Electrochemical investigation of MEH-PPV/C_{60} nanocomposite prepared by Langmuir-Schaefer technique

Paolo Bertoncello [a,b, §] , Hanming Ding[b], Manoj Kumar Ram[b] and Claudio Nicolini[a,b]

[a] Department of Biophysics, M&O Science and
Technologies, University of Genoa, Corso Europa 30,
16132 Genoa, Italy
[b] El.B.A. Foundation, Genoa Section, Corso Europa 30,
16132 Genoa, Italy
§ ECS student active member

The demand for inexpensive, renewable energy sources is a strong driving force for the research efforts on low-cost photovoltaic device technologies. Polymeric materials have technological advantages over conventional inorganic materials in the reduction of production costs by large-scale production, combined with the possibility to produce large area flexible devices and the tunability of the electronic bandgap by chemical synthesis. Various conducting polymeric materials (polythiophenes, polycarbazoles, polyphenylenes and poly (phenylene vinylenes and their derivatives) have been tested for their photovoltaic characteristics. The conjugated polymers/C_{60} system offers the special opportunity to produce all-organic photovoltaic devices due to reversible, ultra fast and metastable photoinduced electron transfer process in such system.

In this context, ultrathin films of MEH-PPV/C_{60} nanocomposite with different amount of C_{60} were fabricated by means of Langmuir-Schaefer technique. The stability of Langmuir film was investigated at different surface pressures for different molar compositions. The fabrication of the nanocomposite LS films was carried out with a barrier compression rate of 50 mm^2/min, as shown in Figure 1. When the percentage of C_{60} is below 10% in composite system, the isotherm is similar to the one of pure MEH-PPV, which shows a transition at about 30 mN/m. With the increment in percentage of C_{60} in composite system, the isotherms are similar to the one of pure C_{60} floating films. The Langmuir film formation of MEH-PPV/C_{60} at air water interface was analyzed by Brewster angle microscopy. The uniformity of MEH-PPV/C_{60} LS films was studied using UV-visible spectroscopy, and atomic force microscopy. Electrochemical measurements of different MEH-PPV/C_{60} LS films were carried in tetrabutylammonium tetrafluoroborate (TBATFB) acetronitrile solution. For MEH-PPV LS films, the voltammograms depict only a reduction peak at very negative potential of –1.8 V. However, with the addition of C_{60}, the CVs change: there are an oxidation peak at 0.65 V and a reduction peak at 0.5V. It is evidenced that MEH-PPV likes to give electrons with addition of C_{60}. It is very interesting that an electrochromic phenomenon was observed during these redox processes. With the increment of percentage of C_{60} in composite system, there appear more redox peaks. In addition, these peaks move to more negative potentials. The calculated diffusion coefficients are 8.15×10^{-10} cm^2/sec for both oxidation and reduction processes, according to Randles-Sevcik equation, when one electron was expected to be participated in the reaction mechanism of the composite system. Photovoltaic effect on materials for switch on and switch off of light source condition are also discussed (Figure 2).

[1] M. Kaneko, in: H.S. Nalwa (Ed.), Handbook of Organic Conductive Molecules and Polymers, Vol. 4, Wiley, New York, 1997, p. 661.

[2] N.S. Braun, D. Sariciftci, C. Zhang, V. Srdanov, A.J. Heeger, G. Stucky, F. Wudl, Appl. Phys. Lett. 62 (1992) 585.

[3] N.S. Sariciftci, L. Smilowitz, A.J. Heeger, F. Wudl, Science 258 (1992) 1474.

[4] N.S. Sariciftci, A.J. Heeger, in: H.S. Nalwa (Ed.), Handbook of Organic Conductive Molecules and Polymers, Vol. 1, Wiley, New York, 1997, p. 437.

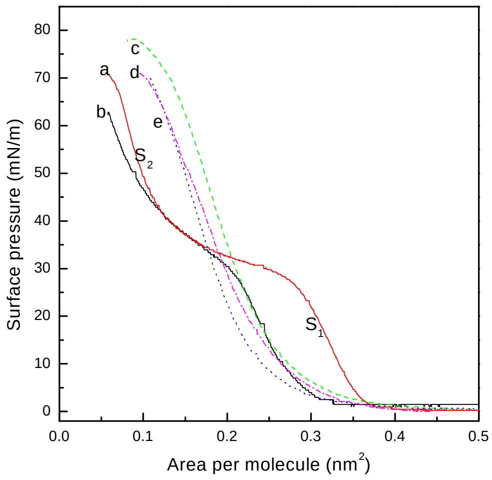

Figure 1. Various surface pressure-area isotherms of MEH-PPV/C_{60} composite system. The percentage shown in the figure is of C_{60}: a) 0%, b) 5%, c) 33%, d) 95%, e) 100%.

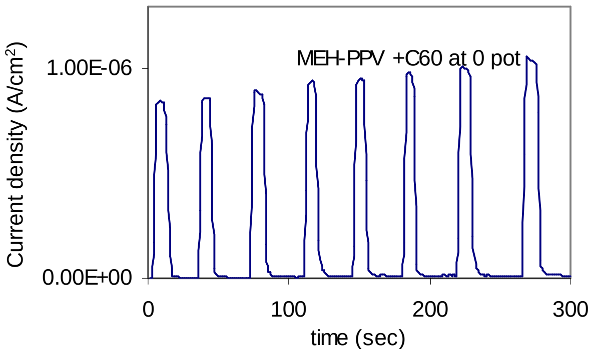

Figure 2. The photoelectrochemical current at zero bias for the MEH-PPV and C_{60} composite films 0.1 M TBATFB solution.