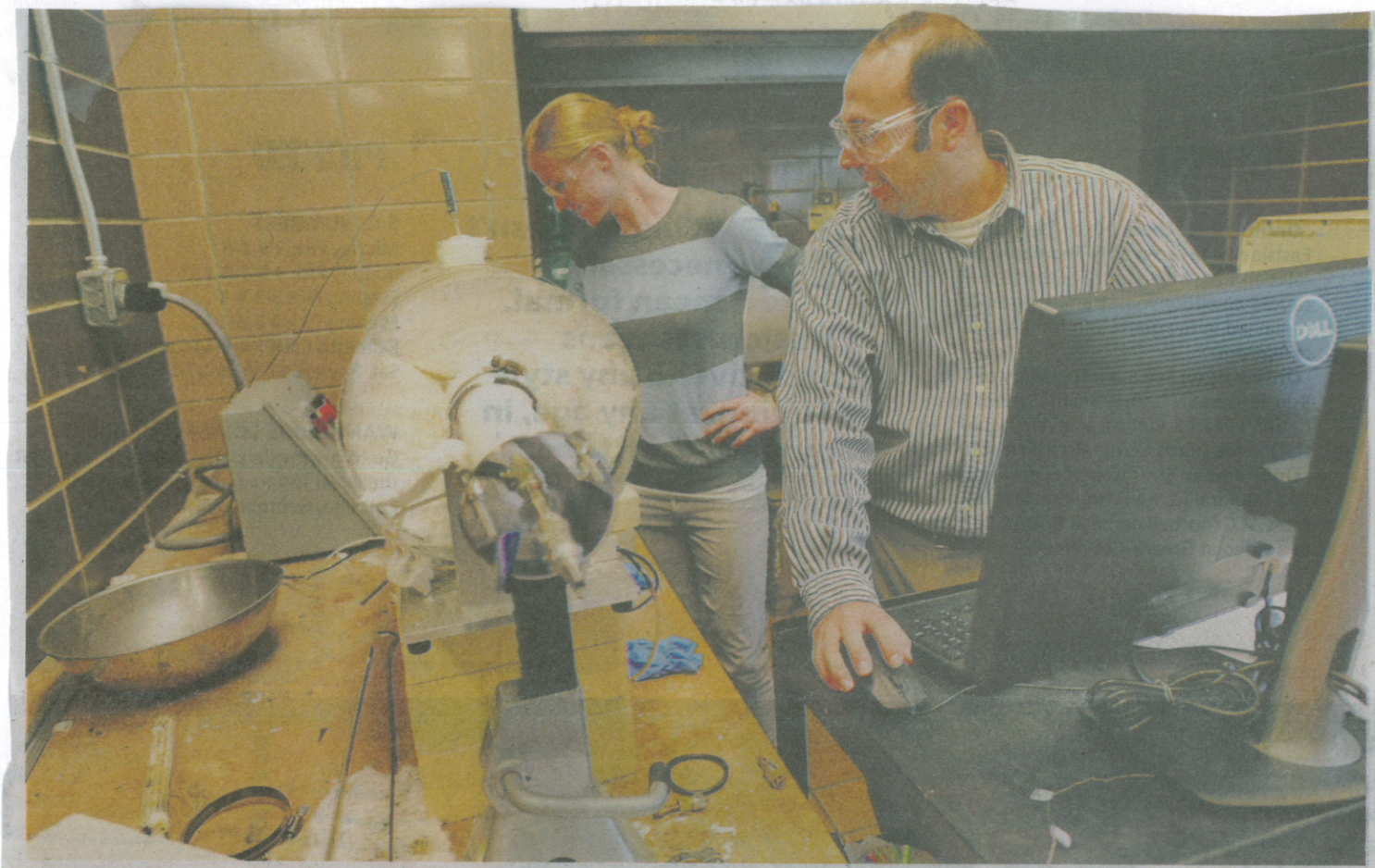


HEIDI HEILBRUNN/STAFF

Clemson University's Kyle Brinkman, right, and Ashley Hearing, a materials science and engineering masters student, are researching new ways to store nuclear waste by coming up with a new crystal.

Crystal clear solution

Clemson scientist developing safer nuclear waste disposal method by locking away lethal radioactive material

By Ron Barnett
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CLEMSON — Imagine trying to lock Lex Luthor inside a manmade crystal prison for all eternity, and you can get some idea of what's going on in Kyle Brinkman's laboratory at Clemson University.

Brinkman, an associate professor of materials science and engineering, and graduate student Ashley Hearing, are trying out different recipes, heating various concoctions of minerals to temperatures of more than 2,000 degrees F. to come up with a new crystal that will be able to safely incarcerate the lethal radioactive waste that's left over from generating electricity from the power of the atom.

It's a project that has real-world implications here in the Upstate.

With every flip of a light switch or press of the remote control on-button, the amount of high-level nuclear waste piling up at Oconee Nuclear Station grows a little more.

And there's no place to put it, at least not for the quarter of a million years it will remain dangerous.

