



Surface active softener containing metal nanoparticles for functional textiles

A thesis submitted by

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ABSTRACT

Textile industry is one of the major industries in Egypt that has great impact on Egypt's revenue. A wide variety of functional properties have been imparted recently to textile fabrics by means of chemical finishing to develop multifunctional textiles. The main aim of this thesis was to develop novel approaches for textile multi-functionalization in single step process to impart multifunctional properties to cotton fabric in addition to enhanced physical properties particularly softness properties keeping in our mind saving both water and energy. We prepared highly stable silver nanoparticles (Ag NPs) in-situ silicon microemulsion matrix and then applied it on cotton fabric. The treated fabrics showed enhanced antibacterial and softness effects with minimal loss in fabric strength properties. Furthermore, we use electrospinning technique to convert the former formula into electrospun with the aid of poly vinyl alcohol polymer. The formed nanofiber mat showed improved antibacterial properties against gram positive and negative bacteria suggesting its promising role to be used as wound healing dressing in the medical field. We also implemented environmentally safe approach to prepare ZnO nanoparticles with the use of Jojoba oil nanoemulsion that was prepared through ultrasound assisted emulsification. Additionally, we applied this novel formula (ZnO-Jojoba nanoemulsion) in the presence and absence of different types of softeners (cationic- silicon) to cotton based fabrics through the use of ultrasonic spray coating technique. Finally, we developed a new finishing formulation using titanium dioxide nanoparticles (TiO₂) homogenously suspended in mixture of cationic softener and herbal oil. Application of this mixture on cotton fabric exhibited great stability, UV-protection, self-cleaning, antibacterial effect and softness properties without affecting fabric physical properties.

KEYWORDS:

Softeners- Electrospinning technique- Spray coating- Nanoemulsion- Herbal- Nanoparticles

Summary

The present work comprises five basic chapters

Chapter 1: Introduction

Textile industry is one of the major industries in Egypt as it represents the second largest industry in Egypt following food industry. It is one of the main revenue sources in Egypt. This chapter describes both advantages and drawbacks of textile cotton in textile industries along with strong emphasis on the use of chemistry and chemistry technology to counteract these problems and also to impart new criteria for textile cotton such as UV protection, antibacterial properties and self-clean. Various softeners and their mechanism of actions to impart soft handle and appealing to wearer are detailed. The chapter also describes the use of herbal extract and new technologies in textile industry such as electrospinning and ultrasonic spray coating. Nanoparticles definition, properties and their applications in textile industry are also highlighted in that section.

Chapter 2: Silicon Microemulsion Softener for In-Situ preparation of Ag NPs and its Application.

In this Chapter we were able to prepare Ag nanoparticle (Ag NPs) in-situ silicon microemulsion matrix, the conformation of the prepared Ag nanoparticle in-situ silicon microemulsion was confirmed by of UV–Vis spectroscopy and TEM. The stability of in-situ prepared Ag nanoparticle was studied for one year and gave excellent stability. Furthermore, the treatment of fabric with the prepared formulation greatly affect fabric performance and imparted multifunctional properties such as soft hand, antibacterial properties with acceptable physical properties.

Chapter 3: Development of soft electrospun mats based on PVA/SiME-AgNPs

In this Chapter we managed to apply the prepared formula described in chapter 2 (SiME-AgNPs) with the aid of spinnable polymer poly vinyl alcohol (PVA) by electrospinning technique to form electrospun mats with desirable properties. The optimum condition for the formation of the nanofiber was reported, the nanofibers were characterized by SEM as well as EDX. The characterization of the electrospinning solution mixture was also reported. The roughness and antibacterial activity of the synthesized mat against gm +ve (Bacillus subtilis and Staphylococcus aureus) and gm –ve (Escherichia coli and Pseudomonas aeruginosa) bacteria were performed. It was concluded that PVA/SiME-AgNPs mat are effective inhibitors of growth of gm (+ve) as well as gm (–ve) in addition to soft hand properties. Therefore, the performed mat could be used in wound dressing as a medical application.

Chapter 4: Development of Jojoba nanoemulsion (JNE) for synthesis and application of ZnO nanoparticle on textile fabric using Spray coating.

In this chapter environmentally safe emulsion was used to prepare ZnO nanoparticles. First Jojoba oil nanoemulsion was prepared using ultrasound assisted emulsification. The nano emulsion was characterized by TEM. The obtained Jojoba nanoemulsion has small particle size range from (15- 30). The prepared nanoemulsion utilized in the synthesis of ZnO nanoparticles. Successful formation of ZnO nanoparticles is followed by characterization using UV-Visible spectrophotometer as well as TEM. Treatment of the new finishing of new formulation (ZnO-JNE) in the presence and absence of different type of softener (cationic-silicon) on different type of cotton fabric was performed. Ultrasonic spray coating technique as a cost effective novel technique was used to apply the finishing formulation on cotton fabric.

Chapter 5: Development and Evaluation of Novel Multifunction Hybrid Containing Cationic Softener /TiO₂ /Herbal Oil for Cotton Based Fabrics

This Chapter was undertaken to develop a new finishing formulation using titanium dioxide nanoparticles (TiO₂) homogenously suspended in mixture of cationic softener and herbal oil. Its utilization as multifunctional finishing formulation to cotton based fabrics was investigated. The properties of the treated fabrics were monitored and compared with the untreated one. These properties included the effect of cationic softener concentration, form of TiO₂ nano particles (mixture of rutile and anatase), type of cotton fabrics (bleached or pre-carboxymethylated) and presence of herbal oil on the properties of the treated cotton fabrics. Moreover, stability of TiO₂ nanoparticles in such finishing formulation was also determined by TEM. The effect of using eco-friendly herbal oil within the same finishing formulation on the antibacterial activities of the treated fabric was also evaluated using a comparative study on different types of bacteria and it was indicated that herbal oil has a positive effect against activity. The treated fabrics give an excellent result for UV-protection, self-cleaning and antibacterial tests. Morphology and structure of TiO₂ nanoparticles were characterized using XRD and TEM. Finally, the treated fabrics showed enhanced UV protection and self-cleaning properties with improving softness properties without affecting the physical properties of treated fabric.

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