

## Eco-friendly process for in situ synthesis of silver nanoparticles on cotton fabrics

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**Abstract:** Silver nanoparticles (Ag NPs) were successfully directly synthesized on the cotton fabrics through the facile eco-friendly in situ synthesis method without using any harmful chemicals. SEM, XRD and FTIR analysis showed that the Ag NPs evenly coated on the cotton fabric displaying an excellent distribution.

### 1. Introduction

As early as 5000 years ago, people mastered the separation and melting technology of metal silver. The first time when people found the antibacterial property of silver can date back to around 400 BC [1]. Silver ions can react with the sulfur groups in the proteins of bacteria, prevent the transfer of nutrients, change properties of the membranes of bacteria, degrade lipopolysaccharide molecules, and then cause the death of bacteria [2, 3]. With such strong antibacterial properties, Ag NPs are widely used in the production and manufacture of functional textiles, hygiene products and protective textile materials [4-6].

There are a number of methods to fabricate silver nanoparticles on textiles [7, 8]. The in-situ synthesis of Ag NPs has always been a popular approach [9, 10]. However, among existing methods, complicated procedures such as preparation, functionalization, final treatment, drying, curing and so on have dramatically increased the costs of its industrial scale production. In view of such current situation, our research is devoted to develop a simple and eco-friendly method for direct in-situ synthesis of silver particles on cotton fibers. The successfulness of the synthesis of silver nanoparticles on cotton fibers are evaluated by SEM, XRD, FTIR analysis.

### 2. Experimental part

#### 2.1 Materials

Silver nitrate was purchased from GuoYao Co., Ltd. (China). Sodium hydroxide was purchased from TianJin HongYan reagent works. Cetyl trimethyl ammonium bromide (CTAB) was purchased from JiNing ZhenXing chemical works and lauryl sodium sulfate (SDS) were purchased from TianJin BoDi chemical engineering Co., Ltd. Cotton fabrics were purchased from ShaoXing Qi Dong Textile Co., Ltd. All chemicals were used as received without any further purification or treatment. Deionized water (18 MX cm) was used in the preparation of all samples. Before chemical modification, the cotton samples (6 mm×3 mm) were cleaned by ultrasonic washing in 2 % sodium laurylsulfonate solution for 30 min, then washed in ethanol (80 %, 2 h) and deionized water (30 min×3 times).

For coating of Ag NPs on fabric, two pieces of 0.2g fabrics were immersed in the mixture of silver nitrate solution (0.01 mol /l), sodium hydroxide solution(0.7407 mol/l) and SDS, and then heated at 40°C for 15 min (pH=10). Subsequently, the temperature was increased to 90°C with constant stirring for 1 h. Finally, the fabrics were taken out and air-dried at room temperature for further characterization measurements.

## 2.2 Measurements

JSM-6700F scanning electron microscope (SEM) was used to observe the in-situ synthesized silver nanoparticles on the cotton fabrics. FTIR spectra were collected from a Nicolet Fourier Transform spectrophotometer (AVATAR 5700, US) with an attenuated total reflection (ATR) accessory. XRD analyses for the modified fabrics were obtained using an X-ray diffract meter (ARL XTRA, Switzerland).

## 3. Results and discussion

### 3.1 Distribution of Ag NPs on Cotton Fabrics

Fig. 1 shows the surface morphologies of original and modified cotton fabrics with Ag NPs under SEM. It can be observed that many Ag nanoparticles are well dispersed on the surface of fabric, making the cotton surface very rough. The diameters of the particles on fabric are around 60 nm, larger than the silver nanoparticles synthesized in aqueous solution. That may be attributed to the high surface energy of silver nanoparticles on the surface of fabric to induce their aggregation.

