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IN-SITU GREEN SYNTHESIS OF ZINC OXIDE NANOPARTICLES (ZnO NPs) ONTO THE COTTON FABRICS BY NEEM (AZARDIRACHTA INDICA) LEAF EXTRACT

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ABSTRACT

This research work was carried out for the green in-situ synthesis of ZnO nanoparticles onto the 100% cotton fabric. Zinc nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$] was used as precursor and the Neem (Azardirachta Indica) leaf extract was used as reducing agent. Scanning electron microscopy (SEM) and X ray diffraction (XRD) were done to investigate the surface morphology and characteristics of developed samples. Moreover the ultraviolet protection factor (UPF), UVA blocking %age, UVB blocking %age, and antibacterial properties were examined. The SEM and XRD confirmed the deposition of ZnO NPs onto the fabric having crystalline structure. The evaluated samples showed very excellent results for, UPF rating, UVA blocking %age, UVB blocking %age, and antibacterial properties.

KEYWORDS

Zinc oxide, Green synthesis, Antibacterial, UV protection, Azardirachta Indica, Nanoparticles.

INTRODUCTION

Zinc oxide nanoparticles have acquired great importance in the field of material science due to their exceptional properties and prominent uses. ZnO is very interesting material because of its conductivity. Its crystalline structure has wurtzite shape, having mixture of both ionic and covalent bonding [1]. ZnO NPs are white in color with low production cost, with vast band gap (3.37ev), and (60 meV) binding energy. In textile industry ZnO NPs are used for antibacterial, UV protection and self-cleaning properties. The nano structure of ZnO NPs release ions which cause the destruction of proteins present in the cell, resulting in the death of bacterial cells. ZnO NPs have the ability to absorb, deflect, scatter, and obstruct the UV rays. So the coating of ZnO NPs on textile fabrics can protect human beings from UV radiations and various types of bacteria [2]. Green synthesis of nanoparticles using plant extract has gained remarkable attention, because it's low cost, simple eco-friendly as well as having fast synthesis rate [3]. Neem (Azardirachta Indica) plant is well known for its medical significance and easy availability in South Asia [4]. Its leaf extract contains many organic molecules which have a great oxidative activity that allows it to be used for reduction of large zinc molecules into its very small nanoparticles [3]. In this research study, insitu synthesis of ZnO NPs onto cotton fabrics was done by the leaf extract of Neem (Azardirachta Indica) plant as a reducing agent and Zinc nitrate hexahydrate as precursors. After synthesis antibacterial and UV protection properties were investigated.

MATERIALS AND METHODS

Cotton fabric having plain weave with 27 ends per inch and 23 picks per inch was obtained from Department of Material Engineering, Technical University of Liberec, Czech Republic. Zinc nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$] was purchased from Sigma Aldrich. Neem (Azardirachta Indica) leaves were collected from crescent sports club Sheikhuppura road Faisalabad, Pakistan.

Figure 1. Shade dried neem leaves.

Neem (Azardirachta Indica) leaves were washed several time with distilled water to remove dust and any type of contamination, then dried under shade at room temperature. Dried leaves were ground by coffee grinder. 20 grams of ground leaves was added in 100 ml of deionized water and boiled on hot plate for 30 minutes to get extract. 0.1 molar solution of zinc nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$] was made in 100 ml of deionized water. Then the (10×10cm) of cotton fabric was immersed in 0.1 molar solution of zinc nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$]. After that Neem (Azardirachta Indica) leaves extract was added drop wise in 0.1 molar solution of zinc nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$] under continuous magnetic stirring at room temperature. Then the temperature was raised to 90°C for 120 minutes under continuous magnetic stirring. The fabric samples were dried in oven at 90°C for 1 hour.

The surface morphology of treated fabric was investigated by SEM TS 5130 Vega 3 Tescan Czech Republic.

The XRD patterns were obtained with X- ray diffractometer (ARL X'TRA powder X-ray diffraction system Thermo scientific USA).

Antibacterial efficacy of the treated fabric samples was investigated against E.coli (gram negative) and S.aureus (gram positive) according to AATCC 100-2012 test method.

Ultraviolet protection factor (UPF) of treated fabric samples was examined according to AATCC 183-2000 standard, using UV-vis NIR spectrophotometer (UV-3101 PC) in the range of 280 nm-400 nm.

RESULTS AND DISCUSSION

SEM analysis

Surface morphology examined by scanning electron microscope (SEM) is shown in Figure 2. It is revealed from the SEM images that ZnO NPs on the surface of treated fabric. While untreated fabric has clean surface. SEM image at high resolution shows that zinc oxide particles are deposited on the surface of fabric at nano scale.

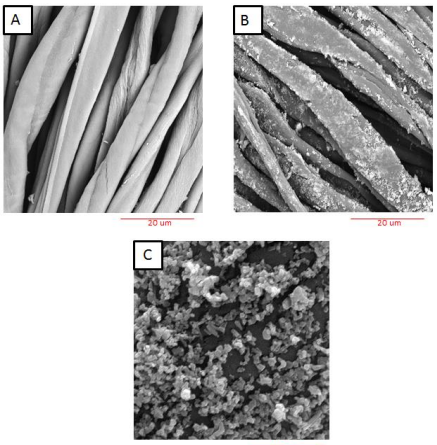

Figure 2. SEM images (A untreated, B ZnO NPs deposited sample, C ZnO NPs deposited sample at high resolution).