As policy-makers squabble over a long-term alternative to storing spent nuclear fuel in pools of water and in concrete and steel mausoleums at Oconee and other power plants, Brinkman's team is moving to develop a material that will keep radioactive super villans locked away for eons.

He has received an $800,000 grant from the U.S. Department of Energy to find a more stable alternative to glass, which is now the best technology available for encasing radioactive leftovers such as cesium.

There are problems with glass. It's not as strong as a crystal, and radioactive materials start to crystalize inside it, which makes the glass unable to hold as much waste. Crystals are more dense, with atoms and molecules aligned in stronger, more stable patterns than other solids.

"So in addition to reducing the waste volume and reducing the cost because you can put more waste into a given amount, you can potentially have them more stable over longer periods of time,"

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HEIDI HEILBRUNN/STAFF

Clemson University's Kyle Brinkman is heating various concoctions of minerals to temperatures of more than 2,000 degrees.

CRYSTAL

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Brinkman said.

The DOE is looking ahead to a time when lawmakers approve recycling spent nuclear fuel rather than simply storing it, he said.

But even after it's been recycled, there will still be radioactive waste that needs to be dealt with.

That's where the project the Clemson-led team is working on comes in.

Brinkman has a head start on the research because he's been studying materials for nuclear waste storage at DOE's national lab at the Savannah River Site for the past seven years. He came to Clemson in January.

The challenge ahead is somewhat like putting together a three-dimensional jigsaw puzzle with pieces that move around over time.

What's needed is a crystal that has some atoms — or spaces between atoms — that are the same shape as the atoms of the radioactive waste, Brinkman said.

A mineral called hollandite that is dug out of the Italian Alps provides a good model to start with because of its atomic structure, Brinkman said.

Researchers can mix together elements that make up hollandite and add materials that are the same shape as the radioactive waste — but without the dangerous radioactivity.

They can replace some of the atoms of the naturally occurring mineral structure with atoms of the dummy nuclear waste, or heat their mixture in such a way that the waste might fit into spaces between the atoms, he said.

"We're tailoring these crystals to look like rocks and minerals that exist already in nature that have been around for millions of years," Brinkman said. "So the hypothesis is that if we can get our radionuclides into similar crystalline arrangements, they're going to be stable like the mineral structures — potentially more stable than glass."

Or, to put it more simply, "Think of it as cooking," he said. "We're using the Alps as a guide to our recipes."

The process involves taking the liquid waste that's left over from the recycling of spent fuel and stirring in the powdered chemicals that make up the recipe and heating the mixture to the appropriate temperature for the right amount of time. The end result is a ceramic crystal that incorporates and renders harmless the radioactive material.

"This looks like a white powder," Brinkman said, holding up a vial of powdered chemicals. "But if you looked at the distance between atoms and how it's structured, it would be the same as that rock," he says, pointing to a watch battery-sized chunk of barium cesium titanate in a tiny plastic case.

"And then the question is, this rock was formed under high pressure and temperature for years. We just made this in a lab in a day," he said. "So now, how do you go from a powder to a rock? That's where the melting comes in."

The project uses melting as its medium because the technology is already well understood in using glass. But one of the goals of this work is to develop more advanced melting techniques, he said.

Although the waste trapped inside the crystal can no longer escape into the environment, it still goes through the process of radioactive decay, which means it changes over time, and the crystal prison has to be able to accommodate that change, Brinkman said.

That challenge is what attracted Hearing, a grad student from New Jersey, to the project.

"I think the application of this project itself is really what drew me to it," she said. "The fact that you have these materials that are going to decay and change state, they're going to be different charge states and different sizes and you have to be able to account for that and be able to develop a material that can withstand those modifications over time."

The three-year project includes researchers from the University of South Carolina and the University of Connecticut, with each taking the new manmade crystals developed at Clemson and analyzing their structure to determine how well they would work.

At UConn, scientists will use X-rays to make a 3-D image of the structure, and USC researchers will use that image to develop computer models for how the material would behave over time, Brinkman said.

Then the Department of Energy will study it to verify that it's doing the job of keeping the waste locked away.

Anand Gramopadhye, dean of Clemson's College of Engineering and Science, said the research is important for South Carolina, where about half the energy is generated by nuclear power.

"It is vital to our health and our environment to find safe storage options for nuclear waste," Gramopadhye said. "We owe it to South Carolina and our nation — not only for us, but also for our children and future generations."

Collaborators on the project are Rajendra K. Bordia, chairman of Clemson's Department of Materials Science and Engineering; Kenneth L. Reifsnider of the University of South Carolina; Wilson K.S. Chiu of the University of Connecticut; and James C. Marra of Savannah River National Laboratory.

"The research will help us strengthen ties between Clemson University and Savannah River National Laboratory," Bordia said. "It also helps South Carolina boost its already strong national reputation in nuclear research. We've built a specialty in finding the safest ways to generate nuclear energy and dispose of the waste."

Several separate nuclear-related projects are underway at Clemson, including one that was recently awarded $5.25 million to conduct field experiments on waste.

Who knew that Clark Kent was a Tiger?