COPPER AND COPPER OXIDE NANOPARTICLES FOR TEXTILE FINISHING

Muhammad SHAHID, *Jakub WIENER and **Boris MAHLTIG

**Department of Material Engineering, Faculty of Textile Engineering, TU Liberec, Czech Republic,*

***Faculty of Textile and Clothing Technology, Hochschule Niederrhein, University of Applied Sciences, Germany.*

muhammad.shahid275@gmail.com

Abstract

Copper and copper oxide nanoparticles have recently drawn attention for their applications in technical textiles epically in healthcare industry. The present studies have been carried out to find the properties of copper and copper oxide nanoparticles for special applications Copper oxide nanoparticles are prepared by wet chemical process. In this technique $CuSO_4.5H_2O$ is added with acetic acid and heated to 100 °C with continuous stirring. NaOH is added to the solution till pH = 7 is reached. The color of the solution changed from blue to black with precipitation. The black precipitation was washed 3-4 times and three different concentrations C_1, C_2 and C_3 were made by diluting the solution. The woven and knitted cotton fabrics were dipped in a bath containing solution of nanoparticles at room temperature for 30 minutes. Then the fabrics were removed from the bath, padded, and dried at different drying temperatures. Scanning electron microscopic (SEM) study was conducted to study the phase and morphology of nanoparticles. Abrasion testing was carried out to find out the concentrations and other parameters affecting the abrasion characteristics of the fabrics. Anti-microbial testing of treated fabrics were performed. The results show that the fabrics can attain Anti-Microbial activity depending on the concentrations of nanoparticles on the fabrics. High concentration of nanoparticles is required for high antibacterial efficiency.

Keywords:Copper Oxide nanoparticles, Finishing, SEM, Abrasion, Antimicrobial Activity.

1. INTRODUCTION

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering.

The nanosize of material results in specific physicochemical characteristics different than those of the bulk materials or larger particles. This effect is mainly credited to high surface-area-to-volume ratio, which results in increased reactivity; hence, the nanoscale materials are more advantageous than their bulk materials. The metallic nanoparticles such as copper, titanium, magnesium, zinc, gold and alginate have a strong bactericidal potential owing to their large surface-area-to-volume ratio[1].

In chemical sciences, synthesis of transition metal and metal oxide nanoparticles is a growing research field. As the metal particles are reduced in size, bulk properties of the particles disappear to be substituted to that of quantum dot following quantum mechanical rules. It can thus be easily understood that metal nanoparticles chemistry differs from that of the bulk materials. Since with size reduction the high surface area to volume ratio lead to enhanced

catalytic activity [2]. Among various metal nanoparticles, copper (Cu) and copper oxide (Cu_2O) nanoparticles have attracted considerable attention because copper is one of the most important in modern technologies and is readily available[3]. Considerable interest has been focused on copper nanoparticles due to their optical, catalytic, mechanical and electrical properties[4].

SEM scans the surface of the sample with a beam of electrons and the resulting image has a three-dimensional appearance that can be useful for the surface structure investigation while image produced by TEM is rather two dimensional and the electrons pass through the sample, so the image is not useful for the surface structure investigation [5].

Abrasion is the physical destruction of fibres, yarns, and fabrics, resulting from the rubbing of a textile surface over another surface [6].Textile materials can be unserviceable because of several different factors and one of the most important causes is abrasion. Abrasion occurs during wearing, using, cleaning or washing process and this may distort the fabric, cause fibres or yarns to be pulled out or remove fibre ends from the surface [7]. Grey fabrics have lower abrasion resistance compared to dyed fabrics with the same construction. During the dyeing operation, fibres on the fabric surface will cling to it, hence the fabric will achieve a closer state, and the movement of fibres within the yarn will be limited [8].

