

SOLAR CELLS BASED ON ORGANIC DISCOTIC MATERIALS

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During the two past decades, great effort has been made to increase the efficiency of organic solar cells. In the early 1970s, the efficiency was as low as 10^{-5} % [1]. In 1986 Tang demonstrated a solar cell with a power conversion efficiency of around 1% [2]. More recently, Shaheen *et al.* reported a photovoltaic cell with a conversion efficiency of 2.5 % [3]. Their ready availability and ease of purification, combined with the potential mechanical flexibility of the resulting devices, make organic materials attractive for use in practical solar cells; however further improvements in efficiency are necessary to make organic solar cells commercially competitive.

The mechanism of generation of photocurrent is based on diffusion and dissociation of excitons within the active area and the transport of the resulting separated charges to the electrodes. Each of these two steps has to be optimized. Long exciton diffusion lengths and high charge-carrier mobilities have been reported in the self-assembled liquid crystalline phases of discotic molecules [4]. Our study concerns the use of such materials in organic photovoltaic cells. Triphenylene ether **1** was used as hole transporting material, combined with perylene ester **2** and benzo[ghi]perylene imides **3** and **4** as electron transporting materials (figure 1).

Quantum efficiencies of already around 5 % are obtained with heterojunction cells made by vacuum deposition of amorphous layers of these materials. In order to determine the factors determining the efficiency, we investigated the carrier mobilities and energy levels, using Time of Flight measurements and Cyclic Voltammetry respectively. In amorphous **2**, the charge carrier mobility was observed to be about 10^{-4} $\text{cm}^2\text{V}^{-1}\text{s}^{-1}$. Methods to improve this mobility by allowing the discotic molecules to self-assemble into homogeneously oriented layers will be reported.

The device performance could strongly be influenced by modifications of the electrode/organic and organic/organic interface structures: The chemical structure of the ITO surface, used as semitransparent electrode, was changed using argon plasma and UV-Ozone treatments. The current-voltage characteristics are found to be dependent on the surface treatment (figure 2). Coevaporation of the hole and electron transporting organics led to mixed layers, giving enhanced photocurrents compared to separately evaporated layers of the two materials. This indicates that the mixed layer consists of microsegregated bicontinuous domains separated by a large interface. Hence, an effective charge separation is achieved.

1. D. Whörle and D. Meissner, *Adv. Mater.* 3, 129 (1991)
2. C. W. Tang, *Appl. Phys. Lett.* 48, 183 (1986)
3. S. E. Shaheen *et al.*, *Appl. Phys. Lett.* 78, 6 (2001)
4. D. Adam *et al.*, *Nature* 371, 141 (1994).

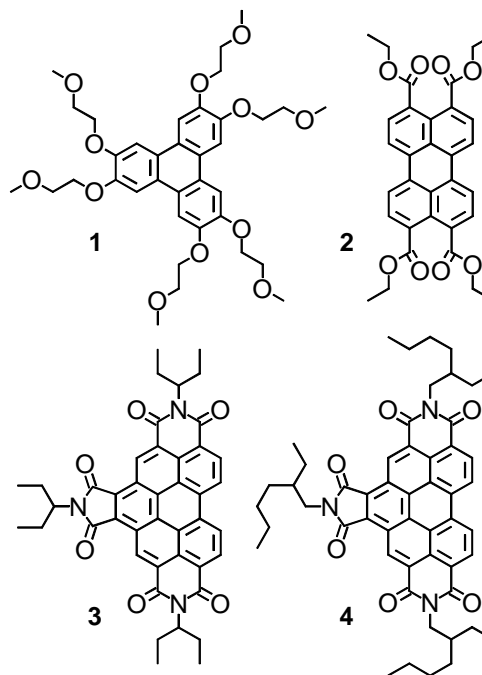


FIG. 1 Chemical structures of the materials used

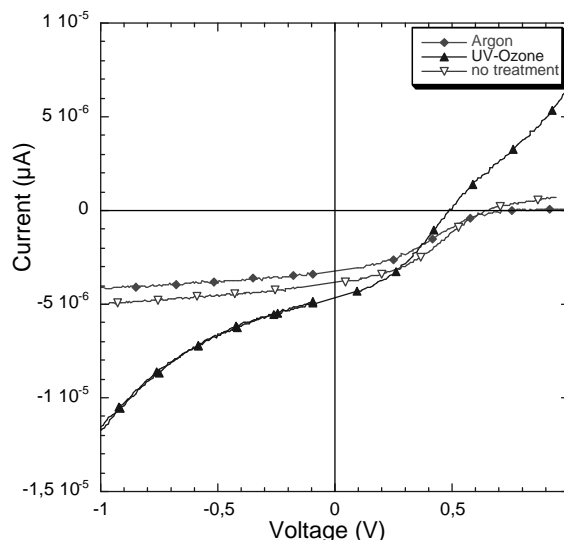


FIG 2. Current-voltage characteristics of the structure ITO/ 1/ 3 / Al with various treatments. a) as cleaned, b) UV-Ozone and C) Argon plasma.