



Laminating of chemically modified silan based nanosols for advanced functionalization of cotton textiles



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ABSTRACT

As per to silver nanoparticles/silicon dioxide nanoparticles ($\text{SiO}_2@AgNPs$) properties (e.g., conductivity, reactant, adsorption, detachment and antimicrobial), many researchers were focused on its preparation technique. A core/shell of silicon dioxide and silver nanoparticles ($\text{SiO}_2@AgNPs$) has been prepared by facile route. The as synthesized core/shell nanoparticles were chemically modified with two different silan compounds, nominated, vinyltriethoxysilan (VTEOS) and (3-aminopropyl)trimethoxysilan (APTEOS). World class facilities such as XRD, FT-IR, TEM, Particle size, DLS, SEM techniques were utilized for the nanoparticles characterization. The nanoparticulate system comprises $\text{SiO}_2@AgNPs$, $\text{SiO}_2@AgNPs/APTEOS$ were applied to cotton fabric using butantetracarboxylic acid (BTCA) as across-linking agent. While UV irradiation by photo initiator was used as crosslinking agent for $\text{SiO}_2@AgNPs/VTEOS$ on cotton fabrics. The Treated cotton fabrics were evaluated for their surface morphology and heat transfer ability as well as antibacterial activity. The obtained data prove that the core/shell was successfully prepared, with AgNPs in core. In addition, both silan compounds (APTEOS, VTEOS) were successfully reacted with the outer shell SiO_2 . The results declared also that the treated fabrics exhibit a good antibacterial activity as well as good thermal properties.

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1. Introduction

Recently, with the advancement of nanotechnology, the expansive reasonable utilization of metal nanoparticles is inferable from some of their exceptional properties. [1,2] Differing physical and chemical techniques are at present extensively used to synthesis metal nanoparticles, which allow one to get particles with the desired features. [3,4] Most of these creation techniques are normally costly, also, are possibly conceivably dangerous to the natural and living organisms. [5] Henceforth, there is an obvious requirement for necessity for an alternative, practical, in the meantime protected, and ecologically safe technique for nanoparticle production. [6]

Biopolymers incorporate an extensive variety of naturally occurring compounds, and some of these polymers, for example, cellulose [1,7–9] and starch [10,11], are effectively utilized as a part of different regular products. It is fascinating to realize that polymeric based solutions contain size-restricted, nano-sized pools of

inter- and intra-molecular source, which can be utilized for synthesis and stabilization of nanoparticles. [12] Linear and even dendritic polymers have been effectively utilized for synthesis of AgNPs, such as heparin [13] and starch. [14]

Additionally, in light of the reality that silica has great chemical stability, high specific surface area, which is high in hydroxyl, bunches with living beings having the great similarity attributes; it has turned into a brilliant bearer material to get ready composite materials. [15–17] The most commonly used precursor for preparation of SiO_2 is tetraethoxysilan (TEOS), which give siloxane after polymerization through sol gel technique. [18–20]

$\text{SiO}_2@AgNPs$ composites have become noteworthy through in conductivity, separation, adsorption, catalytic, biomedical and different fields, because of its optical, electrical, attractive, and synergist properties. [21–23] At present, an assortment of strategies for preparing $\text{SiO}_2@AgNPs$ composite have been created, including reduction, micro-emulsion emulsion, gel-sol, calcination and adsorption techniques, etc. [24–26]

By and large, most of preparation techniques are complicated procedure, expensive reagents and poor stability. Thusly, it is regular alluring to build up a straightforward, minimal effort and naturally stable methodology to prepare $\text{SiO}_2@AgNPs$ composite. In the $\text{SiO}_2@AgNPs$ composite union procedure,

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costly silan compounds or surfactants are utilized to modify the surface of the SiO_2 particles firstly. [8] To enhance the similarity, it must be build up chemical linkages between the soft and hard organic and phases. Strong interfaces conveyed using coupling administrators assembles the interfacial hold quality by method for the advancement of compound bonds. This can be accomplished by utilizing amine ended alkoxysilans, for example, (3-aminopropyl)trimethoxysilan (APT-MOS), 2-aminoethyl-3-aminopropyltrimethoxy-silan (AEAPTMS), (3-aminopropyl)triethoxysilan (APTEOS), epoxy topped alkoxysilans for example, 3-glycidylxypropyltrimethoxysilan (GLYMO), 2(3, 4-epoxycyclohexyl)ethyltriethoxysilan (EHTES); isocyanato topped alkoxysilan, for example, 3-triethoxysilylpropyl-isocyanate (TESPI); unsaturated functional trialkoxysilan, for example, methacryloyloxypropyltrimethoxysilan (MEMO). [18–20] These antecedents have two distinctive responsive functionalities; in particular, organic group and the inorganic alkoxysilan. They can shape at the same time an organic network through the reaction between organic groups, organic binder and inorganic SiO_2 network through hydrolysis and condensation reactions of alkoxysilan groups.

In the present work, silver nanoparticles (AgNPs) are prepared using a new precursor, typically, dextran, which play a dual role of stabilization and reduction during preparation of nanoparticles. Further, the core/shell SiO_2 @AgNPs nanosols is prepared and then functionalized through surface coating with APTEOS and VTEOS for enhancing its functionality and reactivity. Furthermore, harnessing the so obtained SiO_2 @AgNPs/APTEOS, SiO_2 @AgNPs/VTEOS nanosols to cotton fabrics for rendering them highly washing durability as well as heat transfer for clothing insulation materials.

