Photophysical and Electrochemical Properties of Novel Luminescent and Photoconductive Copolymers

Věra Cimrová*, Drahomír Výprachtický, Ivan Kmínek, Vagif Dzhabarov, Veronika Pokorná,

Institute of Macromolecular Chemistry,
Academy of Sciences of the Czech Republic,
Heyrovsky Sq. 2, 162 06 Prague 6, Czech Republic
E-mail: cimrova@imc.cas.cz

Conjugated polymers are extensively studied due to their potential applications in photonics including particularly light emitting diodes (LEDs), photovoltaic devices (PVDs), sensors, batteries, electrochromic devices, etc.. They exhibit the optical and electrical properties of semiconductors with the attractive mechanical properties and processing advantages of polymers. Their great variability enables chemical tuning of optical absorption and emission across the whole visible spectral region and relatively cheap device fabrication in comparison with corresponding inorganic materials. Easy preparation of thin films using common techniques implies that polymers are suitable for large area photonics and electronics such as large-area light-emitting devices, displays or solar cells. White LEDs are promising for application in low energy consumption lighting due to high efficiency and inexpensive production of large surfaces.

In this contribution, we report on photophysical and electrochemical properties of novel luminescent and photoconductive donor-acceptor copolymers. Luminescent carbazole-based, carbazole-fluorene and fluorene-bithiophene copolymers, and the donor-acceptor copolymers consisting of electron-acceptor units (4,6-di(2-thienylthieno[3,4-c][1,2,5]thiadiazole or its 3´,3´´-dialkyl derivatives) and various donor units as 9,9-bis(alkyl)fluorene, 2,5-bis(alkyloxy)benzene, 2,5-bis(alkyl)benzene, bithiophene or 2,7-carbazole derivatives were synthetized and characterized. The series of the copolymers with various alkyl side chains (linear of different lengths or branched) was prepared to study the influence of the chain nature and length on photophysical and electrochemical properties. Optical properties were investigated in the solution and in thin films. Cyclic voltammetry was used to obtain the information on their electronic structure. Carbazole-based amd carbazole-fluorene copolymers exhibit an intense blue photoluminescence (PL) emission in both solution and thin film; whereas fluorene-bithiophene copolymers exhibit intense luminescence emission in green spectral region. The donor-acceptor copolymers possess narrow optical band gap in the range 1.0 - 1.5 eV depending on the character of the donor units. The absorption of thin copolymer films covers the whole visible spectral region extended up to NIR for some copolymers. Intermolecular charge transfers, intermolecular interactions and aggregate formation will be discussed in relation to the copolymer structure and side chain character. In solution, solvatochromic and thermochromic behavior was observed and will be discussed. In addition, spectroelectrochemical study was performed and spectral changes in oxidized and reduced state will be presented.

Novel luminescent copolymers were used as light-emitting materials in LEDs. Electroluminescent properties were investigated and the results were correlated with the results of photoluminescent properties of thin films. Donor-acceptor copolymers with band gap values around 1.5 eV, ionization potentials at about 5.0 eV and high electron affinities 3.5 - 3.6 eV are promising for photovoltaic applications. Thin films made of blends of these copolymers and fullerene derivatives were used as active layers in photovoltaic devices with bulk heterojunction. Their performance was studied and will be discussed.

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