NETL invents improved oxygen carriers

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Oxygen carriers are similar in texture to sand. The oxygen carrier pictured here blends magnesium oxide and hematite.

One of the keys to the successful deployment of chemical looping technologies is the development of affordable, high performance oxygen carriers. One potential solution is the naturally-occurring iron oxide, hematite.

"Hematite is pretty cheap," says Doug Straub, Technical Coordinator for the National Energy Technology Laboratory's Chemical Looping Combustion (CLC) projects and the just-completed Industrial Carbon Management Initiative (ICMI). "You just dig it out of the ground and run it through a screen." That affordability makes hematite attractive as an oxygen-carrier material, but high performance at the conditions imposed by the chemical looping process is also important. Researchers at the DOE lab are investigating how to enhance hematite-based oxygen carriers so they can stand up to high reactor temperatures. Oxygen carriers also need to be resilient in the face of frequent impacts with reactor walls, with each other, and (in coal-burning reactors) with coal particles. Researchers are also improving oxygen carriers so that they more completely combust the fuel.

Their work has paid off. Dr. Ranjani Siriwardane (who leads the CLC oxygen carrier research) and Dr. Duane Miller (a chemical engineer at NETL) have invented an oxygen carrier that pairs magnesium oxide with hematite. During a pilot-scale run through NETL's fluidized bed reactor last year, their carrier showed better performance than carriers that contained just natural hematite.

What's next? In the words of Dr. Siriwardane, "this is a big scale-up problem," and that scale-up can be difficult. The quantities of carriers used at the laboratory scale are small, and techniques for preparing them are easier to control. But, as Dr. Siriwardane explains, "some of the techniques we use for lab-scale preparations are not practical for large-scale preparations, where different techniques and equipment are used. Finding the proper production techniques for our carriers that still deliver the required performance is a big challenge." However NETL researchers are clearly up to the challenge: when Drs. Siriwardane and Miller applied for the patent for their magnesium-oxide-and-hematite carrier, they had about 100 grams of material, just enough for a lab-scale run. Since then, they have worked with NexTech Materials, a commercial materials vendor, to prepare a 400-pound batch of the carrier for the pilot-scale test.

In addition to the hematite-based carrier, NETL is also exploring alternative carrier materials, with the goal of optimizing carrier performance and affordability for specific chemical looping applications. A second carrier developed by Drs. Siriwardane and Hanjing Tian (formerly of NETL but now a West Virginia University faculty member) relies on manmade materials instead of natural hematite. Made of copper oxide, iron oxide, and alumina, it too is ready for pilot-scale testing.

The oxygen carriers that NETL invents to enable CLC could have applications beyond electricity generation. CLC is also useful in industrial steam production, says Dr. Miller, and can be used for the production of hydrogen or syngas from methane. NETL scientists continue research to discover and develop carriers for such real-world applications with the expectation that the energy technologies they enable will one day be very green and very, very affordable.

Provided by Oak Ridge National Laboratory

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