Modification of optical properties of polymer films by addition of PbS nanoparticles

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Abstract

Semiconductor nanoparticles have attracted the interest of many research groups for the last two decades. As the diameter of a semiconductor crystal approaches its exciton Bohr diameter, the electronic properties of the semiconductor start to change. This is known as the quantum size effect. It is commonly observed that as the particle size decreases the optical absorption edge shifts to higher energy (blue-shift) [1].

By doping organic materials with these nanoparticles a variety of nanocomposite materials can be prepared with customizable optical and electrical properties. These nanocomposites are especially interesting if they can be easily synthesized and processed at low cost. In particular, those composites processed from solution that can be cast by simple techniques, such as different printing technologies, drop-casting or spin-coating among others.

Polymers have proved to be a useful matrix in assembling the nanoparticles, improving their stability and helping to control the size of the semiconductor nanoparticles [2].

In this study we use the well known poly[2-methoxy-5-(3',7'-dimethyloctyloxy)-1,4-phenylenevinylene] (MDMO-PPV) semiconducting polymer as matrix, and we will synthesize lead sulfide (PbS) nanoparticles (NPs) directly in it by using a very simple synthetic route.

Assuming that optical properties of semiconductor nanoparticles can also be modified by surface chemical modification, 1,4-fluorothiophenol (SHC_6H_4F) was always used to cap the NPs for the experiment reported here.

$Pb(SPhF)_2$ complex is prepared by reaction of $Pb(NO_3)_2$ and SHC_6H_4F. This complex contains the Pb and the capping radical for the PbS NPs, and it is soluble in dimethylsulfoxide (DMSO). Addition of a small volume of sulfur to this precursor solution produced PbS NPs capped with the organic radical. This reaction is shown in figure 1 [3].

To prepare the nanocomposite a whole batch of solutions containing MDMO-PPV and $Pb(SPhF)_2$ complex were dissolved using 4:1 toluene:DMSO solvents ratio. PbS nanoparticles are synthesized by adding a solution of sulfur in toluene to the polymer-complex solution. Changing the volume of sulfur added to each solution the amount of PbS nanoparticles synthesized inside the polymer can be modified.

The presence of these PbS NPs has been checked by TEM measurements as can be seen in figure 2.

Optical properties of thin films prepared by spin casting from nanocomposite solutions with increasing PbS NPs loading, have been studied.

Quenching of PL emission is observed when the ratio of PbS NPs increases with respect to the polymer suggesting the occurrence of Dexter energy transfer from the polymer to the PbS NPs.

An enhancement of optical absorption is found for nanocomposites with increasing PbS NPs concentration [4]. Optical absorption is markedly increased for nanocomposite films compared to pure polymer film suggesting its potential application in optoelectronic devices such as solar cells.

We demonstrate that optical properties of MDMO-PPV polymer film can be modified by addition of PbS nanoparticles.

References

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Figures

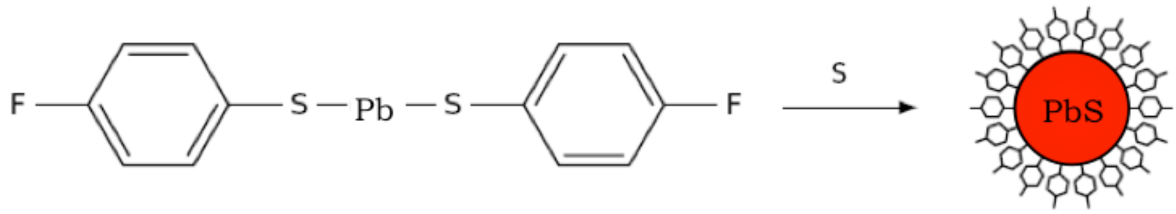

Figure 1: PbS nanoparticles capped with 1,4-fluorothiophenol (SHC_6H_4F) can be obtained by reaction of $Pb(SPhF)_2$ complex with a small amount of sulphur.

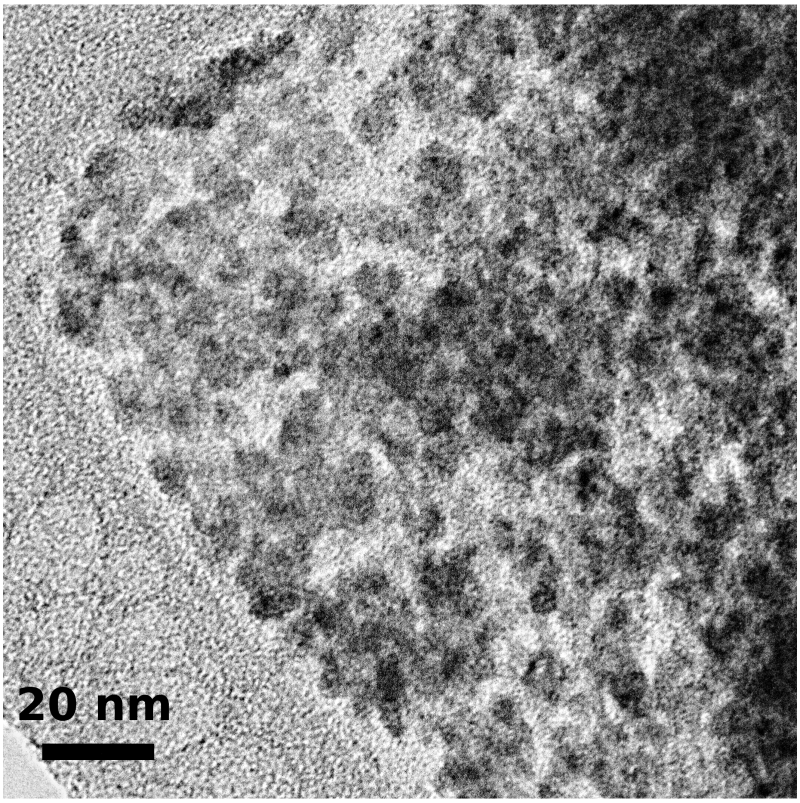

Figure 2: TEM image of an ensemble of PbS NPs within the polymer matrix