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A transparent artificial muscle to enable camouflaging in soft robots

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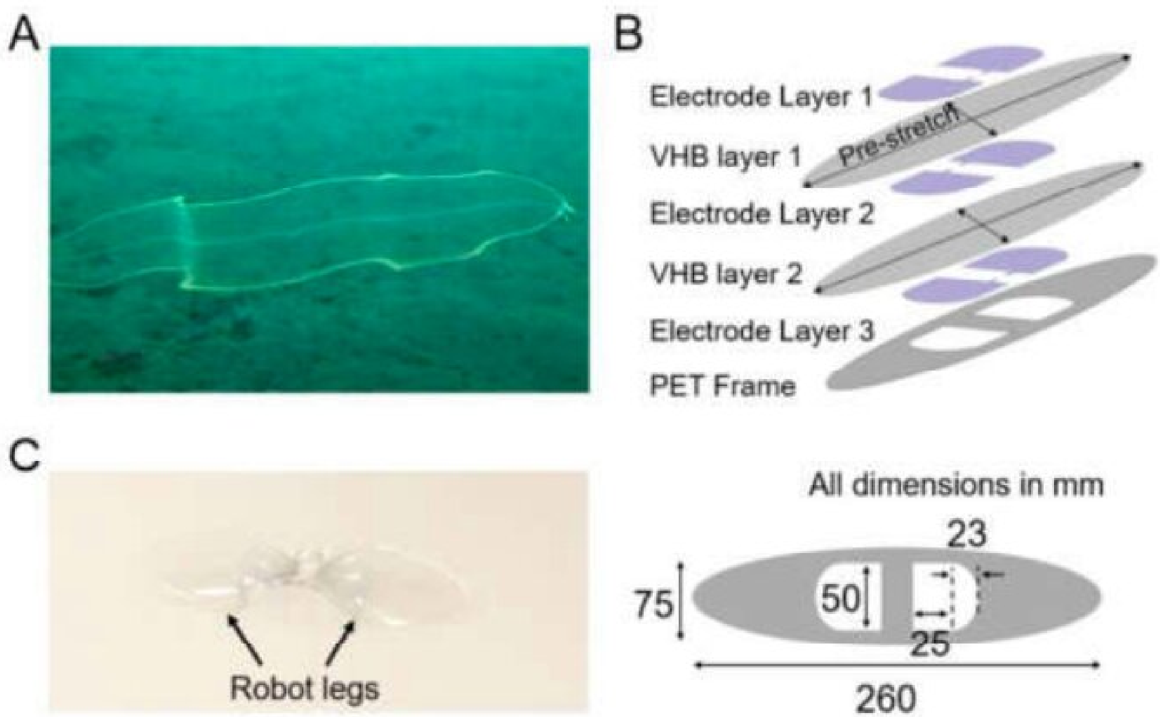

Fig. 1 (A) Transparent leptocephali in nature. (B) Design of the transparent soft robot. (C) A transparent soft robot with thin thickness and high transparency on a white background.

Credit: Wang et al.

The ability to become transparent is a considerable evolutionary advantage, as it allows animals to blend in with their environment, avoid predators and mask their movements. Robots with similar capabilities could be of great value for a number of applications, for instance, aiding surveillance and research that involves observing animals in their natural habitat.

Researchers at National University of Singapore have recently fabricated a transparent artificial muscle that could be used to build bio-inspired robots capable of camouflaging themselves. This unique structure, introduced in a paper presented at the 2019 IEEE International Conference on Robotics and Biomimetics (ROBIO), are based on dielectric elastomer actuators (DEAs), a class of electroactive polymers commonly used to fabricate soft robots, artificial muscles and flexible devices.

Despite their advantageous properties, such as their flexibility and electrical conductivity, conventional DEAs are unable to mimic the transparent appearance acquired by animals with camouflaging capabilities. In fact, most of these polymers are made of viscous dark materials, such as carbon grease, which cannot become transparent. The researchers at National University of Singapore, on the other hand, built their artificial muscle using DEAs that incorporate a blend of clearer materials.

"In this work, transparent artificial muscles are demonstrated by exploiting blends of poly(3,4-ethylenedioxythiphene): poly(styrenesulfonate) (PEDOT:PSS) and waterborne polyurethane (WPU) as compliant electrodes," the researchers write in their paper.

In contrast with carbon grease and other materials that DEAs are typically based on, the PEDOT:PSS/WPU blends used by the researchers are solid, conductive, but also transparent. In a series of initial evaluations, artificial muscles made of these material blends achieved a voltage-induced area strain of 200%, with a transmittance 88% over the entire visible light spectrum.

To demonstrate the feasibility and advantages of the artificial muscles they created, the researchers used them to fabricate a fully transparent soft robot that can blend in with its surrounding environment. This is one of the first transparent robots ever developed that is capable of efficiently camouflaging itself on land, which is far more challenging to achieve than transparency in water.

"The fully transparent robot can vibrate asymmetrically at specific frequencies and demonstrates translational motion while keeping camouflaged in colorful backgrounds," the researchers explain in their paper.

The initial results are highly promising, as the robot they built can both move around efficiently and conceal itself well. In the future, the robot could help biologists to study animal behavior that is difficult to observe, such as prey/predator dynamics. In addition, the same PEDOT:PSS/WPU-based artificial muscle could be used to create other animal-inspired robots that can camouflage themselves.

In their next studies, the researchers could investigate ways to enhance their robot's durability and robustness. This could be achieved, for instance, by using different transparent electrodes and applying additional protective layers on the robot's muscles.

The researchers are also planning to add other electronic components to the transparent soft robot they created, including power sources, circuits and control units; adapting the transparent components they used and the robot's body accordingly. This could ultimately make the robot untethered, allowing it to operate autonomously (i.e., without an external power source) and for longer periods of time.

More information: Yuzhe Wang et al. Bio-inspired Soft Robot Driven by Transparent Artificial Muscle, *2019 IEEE International Conference on Robotics and Biomimetics (ROBIO)* (2020). DOI: 10.1109/ROBIO49542.2019.8961401