2. Experimental

2.1. Materials

Silver nitrate, tetraethylorthosilicate (TEOS), (3-aminepropyl)triethoxysilan (APTEOS), dextran, vinyltriethoxysilan (VTEOS) were obtained from Across Co. (USA). Dextran (from *Leuconostoc* Spp.) was purchased from Sigma-Aldrich Co. (Hungary), 4-benzoyl(benzyl)trimethylammonium chloride ((BTC), as a photo initiator) and 1,2,3,4-butanetetracarboxylic acid (BTCA) were obtained from Aldrich Co. (Germany). Sodium hypophosphite monohydrate (SHP) obtained from Duksan Chemical Co. Nonionic wetting and detergent agent (Egyptol), sodium hydroxide (NaOH), isopropyl alcohol, methyl alcohol, ethyl alcohol, ammonia solution, hydrochloric acid (HCl) were laboratory grade.

2.2. Methods

2.2.1. Preparation of silver nanoparticles (AgNPs)

Silver nanoparticles (AgNPs) was prepared via chemical reduction method (see Scheme 1). For the first time, dextran as a novel precursor have been used as reducing and stabilizing agent of the formed AgNPs. In a typical synthesis of AgNPs with high concentration up to 500 ppm, an appropriate amount of AgNO_3 (0.085 g) was dissolved in 20 ml distilled water. 0.5 g of dextran is completely dissolved in 80 ml distilled water, followed by addition of 0.05 g of NaOH to dextran solution. Then, the temperature is raised to 60°C with stirring at 500 rpm. To this solution, AgNO_3 solution was added drop-wise and stirred for 30 min at 60°C . At the end of reaction, the colorless of AgNO_3 was changed gradually to yellowish brown color confirming the formation of AgNPs.

2.2.2. Preparation of silica coated silver (SiO_2 @AgNPs) nanocomposite

The nano-composite comprise SiO_2 @AgNPs have been prepared using seeded polymerization technique with a sol-gel reaction (see

Scheme 1). Typically, 6 ml of silver nanoparticles sol (500 ppm) is added to 3 ml of distilled water containing ascorbic acid as antioxidant. 0.5 ml of ammonia solution is added to the mixture and then, stirred at 500 rpm for 30 min at ambient temperature. To the previous mixture, 10 ml of tetraethylorthosilicate (TEOS), which dissolved in 25 ml of ethanol, is dripped slowly. The final mixture is kept under stirring overnight. The yellowish precipitation has been collected using centrifuge and dried in air-drying oven at 60°C .

2.2.3. Functionalization of silica coated silver nanoparticles with silan compounds

Scheme 1 represents the suggested reaction between SiO_2 @AgNPs with both silan compounds ((3-aminepropyl)trimethoxysilan and vinyl silan). Freshly prepared SiO_2 @AgNPs (0.2 g) is added to solution consisting of distilled water, methanol and ammonia hydroxide in a 1: 2: 0.125 ratio. Sonication for the solution is occurred for 60 min. After that, VTEOS or APTEOS (2 ml) was added in one portion and the mixture was keeping for stirring another 5 h at 80°C . The precipitate was separated using centrifuge, and then washed with ethanol for several times. After that, dried at vacuum oven overnight.

2.2.4. Pad dry method for cotton fabrics treated with

SiO_2 @AgNPs, SiO_2 @AgNPs/APTEOS and SiO_2 @AgNPs/VTEOS

Supposed reactions of cellulosic fabrics with SiO_2 @AgNPs, SiO_2 @AgNPs/APTEOS or SiO_2 @AgNPs/VTEOS were illustrated in Scheme 1. Cotton Fabric samples were immersed independently in colloidal solutions of AgNPs (50 ppm in 100 ml), SiO_2 @AgNPs, SiO_2 @AgNPs/APTEOS or SiO_2 @AgNPs/VTEOS (0.2%), followed by squeezing to 100% wet pick-up using a laboratory padder at constant pressure. Treated samples with AgNPs, SiO_2 @AgNPs, and SiO_2 @AgNPs/APTEOS were dried at 80°C , for 5 min and then cured at 130°C for 3 min. On the other hand, treated fabric with SiO_2 @AgNPs/VTEOS was treated using UV irradiation (365 nm) for 2 h after drying using 4-benzoyl(benzyl)trimethylammonium chloride (BTC) as initiator (initiator was added to treatment bath with 3%).

2.2.5. Antibacterial and durability of the treated cotton fabrics

Solutions of SiO_2 NPs, SiO_2 @AgNPs, SiO_2 @AgNPs/APTEOS or SiO_2 @AgNPs/VTEOS were prepared by dissolving 0.2 g in 100 ml H_2O under magnetic stirring for 20 min. Also for comparison, the as prepared, colloidal AgNPs (500 ppm) was diluted to 50 ppm and used for fabric treatment. Cotton Fabric samples were immersed independently in colloidal solutions of the previous compounds followed by squeezing to 100% wet pick-up using a laboratory pad at constant pressure. Samples were dried at 80°C for 5 min and cured at 130°C for 3 min.

Durability of the treatment was determined as a function of bacterial resistant of the washed treated fabrics. Where the treated fabrics were washed (5, 10 and 20 cycles) repeated washing cycles. Each washing cycle, was performed with warm water containing 0.5 g/l nonionic wetting agent for 45 min followed by tumble-drying at 70°C . The washed fabrics were evaluated against bacterial activity and then comparing with the result of unwashed treated and untreated fabrics.

2.3. Characterization

UV-vis spectrophotometer (T80, Japan) at wavelength between 300 and 800 nm with 2 nm resolution was used to investigate the obtained AgNPs colloidal solution.

Fourier Transform Infrared (FT-IR) spectroscopy (Shimadzu FT-IR-8400 S, Japan) was used to identify the presence of new function groups in the selected samples using potassium bromide disks. For

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