

Spider-Man suits? Tulane researchers develop new material inspired by superheroes

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Bullet-proof superhero-style suits seem like the stuff of fiction, but a team of researchers at Tulane University is working to develop a material that could make them a reality. Here, they are measuring how much a piece of the material they produced can stretch. (Photo by Kenny Lass)

Bullet-proof superhero-style suits seem like the stuff of fiction, but a team of researchers at Tulane University is working to develop a material that could make them a reality.

Chemistry professors Scott Grayson and Janarthanan Jayawickramarajah at Tulane University School of Science and Engineering are using a grant from the Defense Advanced Research Projects Agency (DARPA) to create a novel material from linked polymers that could have a range of practical uses from wearable body sensors to artificial biomaterials to a Spider Man-style suit for soldiers. DARPA is a research and development arm of the Defense Department that has had a hand in advances ranging from COVID-19 vaccines to personal computers.

Jayawickramarajah and Grayson's research team, which includes graduate students and a post-doctoral fellow, has been working for the past year on synthesizing a type of polymer called polyrotaxane, which is a repeating molecule that looks much like a necklace with the ends held apart: it consists of a long "string" with ring-like units that are able to move freely along it.

Usually, when polymers are connected to each other to make up a larger material, they become stuck in place, meaning the materials they make tend not to be very stretchable. In the case of polyrotaxane, those connections occur on the moveable rings. "The circular units can rotate and move so that means they can slide," Grayson said. "You have a lot of pull, and that's the great thing about these polymers."

The DARPA-funded project aims to create this material at a large scale. Where specialty polymeric materials like this are often created at a small scale of a few grams at a time, Jayawickramarajah and Grayson are attempting to create a half kilogram, or a little more than a pound, of their material, showing that their process can be scaled up.

"One of the great things about our project is that most polymer linking reactions need organic solvents, and inert conditions, but this polyrotaxane is formed in water under ambient conditions," said Grayson. "It's really simple, and we're getting fantastic results."

That means that this material is an excellent candidate for being produced on a large scale.

"If you want such materials to ever have applications, you want to be able to make them easily in a pot just like you would cook some gumbo," said Jayawickramarajah, who is also senior associate dean for academic affairs in the School of Science and

Engineering.

But the team doesn't yet know what the final uses of their material could be. Much more production and testing are needed before the multitude of possibilities become clear. What they know so far is that it is incredibly elastic, conducts electricity with the correct electrolyte, and has phenomenal water retention (or what they call hydrogel) abilities. All of these properties stem from the basic structure of the material and the polymers that create it.

"The idea is that, just like how our fabrics in the macro scale are strong, stretchable, and durable because they've been interwoven, so we're trying to do that on the molecular and nanometer scale, so the molecules are being interwoven at that small of a scale," said Jayawickramarajah.

Many polymers like nylon are used in conjunction with other materials, like cotton or polyester, to provide properties desirable for textiles. This material is being tested for its inherent durability and stretchability, both of which could make it useful not only for sensors that are applied to the human body, but also for things like artificial ligaments or the superhero suits that were an original inspiration for the material initially. It has multiple useful properties on its own, and it could still be blended with other materials if desired.