Spanning the Solar Spectrum: Azopolymer Solar Thermal Fuels for Simultaneous UV and Visible Light Storage

Andrew Saydjari

Andrew Saydjari **is a a student from Yale University studying chemistry and mathematics. He was happy to become a participant in the USA Interns-Program of the Steuben-Schurz-Society and to get an internship at the Max-Planck-Institute for Polymer Chemistry**

Working at the Max Planck Institute for Polymer Chemistry for the past three months has provided me with a unique opportunity to observe and participate in a novel culture of science. While every institution and every group has its own approach to the scientific endeavor, the German scientific method differed radically from any of my previous experiences. Each department has its own director who manages about twenty principal investigators (in Germany, "project leaders").

Forth of right in my MPI group

Further, measurements were far less independent due to the wealth of technicians/specialists. Almost every instrument has one dedicated technician to maintain, teach, and/or obtain measurements for students. This nicely provides a resource from troubleshooting. However, the interdependence it inspires both brings the institute together and also means that "everyone" is constantly waiting for "someone" for help. Despite such timeline issues, and the frequent occurrence of "coffee-time," intense specialization enables many cutting edge publications from every group.

I think the most important take-away from the German approach to research is that asking someone who has more experience should always be the first step. It can save time, money, and a lot of headaches.

My specific work related to the rising need for alternative energy sources. Working with a project leader specializing in azopolymers (a type of photo-responsive polymer), I have now become well versed in the myriad of applications and unique properties of azopolymer-based materials. One interesting application of these polymers is to store solar energy. The photoresponsive chemical unit (azobenzene) isomerizes under irradiation. In other words, light causes the molecule to change shape. After the absorption of light, the higher-energy form of the molecule can act as a fuel source that later releases the energy of the absorbed photon as heat. However, most azopolymers respond to ultraviolet (UV) wavelengths of light which comprise only about 4.5% of the solar power reaching the earth's surface.

Further, visible wavelengths of light cause discharge of the fuel. Hence, all previous studies only demonstrated proof-of-principle energy storage since a true solar spectrum could not be used. Thus, my project was to create a device capable of storing energy under broad-spectrum sunlight. I utilized a rare visible-light responsive my group had developed in conjunction with a standard UV-responsive azopolymer. By carefully matching these polymers with a top-layer of fluorescent dye, I managed to block wavelengths in sunlight that would discharge the cell. However, even better, by rational selection of the dye, the absorbed light was re-emitted as fluorescence at wavelengths that could be stored by the device. Further, since each azopolymer absorbed different regions of the solar spectrum, almost the entire UV-to-visible range of sunlight was accessible.

Final experimentation demonstrated that the system could work in solid-state as well as in solution, making future application feasible. Demonstration that charging/discharging of the system was reversible also supported optimism for future applications.
While at the MPIP, I learned techniques such as differential scanning calorimetry, which uses the heat absorbed or emitted by a polymer to monitor the occurrence of phase transitions; gas phase chromatography, which uses the size of molecules interacting with a porous matrix to determine the extent of polymerization; and optical contact angle measurements, which evaluates how a droplet of liquid sits on a surface. I synthesized new polymers, fabricated micro-structures using soft-lithography, and characterized the spectroscopic properties a multitude of systems. Exposure to polarized optical microscopy, confocal microscopy, and nanoindentation also featured in my on-the-job education.
Overall, my primary work resulted in a first author publication by me, an invaluable aid to my aspirations towards graduate school. During my remaining time in Germany, I contributed to other on-going projects in my group concerning up-conversion nanoparticles, which convert input low-energy light to higher-energies, super-hydro-phobicity, which studies how to increase the tendency of water to roll-off a surface, and host-guest interactions, where two molecules form a weak association by one molecule physically sitting inside the other. Coming up to speed on the past work in these three additional fields helped to expand my familiarity with cutting-edge problems in chemistry, and will hopefully help spark research ideas of my own as I move toward leadership roles in the lab. Further, these collaborations gave me an opportunity to meet a large range of other scientists, a valuable networking and learning experience. A second publication from this summer as a third author resulted from computational work related to the host-guest chemistry project.

Given that I will likely stay in the United States for the remainder of my B.S./M.S., my Ph.D., and my Post Doc., this summer was really one of my last opportunities to travel and see the world. From the ruins of Heidelberg to the industry of Frankfurt, touring the wide variety of German cities and countryside was thoroughly beautiful and rewarding. Thank you so much for this wonderful opportunity. It will feature vividly in my memories of my undergraduate career.

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