2. EXPERIMENTAL

2.1. Materials

100% Woven cotton fabric, 100% Knitted cotton fabrics, Copper Sulphate, Copper Nitrate, Acetic acid, Sodium Hydroxide, Aerosil 200

2.2. Preparation of copper oxide nanoparticles

The aqueous solution of Copper (ii) Sulphate penta hydrate (0.2 M) was prepared in cleaned round bottom flask. 1 ml of glacial acetic acid was added to above aqueous solution and heated to 100 °C with continuous stirring. 8 M NaOH is added to above heated solution till pH reached to 7. The color of the solution turned from blue to black immediately and the large amount of black precipitate is formed in the bottom of the flask. The precipitate was centrifuged and washed 3-4 times with deionized water. Three different concentrations C_1, C_2 and C_3 of these nanoparticles were prepared by diluting solution. Aqueous Suspension of Aerosil 200 was prepared and added to three different concentrations of nanoparticles and stirred constantly for one hour. The woven and knitted cotton fabrics were dipped in a bath containing 10 ml of nanoparticles solutions at room temperature for 30 minutes. Then the fabrics were removed from the bath, padded, and dried at different drying temperatures T_1, T_2 and T_3 in an oven.

3. RESULTS AND DISCUSSIONS

3.1. SEM-EDAX analysis

Microscopic analyses are essential in nanotechnology. Electron microscopes are one of the most common analysis instruments that use the interaction of emission ray of electrons with the sample atoms to provide magnified image. There are several types of electron microscopes according to the type of electrons that has been using for producing image. Hereon SEM and TEM are two main types of electron microscopes. Electron microscopes are precise instruments and play an important role in nanoscale systems. Electron microscopy can be employed in nanostructure imaging, composition, determine physical properties measurements and even building and manipulating nanostructures [9, 10].

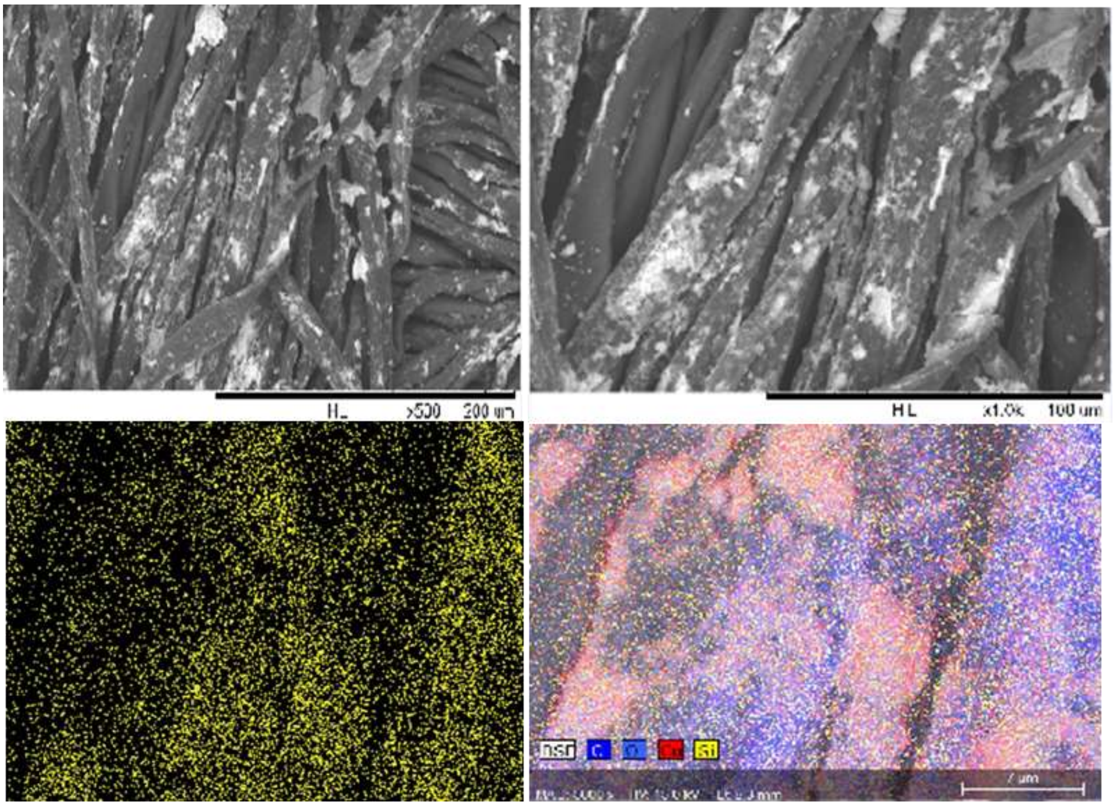

Fig. 1 SEM micrographs of CuO nanoparticles on woven cotton fabrics

In order to obtain insight information about surface morphology and particle size of the samples, SEM analyses were performed. The product is agglomerated from few µm to a few tens of µm. The agglomeration was reduced with increase in grain growth .

