

Structure and optoelectronic properties of PbSe quantum dots /PVA. Does the polymer molecular weight matter?

Waleed E. Mahmoud^{a*}

Polyvinyl alcohol (PVA) with different molecular weights (8000, 14,000, and 132,000 g/mol) capped lead selenide (PbSe) quantum dots (QDs) are prepared. The nanocomposites are characterized by X-ray diffraction (XRD) and transmission electron microscopy (TEM). XRD and TEM studies show that the particle size of PbSe QDs decrease with the increase in PVA molecular weight and/or PVA amount. This may be due to the increase in molecular weight inhibiting further growth of PbSe into the polymer matrix. Thermogravimetric analysis showed that the introduction of PbSe QDs into PVA decreases the crystallinity of the polymer. The optical absorption spectroscopy of prepared nanocomposites showed that the absorption peaks are strongly shifted to the lower wavelength (blue shift) from near infrared region to visible region by increasing the PVA molecular weight. The (*I*-*V*) characteristic curves of the PVA/PbSe nanocomposite films under illumination showed a photovoltaic cell-like behavior. The results indicated that as the molecular weight of polymer increases, the conversion efficiency increases. Copyright © 2010 John Wiley & Sons, Ltd.

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INTRODUCTION

The process of controlling the particle size of nanomaterials becomes the real challenge for many scientists around the world, especially for making all the particles of a nanomaterial of the same size. Semiconductor quantum dots (QDs) are small man-made material objects in which electrons and holes are confined in all three spatial directions, such as in real atoms, and as such are also referred to as nanocrystals or artificial atoms. Taking advantage of the possibility to control the quantum confinement by manipulating their size and/or their shape, these artificial atoms may exhibit enhanced physical properties with no analog in real atoms. Therefore, the enhanced properties, and the resulting applications, are strongly dependent upon the nanocrystal size and shape. This opens up the prospect for creating materials with designed properties, not just by changing the chemical composition of the components, as has been done in the past, but by controlling the material size and/or shape.^[1] Indeed, semiconductor QDs are attracting intense interests as prospects for nanotechnological applications emerged in the areas of spintronics,^[2] optoelectronics,^[3,4] quantum computing,^[5] photocatalysis,^[6] and luminescence labeling.^[7] For such purpose, semiconductor nanocrystal in a transparent polymer will be investigated in this work. The polymer matrix has several important roles to play. It provides the confinement potential in view of its larger band gap relative to the semiconductor material. It also hosts the nanocrystal in the form of a stable matrix. As a transparent host, it can also render the nanocrystals in a form suitable for applications in linear and nonlinear optics. Various polymers^[8,9] have been used as host matrices for embedding semiconductor nanocrystals.

In the present study a IV–VI semiconductor nanoparticle, lead selenide (PbSe), has been selected because it offers a unique possibility of strong quantum confinement as compared with II–VI semiconductor QDs due to their narrow band gap semiconductor ($E_g = 0.28$ eV) with a large exciton Bohr radius (48 nm). Due to its large Bohr radius, PbSe has great potential for applications in NIR lasers, solar cells, optical switches, telecommunications, etc.^[10–12] Modification of physical properties of strongly confined PbSe nanocrystals embedded in stable and device-friendly polymer films is an area that has not received sufficient attention, because several aspects, such as the stability, dopant–host interactions, surface effects, and nature of quantum confinement, remain to be determined in order to realize the full potential of these materials.

Polyvinyl alcohol (PVA) is a hydrophilic polymer frequently used as a matrix for stabilization of IV–VI nanocrystals.^[13,14] The PVA precursor with –OH functional groups at side chains can bind nanocrystal ion through complex interaction and act as a template to direct the distribution of IV–VI nanocrystals in the process. In the present work, we report on the effect of the molecular weight as well as the amount of PVA on the particle size of PbSe nanocrystals and its influence on the other physical properties.

* Correspondence to: W. E. Mahmoud, Department of Physics, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia.
E-mail: w_e_mahmoud@yahoo.com

a W. E. Mahmoud
Department of Physics, Faculty of Science, King Abdulaziz University, Jeddah, Saudi Arabia