Phase Manipulation of Dichloromethane for Use in Soft Actuator

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WeARE Research Area

Soft robotics is the idea of creating robotic systems or devices consisting either partially or holistically of highly compliant materials. These systems usually function very similarly to living mechanisms, and as such have a wide variety of applications within medicine and manufacturing.

Motivation or Background

Research within soft robotics is an area of engineering research that is relatively new, so there is a lot of ground to be covered. It is an exciting field of research as the possibilities for breakthroughs and large advancements in technology are very high. Compliant mechanisms have potential applications within the realm of biomedical devices, as they are essentially modern engineering's mimicry of the human body, in that they bear resemblance to muscles with their flexibility and low stiffness.

Soft actuators in particular have many potential applications in the way of biomedical devices. A soft actuator is effectively a muscle in artificial form. While in their current stage of development, there are not many soft actuators in existence that can reliably produce forces strong enough to move weights heavier than 15-20lbs, it's important to understand that research in their area is still in it's infancy, and the potential for advancement is very high. Such actuators could have potential use as therapeutic aids, exoskeletons, or even prosthetic limb/organ/muscle replacement.

Objectives

1. Create a soft actuator that can be used in one system to create a pulling force, and in another to facilitate locomotion.
2. Design the actuator to function via the use of heating and cooling units to manipulate the volume of Dichloromethane contained within a closed system consisting of a flexible membrane.
3. Select a material for the membrane that will be compliant enough to flex according to demands but also strong enough to withstand certain tensile forces.

Methodology

We eventually settled on using a condom for our flexible membrane. The condom would need to be sealed with a bond strong enough to not only contain the Dichloromethane but also resist the forces generated as expansion occurs within the system as it is heated. This seal would also need to have a high resistance to cyclic fatigue as the expansion and contraction of the actuator will operate in cycles during locomotion.

To tackle this challenge we attempted a few different methods of sealing the condom. The first attempted method was to seal it using a generic plastic bag sealer that can be found on almost any online shopping website. The problem with this method is that despite being a good idea on paper, the sealing device did not get hot enough to melt the latex compound used in the condoms we had available to us, therefore a sufficient seal could not be achieved. The next method attempted was sealing the condom via compressing it between two heated knives. This is essentially the same idea as the sealing machine, but at greater temperatures.

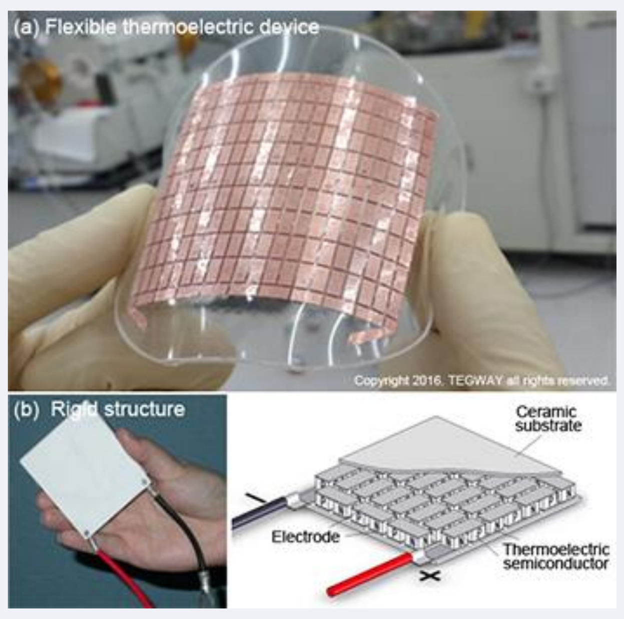

Fig. 1
TEGWAY flexible thermoelectric device

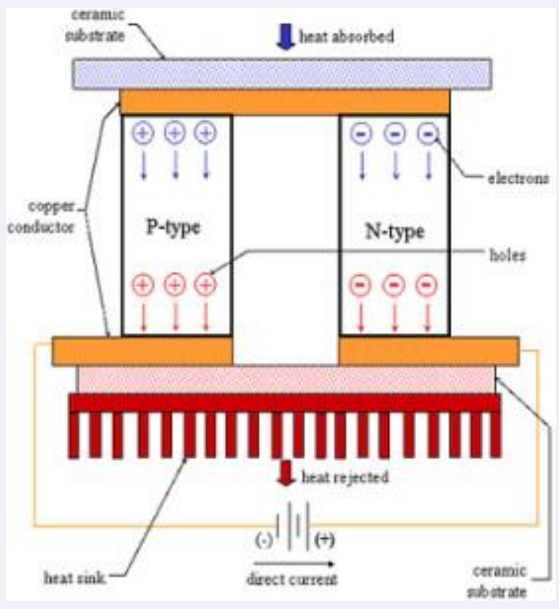

Fig. 2
Schematic of a peltier cooler

Results

Unfortunately, due to the COVID-19 outbreak, I was unable to conduct tests to the extent I would have liked. I worked on this project only from the beginning of the spring semester until quarantine began. During this timeframe I was unable to achieve a seal strong enough to be of use in our actuator, but the switch in methodology from using a sealing machine to the hot knives was a huge leap in the right direction, as I was able to obtain a seal that was a great degree of magnitude stronger than I was able to with the sealing machine. It is clear that the issue with the sealing machine was the temperature of the sealing medium not being high enough and the length of exposure time not being long enough. I also believe that we should experiment with cooling the melted latex via water or other media instead of allowing it to cool via convection with air at room temperature. I believe that in the near future I will be able to build upon my findings and that we are on the cusp of obtaining a sufficient seal.

Skills and Experience

- Material Selection
- Thermodynamic systems
- Mechatronics and Compliant Mechanisms
- Circuits and programming as used to control heating and cooling units

What I Learned

I was able to gain an understanding of how materials react to rapid heating and cooling in the process of trying to get a good seal for our membrane. I was able to apply the material I learned in my material engineering class about polymers and heating/cooling of materials.

Future Plans

Our next steps for this project are to perfect the seal and then set up the actuator in such a way to where it can create a pulling force. This would involve the use of a refrigeration unit to pull heat out of the system and thus rapidly decrease the volume. In doing this we will discover whether or not the condom will be suitable for the membrane as we will discover whether or not it can support the tensile forces it will be exposed to during this process. After that's done, we will work on using the actuator to create locomotion, similar to how an inchworm moves.

Acknowledgments

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References

- "ThermoElectric Device Embedded Controller." *Boyd Corporation*, 2019, www.boydcorp.com/resources/resource-center/blog/229-thermoelectric-device-embedded-controller.html.
- Fernando, W. Mevan. "Thermoelectric Peltier Cooler Explained & Initial Testing." *Arxterra, The Telerobotic Community*, 6 May 2014, www.arxterra.com/thermoelectric-peltier-cooler-explained-initial-testing/.