Nanooptics and nanophotonics

Influence of component material on spectral dependence of polymer nanocomposites photosensitivity

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Influence of a matrix on optical and photovoltaic properties of nanocomposite films made of polymethine dyes at high concentration was analyzed. We used V_2O_5 xerogel, polyvinyl alcohol (PVA) and polyphenylenevinylene (PPV) as matrices and Indocyanine Grey (CG), meso-Cl, Hexaindoletricarbocyanine (HITC) and $ZnPc(NH_2)_4$ as dyes. The film thickness was in the range 30-100 nm.

We determined that H-aggregates of the dyes with different energy formed in the films of polymer composites with polymethine dyes. Some H-aggregates have higher efficiency of charge carrier photogeneration than that for quasi-isolated molecules of the dyes. It resulted in essential widening of spectral region absorption and photosensitivity (in comparison with absorption range of molecules in solution) to range of 1.6-2.0 eV. Energy maxima for the H-aggregates weakly depend on molecular structure of the matrix, whereas photosensitivity maxima of the H-aggregates mainly depend on molecular structure of the dyes. In the range of 2.2-2.7 eV, photosensitivity of nanocomposites is low and depends on the matrix. Minimum and maximum sensitivity in this spectral range are observed in composites with V_2O_5 and PPV matrices, respectively. The electrical conduction of V_2O_5 films is significantly higher, than conduction of the polymer films. It may be caused by the low sensitivity of xerogel nanoparticles. Probably, an increase of the photosensitivity in nanocomposites of PPV may be due to higher photosensitivity of PPV in the range of 2.2-2.7 eV. It is supported by comprehensive investigation of absorption, luminescence and photovoltage of PPV films. The presence of effective charge carrier photogeneration and appearance of photovoltage in these films in the range of 2.0-3.0 eV were verified by these studies.

In addition, in composite material with meso-Cl, the dye molecules interact with PPV molecules more effectively; so photosensitive charge-transfer complex of polymer molecule and dye is formed. It leads to appearance of photosensitivity at energy, which is below the excitation energy of the dye molecule. Spectral region of HITC/PPV composite sensitivity is wider than presented in spectral dependence of developed plastic solar cells based on the polymer with C60 derivatives.