ND*nano* Undergraduate Research Fellowship (NURF)
2011 Project Summary

Student name: Michael Ashley
Faculty mentor name: Abhijit Biswas
Project Title: Sprayable Nanocomposite Coatings for Large-Area Carbon Capture and Storage

Project Summary:

As we enter a new era with changing views of the environment, cost-effective and easily available carbon capture technology will be necessary to curb global climate change. Because current carbon capture methods remain expensive and energy inefficient, this technology must be refined. Furthermore, for energy sustainability, a low-cost technology needs to be developed that, in addition to capturing carbon dioxide (CO_2) with a high binding efficiency, would convert it into useful products such as environmentally benign stable carbonates or hydrocarbon fuel (especially methane). Multi-component polymer-based nanocomposites could be the low-cost solution to carbon capture needs. The homogenous mixture of a polymer matrix with metal oxide nanoparticles has demonstrated its ability to bind CO_2 with high efficiency. Both the organic and inorganic components of this type of solution provide distinct benefits: the metal oxide catalysts offer high selectivity as well as mechanical and thermal stability, while the polymer phase offers flexibility and the possibility of a "sprayable" CO_2 absorbing membrane. In order for this technology to gain commercial popularity, several challenges must be overcome. Most importantly, we must be able to fabricate the nanocomposite on a large scale using low-cost materials. An additional challenge is the prospect of fabricating large quantities of nanocomposite while ensuring homogeneity and easy processability. Then, we must be able to spray this nanocomposite onto large areas, which will only be possible if the nanomaterials are in low enough concentration relative to the polymer matrix that it does not become a paste-like substance.

My project goals were to design and synthesize multi-component nanocomposites using a drop-casting method. The samples contain combinations of MgO, CuO, SiO_2, TiO_2, RuO_2, and Fe_2O_3 nanoparticles dispersed in a polyethylene glycol (PEG) matrix. They were prepared by individually adding the metal oxides, using an alternating pattern of mechanical shaking and sonication in order to ensure homogeneity, a necessary quality for the functionality of the nanocomposites. The completed samples were analyzed for their CO_2 binding efficiency, conversion into environmentally benign carbonate minerals on the surface of the nanoparticles, and the presence of methane (for which data collection is still underway). The three samples for which we have data consist of: 1) MgO in PEG, 2) MgO, TiO_2, and Fe_2O_3 in PEG, and 3) MgO, SiO_2, CuO, TiO_2, and Fe_2O_3 in PEG. These samples range from simple to quite complex systems. Figure 1 shows a scanning electron microscope image of sample 3, which contains 5 inorganic components. We have determined that the dispersion of catalytically active nanoparticles in a fibrous polymer matrix enhances CO_2 trapping and conversion, as shown by the presence of carbonate after

reaction with CO_2. Additionally, a multicomponent system results in multifunctionality, combining the functions of each catalytically active component and improving capture properties when the nanocomposite membrane is exposed to a gas stream. Figure 2 shows a representative Fourier Transform Infrared (FTIR) image. It displays the post-reaction composition of our samples that includes carbonate.

