Fullerene-based materials for organic electronics

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Discovery of fullerenes and their soluble derivatives brought revolutionary breakthroughs in the fields of organic electronics and material science. Parent fullerene C_{60} is the most advanced organic n-type semiconductor that showed electron mobilities as high as 5-10 cm^2 /V s when measured in organic field effect transistors (OFETs). Organic derivatives of fullerenes serve as solution processible n-type semiconductors.

In this lecture we will summarize the most sound literature data and results obtained in our group with the focus on the following major applications of the fullerene-based materials.

1**. Electronic circuitry.** Fullerene C_{60} and its derivatives are widely used for design of OFETs and more sophisticated electronic devices such as ring oscillators and other functional integrated circuits. There are few companies on the market that develop smart cards, smart tags and some other consumable electronics built entirely from C_{60}-based transistors. Functionalized fullerenes are materials of choice for low cost printable organic electronics. We will show preliminary data on the performance of some our soluble fullerene derivatives in OFET structures.

2. **Organic solar cells** based on conventional organic materials showed power conversion efficiencies of less than ~1% in 2000. A remarkable breakthrough in the field was achieved when fullerene-based materials were applied. A rapid evolution of organic photovoltaics resulted in power conversions efficiencies of >5% certified for single cells by Konarka Technologies. Calculations revealed that power conversion efficiencies of 10-14% are feasible for organic solar cells based on appropriate photoactive materials. We will present our state of the art results on the design of novel fullerene-based materials for organic photovoltaics.

3. **Organic photodiodes and photodetectors**. Photodiodes based on composites of fullerene derivatives and conjugated polymers have advantages of exceptionally high sensitivity, fast photoresponse, low or even zero energy consumption and a low cost. Siemens AG demonstrated position-sensitive photodetectors, two-dimensional image scanners and digital cameras based on arrays of organic photodiodes. These developments are currently used in electronic equipment for medicinal diagnostics, in particular, for X-ray imaging. We will present photodetectors based on novel materials that showed quantum efficiencies of 20-70% under zero applied potentials and response times of 30 ns – 1 μs in devices with the active areas of 0.1-0.5 cm^2.

4. **Organic light emitting diodes (OLEDs)** comprising fullerene C_{60} as electron transporting material will also be considered.

Successful application of the fullerene-based materials in organic electronics resulted in appearance of a number of commercialized products that prove unambiguously that “fullerenes are not just beautiful, they are useful”.