

ENHANCED PHOTOCONDUCTING PROPERTY OF POLY(*N*-VINYL CARBAZOLE)/GOLD NANO-COMPOSITE LANGMUIR-SCHAEFER FILMS

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1. Introduction

The preparation of nanostructured materials has become an important research field because these materials have specific optical and electronic properties that differ significantly from the bulk. There is a growing need to prepare and understand the properties of nano-sized objects due to the rapid growth of nanotechnological applications. In particular, the use of gold nanoparticles (GNPs) opens fascinating possibilities in various fields, especially by their size-related electronic and optical features [1]. GNPs dispersed into polymeric network are already used as various sensors, for catalytic purposes, in conductive inks, and for electron or energy storage [2]. However, it is a key challenge to disperse thermodynamically unstable nanoparticles into polymer matrices because metal nanoparticles, such as GNPs, tend to cause agglomeration because their high surface reactivity and instability.

Among the different polymeric materials currently available, poly[3-3'(vinylcarbazole)] (PVK) has emerged as one of the more useful materials for electro-optically active applications, including light-emitting diodes and xerography. The main aim of this research is to design and synthesis of electro-optical polymers and multifunctionalized photorefractive materials heralded as promising for application in high technology. In recent years, considerable attention has been focused on the modification of special vinyl addition polymers and condensation polymers, particularly delving into ways to improve their bulk properties [3]. It is believed that the combined effect of GNPs and the homopolymer PVK to form a polymer composite should improve the mechanical properties of the polymer. Thus, an attempt is made in this study to synthesize a new polymer composite of PVK containing GNPs. The synthesis was performed via a

simple *in situ* bulk polymerization of *N*-vinylcarbazole in the presence of GNPs at an elevated temperature. The synthesized composite was characterized by some instrumental methods and the Langmuir-Schaefer (LS) film of the composite was fabricated and used to study the photoelectrochemical behaviors, pressure-area isotherms, and I-V characteristics of the composite at room temperature.

2. Experimentals

Synthesis of PVK nanocomposite containing GNPs (PVK-GNP nanocomposites) LS films

Among the other methods available, citrate reduction of gold (III) in water presents the most popular approach to GNPs preparation. In this method, citrate serves as both a reducing agent and an anionic stabilizer. The easiest way of synthesizing PVK is oxidizing the NVC monomer using FeCl₃ as the oxidizing agent. In this study, we attempted to synthesize PVK-GNP composites via a simple-solid state polymerization technique [3]. In a typical synthesis procedure, a mixture of 2.0 g of NVC and 0.5 g powder of GNPs obtained by the method above was placed in a conical flask and heated at 70 °C for about 2 h under an N₂ atmosphere. Then, 5 mL of distilled tetrahydrofuran was added to the reaction mixture; stirring was continued for another 2 h. The entire reaction mixture was carefully transferred to a beaker containing methanol. The composite formed by the solid-state polymerization was precipitated as a slightly red-colored mass. The obtained PVK-GNP nanocomposite was filtered and washed repeatedly with boiling methanol to remove any unreacted NVC monomer, followed by washing with acetone. The resulting mass was dried at 100 °C for about 6 h. Thin films of PVK and PVK-GNP polymers were

deposited by the horizontal lift technique, also known as the LS film method [4].

3. Results and Discussion

Langmuir isotherm PVK and PVK-GNP composite LS films

Figure 1 shows the surface (II)-area (A) isotherms of the LS thin films for the homopolymer PVK and the composite PVK-GNP at a barrier speed of 2.0 mm s^{-1} . The isotherms observed in this study appear to resemble a nearly condensed shape. A steep increase in the condensed phase and a hysteresis in a compression-expansion cycle as well as an increase in the condensed phase is also observed. It means that the surface pressure seems to increase with the inclusion of GNPs into the PVK polymer to form composites. The GNPs are smaller in size, which can be easily associated with the PVK homopolymer. Based on our studies of isotherm, we consider that LS films from the PVK-GNP composites are deposited at an applied surface pressure of $\sim 40 \text{ mN m}^{-1}$ and a barrier speed of 2.0 mm s^{-1} .

Photocurrent measurements I-V characteristics of PVK and PVK-GNP LS films

Figure 2(a) shows the photocurrent transient for the polymer blends with 30 layers of the PVK homopolymer and the composite PVK-GNP LS films at 0.4 V in $10^{-2} \text{ mol dm}^{-3} \text{ LiClO}_4$. The potential of the working electrode was set at 0.4 V (vs. Ag/AgCl). A fast and uniform photocurrent response was observed in each of switch-on and switch-off condition. The figure shows that the photocurrent rise time is shorter than the time between light switch-off and switch-on for both PVK and PVK-GNP LS films and shorter than the time between light switch-off and switch-on for the LS films of both PVK and the PVK-GNP composites. The increases in the current of the sample under illumination are ~ 0.03 and $\sim 0.9 \mu\text{A cm}^{-2}$ for PVK and the PVK-GNP composite, respectively, mainly depending on the applied potential. There is a larger increase in the photocurrent; $0.9 \mu\text{A cm}^{-2}$ was observed for PVK-GNP and this decreases when the applied potential is shifted to negative values.

From the results, it is clear that both PVK and the PVK-GNP composites display ohmic behavior. Due to the presence of coated GNPs by PVK, the composite PVK-GNP shows an increase in the conductivity of the composite film.

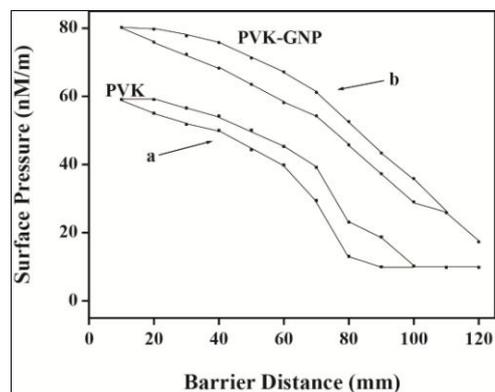


Fig. 1. Pressure (II)-area (A) PVK and PVK-GNP composite LS films as a function of the barrier speed: (a) 1.5 and (b) 2.0.

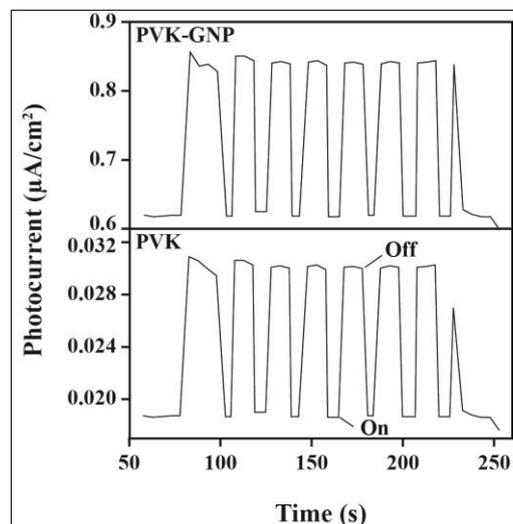


Fig. 2. Photochemical current for PVK and PVK GNP LS films at 0.4 V in $10^{-2} \text{ mol dm}^{-3}$ of LiClO_4 .

4. References

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