P3HT:VOPcPhO composite nanorods arrays fabricated via template–assisted method: Enhancement on the structural and optical properties

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ABSTRACT

In this study, the fabrication of poly(3-hexylthiophene-2,5-diyl) (P3HT) and vanadyl 2,9,16,23-tetraphenoxy-29H,31H phthalocyanine (VOPcPhO) composite nanorods is reported. P3HT:VOPcPhO composite nanorods have been synthesised from the solution concentration of 5 mg/ml via the template-assisted method. TEM images show that P3HT nanotube was first produced which has led to the infiltration of VOPcPhO. The composite nanorods have replicated the porous diameter of template of ~200 nm. If compared to the P3HT:VOPcPhO composite thin film, UV–vis spectrum of composite nanorods shows a wider band absorption and the peak absorption was shifted to the longer wavelength, which could be due to the improved interaction between small molecules and P3HT segment at their interfaces. The better absorption that portrayed by composite nanorods was supported by the quenching of intense peak in photoluminescence spectrum. Owing to the quenching, the photo-induced charge transfer and charge carrier dissociation in the composite nanorods is pragmatic.

1. Introduction

The studies on the fabrication of polymer and dye material composites are essential for the facile production of electronic devices. Conjugated polymer and dye material composites have attracted much research interest due to their potential for low cost electronic devices such as sensors, solar cells and capacitors [1–4]. The dielectric, mechanical, structural, optical and electrical properties of nanocomposites have been widely reported for their exceptional features [2,5–8]. Typically, the preparation of nanocomposites is performed via a blending/mixing solution method [1–4] which will only produce the composite thin films instead of novel nanostructured composite. The approach to the highly facile fabrication of novel nanostructured composite can be realised via the integration of templating method [6,9–11]. Polymer of poly(3 hexylthiophene 2,5 diyl) (P3HT) and dye material of vanadyl 2,9,16,23 tetraphenoxy 29H,31H phthalocyanine (VOPcPhO) composite thin films have been reported to have an enhancement on its optical properties [1]. In conjunction with this finding, a novel nanostructured composite composed of P3HT and VOPcPhO would potentially stimulate a great deal of interest in producing the remarkable electronic devices.

In this paper, we report the production of novel polymer/dye composite nanorods with enhanced structural and optical properties. The preparation of P3HT:VOPcPhO composite nanorods is fully assisted by a porous alumina template. Based on the studies, the comparison of structural and optical properties between P3HT:VOPcPhO composite nanorods and thin films are discussed in details.

2. Experimental

The P3HT and VOPcPhO from Sigma Aldrich were used without further purification. P3HT and VOPcPhO were dissolved in chloroform and prepared in the solution concentration of 5 mg/ml, respectively. The porous alumina templates used in this study were commercially available filter membrane (Whatman Anodisc) with nominal pore diameters of 200 nm and a thickness of 60 μm. 5 mg/ml of P3HT was first dropped onto the cleaned porous alumina template, spin coated at 1000 rpm and annealed at 150 °C prior to the drop casted of VOPcPhO of the same spin coating’s speed. After annealing process, the alumina template was dissolved in 3 M sodium hydroxide and the remaining P3HT:VOPcPhO composite nanorods were rinsed in deionized water.
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Table 1  
Raman peak positions of P3HT:VOPcPhO composite nanorods and thin films.

<table>
<thead>
<tr>
<th>Raman shift (cm⁻¹)</th>
<th>Thin films</th>
<th>Nanorods</th>
<th>Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>727</td>
<td>727</td>
<td></td>
<td>Macrocycle stretching</td>
</tr>
<tr>
<td>1003</td>
<td>1003</td>
<td></td>
<td>Benzene ring breathing</td>
</tr>
<tr>
<td>1091</td>
<td>1088</td>
<td></td>
<td>C–H bending</td>
</tr>
<tr>
<td>1182</td>
<td>1186</td>
<td></td>
<td>C–H bending</td>
</tr>
<tr>
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<td></td>
<td>C–C stretching</td>
</tr>
<tr>
<td>1449</td>
<td>1449</td>
<td></td>
<td>C=O stretching</td>
</tr>
<tr>
<td>1520</td>
<td>1520</td>
<td></td>
<td>Pyrrole stretching</td>
</tr>
<tr>
<td>2897</td>
<td>2828</td>
<td></td>
<td>C–H stretching</td>
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<td>2897</td>
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References