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Andrea S. Carlini recognized for her work on bio-compatible soft materials

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From fitbits to targeted gene therapy, the age of precision health has dawned. But scientists will need to develop new materials for us to realize the full potential of personalized medicine.

The National Science Foundation has recognized UC Santa Barbara Assistant Professor Andrea S. Carlini with a CAREER Award, the agency's most prestigious distinction for early-career faculty. The award honors scientists with the potential to serve as academic role models in research and education and to lead advances in the mission of their department or organization.

"The NSF CAREER Award supports not just a research idea, but the long-term vision behind it – designing materials that make disease visible in real time and mentoring the next generation of scientists who will carry that vision forward," said Carlini, who is part of the chemistry department. "I'm especially proud that our work connects fundamental chemistry with real biomedical needs, and that this award supports

both innovation and education together. For me, it affirms that the interdisciplinary materials we're developing — synthetically accessible, yet behaviorally sophisticated — can transform how we detect and treat chronic conditions."

"Professor Carlini has established herself as an inspiring force in our chemistry and biochemistry community with an impressive array of accomplishments and initiatives," said Department Chair Alison Butler.

Carlini's lab develops structurally dynamic polymers: materials designed to autonomously sense, respond to and report on their environment. In other words, these materials can detect chemical or physical signals around them, react in real time by changing shape or assembly, and provide a measurable output that signals what they're doing. "Our work aims to develop programmable materials that actively interact with biological systems — across time and space — to enable smarter, more responsive solutions in biotechnology and medicine," she said.

The NSF CAREER project brings together two major threads of Carlini's work — disease sensing and light-activated chemistry — to create a new class of intelligent materials. "Imagine a soft material that can be placed in the body and, instead of waiting for symptoms to appear, continuously monitors tissue health by lighting up when something's wrong," she said. That's what her lab is working to develop: injectable or wearable polymers that detect a stress-related molecule called peroxynitrite, which our bodies produce during serious conditions associated with injury, inflammation and disease.

The materials developed by Carlini's group are designed to last much longer than conventional peroxynitrite probes and to be detectable deeper in the body, enabling non-invasive monitoring. A big challenge they face is that peroxynitrite is highly reactive and vanishes in milliseconds. So her team has to design a material that can detect this molecule without getting destroyed itself. On top of this, they hope to make the response reversible, so the same material can continue tracking tissue health in chronic conditions such as wounds, tissue transplant rejection and cancer recurrence.

This work opens the door to continuous, non-invasive monitoring of chronic diseases.

"Our materials could give physicians a real-time readout of tissue health, reducing the need for repeated imaging or invasive biopsies," Carlini said. In the long-term, she envisions a technology that can also deliver treatment in direct response to

these biochemical changes.

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