Synthesis and band gap modulation of polyaniline with the incorporation of silver nanoparticles

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Abstract

Silver–polyaniline (Ag–PANI) nanocomposite was synthesized by chemical oxidative polymerization of aniline with ammonium peroxy disulphate as an oxidizing agent in the presence of hydrochloric acid (HCl) and silver nanoparticles (Ag NPs). Silver nanoparticles are prepared by sodium borohydride reduction method. Synthesized Ag–PANI nanocomposite was characterized by using UV–visible (UV–Vis) and field emission scanning electron microscopy (FE-SEM). Ag NPs with diameter 35–60 nm were observed in FE-SEM images. UV–visible spectra of the synthesized nanocomposite showed a sharp peak at 380 nm corresponding to the surface plasmon resonance (SPR) of the silver nanoparticles (Ag NPs) embedded in the polymer matrix which is overlapped by the polaronic peak of polyaniline appearing at that wavelength. Increasing content of silver nanoparticles decreases The optical band gap of nanocomposite. The electrical conductivity of polyaniline–silver nanocomposite increases with increase in silver nanoparticle content.

Keywords: Polyaniline, Silver nanoparticle, Plasmonic absorption, Electrical conductivity, band gap energy.

Introduction

Polymers are generally insulators and to exhibit electrical conductivity they shoud be doped [1]. Conductive polymer with polyaromatic backbone includes polypyrrole, polythiophene, polyaniline, etc [2]. These polymers have unique electrical, optical, magnetic and chemical properties leading to the wide range of technological applications in rechargeable batteries, electrodes, electromagnetic interference shielding, sensors, corrosion, drug delivery systems, plastic transistors, and catalysts [3]. Among conducting polymers polyaniline (PANI) has received a great deal of attention due to its unique electrical, electro chemical properties, easy polymerization, and low cost of monomer, high absorption coefficients in the visible part of the spectrum, high mobility of charge carriers and tremendous stability [3]. However, the insolubility in common solvents, low processibility and poor mechanical properties of PANI has obstructed its potential applications. Electrical properties of PANI could be reversibly controlled by the process of doping which may be carried out through a chemical, electrochemical or photochemical route and the properties of conductivity can be controlled by charge transfer from dopant to polymer or from polymer to dopant. Doping these conductive polymers can induce high conductivity similar to metals. They combine the electrical properties of metals with the advantage of polymers such as low weight, greater processibility, resistance to corrosion and lower cost [4]. PANI exists in a number of forms which are emeraldine (semi oxidized), leucoemeraldine (totally reduced), pernigraniline (totally oxidized) and conducting emeraldine salt (half-oxidized and protonated form). Among the various types of polyaniline emeraldine base is regarded as the most useful form due to its high stability at room temperature and high electrical conductivity A.A. Athawale, M.V. Kulkarni, synthesized and used polyaniline and its substituted derivatives as sensor
for aliphatic alcohols, Sens. Actuators, B: Chem. 67 (2000) 173–177. [2].
The properties of PANI can be change by different oxidation states, dopants or through blending it with other organic, polymeric or inorganic nanosized semiconducting particles.
Silver has high electrical and thermal conductivity among the metals, so the composite of PANI with silver causes dramatic improvement of thermal, optical, mechanical, conducting and dielectric properties [3, 4]. These properties are sensitive to metal content, size and shape of the nanoparticles. Ag NPs could act as conductive junctions between the PANI chains that result in an increase of the electrical conductivity of the nanocomposites [15,16].
different approaches have been used for preparation of conducting polymer–metal and conducting polymer–inorganic nano particles such as physical mixing [5, 6], sol–gel technique [5], in situ