

Photoluminescence of P3HT-Graphene composites

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ABSTRACT: Poly3-hexyl thiophene (P3HT) is one of the most attractive conjugate polymer used in organic photovoltaics because of high electrical conductivity and good solubility in various solvents. Unlike CNTs based composites, graphene based composites have been proven as promising material for efficient device performance. But still practical use of the composite material for photovoltaic has been hampered due to drawbacks related to the exciton dissociation at the interfaces. Using interface engineering, performance of device can be improved. Here we focus on photoluminescence (PL) properties of P3HT and P3HT-Graphene composite. P3HT and P3HT-Graphene composite were excited at 420 and 480 nm wavelengths and it was found that PL of P3HT-Graphene composite is effectively reduced from that of pure P3HT. Thus quenching of PL emission of P3HT shows that graphene can be considered as an efficient electron acceptor for organic photovoltaic applications.

Keywords: Graphene composite; photoluminescence; exciton; quenching.

INTRODUCTION: These days' researchers focus much on the recital of photovoltaic devices. A photovoltaic device operates via photo voltaic effect [1] by employing direct conversion of solar energy into electrical energy. Traditionally inorganic polymers are employed in photovoltaic devices but after the discovery of conjugated polymers [2] and bulk heterojunction [3]; research has been increased more toward organic photovoltaic due to easy fabrication, lesser cost and lighter in weight. P3HT (Poly-3-hexyl thiophene) is one of the most attractive conjugate polymer used in organic photovoltaic as donor because of large absorption coefficient, high electrical conductivity and good solubility in various solvents. Also it can be deposited using cheap deposition techniques such as spin coating, dip coating etc. [4]. As photovoltaic device are excitonic and the dissociation of photo induced exciton require that there should be desirable offset between energy levels of donor and acceptor material [5]. CNTs have already shown their potential as acceptor material [6] but they have limited technological applications because of insolubility of CNTs in common solvents and low efficiency. Another allotrope form of carbon viz; Graphene which is a one atom thick layer of sp^2 bonded carbon atoms [7] can be preferred as acceptor. It has been experimentally proved to be stable at ambient condition [8]. It has high charge carrier mobility and good electrical conductivity at room temperature [9] due to which charge carriers easily move towards electrodes. Also it has large specific surface area [10], which provides large interfacial area for P3HT when it is blended with P3HT. Also it has high electron affinity of 4.5eV [11] than that of P3HT which is about 2.8eV [12]. Thus graphene is expected to be a good electron acceptor with P3HT as donor. Here in this study, we have pre-

pared P3HT-Graphene composites via ex-situ method and their photoluminescence spectra is studied under two different excitation wavelengths.

EXPERIMENTAL:

Materials and Method:

Graphite powder, P3HT and Ortho dichloro benzene (ODCB) were used as it is as procured. The chemical structure of P3HT is shown in Figure 1. For preparing P3HT-Graphene composites, firstly graphene was prepared in ODCB and then blended in P3HT solution with the aid of magnetic stirring. In a typical synthesis procedure, 100 mg graphite powder was dissolved into 20 ml ODCB with the help of ultra-sonicator horn at 220 V for 45 minutes and then left for 1 hour. After that top portion of solution was taken and centrifuged at 1500 rpm for about 1 hour and the supernatant of this solution which contains single and bi-layer graphene was retained [13]. Meanwhile 3 mg/ml solution of P3HT was prepared in ODCB. After that P3HT-graphene composite with 0.25wt % graphene was prepared by simple blending of P3HT and graphene solution with aid magnetic stirring for half an hour.

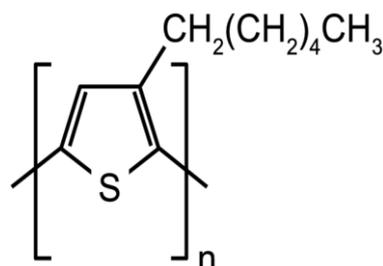


Figure 1: Chemical structure of P3HT

Sample Preparation and Characterization:

The samples for photoluminescence (PL) measurements were prepared by depositing thin films of P3HT and P3HT-Graphene composite on quartz substrate with spin coating at 400 rpm. Photoluminescence (PL) study was carried out on Ocean Optics Spectrometer, having a CCD array sensor and fiber optic probe at National physical laboratory (NPL), Delhi.

