Don't toss that crab shell. A substance found in it could be key to renewable energy, researchers say

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At summertime backyard feasts, crab shells are just a barrier between hunger and satisfaction. Marylanders smash the crustaceans' protective

casings with wooden mallets, pick out the tasty meat and toss the remnants aside.

But what if crab shells could have a bigger impact, playing a vital role in harnessing renewable energy and reducing planet-warming emissions?

University of Maryland researchers are changing the way people look at those thin exoskeletons—investigating the feasibility of putting them to work in an innovative battery.

"People never thought of that before," said Lin Xu, 31, a postdoctoral researcher in the Department of Materials Science and Engineering at College Park.

Xu and a team of researchers have been exploring the use of a chemical that comes from crustacean shells in a zinc-ion battery designed to store renewable energy.

Last fall, working under the direction of Liangbing Hu, a Maryland professor who said he conceived the idea, the team published their findings on chitosan, a substance found in a variety of seafood shells, including crab and lobster.

Since appearing in a scientific journal, their work has turned heads.

"The paper has been cited already more than 20 times," said Xu, who grew up in China and received his doctorate at Massachusetts Institute of Technology. "That's very fast."

He and his colleagues are attempting to solve the problem of how renewable energy—like that generated from solar or wind power—can be stored.

"It's just like a reservoir," Xu said of the way batteries function, essentially holding onto energy until it is needed.

At night, for example, a home's appliances still could be powered by energy from the sun if a battery hooked up to solar panels on the roof stored energy generated during the day. On a larger scale, a battery plant placed next to a solar panel farm could stockpile energy to power a nearby city.

"We still need to find the material to store that energy, to act as a reservoir," Xu said.

While lithium-ion batteries like those that power cellphones and electric vehicles might seem suited to the task, Xu said they are expensive, and the price tag may rise as demand grows for lithium, a finite resource.

There are also safety concerns surrounding lithium-ion batteries, which can explode and cause fires, said Xueying Zheng, a researcher who has worked alongside Xu.

"If we use a very large scale of lithium-ion batteries packed together … if one pack explodes, that will cause all of the batteries to explode," Zheng said.

The zinc-ion battery has a different drawback: It doesn't have a long lifespan, operating at full capacity for only a few days or a week, Xu said.

That's where crab shells provide a solution perhaps.

With a gel membrane containing chitosan, the chemical found in seafood shells and pronounced CHI-tuh-sn, a zinc-ion battery can last a year and still function at 70% of its initial capacity. They're also much safer,

Zheng said.

The battery created and studied by UMD researchers is coin-sized, Xu said, but could be scaled up—with the goal of a more reasonable cost compared to alternatives since chitosan abounds in nature. The substance has an array of applications from biopesticides in agriculture to bandages that aid wound healing in medicine, according to Hu.

In the lab, chitosan arrives as a light yellow powder that is transformed into a translucent gel when dissolved into a solution, according to Hu, who is the director of UMD's Center for Materials Innovation and teaches materials science and engineering.

Chitosan, a carbohydrate, "is most abundantly found in the hard outer skeletons of shellfish, including crabs, lobsters, and shrimps," Hu wrote in an email to The Baltimore Sun. After the shells are washed and dried, they're "pulverized into fine powders," he explained, then treated with chemicals.

Hu's lab has purchased chitosan from Sigma-Aldrich, a chemical and life sciences company. On its website, chitosan sells for around $300 for 250 grams, the equivalent of a little over half a pound.

A spokesperson for Merck, which owns Sigma-Aldrich, said the company could not provide details about how or where it sources chitosan since it is "proprietary information."

"Many researchers are using our products and solutions in very interesting and unique ways," the spokesperson told The Sun via email. "Scientific breakthroughs, both big and small, are exciting to us—especially as they positively impact life and health to create a more sustainable future."

In Maryland, a state known for its blue crabs, some in the crab processing industry have taken notice of the potential new use for their scraps.

"I was blown away when I first saw it, thinking 'Isn't that crazy?'" said Jack Brooks, who read about the battery research in a seafood trade newsletter.

Brooks, 71, is president of the Chesapeake Bay Seafood Industries Association and also co-runs J.M. Clayton Co., a family-owned crab and oyster processing plant that has been operating in Cambridge since 1921.

In a single day, J.M. Clayton processes 80 to 350 bushels of crabs with each bushel containing roughly 100 crabs. The crabs are sorted and steamed before being stripped of meat in a "picking room," Brooks explained.

From there, the discarded shells have faced different fates over the decades.

Starting in the 1920s, when J.M. Clayton operated a dehydrating plant in Cambridge, the exoskeletons were turned into a heavy powder called "crab meal," Brooks said.

The product was used as fertilizer and chicken feed, but the equipment was "old and primitive," he said, and his family closed the plant in the 1970s.

For about a decade after that, the shells went straight to the landfill, "which was unfortunate," Brooks said.

Today, J.M. Clayton has a contract to provide crab shells daily—via dumpster truck—to a Dorchester County farm, where they're used as

part of a fertilizer program, he said.

"It's a very good source of nutrients for the ground," Brooks said.

Other area processing plants have similar arrangements, he said.

A.E. Phillips & Son, a crab processor that sells to Phillips Seafood Restaurants and other local restaurants and seafood distributors, operates a plant in Fishing Creek that has offloaded its crab shells to a farmer for use as fertilizer since 2018.

It's the most cost-effective option for the plant, which doesn't make any profit from the shells but likely spends less money than it would hiring a private waste removal company, said Brice Phillips, whose great-grandfather started A.E. Phillips & Son over a century ago.

"This is not just normal waste; this is waste that if you don't get rid of it quickly, it starts to rot—and it really stinks," said Phillips, 47, who serves as vice president of sustainability for the separate Phillips Foods.

But A.E. Phillips & Son's processing of 60,000 pounds of crab meat per year in Maryland is dwarfed by Phillips Foods' production in Asia. There, Phillips said, four factories in Indonesia, one in Vietnam and another in India process a combined 100,000 pounds of crab meat each week.

Phillips said he's not sure what happens to the crab shells after they're picked at those plants. But he suggested Asia is an ideal place for innovation.

"Whoever's running this battery research, if they're ever going to do anything with this, they're basically going to be setting up a plant in Asia to get the crab shells," Phillips said.

In Asia, each pound of crab meat comes with four pounds of "guts and shells," he noted.

Both Brooks and Phillips said they'd be open to embracing a new use for shells.

"We've seen ideas come and go, but in this day and time, with all the research and technology and creative minds out there, I mean, hey, anything's possible," Brooks said.

Phillips views it as a potentially fruitful business venture, especially since "it seems there is no demand" for crab shells currently.

"My entrepreneurial spirit's already just grinding the gears, trying to figure out what's the best way to collect this stuff in mass," he mused. "How would it be processed, where would it be processed? Where would the battery production be?"

There's still a long way to go to make chitosan-based batteries a reality outside of the lab. A startup to commercialize the new technology is in its infancy, according to Xu.

If chitosan proves to be part of the solution—and if locally processed crab shells can be put to use—it's likely something people in the state would get behind.

"Marylanders certainly love their crabs, and I think most people like renewable energy," Phillips said.

More information: Liangbing Hu, A sustainable chitosan-zinc electrolyte for high-rate zinc metal batteries, *Matter* (2022). DOI: 10.1016/j.matt.2022.07.015.
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