XRD analysis

The Figure 3 shows the XRD patterns of untreated cotton fabric and ZnO NPs coated cotton fabric. It can be seen that untreated fabric has only characteristic peaks of cellulose [5], while treated sample has additional characteristic peaks of hexagonal wurtzite ZnO structure [6].

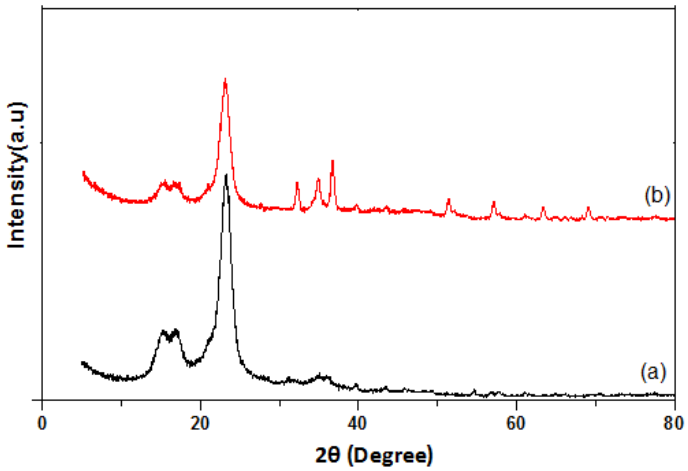

Figure 3. XRD patterns (a) untreated fabric (b) ZnO coated fabric.

Antibacterial activity

Figure 4 and Figure 5 show the antibacterial activity of untreated and treated fabric samples against E.coli and S.aureus bacteria respectively. It can be seen from the Figure 4 and Figure 5 ZnO loaded samples showed the 100% reduction for both E.coli and S.aureus bacteria. The antibacterial activity of ZnO NPs loaded fabric is due to the disruption of the bacterial membrane by ZnO NPs [1], [2].

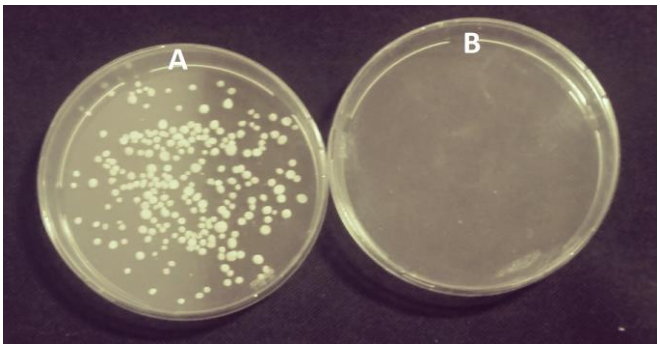

Figure 4. Antibacterial activity against E.coli (A) untreated fabric (B) ZnO NPs coated fabric.

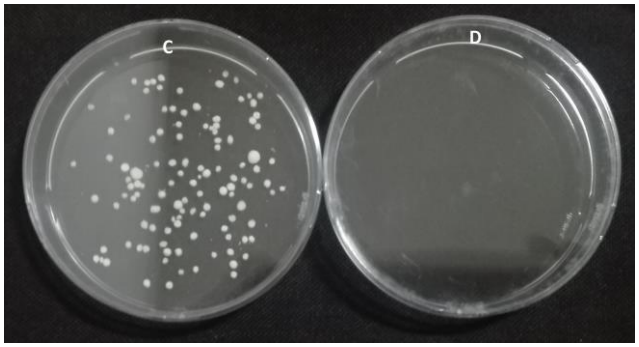

Figure 5. Antibacterial activity against S.aureus (C) untreated fabric (D) ZnO NPs coated fabric.

UV protection ability

The UPF, UVA blocking %age and UVB blocking %age values of treated and untreated samples are shown in Table 1. It is clear from the Table 1 that untreated fabric has UPF only 4.57 and UVA blocking %age and UVB blocking %age 72.81 and 78.69 respectively. On the other hand ZnO NPs coated fabric has UPF value 114.73. While UVA blocking %age and UVB blocking %age values are 98.41 and 99.02 respectively. This blocking behaviour of coated fabric can be explained as UV absorbance by ZnO NPs [1].

Table 1. UV protection behaviour of untreated fabric and treated fabric.

	UVA BLOCKING % AGE	UVB BLOCKING %AGE	UPF
UNTREATED FABRIC	72.81	78.69	4.57
TREATED FABRIC	98.41	99.02	114.73

CONCLUSIONS

In this research work Zinc Oxide nanoparticles were insitu synthesized and loaded onto the surface of 100% cotton fabric by green method, using Neem (Azardirachta Indica) leaf extract. Scanning electron microscopy and XRD analysis confirmed the presence of zinc oxide nanoparticles onto the surface of the 100% cotton fabric. Moreover treated samples showed very excellent antibacterial and UV protection ability.

ACKNOWLEDGMENT

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