RESULTS AND DISCUSSION: PL spectra for Pure P3HT and P3HT-Graphene composite films are obtained at two excitation wavelengths 420 and 480 nm; which lie between absorption band of P3HT [14]. Figure 1(a), 1(b) and 1(c) are showing the PL emission of pure P3HT, graphene and their composite films respectively at excitation wavelength of 420nm. The PL spectrum of pure P3HT film (Figure 3 (a)) shows strong and broad emission between wavelengths 600 and 750nm with maxima occurring at 663nm which is also supported by available literature [15]. As P3HT belongs to the class of thiophene; so this broad emission may be owned to radiative transition from bulk emissive state to ground state (Figure 2) [16].

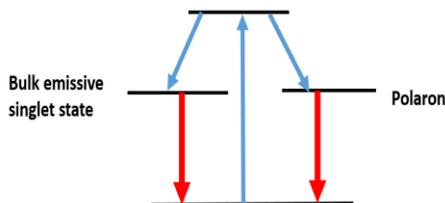


Figure 2: Radiative transition from bulk emissive state to ground state

The PL emission spectrum of graphene (Figure 3 (b)) contains no strong emission peak. The zero band gap of graphene could be the possible reason. Some peaks of very small intensity observed in the PL spectra may be attributed to structural defects of as prepared graphene [17].

Further the range of PL emission in case of P3HT-Graphene composite (Figure 3 (c)) shows no significant change from that of pure P3HT, but the maximum emission shows blue shift from 662 nm to 640 nm. As maximum emission wavelength in PL is related with relative position of excited state with respect to ground state of P3HT [18]; therefore shifting of peak towards low wavelength is associated with some changes in structural order of P3HT due to its interaction with graphene [19]. Also, the emission intensity is much decreased than that of pure P3HT and this reduction in PL intensity may be attributed to

quenching of excited fluorophore in P3HT. The possible reason for this is efficient exciton dissociation at interface [20] between graphene and P3HT which leads to photo induced charge transfer [21] from P3HT to graphene. That means more charge gets separated which is in favour of increase in efficiency of device if composite material is used as active layer in photovoltaic device. Thus reduction in PL emission is an indication of electronic interaction at P3HT/Graphene interface which results in improved efficiency.

Same variations in PL emission spectra were verified with 480nm excitation wavelength (Figure 4).

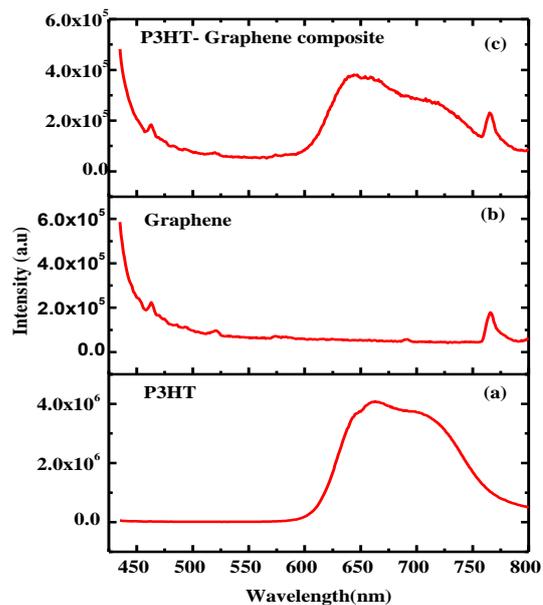


Figure 3: PL emission spectra of (a) P3HT, (b) Graphene and (c) P3HT-Graphene composites at 420 nm excitation wavelength

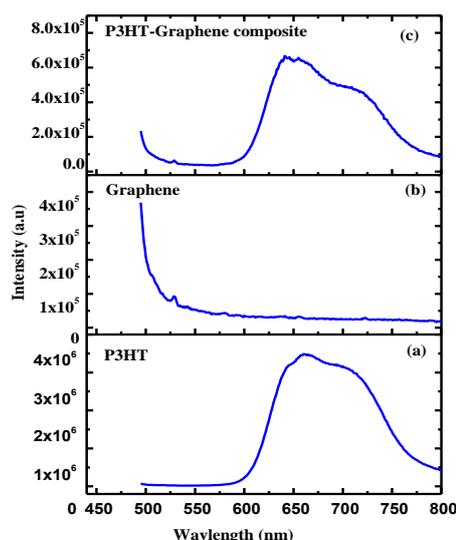


Figure 4: PL emission spectra of (a) P3HT, (b) Graphene and (c) P3HT-Graphene composites at 480 nm excitation wavelength

CONCLUSIONS: The PL emission of P3HT shows a quenching effect on making its composites with graphene which supports the exciton dissociation. That means interaction between graphene and P3HT makes P3HT-Graphene composite film as an efficient active layer in photovoltaic device. Thus graphene proves to be a potential electron acceptor material for photovoltaic devices.

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