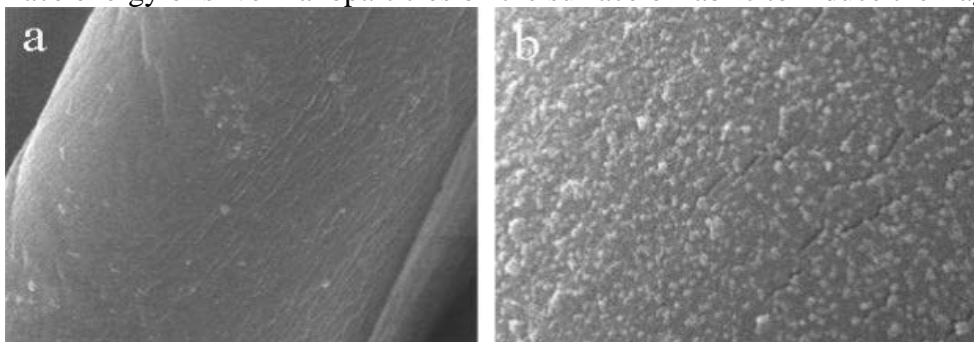


Fig. 1 SEM images of (a) original and (b) Ag coated cotton fabrics

### 3.2 Characterization of Cotton Fabrics with Ag NPs

Fig. 2 shows the XRD spectra of the original and modified fabrics respectively. obviously, original cotton fabric has XRD peaks at  $15^\circ$ ,  $22^\circ$ ,  $34^\circ$  assigned to cellulose planes, respectively. For the Ag modified one, the typical peaks at  $38^\circ$ ,  $44^\circ$ ,  $64^\circ$  and  $77^\circ$  are assigned to the Ag (111), (200), (220), and (311) planes, respectively. These result confirms the Ag NPs have been loaded on the cotton fabrics. Based on XRD pattern and Debye-Scherrer equation, it is calculated that the Ag NPs on the Cotton fabrics have average sizes of 60 nm. This result is in good agreement with our statistical data based on SEM images.

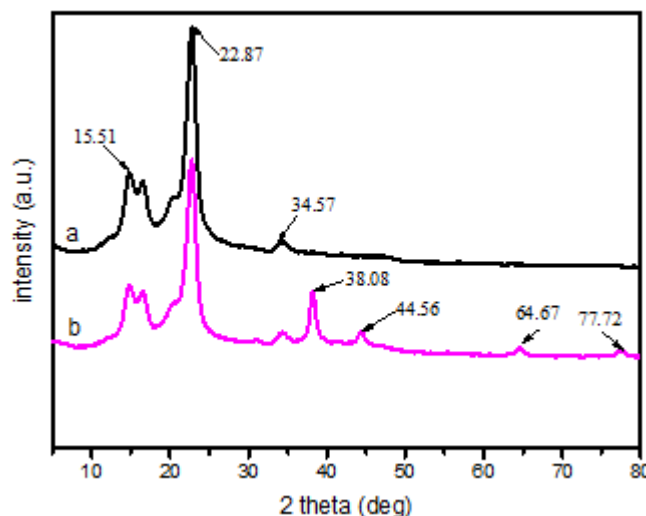


Fig. 2 XRD pattern of (a) original and (b) Ag coated cotton fabrics

Fig. 3 shows ATR-IR spectra of original and Ag coated cotton fabrics, respectively. The main

peaks at 3304 (OH stretching), 2901 (CH stretching), 1337 (OH bending) and 1022  $\text{cm}^{-1}$  (C–O–C bending) can be observed in both samples [11–13]. Comparing with the original one, the intensity of peak at 1022  $\text{cm}^{-1}$  (attributable to C–O–C bending) is decreased due to the Ag coating. This suggests that binding formation occurs between the cotton fabric and Ag NPs.

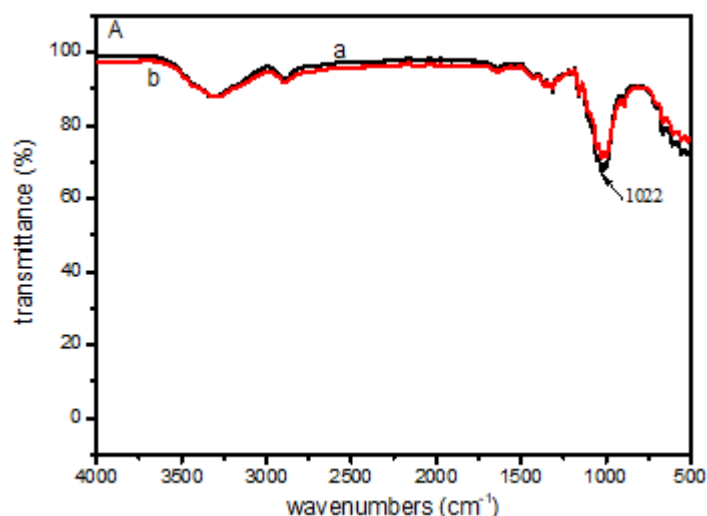


Fig. 3 FTIR spectra of (a) original and (b) Ag coated cotton fabrics

#### 4. Conclusion

In this research, an eco-friendly in-situ synthesis method was established for fabricating Ag NPs on cotton fabrics without using any harmful chemicals. By SEM, it was found the silver nanoparticles were uniformly distributed on cotton surface with the average size of silver nanoparticles about 60 nm. The XRD and FTIR analysis confirmed that silver nanoparticles have been fixed and well deposited on the cotton fibers.

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