ACS Cross-Journal Virtual Special Issue on Photovoltaic Materials

EDITORIAL

Advances in organic and inorganic polymer and materials chemistry coupled with new approaches to construction and characterization of nanostructured materials have led to significant advances in organic and hybrid solar photovoltaic cells (1). This began more than 15 years ago, with important discoveries relating to both kinds of cells (2–4). Work in this field has taken on a new significance given the current emphasis on the development of renewable energy sources, driven by increased concern about global warming and depletion of fossil fuel sources. Scientists and engineers with diverse research expertise have driven fundamental research in this area, pushing toward applications and new technologies.

With this background, we introduce the theme "Photovoltaic Materials" for this inaugural multijournal virtual special issue, which features content drawn from four American Chemical Society journals: *ACS Applied Materials & Interfaces*, *Chemistry of Materials*, *Langmuir,* and *Macromolecules*. Access to this Virtual Special Issue is available free online at http://pubs.acs.org/page/vi/2010/photovoltaic.html. The photovoltaic materials theme will be of broad interest to scientists and engineers working in organic, inorganic, and hybrid materials chemistry, polymer chemistry and science, and interfacial science and engineering. The 41 articles here, published over the past 6 months, were selected for this virtual special issue as examples of the highest impact work in this area in these journals. Although the research area provides a common theme, the contributed articles also highlight the differences among the editorial scopes of the participating journals. *ACS Applied Materials & Interfaces* has an interdisciplinary science and engineering focus on applications. This contrasts with the fundamental advances in the chemical understanding of materials published in *Chemistry of Materials,* the interdisciplinary papers on colloids and surfaces in *Langmuir,* and the focus on fundamental aspects of polymer science found in *Macromolecules*.

The articles from *ACS Applied Materials & Interfaces* that are highlighted in the "Photovoltaic Materials" virtual special issue exemplify the emphasis on *application*, as opposed to fundamental studies focused on materials synthesis, processing, or characterization. For example, several of the articles from *ACS Applied Materials & Interfaces* focus on processing organic and hybrid materials into solar cells, with testing to correlate the properties of the resulting cells with processing conditions and construction. Krebs and co-workers describe the use of a thermally cleavable polymer in roll-to-roll processing that promises large-area polymer solar cell modules. They describe processing methodology as well as batch test results of their solar cells (5). Hashimoto et al. describe a thermal lamination technique to construct multilayer formats leading to tandem solar cells exhibiting broad response through the visible spectral region (6). Marks and Wasielewski use a novel organic surface-active interfacial agent to modify the interface between the electrode and the photoactive layers in an organic solar cell, and they report the agent's effect on cell efficiency (7). Park et al. describe the beneficial effects of a light scattering layer consisting of submicrometer-sized Al_2O_3 particles on the efficiency of hybrid dye-sensitized solar cells (DSSC) (8). Each of these articles emphasizes application of fundamental research and materials toward photovoltaic devices, with testing being an important aspect.

Articles published in *Chemistry of Materials, Macromolecules,* and *Langmuir* are further upstream from applied research, and focus more on fundamental properties, synthesis, and/or characterization of the materials.

Chemistry of Materials publishes original contributions on forefront research at the interface of chemistry and materials science. For example, the paper by Holdcroft et al. describes templated growth of one-dimensional nanoscale assemblies of perylene diimide units blended with a functionalized conjugated polymer. The architecture of the assemblies is characterized by electron microscopy and a mechanism for their formation is discussed (9). Frechet et al. describe a set of novel conjugated organometallic polymers, including optical and photophysical properties (10). Although the use of these polymers in solar cells is explored, the study is focused on the fundamental optical properties of the materials. Mitzi

Published on Web 05/19/2010

and co-workers (11) describe the effect of antimony doping on the grain size and crystallinity of $Cu(InGa)Se_2$ (CIGS) and its correlation with photovoltaic performance.

Macromolecules focuses on fundamental aspects of polymer science. For example, another paper by Krebs et al. in the special issue focuses on a thermally cleavable low band gap polymer for use in bulk heterojunction solar cells (12). It discusses the synthesis and properties of the polymers, along with the morphology of blends of the polymers and fullerene derivative PCBM. Although photovoltaic cells are included, the focus of the investigation is the properties and synthesis of the polymers. Several other papers also describe structure–property relationships between novel conjugated polymer structure, blend morphology, and photovoltaic performance. In particular, Hashimoto et al. correlate molecular structure, absorption spectroscopy, and electrochemical properties (band energy levels) with performance in organic solar cells (13). Watt provides insightful results that reveal evolution of the morphology of a poly(3-hexylthiophene)-fullerene blend during thermal annealing in real-time using low-voltage, high-resolution electron microscopy (14). Although this study does not include solar cell data, it provides considerable fundamental insight into the evolution of the structure and morphology of one of the most important polymer blend systems used in organic photovoltaic cells. It is believed that the morphology of the blends and degree of crystallinity of the component materials is key to the performance of organic photovoltaics.

Langmuir is devoted to reporting new and original experimental and theoretical research in surface and colloid chemistry, with an emphasis on fundamental research. The papers in this special issue provide an interesting contrast with some of the content from the other journals. For example, Osterloh and Parkinson present fundamental studies of semiconductor materials that undergo photoinduced charge separation. The focus of the work reported by Osterloh is on the mechanism of charge separation in a $KCa_2Nb_3O_{10}$ nanosheet photocatalyst (15). The technique of photolabeling is used to probe regions where photoreduction occurs within the nanosheets. In related work, Parkinson et al. uses high-resolution atomic force microscopy combined with ultrasensitive photocurrent measurements to correlate charge injection efficiency with morphology in CdSe nanocrystal/single-crystal TiO_2 junctions (16). Two other papers describe materials processing methods that ultimately could be used to improve the performance of photovoltaics. DeSimone et al. describe the application of PRINT technology to assemble CdSe nanoparticles into structures that are organized on the nanoscale (17). The ability to pattern photovoltaic materials may lead to more efficient solar cells, for example, by enabling light management. Kim and co-workers present a spin-coating method to fabricate optical coatings that display broad-band antireflection properties throughout the visible and near-infrared spectrum regions (18). Decreasing the reflection at the incident surface is key to improving the overall cell efficiency.

In summary, the collection of papers included in this special issue on “Photovoltaic Materials” provides an up-to-date snapshot of current research activity in various areas of polymers, materials chemistry and science, and colloids and interfaces. It highlights the breadth and quality of scientific content in the American Chemical Society journals in these areas. Significant insight is being gained with respect to new materials for converting light to electrical energy. Look for more virtual special issues on other important research themes from this collection of journals in the future. If there are particular themes you would like to see covered, please send suggestions to me (kschanze@chem.ufl.edu) and/or to my fellow Editors in Chief: Leonard Interrante (eic@cm.acs.org), Timothy Lodge (macro@macromol.acs.org), and David Whitten (langmuir@unm.edu).

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AM100400M