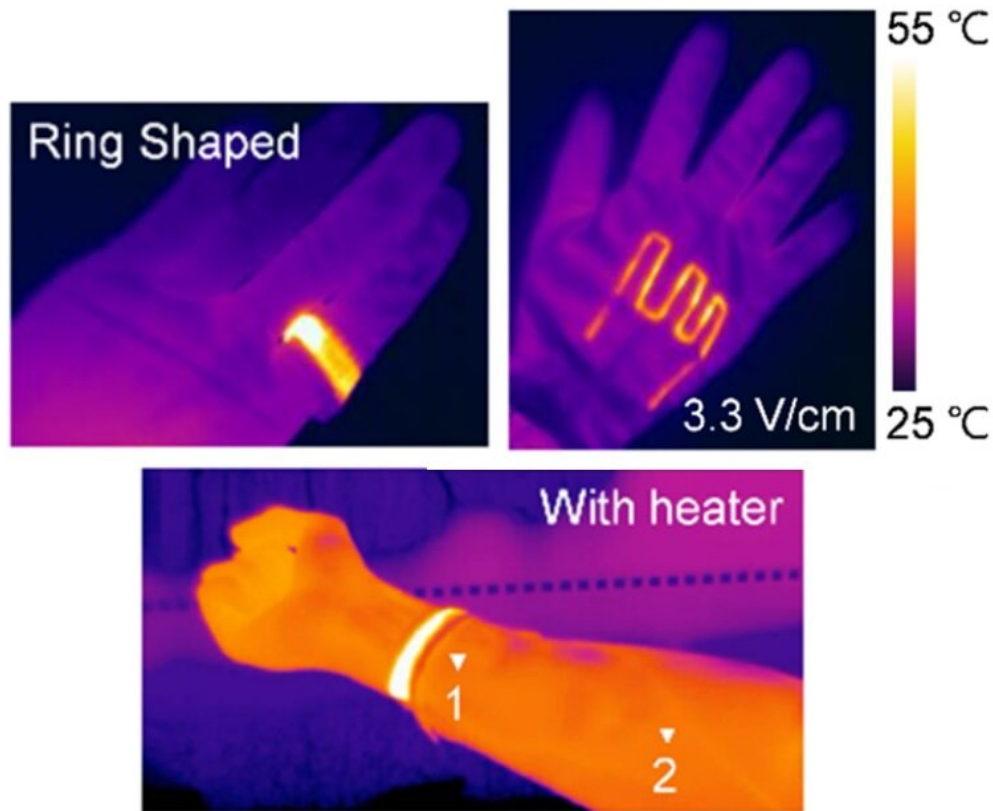


# Heated crystal flakes can be sewn into clothing for thermotherapy

June 10 2019, by Lisa Zyga



IR images of the MXene fabric heater formed into a ring, cotton glove, and bracelet. Credit: Park et al. ©2019 American Chemical Society

Heated gloves, bracelets, and even rings are some of the potential applications of highly conductive MXene, a 2-D material made of

alternating atomic layers of titanium and carbon. In a new study, researchers have fabricated MXene flakes, then electrostatically adhered the flakes to threads, and finally sewed the threads into ordinary fabrics that can be safely heated under a low voltage.

The researchers, led by Chong Min Koo, at the Korea Institute of Science and Technology and Korea University, and Cheolmin Park, at Yonsei University, have published a paper on the shape-adaptable MXene heater in a recent issue of *ACS Nano*.

In recent years, researchers have been investigating [different materials](#) to be used as flexible, wearable heaters. Although materials such as carbon nanotubes and graphene have excellent electrical and optical properties, it has been challenging to process them for use in applications.

A newer material, MXene was first introduced in 2011 by researchers at Drexel University. MXene is a 2-D crystalline material that exhibits metal-like conductivity and strong electric-to-heat conversion behavior. It can also be easily processed into thin films and fabrics.

"We were able to develop novel light-weight, cost-effective but [high performance](#) electrical heaters based on emerging 2-D materials of MXene, which are suitable for wearable and on-body applications," Park told *Phys.org*. "Several candidates for the purpose have been proposed, based on carbon nanomaterials, but they are restricted by either their poor processability or low electrical conductivity involving harmful and toxic chemicals. We resolved these issues with solution-processed MXene flakes."

In the new study, the researchers first used MXene flakes to fabricate a transparent thin-film heater. Under an applied 15 V, the heater's temperature increased at a rate of 8°C/second to reach a maximum of 120°C (248°F). By submerging the heater in liquid nitrogen for 5

minutes, the researchers demonstrated that the heater could function as a defroster, rapidly removing the frost on its surface under 12 V. As a demonstration of its high flexibility, the heater could be folded at a 90° angle without any increase in resistance, and continued to function even when folded in half, although with greater resistance.

The researchers also demonstrated that the MXene flakes can be used to make heated fabric. To do so, the researchers treated commercial polymer threads with a coating to enhance their electrostatic interaction with the MXene flakes. Then they dipped the threads into a water solution containing MXene flakes. The electrostatic interaction between the positively charged threads and negatively charged flakes caused the flakes to self-assemble onto the individual fibers, turning the white threads black in the process.

The MXene-coated threads were then sewn together with cotton to make heated clothing. Under a small voltage, each MXene flake acted as a tiny heater. By controlling the voltage, the researchers could gradually raise the temperature of cold skin back to normal body temperature without damage to the skin. In future applications, the heated clothing could be powered by conventional batteries or alternative power sources.

"Potentially, our heater can be powered by the energy stored in batteries and/or supercapacitors from a variety of emerging [renewable energy sources](#), such as wearable solar cells, triboelectric energy generators, and so on," Park said.

The researchers expect that the robust, flexible heated clothing could be useful for healthcare thermotherapy and monitoring, among other personal applications.

"Since the MXene flakes we developed with the solution process are highly conductive and optically transparent, a variety of applications are

possible, in particular, requiring transparent electrodes," Park said. "Examples include the development of mechanically flexible and thus wearable organic light emitting diode displays, photodetectors, and transparent touch and/or pressure sensors."

**More information:** Tae Hyun Park, Seunggun Yu, et al. "Shape-Adaptable 2D Titanium Carbide (MXene) Heater." *ACS Nano*. DOI: [10.1021/acsnano.9b01602](https://doi.org/10.1021/acsnano.9b01602)

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