

SYNTHESIS, CHARACTERIZATION AND ANTIBACTERIAL APPLICATION OF Au@SiO₂ CORE-SHELL NANOPARTICLES

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Abstract

Au@SiO₂ was synthesized by sol-gel method. The surface morphology of the material were characterized by scanning electron microscopy (SEM) with energy dispersive X-ray analysis (EDX). It is found that Au is trapped on the pores of the silica matrix. In addition, antibacterial activity was tested by using this nanoparticles has been discussed.

Keywords: Core-shell structures, Nanomaterials, Surface morphology, Sol-gel process, Antibacterial activity.

1. INTRODUCTION

In nanotechnology the rapid development has urged noteworthy interest in the environmental and biological applications of nanostructures. Nanostructures are excellent adsorbents, catalysts, and sensors due to their large specific surface area, superior durability, greater selectivity, and high reactivity [1]. Metal-silica core-shell particles, consisting of the nanostructured metal core and siliceous shell, attracted a lot of attention in the recent years due to their unique properties relevant for many applications such as catalysis and spectroscopy [2,3]. Since the outer shell of these particles is highly non-porous silica sphere and the inner core is composed of metal nanoparticles, the resulting composite particles are called the silica shell-metallic core nanostructures. These nanostructures are of great interest for numerous applications ranging from catalysis, sensing and medicine [4].

Microbial contamination is a serious issue in healthcare and food industry, so that development of antimicrobial agents has been attracted increasing attention in recent years [5]. Nanomaterials have arisen as new promising antimicrobial agents due to their high surface/volume ratio, as well as their unique chemical and physical properties [6]. Antibacterial agents are of great importance in several industries, e.g., water disinfection, textiles, packaging, food and medicine. Inorganic antibacterial agents such as metal oxides are advantageous compared to organic compound due to their stability [7]. Doping with metal ions have been recently known to be a promising antibacterial agent that acts as broad range of target sites both extracellular as well as intracellular. Hence there is a huge scientific progress in the study of antimicrobial application of metal ion doped inorganic metal oxides [8-15].

2. EXPERIMENTAL

2.1. Materials and methods

2.1.1. Culture medium

Nutrient broth was used for the preparation of inoculum of the bacteria and nutrient agar was used for the screening method [16-21].

2.1.2. Composition of Nutrient agar medium

Peptone (5.0 g), sodium chloride (5.0 g), beef extract (1.5 g), yeast extracts (1.5 g), agar (15.0 g), distilled water (1000 mL) and pH (7.4 ± 0.2).

2.1.3. Determination of antibacterial activity by disk-diffusion method

Nutrient agar plates were prepared under sterile conditions and incubated overnight to identify contamination. About 0.2 mL of working stock culture was shifted into separate nutrient agar plates and spread thoroughly using a glass spreader [22-29]. Whatmann No.1 discs (6 mm in diameter) were impregnated in the testing compounds dissolved in DMSO (200 mg/mL) for

about half an hour. Commercially available drug disc, Ciprofloxacin (10 mg/disc) was used as positive reference standard. All the compounds were tested at dose levels of 1000 µg and DMSO used as a control. The solutions of each test compound, control and reference standard were added separately in the cups and the plates were kept undisturbed for at least 2 hours in a refrigerator to allow diffusion of the solution properly into nutrient agar medium. Petri dishes were subsequently incubated at 37 ± 1 °C for 24 h. After incubation, the diameter of zone of inhibition surrounding each of the cups was measured with the help of an antibiotic zone reader [193,194][30-35].

2.2. ANTIBACTERIAL ACTIVITY

The synthesized nanomaterials were screened for the antibacterial activity against two Gram-positive bacteria viz., *Bacillus subtilis* and *Staphylococcus aureus* and two Gram-negative bacteria viz., *Escherichia coli* and *Pseudomonas aeruginosa* by using the disc diffusion method. Ciprofloxacin was used as reference standard for comparing the results[36-41].

2.3. Characterization methods

Scanning electron microscopy and elementary dispersive X-ray analysis experiments were carried out on a FEI Quanta FEG 200 instrument with EDX analyzer facility at 25 °C. The sample was prepared by placing a small quantity of prepared nanocomposites on a carbon coated copper grid and allowing the solvent to evaporate[42-45].

3. RESULTS AND DISCUSSION

3.1. Characterization of the synthesized nanoparticles

The SEM image of the Au@SiO₂ is shown in Figure 1a. From the SEM images of the nanoparticles possess a spherical shape, showing a relatively homogenous distribution of Au particles throughout the amorphous silica network. Au@SiO₂ shows an average particle size of

90 nm. EDX analysis confirms Si, Au and O are present in Au@SiO₂ (Figure.1b), which provides direct evidence that the Au nanoparticles were completely encapsulated within the silica shell.

