Electronic solid could reduce carbon emissions in fridges and air conditioners

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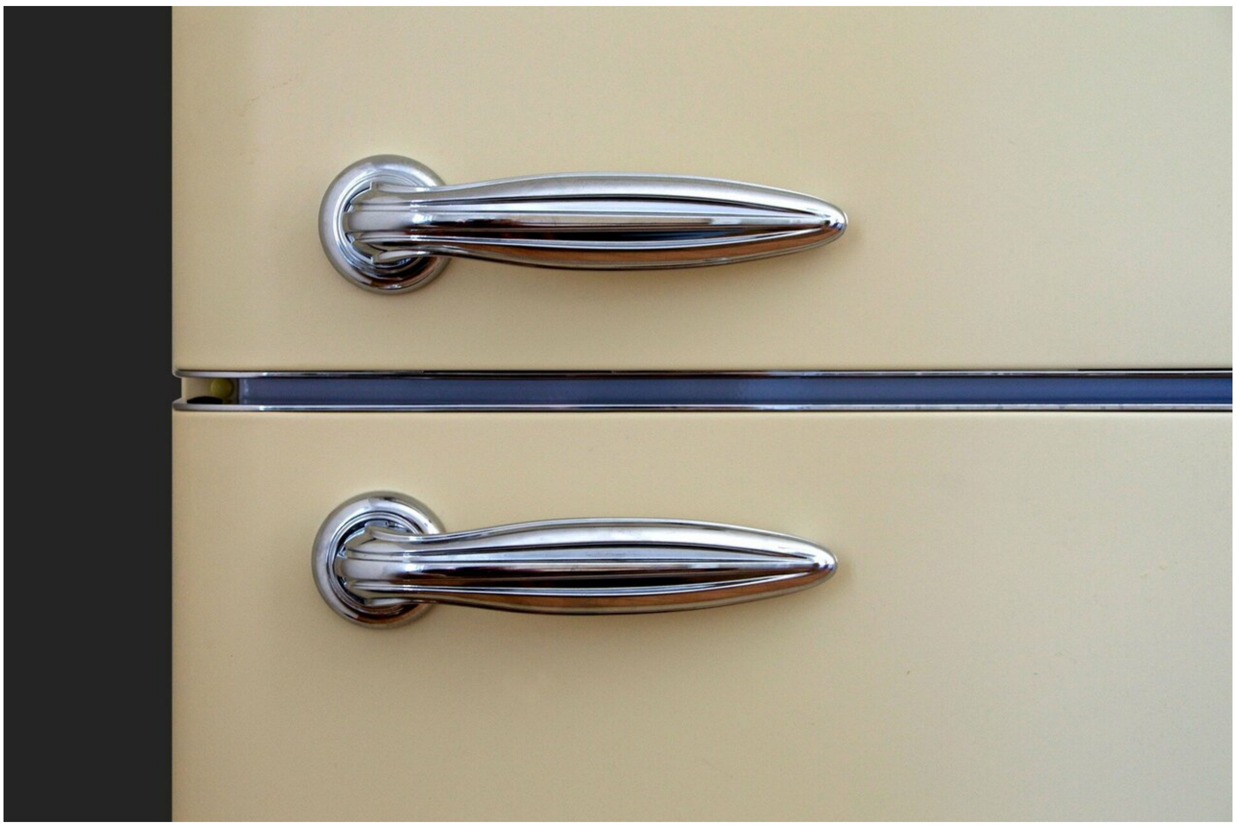

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A promising replacement for the toxic and flammable greenhouse gases that are used in most refrigerators and air conditioners has been identified by researchers from the University of Cambridge.

The device is based on layers of a material composed of oxygen and three metallic elements known as PST, and it displays the largest electrocaloric effects—changes in temperature when an electric field is applied—yet observed in a body large enough for cooling applications.

The results, reported in the journal *Nature*, could be used in the development of highly-efficient solid-state refrigerators and air conditioners, without the need for bulky and expensive magnets.

"When facing a challenge as big as climate change and reducing carbon emissions to net zero, we tend to focus on how we generate energy—and rightly so—but it's critical that we're also looking at the consumption of energy," said co-author Dr. Xavier Moya from Cambridge's Department of Materials Science & Metallurgy.

Refrigeration and air conditioning currently consume a fifth of all energy produced worldwide, and as global temperatures continue to rise, demand is only going to keep going up. In addition, the gases currently used in the vast majority of refrigerators and air conditioners are toxic, highly flammable greenhouse gases that only add to the problem of global warming when they leak into the air.

Researchers have been trying to improve cooling technology by replacing these gases with solid magnetic materials, such as gadolinium. However, the performance of prototype devices has been limited to date, as the thermal changes are driven by limited magnetic fields from permanent magnets.

In research published earlier this year, the same Cambridge-led team identified an inexpensive, widely available solid that might compete with conventional coolants when put under pressure. However, developing this material for cooling applications will involve a lot of new design work, which the Cambridge team are pursuing.

In the current work, the thermal changes are instead driven by voltage. "Using voltage instead of pressure to drive cooling is simpler from an engineering standpoint, and allows existing design principles to be repurposed without the need for magnets," said Moya.

The Cambridge researchers, working with colleagues in Costa Rica and Japan, used high-quality layers of PST with metallic electrodes sandwiched in between. This made the PST able to withstand much larger voltages, and produce much better cooling over a much larger range of temperatures.

"Replacing the heart of prototype magnetic fridges with a material that performs better, and does not require permanent magnets, could represent a game-changer for those currently trying to improve cooling technology," said co-author Professor Neil Mathur.

In future, the team will use high-resolution microscopy to examine the PST microstructure, and optimise it further in order to apply even larger voltages.

More information: Large electrocaloric effects in oxide multilayer capacitors over a wide temperature range, *Nature* (2019). DOI: 10.1038/s41586-019-1634-0 , nature.com/articles/s41586-019-1634-0

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