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Full Length Article

Silver-polymer functional-nanocomposite: A single step synthesis approach with *in-situ* optical study

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ABSTRACT

In this report, a one-step synthesis method has been documented for the fabrication of silver (Ag)-polymer composite material, where the metal nanoparticles are encapsulated within the polymer matrix. The formation of composite material was optically monitored using UV–vis and photoluminescence spectroscopic techniques. Other surface characterization and microscopic techniques were applied to realize more detail structural information of the composite. The synthesized composite material was applied as a catalyst for the electrochemical recognition of Epinephrine.

1. Introduction

Fabrication of a composite is an effective way for creating the multiple performance in a single architecture by combining the physical features of the different participating materials. Assembly of metal particles within the polymer has become an exciting tool for creating the multi-functional composite materials where the characteristics of the original polymer can be significantly changed [1]. Incorporation of metal or metal ion in the polymeric matrix could alter the magnetic [2], electrical [3], optical [4], catalytic [5] and sensing [6] properties for both the components. For metal-polymer composite system to achieve such functional properties the control of particle size, particle distribution and the particle-polymer interactions, through functionalization [7], are the essential conditions. Metal nanoparticles, particularly, Au, Ag and Cu show unique optical and interesting electronic properties. The optical properties of nano-sized metal particles have been focused for the applications in sensing [8], optoelectronics [9] and cell imaging [10].

Majority of the applications of the silver nanoparticles are based on plasmon mediated catalysis due to its unique optical properties [11–13]. Silver nanoparticles establish a promising approach for the bactericidal effects through the mechanistic action driven by the oxidation of the nanoparticles [14]. Heterogeneous gas phase reaction for the oxidation of styrene using silver nanoparticles has also been documented in the literature [15,16]. Silica-supported Ag-particles has been reported as an effective catalyst for Diels-Alder reaction [17]. Silver nanoparticles are extremely important in catalysis, organic transformations and the synthesis of fine chemicals. Recently published review articles cover an extensive overview for the application of nano-silver in organic transformations including carbon-carbon, carbon-nitrogen, carbon-sulphur, carbon-oxygen bond formation reactions as well as reduction and oxidation reactions [18,19]. The polymer stabilized Ag-nanoparticle also showed sensing activity for the nonenzymatic detection of H_2O_2 and also exhibited catalytic activity for the proton coupled electron transfer (PCET) reaction [20].

In this report, a single step wet chemical route has been adopted for the synthesis of Ag-polymer composite, where *1, 8*-di-aminonaphthalene has been used as a reducing agent for the silver nitrate for the preparation of silver nanoparticles, on the other hand, during the reaction, aminonaphthalene (AN) has been oxidized and produced poly-aminonaphthalene (*p*AN). The process of nanoparticle formation and polymerization are happened simultaneously and that ultimately produced metal-polymer composite material and has been used for an effective catalyst for the electrocatalytic detection of Epinephrine.

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2. Experiment section

2.1. Materials

Analytical grade chemicals and the solvents were used for this experiment without further purification.

2.2. Material characterization

Microscopy studies of the synthesized material were performed using a JEOL, JEM-2100 analytical electron microscope. Surface property of the material was characterized using Shimadzu XD-3A X-ray diffractometer operating at 20 kV using Cu-Kα radiation (k = 0.1542 nm) within the diffraction angle range (2θ) from 20° to 80°, whereas, the X-ray photoelectron spectra (XPS) were collected using a Physical Electronics 560 ESCA/SAM instrument. Optical property of the synthesized material was measured using Shimadzu IRAffinity-1, Shimadzu spectrophotometer (UV-1800) and Shimadzu spectrofluorophotometer (RF-5301PC). Electrochemical studies were carried out with a potentiostats, Bio-Logic SP-200, connected to a data controller, where a glassy carbon electrode (GCE) as the working electrode.

