Development of Organic Solar Cells in Ukrain: Near IR- Photosensitive Organic Devices

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In the first part of our talk we will report about research efforts on organic solar cells which had started in the Ukraine already more than 20 years ago. These were concentrated mainly on heterostructures (HS), their basic properties, the investigation of recombination processes near the HS interface as well as the determination of the optimal thickness of solar cell components and the minimization of degradation processes (photochemical reactions). A special emphasis was put on organic/ inorganic HS devices as e.g. made from CdSSe and organic photoconductors such as polyacenes and phthalocyanines.

We e.g. concluded that weak charge transfer complexes (CT-complexes) are formed in organic films of polyacenes and phthalocyanines upon oxygen adsorption. The efficiency of CT-complex formation depends on both, the molecular structure (for example, the nature of the metal phthalocyanine central atom) and their type of crystallites. The latter strongly influences interface parameters such as the potential barrier formed at the heterojunction. Thus it is experimentally confirmed for lead phthalocyanine based solar cells that a change of the crystal type can cause dramatic changes and even the inversion of the band bending direction near the interface. It was confirmed that the rate of surface recombination of the organic film at the CdSSe interface is considerably smaller than for its interface with metals, SnO_2 or Cu_2 S. As a result, the efficiency of solar cells based on a CdSSe organic film heterostructures is improved for the illumination through the organic layer.

The main reason for the degradation of solar cell parameters is a photochemical reaction in the top electrode film near its interface. However, it is shown that the degradation of solar cell parameters made from ClAlClPc/ CdSSe heterostructures is much smaller than for ClAlClPc/metal solar cell. Also, the influence of such reactions can be minimized by efficient sealing.

High efficient solar elements as Si or even $CuInSe_2$ effectively transform solar illumination in the wevelength region up to about 1100-1200 nm. On the other hand the best as yet developed organic solar cells absorbe light only in 400-800 nm region [1,2]. This is one of the reasons for their smaller integral efficiency. Therefore our purpose

was the development of organic layers which are photosensitive even in the near IR-region.

In order to solve this problem a few polymethine dyes [3] were esspecially synthesized by us. These dyes have an absorbance maximum in the 850-1050 nm region. Their absorbance and luminescence can be tuned in a wide range of wavelengthes simply by modifying the chemical structure of the hetero-cyclic groups and the length of the polymethine chain. In addition, for achiving easy processability, high solubility both in strong polar and in weak polar organic solvents was achieved by modifying the structure of various fragments of the dyes. Such modification allow to deposit films and polymeric composites with high concentrations (5˚—˚20˚%)of dyes. Such obtained films and composites absorb in the 600-1500 nm region with a maximum in the 950-1050 nm region.

Measurements of the photovoltaic properties using the Berger method confirm the presence of a noticeable photosensitivity in these films between 600 and 1400 nm with a maximum at 800-1100 nm. The photosensitivity of the best samples prepared from polymethine dyes is comparable to the photosensitivity of corresponding films of phthalocyanines of Cu and Pb, measured by the same method under the same conditions. Naturally, the photosensitivity of films based on these polymethine dyes is strongly depending on a the molecular structure as well as the morphology as determined by the method of preparation.

We currently work on the optimization of dye structures and the methods of films preparation to reach maximum absorption at around 1000 nm.

Two-layer structures prepared, for example, from C_{60} in PPV composites and the polymethine dyes in polymers, should effectively absorb solar light to create charge carriers in the spectral range from 400 to 1200 nm, with a good perspective for plastic solar cells development.

References:

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