

Photoresponsive hybrid nanocomposites

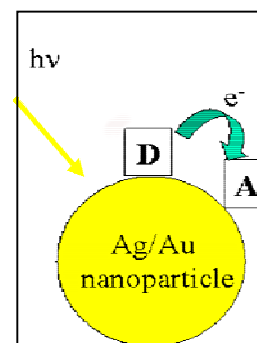
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Plasmonic noble metal nanoparticles were proposed to improve performance of many optoelectronic devices. Their unique electronic and optical properties are considered also for the design of solar energy conversion elements. There are several mechanisms proposed for nanoparticle action in the organic photovoltaic devices: (i) modification of the photoinduced charge transfer from donor to acceptor, (ii) modification of the deactivation processes of excited molecules, (iii) optical absorption enhancement due to surface plasmon extinction and/or increased electric field in the vicinity of nanoparticles, (iv) increased optical path resulting from light scattering on nanoparticles, and (v) charge carrier recombination on nanoparticles forming inner electrodes in tandem cells.

We prepared nanocomposites consisting of noble metal (Ag, Au) nanoparticles in π -conjugated polymers soluble in organic solvents: poly(3-octylthiophene-2,5-diyl), P3OT, and poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene], MeH-PPV. In our approach nanoparticles were prepared without additional stabilizing agent in-situ in a polymer using reduction of tetrachloroauric acid with sodium borohydride in a two-phase system. Tetraoctylammoniumbromide (TOAB) was used as a transfer agent in the reaction. By optimization of reaction conditions, namely the concentration of TOAB and the duration of induction period before addition the reducing agent, the π -conjugated polymers were prevented against oxidation during reaction. P3OT composites contained very small metal nanoparticles (1-10 nm), whereas for (MeH-PPV) aggregation of gold nanoparticles was observed with increasing polymer concentration. The interaction between nanoparticles and polymers were documented by measurements of Surface Enhanced Raman Scattering.

Stabilizing effect of Au nanoparticles on electrical conductivity of P3OT based composite films was investigated. For Au nanoparticles content above 1 vol% the turning point where the conductivity decreases shifts to 110 °C, compared to 50 °C for the pure polymer. At low temperatures, the composites show common activation energy of conductivity $E_a=0.3$ eV independent on Au nanoparticles concentration. It corresponds to the activation energy of pure polymer and suggests that the conductivity in the composite is controlled by the same mechanism.

A new approach to the formation of *donor-acceptor (D-A) nano hybrids* has been introduced in which Ag and/or Au nanoparticles are formed by laser ablation (LA) in the presence of solutions of selected organic D/A molecules. In this system the chromophore is able to directly interact with nanoparticle surfaces. The properties of the system can be controlled by (i) wavelength and (ii) energy of laser pulses used for LA, (iii) solvent, (iv) adsorbate concentration. Using laser pulses with wavelength of 1064 nm, the chemical structure of the adsorbate and its functionality may be preserved.



The *transport of charge carriers* was modeled theoretically with regards to the influence of polar additives. The model considers possible jumps between arbitrary energy levels of adjacent polymer chains and allows for thermalization of charges to Boltzmann statistics after each jump. It was shown that the change of dipole-moment, induced e.g. in photochromic additives upon illumination, can change the charge carrier interchain mobility almost three orders of magnitude.