2.3. Synthesis of Ag-pAN composite

For a particular experiment, aminonaphthalene (0.375 g) was dissolved in methanol and aqueous solution of $AgNO_3$ (7 mL of 1.0×10^{-3} M) was added to the above solution. A precipitation was developed at the bottom of the reaction pot and the colour of the precipitation was changed from white to brown and then dark brown with time. The reaction was performed under the ambient temperature and pressure condition for the period of an hour. The precipitate was used for TEM and FTIR analysis and also for the demonstration the electrochemical sensing performance for Epinephrine. The residual fraction of the material was dried for XRD and XPS measurements. For the control experiment, pAN was synthesized using ammonium peroxodisulfate (APS) as an oxidizing agent. Small amount of the precursors (AN in $AgNO_3$ and AN in APS) with identical proportion and condition, as mentioned above, were mixed and used for the *in-situ* UV–vis and photoluminescence studies.

2.4. Electrocatalytic recognition of Epinephrine

A GCE was cleaned using a conventional procedure and the measured amount of synthesized materials, Ag-*p*AN and *p*AN, were deposited onto the GCE surface for the electrochemical detection

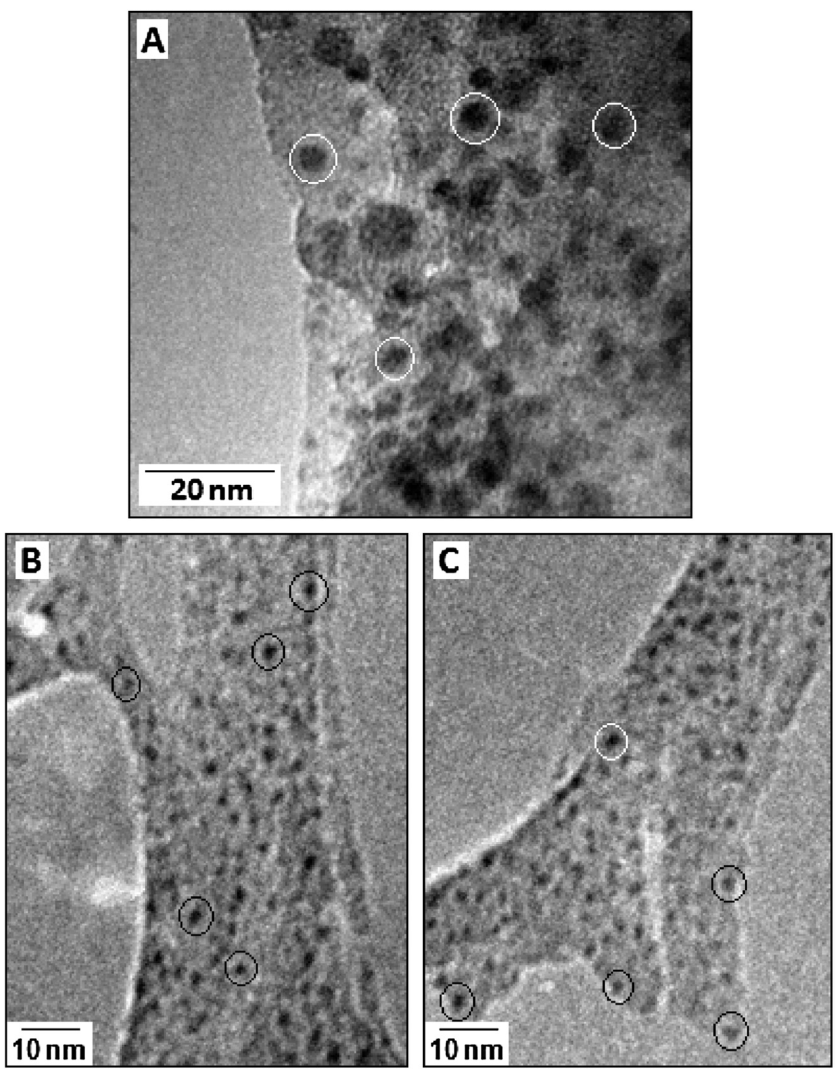

Fig. 1. The TEM image of the Ag nanoparticles. Based on the size distribution, two different types of silver particles are formed within the polymer matrix. (A) Ag nanoparticles within range of 5–10 nm in size. (B and C) Ag nanoparticles (dark spots), within range of 2–3 nm the size. Some of the representative particles are within the circles.