Researchers create safe, resistant material to store waste

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The researchers' material, shown being installed at a site in the Middle East, combines sodium bentonite clay and polymers to create a substance that can withstand industrial waste. Credit: CETCO

(Phys.org) —Storing industrial waste has never been a pretty job, and it's getting harder. New techniques for refining such metals as aluminum and vanadium, for example, also yield new byproducts that have to be sealed away from human and environmental contact. And the practice of "scrubbing" the exhaust of coal-fired power plants keeps chemicals like sulfur dioxide from entering the air, but produces a more concentrated residue.

Now, many of these wastes are proving too acidic, basic or concentrated for commonly used storage materials.

That's why University of Wisconsin-Madison researchers, partnering with companies through the National Science Foundation's Grant Opportunities for Academic Liaison with Industry program, set out to reinforce those materials by fusing them with polymers.

Their starting point is sodium bentonite clay, which has proven reliable in a variety of environmental applications, essentially swelling up and forming a seal when exposed to water or other liquids. But the clay sometimes fails to swell up adequately when subjected to harsh conditions, such as the extreme pH levels of "red mud," the alkaline residue produced by aluminum extraction.

"You have to be able to store the waste into perpetuity—hundreds of acres of this liquid," says Craig H. Benson, the Wisconsin Distinguished Professor of civil and environmental engineering and geological engineering at UW-Madison. "Effective containment is part of the social contract these companies have with their community."

Benson, colleagues Tuncer Edil and William Likos and former Ph.D. student Joe Scalia have spent the past five years experimenting with different ways to incorporate polymers into the bentonite clay. They eventually discovered that the best method was to let polymer molecules move around on the bentonite's surface, essentially finding a way into the flow path of the liquid as the clay swells up. The resulting material can withstand pH levels as low as 1—highly acidic—and as high as 14—highly basic—depending on the concentration of the substances involved.

To adapt their material to commercial uses, the researchers partnered with engineers at the large mineral technologies company CETCO. Chris Athanassopoulos, who works as a technical services manager in CETCO's suburban Chicago branch, says the involvement of UW-Madison engineers made it much easier to get people in industry interested in the new product.

"When you're talking with a design engineer or a regulator, unfortunately they have lots of experience talking to salespeople, or people who promise the world to them without backing it up with good technical information," Athanassopoulos says. "The fact that we were able to have data from Craig's lab over the long term, with some of these materials, was probably the biggest benefit in terms of getting acceptance."

Athanassopoulos and his CETCO co-worker Mike Donovan gradually came up with ways to manufacture and market the product, now sold as Resistex GCL, and are still experimenting with another iteration, dubbed Continuum GCL.

So far, the products have been accepted by one of the world's largest producers of aluminum, Alcoa, which recently used the material to line one of its storage facilities for aluminum tailings.

To build on this success, Benson plans to focus on understanding the chemistry of how the material works, and eventually build off the material's design to create a suite of different materials tailored to contain different kinds of extreme chemistries. Beyond industrial waste storage, Benson sees potential for this research in applications as diverse as plugging wells and building containment walls that seal off contaminated groundwater areas from the rest of the water supply. And as UW-Madison researchers learn more about the science of extremely resilient environmental materials, partners in industry are learning how to adapt their manufacturing processes to spread the benefit of these materials.

"Craig and his team are always asking questions and developing tests," Athanassopoulos says. "We've learned a lot from them."

Provided by University of Wisconsin-Madison