Colloids and Surfaces A: Physicochem. Eng. Aspects 439 (2013) 167–175

Contents lists available at ScienceDirect

Colloids and Surfaces A: Physicochemical and Engineering Aspects

journal homepage: www.elsevier.com/locate/colsurfa

Synthesis of nano copper/nylon composite using ascorbic acid and CTAB

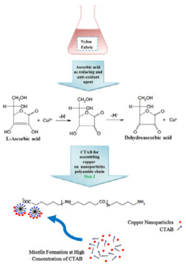
Z. Komeily-Nia, M. Montazer*, M. Latifi

Textile Engineering Department, Centre of Excellence in Textile, Amirkabir University of Technology, Tehran, Iran

HIGHLIGHTS

- Synthesis of nano copper particles on/within nylon fabric through chemical reduction.
- Improving mechanical properties of fabric after nano copper treatment.
- Role of CTAB in assembling nanoparticles on nylon fabric.
- Antibacterial and coloration effects of copper nanoparticles on nylon fabric.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 30 December 2012
Received in revised form 27 February 2013
Accepted 2 March 2013
Available online 14 March 2013

Keywords:
Copper nanoparticles
In situ synthesis
Nylon fabric
Spectrophotometer
Tensile strength

ABSTRACT

In this paper, an in situ synthesis of copper nanoparticles on or within the polyamide chains of nylon fabric was introduced through a simple chemical reduction method by using ascorbic acid as reducing agent and cetyl trimethyl ammonium bromide as capping agent. Also, a coloring effect on nylon fabric was shown through synthesis of copper nanoparticles as indicated by reflectance spectrophotometer. The distribution of copper nanoparticles on the fabric surface was shown by scanning electron microscopy images within 85 nm. Further, Energy Dispersive X-ray spectroscopy and X-ray Diffraction confirmed effective assembling of copper nanoparticles on the surface of nylon fibers. The fabrics treated with copper nanoparticles showed higher tensile strength, lower bending length and reasonable antibacterial activities against *Staphylococcus aureus*.

1. Introduction

There are many investigations on using silver nanoparticles and their applications on textile substrate. However, there are few studies focused on application of copper nanoparticles on various fabrics. Gold and silver are relatively expensive to use in different industries while copper is inexpensive and good candidate for replacement of gold and silver.

Copper nanoparticles attracted considerable attention due to their catalytic [1,2], optical [3,4], antibacterial [5,6], antifungal [7] and conducting properties [8] on account of high large ratio of surface area to volume. Currently synthesis of copper nanoparticles has been achieved via various routes, including chemical reduction [9,10], thermal decomposition [11,12], polyol method [13,14], reverse micelles [15,16], electron beam irradiation [17], vacuum vapour deposition [4], micro-emulsion techniques [18], wire explosion [19] and in situ chemical synthesis [20]. These methods can be divided basically into two classes of physical and chemical methods [21,22] .The synthesis through physical method produces various range of metal nanoparticles with high quality however it is expensive and needs some special supplementary devices. The chemical approaches are more reasonable for experiments performed in laboratories that are simple and economical yielding a large variety of dispersions in terms of their particle characteristics (size, morphology and stability) by altering experimental parameters (concentrations, reducing agent, temperature, pH, surfactant, capping agent and solvent) [23].

---

* Corresponding author. Tel.: +98 2164542657; fax: +98 2166400245.
E-mail address: tex5mm@aut.ac.ir (M. Montazer).

0927-7757/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.colsurfa.2013.03.003

Nevertheless synthesis of copper nanoparticles is often more challenging in comparison to noble metals such as silver and gold. Copper sulfate in aqueous solution tends to form Cu_2O due to the relatively low CuO/Cu^{2+} redox potential (+0.34 V) and spontaneous oxidation of the nanoparticles at ambient conditions. Thus copper nanoparticles were often contaminated with copper oxide due to their high air sensitivity [24].

There are several approaches applied to protect copper nanoparticles against oxidation during preparation and storage including using non-aqueous solvents, employ low precursor concentrations, perform synthesis under protection of an inert gas [25], using a compound with ability of forming complex with metal ions such as surfactants and ligands preventing nanoparticles from agglomeration during synthesis process [26–29].

A small amount of nano size species can interfere with polymeric matrices and exhibit their properties on polymer matrix [30]. A high reactivity and good metal releasing properties can be expected due to the large nanoparticle/polymer interface area and highly dispersed nature of the metal that makes them good candidate for biotechnological applications [7]. These materials have relatively better formation control over nano metal cluster [31].

Nowadays there is an increasingly demand for antibacterial fabrics in the form of medical clothes, protective garments, and bed spreads to minimize the chance of nosocomial infections [32]. Biocide textiles can basically be divided into three groups of photoactive properties, non-diffusible biocides and controlled release of the embedded biocide. The last group is comprised of coatings where the biocides such as triclosan, Ag^+ and Cu^{2+} diffuse out of the matrix. In the case of metallic antibacterial agents, the nanoparticles in the matrix are oxidized by air. The formed cations diffuse out of the matrix inhibit bacterial growth [33]. The unique properties of nanoparticles on biosystems are: 7–50 times less toxic than their corresponding ionic forms; producing a prolonged effect, serving as a depot for elements in an organism; introducing in biotic stimulating the metabolic processes of an organism with multifunctional properties [34].

