New class of compounds promise better drugs, clean energy

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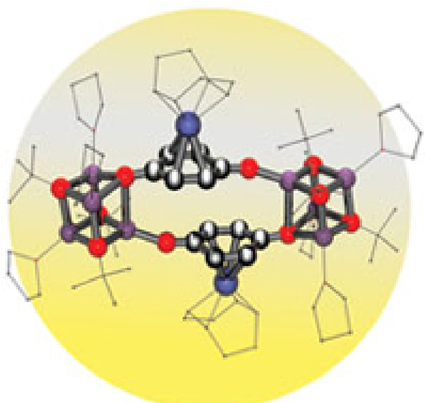

A model of two rhodium quinones, shown here in the center as the blue and silver structures. Image: Jeffrey Reingold, Brown University

By combining a common organic compound with a rare metal, a team of Brown University chemists has created a new class of molecules that have potentially important applications for the pharmaceutical, chemical and energy industries.

To create the mixture, scientists working in the laboratory of Dwight Sweigart, a Brown professor of chemistry, combined two compounds. One is hydroquinone, pale organic crystals critical for many biological processes as well as the manufacture of everything from skin bleaching creams to high-performance plastics. The other is the precious metal rhodium. The resulting reaction produced rhodium quinones.

"This mixture has marvelous properties," Sweigart said. "Rhodium quinones are very fast and efficient catalysts. They also have pores, or channels, that act like a sponge, giving them the ability to store gases. The secret is rhodium. It's the Superman of elements."

Rhodium is lighter than platinum, rarer than gold, and, at about $3,000 an ounce, the priciest of precious metals. The silvery white substance is prized as a potent, long-lasting catalyst and is used to concoct antifreeze, detergents and other industrial chemicals as well to make automotive catalytic converters, which cut down on air pollution. Rhodium is also the most reflective element on the periodic table and can be found in searchlights, dental mirrors, and giant microscopes known as synchotrons.

Discovery of rhodium quinones has landed Sweigart and his research team in premier chemistry journals, including the Journal of the American Chemical Society and Angewandte Chemie, the publication of the German Chemical Society, which put the compounds on its December cover. This month, the research landed on another cover: the British journal Chemical Communications.

Together, the articles outline potential applications of rhodium quinones:

Catalysis – Rhodium quinones are highly effective catalysts for so-called carbon-carbon coupling reactions. These reactions are essential to make drugs for cancer, depression and other diseases. Rhodium catalysts promise a conceptual advance over current production systems by boosting the amount of end product and by making new drugs possible. Sweigart is currently working with William Trenkle, an assistant professor of chemistry at Brown, and graduate student Julia Barkin to use the compounds to make drugs for asthma, depression and other conditions. Through Brown, the pair filed preliminary patents on the use of rhodium quinones as catalysts.

Synthesis – Rhodium quinones can also be used to make a new class of organolithium reagents. These compounds are used to make a wide variety of industrial chemicals, such as polymers and plastics, and are among the most important reagents available for the synthesis of new materials. The rhodium quinone-based class of organolithiums promises to improve these reagents by allowing the incorporation of active transition metals.

Storage – Energy experts hope that hydrogen will eventually replace fossil fuels as a clean source of power. The promise: Convert the gas to electricity, leaving water as the only byproduct. But to create this "hydrogen economy," major hurdles must be overcome to make, transport and store hydrogen. Sweigart and his team have shown that rhodium quinones, in a solid state, feature channels suitable for storage of hydrogen and other gases, and might be used in fuel cells to generate electricity.

"After routinely working until 2 or 3 a.m. in the lab, creating the new compound is extremely exciting," said Jeffrey Reingold, a graduate student working in the Sweigart lab. "The rhodium and the quinone parts of the molecule each contribute unique characteristics to generate a powerful new reagent with enormous potential. Much of our future research will focus on the development of this fascinating chemistry."

The research team also includes chemistry graduate student Sang Bok Kim, professor emeritus of chemistry Gene Carpenter, and Seung Uk Son, a former Brown post-doctoral research fellow and current assistant professor of chemistry at Sungkyunkwan University.

Source: Brown University