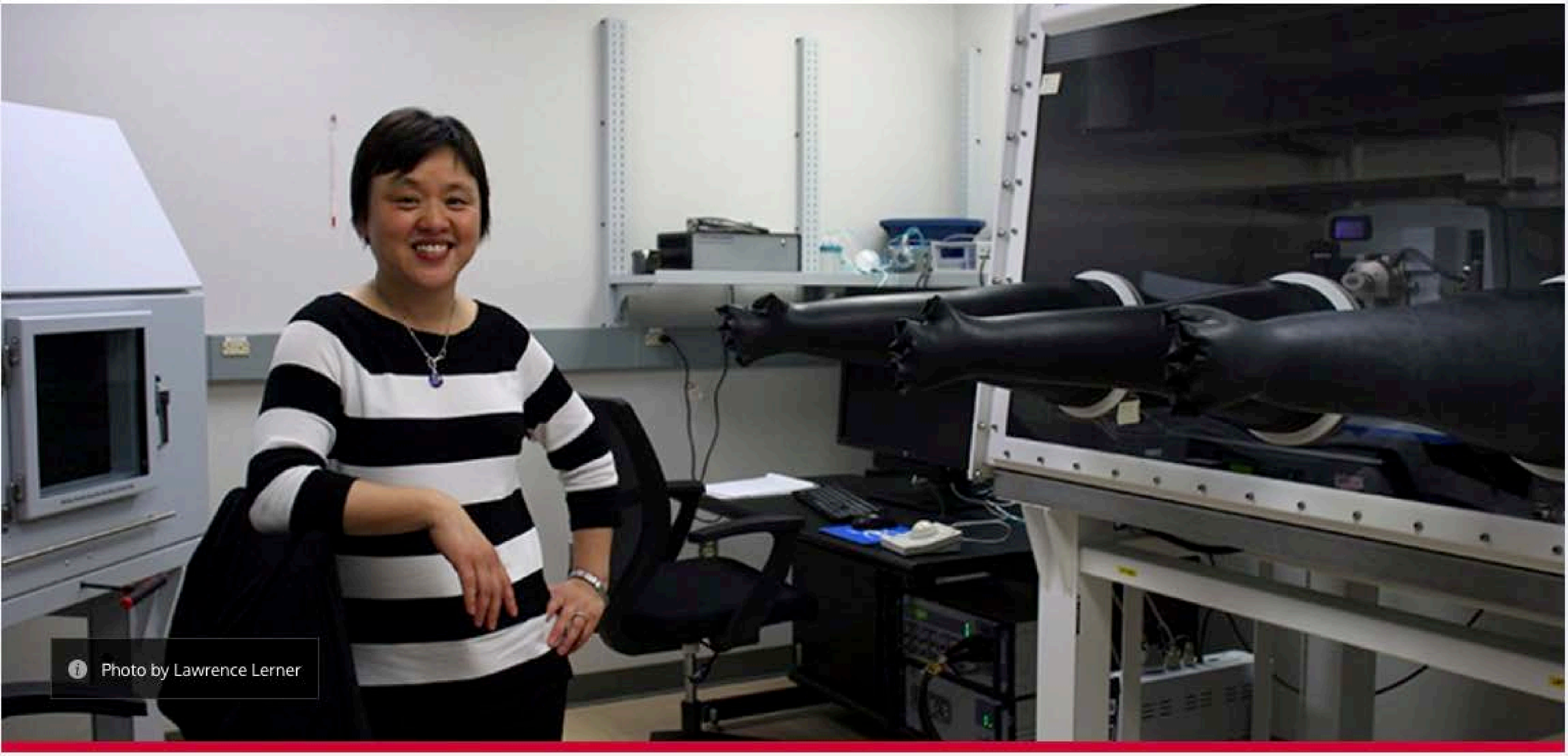
Photo by Lawrence Lerner

Chemistry Researcher's Search for New, Greener Catalysts Could Pay Big Dividends

By Lawrence Lerner

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Platinum. Palladium. Iridium. Ruthenium.

Reciting these names, you'd be excused for thinking you're in ancient Rome. But these Latin derivatives have a more modern connection: They are all precious metals with vast industrial applications—in everything from computers, electronics and plastics to pharmaceuticals, automobiles and fuel cells.

In the world of chemistry, they're also known as excellent *catalysts*, capable of jump-starting chemical reactions in an instant when they might otherwise take years.

But if there's one glitch, it's that these metals are rare, expensive and finite. That's why chemists like Rutgers University-Newark's Huixin He are looking for environmentally sustainable alternatives to these metal catalysts.

"The chemistry community has been working to develop greener catalytic processes," says He. "We're going to run out of these metals, and they are also toxic when exposed to water sources. So, we have to come up with non-metal catalysts, or ones that use only a tiny bit of metal."

Catalysts can be thought of as homebreaker-matchmakers: They tear apart and bring together atoms from different molecules with minimal energy to produce chemical activity.

Some molecules are stubborn (or stable), refusing to relinquish their atoms so easily, while others are more amenable to lending their atoms to other molecules. The more efficient the catalyst, the more quickly it can shuffle and rebuild pairings, then get out of the way, with very little energy expended.

Platinum, for instance, has been instrumental in catalytic converters, removing pollutants from auto exhaust. It also plays a starring role in hydrogen fuel cells, reacting with hydrogen and oxygen to make water and electricity. We even have chemical catalysts in our bodies in the form of enzymes, which break food down into nutrients and help cells make energy.

In short, chemical catalysts are one of the engines of modern life, and scientists have taken different approaches in the push for greener versions.

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Some are working with cheaper, more abundant non-metal materials such as carbon to make it behave more like these precious metals. Others are resorting to biology, repurposing nature's enzymes to do the work of catalysts in more industrial applications. Others are rethinking how metals like platinum can be used more efficiently.

He and her team have been working with carbon, whose atoms can arrange themselves into flat sheets of hexagonal rings resembling chicken wire, called grapheme. When these are rolled into hollow tubes, they are stronger than steel for their weight. But pure grapheme is not catalytically active.

To fix that, many scientists have been changing its structure with nitrogen. He and her team have chosen a different route, using phosphorous instead.

The key, however, has been to find a cheap, abundant, sustainable source of phosphorous that is benign—or safe and easy to work with—and that can be simply and efficiently transformed into a high-quality catalyst.

In the course of their experiments, He and her team stumbled upon an answer: liquid phytic acid, a natural and benign substance found in food. Microwaving it for less than a minute transformed it into a black, sooty, flakey material that is catalytically active, much to their delight and surprise.

"Under a microscope, the flakes have a wavy outer boundary and large, porous middle that enable molecules to enter and leave easily to create chemical reactions," says He. "This is exciting because potentially it can be produced easily and sustainably in large quantities for industrial applications outside of fuel cells."

She also knows that there's much more research to be done.

Indeed, He and her team have also experimented with agents other than phosphorous, sprinkling bits of nitrogen, boron or sulfur to further change the carbon-grapheme structure and make the catalyst more efficient.

And recently, they've been altering the structure with minute quantities of palladium, ruthenium, copper, nickel or tin, which has increased the carbon's catalytic power dramatically. The results are promising. And while He is pleased with her team's progress, she is not one to rest on her laurels. In fact, her team's early success only motivates her more.

"It's like digging for copper and getting diamonds instead," she says. "It feels really good and is driving us to go further and further with our work."

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