The agglomeration of particles is usually explained as a common way to minimize their surface free energy, and the SEM micrographies for pure and CuO nanoparticles are shown in Fig. SEM micrographs clearly show the surface features, by which it highlight that CuO nanoparticle was successfully prepared.

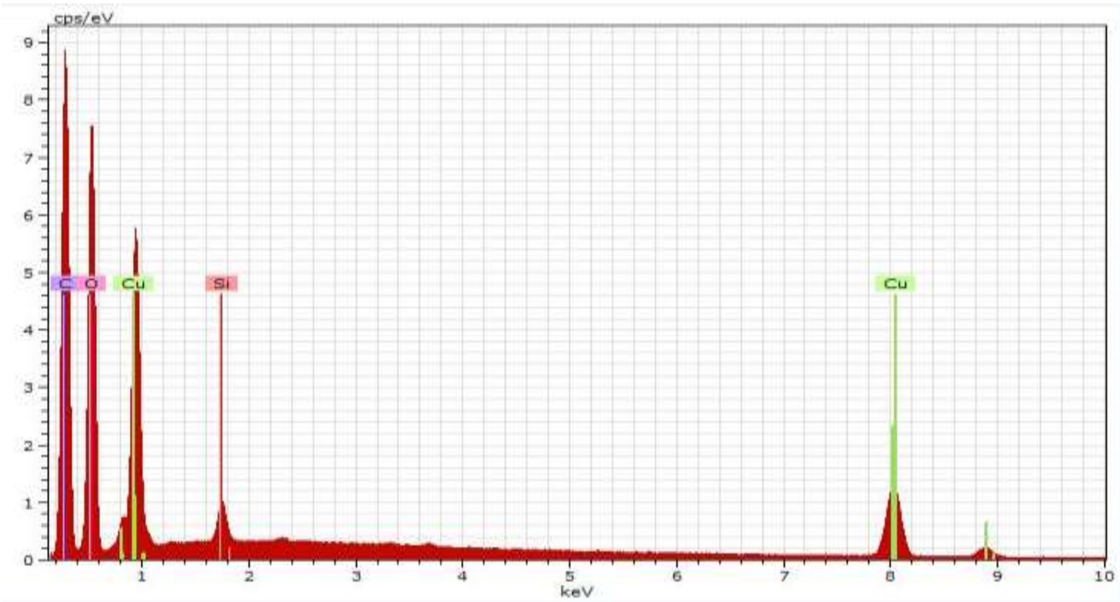

Fig. 2 EDAX spectrum of CuO nanoparticles on woven cotton fabric

3.2. Abrasion resistance

The resistance of textile materials to abrasion as measured on a testing machine in the laboratory is generally only one of several factors contributing to wear performance or durability as experienced in the actual use of the material. While “abrasion resistance” (often stated in terms of the number of cycles on a specified machine, using a specified technique to produce a specified degree or amount of abrasion) and “durability” (defined as the ability to withstand deterioration or wearing out in use, including the effects of abrasion) are frequently related, the relationship varies with different end uses, and different factors may be necessary in any calculation of predicted durability from specific abrasion data [11].

Finishing treatments, the types and concentration of the chemicals used in the treatment processes are also the parameters affecting the abrasion characteristics of the fabrics. Fabric samples with different concentrations of nanoparticles show different results for abrasion testing, sample with high concentration of nanoparticles shifted more on the reference fabrics as compared to fabrics sample with low concentrations. Figs show the results of ‘Abrasion Testing’ performed by ‘‘Nu-Martindale Abrasion and Pilling Tester’’ in Hochschule Niederrhein University of Applied Sciences, Germany at different cycles.