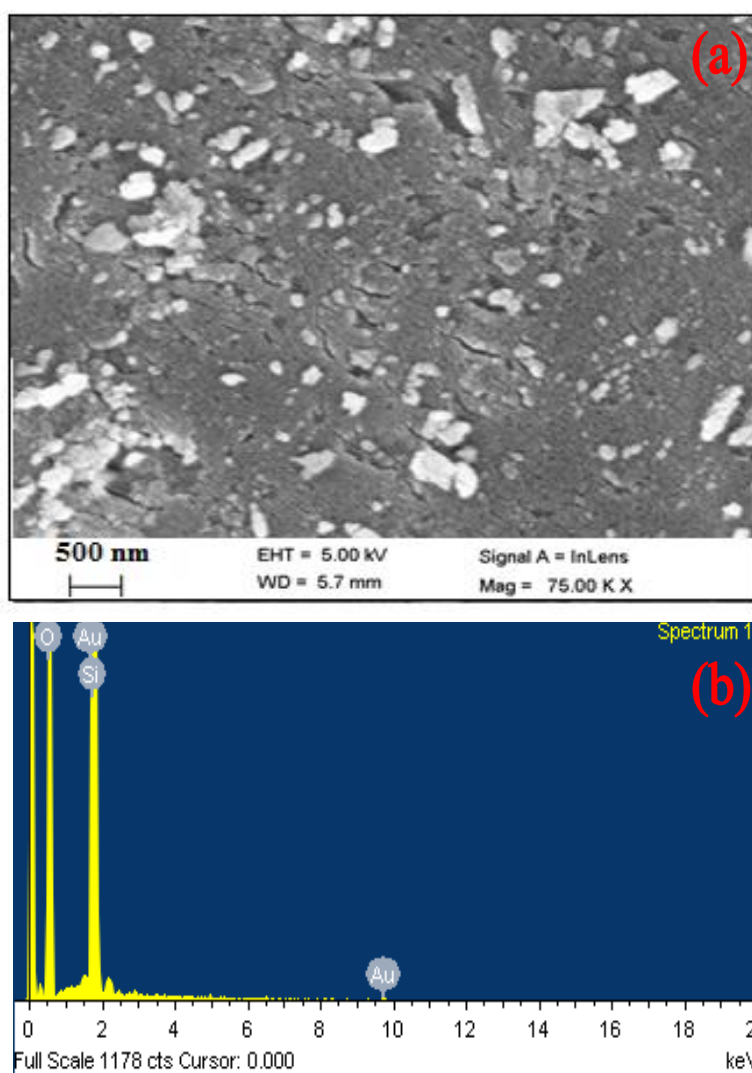


Figure. 1 (a) SEM image of Au@SiO₂ nanoparticles and (b) EDX analysis of Au@SiO₂.

3.2. Antibacterial activity of Au@SiO₂

The synthesized Au@SiO₂ were screened for the antibacterial activity against both Gram positive (*Bacillus subtilis*) and Gram negative (*Escherichia coli*) bacterial strains by using the disc diffusion method. Ciprofloxacin was used as reference standard for comparing the results. The antibacterial activities of the Au@SiO₂ are shown in Figure 2.

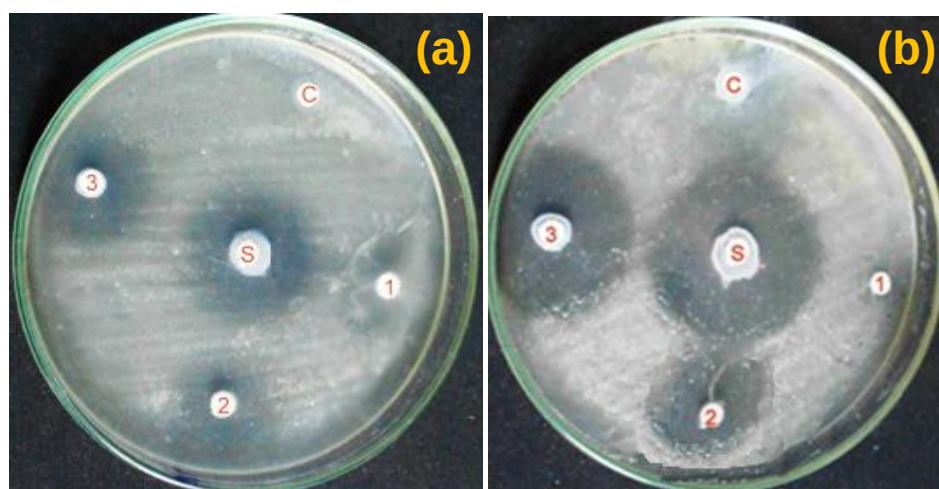


Figure 2. Antibacterial activity of Au@SiO₂ [(1) 0.01 g, (2) 0.05 g and (3) 0.1 g] against (a) *Bacillus subtilis* and (b) *Escherichia coli* [C-control (DMSO), S-standard antibiotic disc (Ciprofloxacin)]

The screening results indicate that Au@SiO₂ showed significantly higher activity. The enhanced antibacterial activity of the Au@SiO₂ can be attributed to physical and chemical properties of the nanoparticles together with the large surface area.

4. Conclusions

Au-doped Silica material was synthesized by simple and cost effective sol-gel method. The material was characterized by SEM with EDX analysis. Au@SiO₂ showed better antibacterial activity against both Gram-positive (*Bacillus subtilis*) and Gram-negative (*Escherichia coli*) bacterial strains.

Conflict of interest

The author declares no competing financial interest.

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