Researchers closer to the ultimate green 'fridge magnet'

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In the summer, air conditioning and refrigeration accounts for half the USA's energy use.

(PhysOrg.com) -- Scientists are a step closer to making environmentally-friendly 'magnetic' refrigerators and air conditioning systems a reality, thanks to new research published today in *Advanced Materials*.

Magnetic refrigeration technology could provide a 'green' alternative to traditional energy-guzzling gas-compression fridges and air conditioners. They would require 20-30% less energy to run than the best systems currently available, and would not rely on ozone-depleting chemicals or greenhouse gases. Refrigeration and air conditioning units make a major contribution to the planet's energy consumption - in the USA in the summer months they account for approximately 50% of the country's energy use.

A magnetic refrigeration system works by applying a magnetic field to a magnetic material - some of the most promising being metallic alloys - causing it to heat up. This excess heat is removed from the system by water, cooling the material back down to its original temperature. When the magnetic field is removed the material cools down even further, and it is this cooling property that researchers hope to harness for a wide variety of cooling applications.

The technology, based on research funded in the UK by the Engineering and Physical Sciences Research Council (EPSRC), has proved possible in the lab but researchers are still looking for improved materials that provide highly efficient cooling at normal room temperatures, so that the technology can be rolled out from the lab to people's homes and businesses.

They need a material that exhibits dramatic heating and cooling when a magnetic field is applied and removed, which can operate in normal everyday conditions, and which does not lose efficiency when the cooling cycle is repeated time after time.

The new study published today shows that the pattern of crystals inside different alloys - otherwise known as their microstructure - has a direct effect on how well they could perform at the heart of a magnetic fridge. The Imperial College London team behind the new findings say this could, in the future, help them to custom-design the best material for the job.

Professor Lesley Cohen, one of the authors of the paper, explains that by using unique probes designed at Imperial, her team, led by Dr James

Moore, was able to analyse what happens to different materials on a microscopic level when they are magnetised and de-magnetised. This enabled the team to pinpoint what makes some materials better candidates for a magnetic fridge system than others.

Professor Cohen, from Imperial's Department of Phsyics, said: "We found that the structure of crystals in different metals directly affects how dramatically they heat up and cool down when a magnetic field is applied and removed. This is an exciting discovery because it means we may one day be able to tailor-make a material from the 'bottom up', starting with the microstructure, so it ticks all the boxes required to run a magnetic fridge. This is vitally important because finding a low-energy alternative to the fridges and air conditioning systems in our homes and work places is vital for cutting our carbon emissions and tackling climate change."

This new research follows on from another study published by the same Imperial group in Physical Review B last month, in which they used similar probing techniques to precisely measure the temperature changes that occur when different materials are removed from a magnetic field, and to analyse the different ways they occur.

The lead scientist Kelly Morrison found that at the molecular level two different temperature change processes, known as first- and second-order changes, happen simultaneously in each material. The team think that the extent to which each of these two processes feature in a material also affects its cooling capabilities.

Professor Cohen says this means that whilst the majority of research to perfect magnetic refrigeration worldwide has tended to involve analysing and testing large samples of materials, the key to finding a suitable material for everyday applications may lie in the smaller detail:

"Our research illustrates the importance of understanding the microstructure of these materials and how they respond to magnetic fields on a microscopic level," she concluded.

More information:

1. 'Metamagnetism seeded by nanostructural features of single crystalline Gd5Si2Ge2', *Advanced Materials*, XX May 2009.

2. 'Capturing first- and second-order behavior in magnetocaloric CoMnSi0.92Ge0.08', *Physical Review B,* 6 April 2009.

Source: Imperial College London (news : web)