High Performance Polymer Photovoltaics

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The energy contained in 1 hour of sunlight is sufficient to power the world for an entire year. Nevertheless, a cost-effective method to harness solar energy has not been developed; with current technology, the cost of electricity from solar cells, also known as photovoltaics (PVs), is 4 - 10 times that of fossil-fuel based energy. This is due in part to costly high-temperature and high-vacuum processing methods needed to fabricate silicon PVs.

Polymer-based PVs represent an emerging technology with significant potential for providing cheap and scalable solar energy. Flexible, large-area polymer PV arrays can be made using liquid-based methods such as ink-jet printing and roll-to-roll coating, techniques used by the plastic industry to fabricate a variety of inexpensive consumer materials. Polymeric-based PVs therefore offer the prospect of significantly cheaper solar energy as well as potentially recyclable and portable solar cells. However, the solar conversion efficiencies of the best polymeric PVs are insufficient to make these devices economically competitive. While theoretically current materials should be capable of converting 20 % of incident sunlight into electricity, only 8% conversion has been achieved. Our goal in this work is to prepare polymeric PVs that can give us a better understanding of this limitation and perform better than materials currently being studied.

We believe that nanotechnology provides a path to better polymeric solar cells. Polymeric PVs require at least two components to function properly: an electron-conductor and a hole-conductor for transporting negative and positive charges, respectively. In the state-of-the art polymer PVs, the hole conductor is a semiconductive polymer and the electron-conductor is a C_{60} fullerene. While these components provide good charge transport, a practical challenge arises when attempting to blend the two components in the active layer of a polymer solar cell. The components do not mix uniformly, and as a result the active layer is heterogeneous and contains non-ideal pathways for photon absorption and charge transport

Our approach to solving this problem is shown schematically in the figure below**.** Instead of blending two components, we can use advanced chemical synthesis techniques to link the two molecules together at the nanoscale. We hypothesize that by doing so, we can not only prevent the two components from separating, but through a process known in the nanotechnology field as "self-assembly" generate controlled nanoscale patterns of the electron-conducting and hole-conducting components. If true, this is expected to lead to a significant improvement in the efficiency of solar energy conversion and provide us with an approach to answer still-unanswered fundamental questions about how polymeric PVs function. In the long run, we believe that our work will lead to much better power conversion efficiencies in polymer PVs and an improved understanding of how nanoscale properties affect the conversion of sunlight to electricity in polymeric PVs.

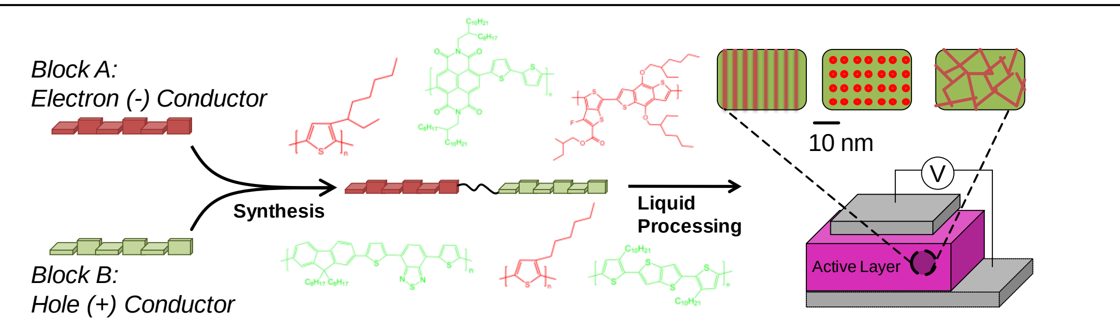

Figure 1. Semiconductive block copolymers can be used to prepare "self-assembled" PVs