Innovations with far-reaching potential for the environment and health

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The Kavli Foundation Lecture series today features two prominent scientists: one in the booming area of ionic liquids, the other in medical materials. The former has made a novel compound with the potential to lower the energy it takes to capture carbon dioxide (CO_2) from smoke stacks. The latter has engineered tissues and medical materials such as a stretchy glue that could transform surgery. They will make presentations today at the 248th National Meeting & Exposition of the American Chemical Society (ACS).

Joan Brennecke, Ph.D., will deliver "The Fred Kavli Innovations in Chemistry Lecture." She investigates and develops new substances called ionic liquids that are widely considered greener alternatives for a broad range of processes that currently use toxic solvents.

"The thing that makes ionic liquids special is that they don't evaporate," Brennecke says. "That means they won't cause air pollution, and they're essentially not flammable."

One of the major global problems that ionic liquids could solve is how to capture the greenhouse gas, CO_2, from power plants. And in an unanticipated development, Brennecke hit upon an exciting option around the same time President Obama announced his initiative to reduce emissions of the gas from power plants by 30 percent.

"It was total serendipity," she says.

While studying one of the materials Brennecke's team at the Center for Sustainable Energy at Notre Dame had developed, a graduate student accidentally turned the heat off during an experiment when it was supposed to be on—with an unexpected and elegant result.

That substance was solid at room temperature. But when CO_2 was added, the substance grabbed onto the gas molecules and condensed into a liquid, effectively removing the CO_2 from the air flow without adding heat. Brennecke explained that this process could dramatically reduce the energy required to capture CO_2. The new substance from Brennecke's lab can potentially do the same job using less than a quarter of a plant's energy production, compared to current methods, which eat up nearly a third of the output.

Just prior to Brennecke's lecture, Ali Khademhosseini, Ph.D., will present "The Kavli Foundation Emerging Leader in Chemistry Lecture."

Khademhosseini is at the Harvard-Massachusetts Institute of Technology Division of Health Sciences and Technology, Brigham and Women's Hospital and Harvard Medical School, as well as the Wyss Institute for Biologically Inspired Engineering.

His research involves the development of micro- and nanoscale technologies to control cellular behavior and systems for tissue engineering and regenerative medicine. He is also developing innovative medical materials, including surgical sealants and injectable gels that could stop internal bleeding in a noninvasive way. For these applications, he uses protein-based hydrogels.

"For example, these materials could be used in lung surgery," Khademhosseini explains. "If there's a tumor, the surgeon cuts it out and can suture the site. But sutures don't completely close the incision, so air and liquid can leak. To avoid these leaks, you need to put in some kind of sealant."

The trick is making the sealant tough but stretchy. Khademhosseini's team has developed a gel material that meets these criteria. And because it's made out of a human protein, the gel shouldn't raise the immune system's alarms. The researchers are currently testing the sealant in animals.

More information: Title: How ionic liquids can contribute to global stewardship

Abstract
Ionic liquids (ILs) are low melting salts that are being designed, developed and explored for a myriad of applications. While it is possible to make ILs that are highly toxic (and these should certainly be avoided), their real potential for contributions to global stewardship are the applications. Here we will explore how the unique properties of ILs – low vapor pressure, good thermal stability, widely tunable solvation properties and chemical functionalization – make previously inaccessible products and processes possible. These include low energy separation of carbon dioxide from post-combustion flue gas, elimination of ozone depleting, global warming and flammable refrigerants, safer batteries and supercapacitors, chrome plating without exposure to highly toxic hexavalent chromium, homogeneous phase processing of biomass into chemicals and fuels, reactions and separations without fugitive emissions, non-volatile lubricants and heat transfer fluids, and more cost efficient harvesting of solar energy.

Ali Khademhosseini, Ph.D.:

Title: Engineered hydrogel biomaterials for regenerative medicine applications

Abstract
Engineered materials that integrate advances in polymer chemistry, nanotechnology, and biological sciences have the potential to create powerful medical therapies. Our group aims to engineer tissue regenerative therapies using water-containing polymer networks, called hydrogels, that can regulate cell behavior. Specifically, we have developed photocrosslinkable hybrid hydrogels that combine natural biomolecules with nanoparticles to regulate the chemical, biological, mechanical and electrical properties of gels. These functional scaffolds induce the differentiation of stem cells to desired cell types and direct the formation of vascularized heart or bone tissues. Since tissue function is highly dependent on architecture, we have also used microfabrication methods, such as microfluidics, photolithography, bioprinting, and molding, to regulate the architecture of these materials. We have employed these strategies to generate miniaturized tissue modules. To create tissue complexity, we have also developed directed assembly techniques to compile small tissue modules into larger constructs. It is anticipated that such approaches will lead to the development of next-generation regenerative therapeutics and biomedical devices.

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