. Adhesion of coated coir fibers is tested by washing the samples for several times and the results show a little decrease in water repellency factor after each period of washing.

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1. INTRODUCTION

An increasing world trend towards the maximum utilization of natural resources, through new process and products, has been driving the study of renewable natural materials such as lignocellulosic fibers. 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 grows 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 competition 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].

With development of new technologies such as vacuum deposition and nanoparticle coating there is a surge in the surface functionalisation of natural fiber surfaces. Vacuum deposited metal coating has been investigated extensively because of their unique physical and chemical properties, and wide potential applications. Since aluminium is a non-toxic, cheap and a natural inorganic metal it appears to be an attractive material for usage in the surface modification of natural coir fibers. Aluminium deposited fibers can be used to make smart textiles, which have potential application in the field of hydrophobic thermo regulated textile to electromagnetic interference shields and electronic sensors [5].

Apart from various conventional techniques to apply metal coating on fibers, such as wet chemical processing, sputtering is an attractive alternative. As a dry and eco-friendly technique, it adds new functionalities such as water repellency, electrical, antibacterial and mechanical properties [6, 7]. In this work the physical properties of the aluminium coated coir fibers, using a magnetron sputtering technique have been studied. Their morphological characterization is carried out by a scanning electron microscope. Water repellent property is evaluated by using contact angle measurements.

2. 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 deionized 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 $1 \text{ \AA}/\text{sec}$ 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.

The surface morphology and chemical composition analysis of the silver coated coir fibers are performed by a scanning electron microscope (SEM). Water contact angle (WCA) of the samples is measured at ambient temperature using a SEO Phoenix optical contact angle system. A volume of 5 μ l water is applied in this test. The water repellent property is further confirmed by water drops tests.

3. Results and discussion

a. SEM Study

The surface morphology of the coated and uncoated coir fibers is shown in the Fig.1 The SEM study confirms that aluminium particles are grafted on to the fiber surface. The surface of uncoated coir fiber shows the presence of micro pores. Metal coated fiber, on the other hand is smooth and without any pores indicating the formation of metal layer on the surface. With an increase in the sputtering time homogenous depositions of aluminium particles on the coir fibers are observed.

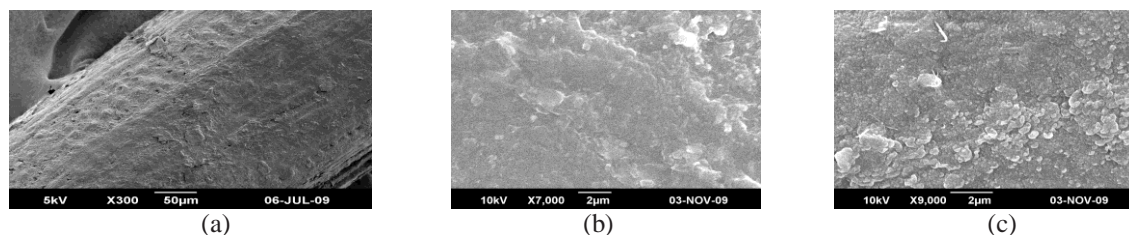


Figure 1. SEM micrographs of (a) untreated coir fiber (b) aluminium coated coir fibers with sputtering time 10min (c) aluminium coated coir fibers with sputtering time 20 min.

b. Contact angle and water drops tests.

The quality of water repellency of the samples is evaluated by water contact angle measurements. From Fig 3 (a) it is evident that the water contact angle on an untreated coir fabric is 0 °C. Natural Coir fibers are hydrophilic in nature. Therefore the result shows that the untreated coir fibers have extremely poor hydrophobic property. But when the surface of the coir fabrics are coated with aluminium, after sputtering for 10minutes, the fabric showed a water contact angle 105 °C. This indicates the deposition of aluminium on the surface and the spaces between the yarns, which further reduces the vacant areas in the fabric and decreases the water penetration of aluminium coated coir fabric. Results confirm that the deposition of aluminium enhances the hydrophobicity of the untreated coir fabric. After the sputtering for 30 minutes the water contact angle is increased to 110.2 °C. This indicates that the metal coating has a profound influence on the hydrophobic properties of the inherently hydrophilic coir fabric.

The increase in the water contact angle can be attributed to the change in the surface roughness of the coir fibers with coating [8]. From the SEM images it is clear that the surface of the aluminium coated fiber after 10min sputtering is smoother than that after 30min. At the same time the surface of the aluminium coated fiber after 30min sputtering time is found to be rougher than that with aluminium coated with 10minutes, and hence it has a larger

contact angle. Therefore, all the aluminium coated coir fabrics showed sufficient and effective water repellent properties.

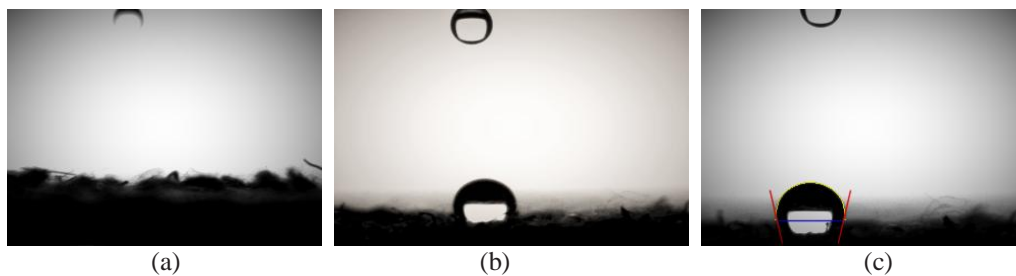


Figure 3 Microscopic view of water contact angle (a) untreated coir fiber (b) aluminium coated coir fibers with sputtering time 10min (c) aluminium coated coir fibers with sputtering time 20 min.

Wettability of the untreated and coated coir fabric are further evaluated by water drops tests, where the water drops of controlled size are placed at a constant rate upon the fabric surface and the duration of the time required to penetrate it into the fabric are measured. The results are shown in Table1. As seen the water repellency of the coir fabrics has been increased with sputtering time. In the case of uncoated coir fabric the water droplet disappears immediately within seconds, with water spreading over large areas. In the case of coated fabric the droplet remained spherical even after 30min with no spreading, indicating that all the modified fabrics are hydrophobic with good water repellence.

Table 1

Absorption time for untreated and aluminium coated coir fabrics

Samples	Absorption time
Untreated	3s
Al coated sample sputtered for 10min	>30min
Al coated sample sputtered for 20min	>30min

c. Adhesion Test

Adhesions between the metal coating and coir fibers are tested by measuring the water repellency of the fabric after washing for several times. The water repellency is found to be decreasing after each period of washing. The reason for this decrease in water repellency of coated fabric is due to the slow removal of metal particles from the surface of the coir fabric during washing.

4. Conclusion

Aluminium coated coir fabrics are fabricated using sputtering technique. According to the SEM images it is clear that a uniform layer of aluminium is formed on the surface of the coir fabric after sputtering. After the surface functionalisation with aluminium the wetting property of coir fabric changed from hydrophilic to hydrophobic. Such aluminium coated coir fabric can be used in functional textiles with hydrophobic coating.

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