Fullerenes in photovoltaic devices: spectroscopic, electrochemical and spectroelectrochemical studies.

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Recent developments on organic photovoltaic devices (e.g. plastic solar cells) based on the photoinduced charge transfer from a donor type semiconducting conjugated polymer onto acceptor type molecules like fullerenes are described. New strategies to improve the nanostructure, like the preparation of so called "double-cable" polymers, where the polymeric electron donor and the electron acceptor are covalently linked, will be discussed. Other developments for the adaptation of the spectral response of the device to the solar spectrum, using low band gap polymers, are presented. For effective light harvesting, another approach using organic molecular dyad systems based on fulleropyrrolidine-phthalocyanine compounds, where phthalocyanines and fullerene structures are covalently linked, looks very interesting.

In order to determine the properties of the individual components and the actual mixtures in organic photovoltaic devices, the materials are characterized with different investigation techniques. Electrochemistry (especially cyclic voltammetry) gives information on the redox properties and consequently on the electronic parameters. A defined relation of the electronic levels of the donor and the acceptor compounds is essential for the photoinduced charge transfer as the primary step for charge separation. Moreover, it turned out that the open circuit voltage in plastic solar cells is directly related to the acceptor strength of the fullerenes, which can be correlated to their first reduction potentials.

With photoexcited spectroscopy (photoinduced absorption, light induced ESR spectroscopy), the charge separated state can be investigated. Positive charge carriers on the conjugated polymer (usually described as polarons) and negative charged fullerene radical ions have typical optical absorption and ESR features, which can be studied for the characterization of the photoinduced charge transfer. In addition, spectroelectrochemical investigations are presented, which are important for the correlation of electrochemical with spectroscopic features and for the identification of photoexcited spectral results.