Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **4264** Type: **Oral Competition (Graduate Student) / Compétition orale (Étudiant(e) du 2e ou 3e cycle)**

(G*) Exciton recombination at the poly[2-(3-thienyl)ethyloxy-4-butylsulfonate]-sodium bathocuproine (PTEBS:BPC) interface and its application to organic solar cells

Monday 27 May 2024 15:15 (15 minutes)

The study of organic solar cells is intriguing from a fundamental point of view because of the very short lifetime of excitons -strongly-correlated electron-hole pairs- in these devices. While the origin of short exciton lifetime is still an open scientific problem, it is now apparent it is somewhat linked to strong electron-phonon coupling, which is also depending on the dielectric function of the excitonic environment in these devices. The photoactive layers of organic solar cells is made by polymers, small organic molecules, or their combination. To date, photoconversion efficiencies (PCEs) approaching 20% have been reported for binary organic photovoltaics by modulating the exciton recombination processes, which allows for enhanced electron-hole separation. Here we will show that tunable electron transfer is possible between poly[2-(3-thienyl)ethyloxy-4-butylsulfonate]-sodium (PTEBS, a water soluble organic polymer) and bathocuproine (BCP).a small organic molecule. We demonstrate PTEBS:BCP electron transfer through quenching of the photoluminescence of PTEBS in the presence of BCP in aqueous acidic solutions, and in thin films fabricated from these solutions. As UV-visible spectroscopy shows only moderate changes of the optical band gap of PTEBS depending on the pH of the starting solution, the dramatic change in PTEBS:BCP electron transfer when the pH of the solutions change from basic to acidic is assigned to the increase of exciton Bohr radius at lower pH (of 4 or more). We also corroborated this effect by direct measurements of the dielectric constant of PTEBS which is shown to decrease at increasing pH, where electron spin resonance (ESR) measurements on PTEBS, show increasing free carrier concentrations in the polymer chain. All of these data has been used to design organic solar cells with PTEBS:BCP as the active layer, C60-fullerene as electron transport layers and Nickel Oxide as hole-blocking layers, with energy levels matching, respectively the conduction and valence band of PTEBS. OPV photoconversion efficiency (PCE) is about 2.8% for PTEBS:BCP active layers prepared from acidic water solutions, while dropping to significantly lower values (PCE < 0.5%) from basic solutions. Therefore, our study presents among the best organic photovoltaics obtained to date from water-based polymer solutions, and highlights the importance of the dielectric environment and exciton dissociation at the donor-acceptor interface in designing high-quality organic solar cells.

Keyword-1

Organic quantum materials

Keyword-2

Excitons

Keyword-3

Solar cells

Primary authors: Ms WEI, Xin (University of Western Ontario); STOCEK, Noah (University of Western Ontario); Mr WILLIAMS, Daniel (University of Western Ontario); FANCHINI, Giovanni (University of Western Ontario)

Presenter: Ms WEI, Xin (University of Western Ontario)

Session Classification: (DCMMP) M2-7 Soft Condensed Matter II | Matière condensée molle II (DPMCM)

Track Classification: Technical Sessions / Sessions techniques: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)