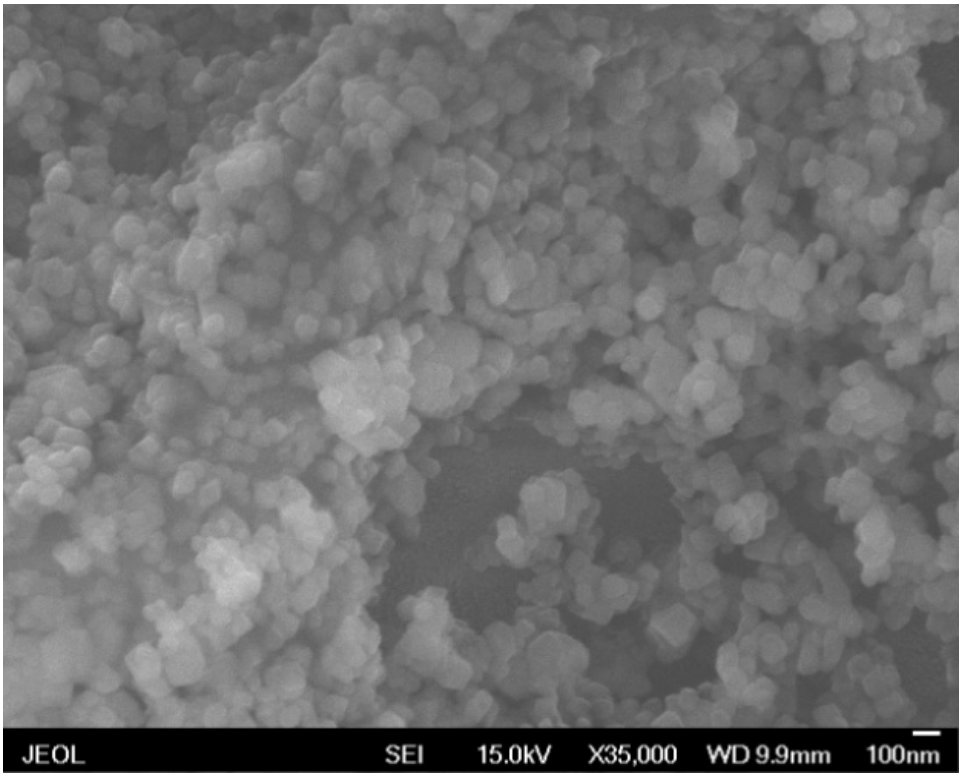

Figure 1: Scanning Electron Microscope (SEM) image of 5-component system (MgO, SiO_2, CuO, TiO_2, and Fe_2O_3 in PEG)

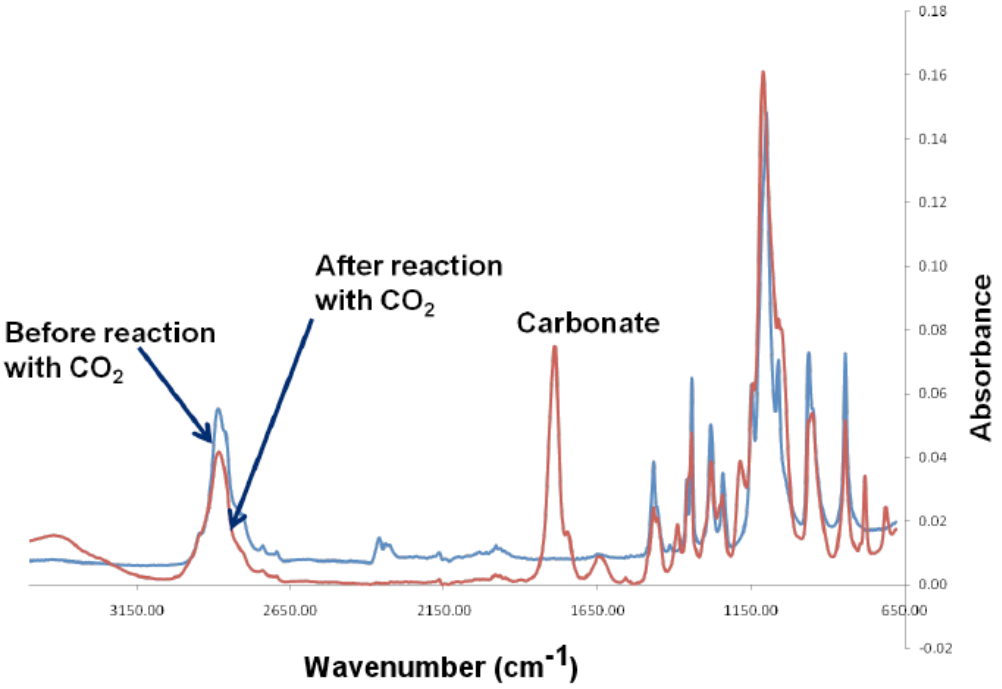

Figure 2: Representative FTIR data showing the presence of carbonate after reaction with CO_2

Publications/Presentation

[1] Michael Ashley, Enkeleda Dervishi, Alexandru Biris, Anindya Ghose, Mathew Labriola, Tao Wang and Abhijit Biswas,
Solution Processable Sprayable Nanocomposite Coatings Consisting of Different Metal Oxide Nanoparticles in a Polymer Matrix: A Novel Strategy for Large-Area Carbon Capture, to be published.

[2] Michael Ashley, **2011 SUMMER UNDERGRADUATE RESEARCH SYMPOSIUM**, August 5, 2011, Jordon Science Hall, Notre Dame, Poster Presented.

[3] Matthew Labriola, Michael Ashley, Ilker Bayer and Abhijit Biswas, Nanomedicine: Medical Applications of Nanotechnology, Vacuum Technology & Coating Magazine, Vol. 12, August, 2011.

[4] Michael Ashley, Matthew Labriola, Anindya Ghosh, Alexandru Biris, Ilker Bayer and Abhijit Biswas, Nanotech-Enabled Sustainable Energy: Green Nanoenergy, Vacuum Technology & Coating Magazine, Vol. 12, September, 2011.