FORMATION OF POROUS MATERIALS CALLED COVALENT ORGANIC FRAMEWORKS

By: Caitlyn Tynes

With rising global awareness of greenhouse gases and al ternative energy, scientists are eager to form new ways of storing energy and absorbing gases. Covalent organic frameworks (COF), a class of organic porous polymers that do just that, are igniting scientific curiosity.

Millersville University's Natalie Sukanick has been working with Dr. Kathryn Allen and a team of undergraduates to develop new forms of COFs. Natalie, a senior earning a Chemistry degree, has spent her undergraduate research creating new COFs. Sukanick and Allen are primarily interested in creating and characterizing large COFs, with the intent of applying their research to maximize electricity storage in solar panel cells.

WHAT ARE COFS?

Short answer? COFs are spongy and porous macromolecules. The long answer is that COFs are organic two- or three-dimensional porous crystalline solids. They are constructed of strong covalent bonds and reversible covalent linkages. Their composition of lightweight elements allows for properties such as low density, large surface area, and malleable pore size and structure. COFs are insoluble in water and can remain stable in extreme temperatures. These characteristics make them ideal for scrubbing CO_2 from the atmosphere or storing electrical energy.

HOW ARE THEY CLASSIFIED?

COF can be classified using multiple techniques, including powder X-ray diffraction, solid-state spectroscopy, and thermogravimetric analysis. Powder X-ray diffraction provides information on the unit cell dimensions, or how each unit repeats to form its crystalline shape. Solid-state spectroscopy is similar to standard spectroscopy. Spectroscopy utilizes light to evaluate a solvent's structure, but solid-state spectroscopy allows for a solid to be evaluated instead. Thermogravimetric analysis examines the mass of a sample over time as the temperature changes. Each of these techniques illuminates the characteristics of each COF.

WHAT DID THEIR STUDY COMPARE?

Sukanick created two new COFs in the last two years. She wanted to compare COF starting materials to see how it would impact symmetry of the resulting COF. They specifically compared symmetrical COF starting materials (Figure 2, structure 1) and asymmetrical COF starting materials (Figure 1, structure 1). They knew molecular symmetry can influence physical properties of many materials but didn't know if it would impact the storage efficiency of COFs.

As seen in the resulting COF in Figure 1, having only asymmetrical starting materials results in an asymmetrical COF. An asymmetrical COF isn't truly crystalline and is therefore less efficient at storing energy and gases. Based on her data, COFs starting materials must be perfectly symmetrical to become a crystalline COF, and only crystalline COFs are capable of more efficient energy and gas storage.

HOW DO COFs EFFECT ENGERGY STORAGE?

Solar cells act like a battery. The material A that donates electron is the anode, and the material B that accepts electron is the cathode. When a ray of light strikes the cell, it causes the electrons to move from anode to cathode (electrons move from A to B). This movement of electrons is current.

The problem is that most solar panel pathways from anode to cathode is made of polymers. This polymer causes the electrons to take