Nanoparticles are attractive for medical applications due to their unique properties, such as large surface area and ability to adsorb and carry other compounds. Nanoparticles can bind and carry other compounds such as drugs and proteins. Nanoparticles with having dimensions under 100 nm are necessary for loading a sufficient amount of drug onto the particles [35]. Functionalized textiles can be obtained by immobilization of nanoparticles in order to release active molecules. The nanoparticles allow encapsulation of active agent on the textile [36] introduced as Cosmeto textiles with ability to release pharmaceuticals, cosmetics, fragrances, and others over the time at a molecular level under the influence of an external stimulus. The release pattern of the microcapsules is triggered by an impact, such as friction or pressure between the body and fabric, breaking the capsules into fragments and liberating the cosmetic properties [37].

A textile functionalization or surface modifications are performed by changing the surface properties of a fabric in order to make different properties such as self-cleaning, hydrophobic or lipophobic properties. The fabric surface charges modifications are due to the changes in the fiber surface groups such as hydroxyl and carboxyl groups. Electrokinetic techniques and especially streaming potential measurements allow determining in situ particle deposition kinetics [36].

It has been indicated that the presence of metal nanoparticles on fabric and polymer, impart new properties such as protection against UV radiation [38], thermal conductivity [39], enhance fabric strength and crease recovery angle, improve dyability [40], and flame retardant properties [41]. Examples of recent reports on this field are presented in Table 1.

Table 1
various research on assembling different nanoparticles on textiles.

Reference	Experimental condition	Method of assembling nanoparticles	Textile modified by nanoparticles
[42]	Ag nanoparticles were synthesised simultaneously through wool yarn drawing process (10 min at 50 °C with 30% extension) using chemical reduction method. Silver nitrate was employed as precursor, sodium dithionite and sodium bisulphite as reducing agent.	In situ	Ag/Wool fiber
[43]	Fabric was first pretreated with Kmno$_4$ then nano TiO_2 assembled on fabric through exhaustion using cross-linking agent (BTCA* or CA*), SHP*, and TiO_2 finally cured at 120 °C for 2 min.	Ex situ	TiO_2/Wool fabric
[44]	SDCB nanoparticles were prepared from CB nanoparticle powders by a special method then exhausted on various fabrics with a liquor ratio of 50:1 at 100 °C for 30 min.	Ex situ	CB*, SDCB*/Cotton, Wool, Acrylic and Nylon fabrics
[45]	CuO nanoparticles were synthesized on fabric by a chemical reduction method using $CuSO_4$ as precursor and NaOH as reducing agent.	In situ	CuO/Cotton fabric
[46]	A green approach was applied by using extarct leaves of *Eucalyptus triodoraand* and *Ficus bengalensis* to reduce silver nitrate. Fbres were immersed in the filtrate leaf broth containing silver nanoparticles and kept on a shaker at room temperature for 24 h and then dried.	In situ	Ag/Cotton fiber
[47]	TiO_2 nanoparticles were synthesized using sol–gel method. The fibre impregnated into the formed TiO_2 particles in the liquid phase. The thin film covered the fibre which is then soaked in $HAuCl_4$ aqueous solution. Finally dried at room temperature to obtain gold nanoparticles by a photo reduction process.	Ex situ	Au/TiO_2/Cotton fabric
[48]	ZnO nanoparticles were synthesised using reverse micelle of PS-b-PAA* block copolymer. The fabric was then stirred for 30 min in nano ZnO solution.	Ex situ	ZnO/Cotton fabric
[49]	Clay and POSS have been added to the PU (resin) as additives then coat on fabrics.	Ex situ	PU*/Clay and PU/POSS* on Cotton and Polyester fabric
[50]	Silver nanoparticles were synthesized by UV irradiation of silver nitrate in presence of PMA* as reducing agent and deposition process carried out by alternatively dipping the fibers in PDADMAC* and silver nanoparticles solution.	Ex situ	Ag/Nylon fabric, Ag/Silk fiber
[51]	Fabric was treated with WR* agent and subsequently silica nanoparticles were synthesized via a sol–gel process. The cotton fabrics were immersed in a sol of silica.	Ex situ	Silica/Cotton fabric
[52]	Fe_3O_4 particles were synthesized on PA6 fabric by using hydrothermal process	In situ	Fe_3O_4/Polyamide 6 fabric
[53]	Zn/ZnO particles by the method of physical vapor deposition (PVD) on fabric.	In situ	Zn/ZnO/Cotton fabric

amphiphilic polystyrene-block-poly(acrylic acid) (PS-b-PAA) – poly (methacrylic acid) (PMA) – poly(diallyldimethylammonium chloride) (PDADMAC) – butane tetracarboxylic acid (BTCA) – citric acid (CA) – sodium hypophosphite (SHP) – Carbon black (CB) – Self-dispersible carbon black (SDCB) – polyhedral oligomeric silsesquioxanes(POSS) – Polyurethane (PU) – water-repellent agent (WR agent).