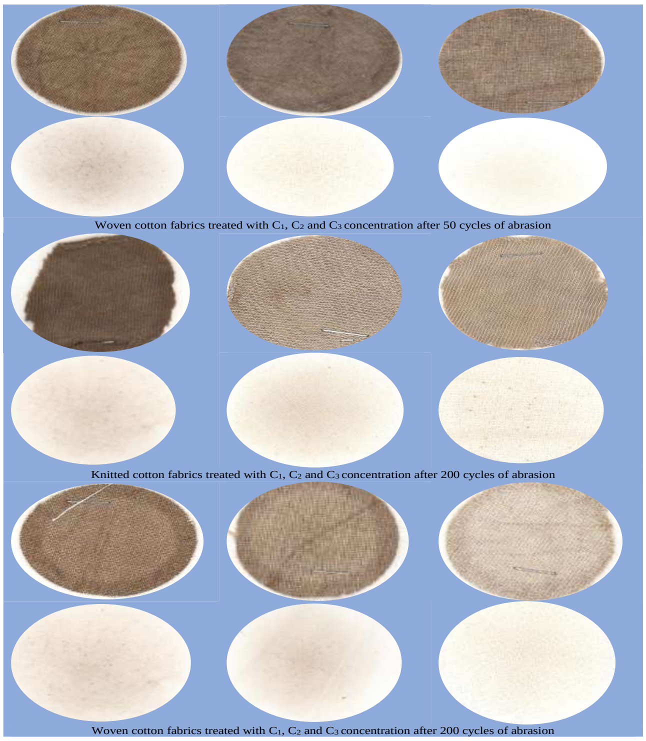

Fig. 3 Abrasion resistance of treated fabrics

CONCLUSION

As CuO is cheaper than silver, easily mixes with polymers and relatively stable in terms of both chemical and physical properties, it finds a wide applications. SEM micrographs clearly show the surface features, by which it pinpoints that CuO nanoparticles are successfully prepared.

The abrasion mechanism of textiles is a complex phenomenon and associated with the properties of fibers, yarns, fabric structure and applied treatments. Transformation of nanoparticles from one surface to another was measured by ‘‘Nu-Martindale’’ Abrasion and pilling Tester. Good results of abrasion were showed by figures. Cotton fabrics with higher concentrations of copper oxide nanoparticles show good antimicrobial results.

ACKNOWLEDGEMENTS

For helpful discussion during material preparation we would like to thank Mister Dipl.-Chem. Thomas Grethe. Also many thanks are owed to Prof. Dr. Hajo Haase from RWTH Aachen for testing antimicrobial activities.

REFERENCES

[1] AHMAD, Z., et al., Alginate Nanoparticles as Antituberculosis Drug Carriers: Formulation Development, Pharmacokinetics and Therapeutic Potential. *Indian journal of chest diseases and allied sciences*, 2006, 48, nr. 3, page 171.

[2] SALAVATI-NIASARI, M., F. DAVAR, AND N. MIR, Synthesis and Characterization of Metallic Copper Nanoparticles via Thermal Decomposition. *Polyhedron*, 2008, 27, 17, page 3514.

[3] GUAJARDO-PACHECO, M.J., et al., Synthesis of Copper Nanoparticles Using Soybeans as a Chelant Agent. *Materials letters*, 2010, 64, nr. 12, page 1361.

[4] He, Y., A Novel Solid-Stabilized Emulsion Approach to Cuo Nanostructured Microspheres. *Materials research bulletin*, 2007, 42, nr. 1, page 190.

[5] STADTLÄNDER, C., Scanning electron microscopy and transmission electron microscopy of mollicutes: challenges and opportunities. Modern research and educational topics in microscopy, 2007. 1: p. 122-131.

[6] Abdullah, I., et al., Abrasion Phenomena in Twill Tencel Fabric. *Journal of applied polymer science*, 2006, 10, nr. 2, page 1391.

[7] Hu, J., *Fabric testing*. 2008, Elsevier.

[8] AKAYDIN, M., Characteristics of Fabrics Knitted with Basic Knitting Structures from Combed Ring and Compact Yarns. *Indian journal of fibre & textile research*, 2009, 34, nr. 1, page 26.

[9] MEYER, G., B. NEU, AND K.H. RIEDER, Building Nanostructures by Controlled Manipulation of Single Atoms and Molecules with the Scanning Tunneling Microscope. *physica status solidi (b),* 1995, 192, nr. 2, page 313.

[10] MATIVETSKY, J., et al., Molecular Resolution Imaging Of C60 on Au (111) by Non-Contact Atomic Force Microscopy. *Nanotechnology*, 2004, 15, nr. 2 S40.

[11] ASTM, ASTM D 4966-10 Standard Test Method for Abrasion Resistance of Textile Fabrics in *Annual Book of ASTM Standards*. 2014, ASTM International: West Conshohocken, PA, 19428-2959 USA.