Highly Porous, High Surface Area TiO_2 for Photovoltaic Applications

Jeremy J. Pietron and Debra R. Rolison
Naval Research Laboratory
Washington, DC 20375

Aerogels are mesoporous materials with extremely high porosity (~80% to 99% porous) and high surface areas (100 to 1000 m^2/g).[1] Both the pore network and the network of nanometer-scale solid particles that comprise an aerogel are continuous, allowing rapid mass transport of gases, liquids and solutes through a three-dimensional, nanostructured network. We have fabricated aerogel films of titanium dioxide on transparent, conducting oxides for use in photovoltaic cells.

Anatase titanium dioxide is a wide band gap semiconductor that has been intensely studied in the well-known Grätzel cell. Factors that have limited the performance of the Grätzel cell to date (in terms of efficiency of converting photons to useable electricity) have been 1) the need for photosensitizing dyes in monolayer quantities on the surface of the titania film in the electrode as well as 2) a rate of electron injection into the electrode that is limited by the rate of diffusion of donors to the electrode surface. Aerogel titania is a good candidate to overcome both of these limitations. The high specific surface area of aerogel titania (~150-200 m^2/g) significantly amplifies dye coverage and thus the number of photosensitizing centers, while the continuous pore network permits rapid mass transport of diffusing electron donors through the film.

An additional advantage of expressing titania as an aerogel film is the ability to include guest materials into the film.[2] We have developed a means of including nanometer-sized gold particles into titania aerogel. Chandrasekharan and Kamat have recently demonstrated that adsorption of gold nanoparticles on the surface of dense colloidal titania films improves photoelectrochemical performance 3-fold, likely by creating sites for improved charge-transfer kinetics at gold–titania interfaces.[3] We expect amplifications of this advantage *viz.* dispersion of nanoscale gold-titania junctions throughout the volume of the aerogel film.

In this presentation, the construction, modification, characterization and initial performance of titania aerogel film-modified electrodes as photovoltaic electrodes will be described.

References:

1. N. Hüsing and U. Schubert, *Angew. Chem. Int. Ed. Engl.***37,** 22 (1998).
2. a. C. A. Morris, M. L. Anderson, R. M. Stroud, C. I. Merzbacher, D. R. Rolison, *Science,* **284,** 622, (1999). b. M. L. Anderson, R. M. Stroud, C. A. Morris, C. I. Merzbacher, D. R. Rolison, *Adv. Eng. Mater*. **2,** 481 (2000).
3. N. Chandrasekharan and P. V. Kamat, *J. Phys. Chem. B.* **104,** 10851 (2000).