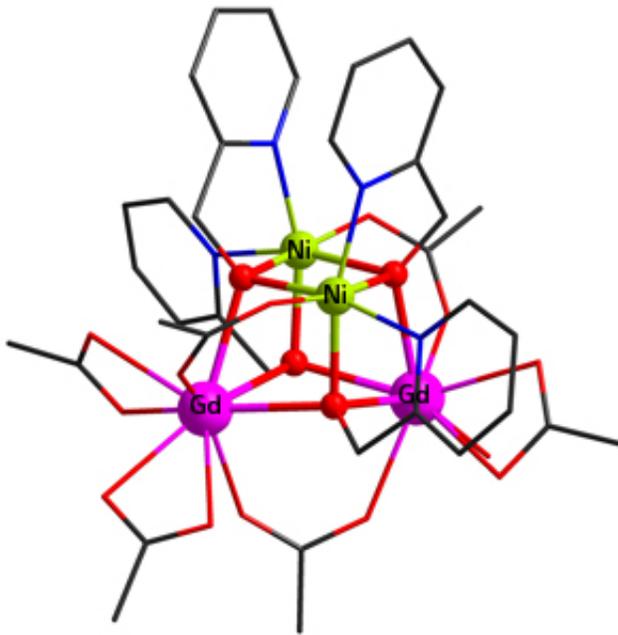


Gadolinium-based material that can be cooled by varying magnetic field

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The magnetic refrigerant contains a cubic structure made of two gadolinium ions (pink), two nickel ions (green) and four oxygen atoms (red), surrounded by 2-(hydroxymethyl)pyridine molecules. Credit: © 2014 A*STAR Institute of Materials Research and Engineering

Magnetic refrigeration is attracting attention as an efficient way to chill sensitive scientific instruments. This refrigeration method exploits the magnetocaloric effect, in which an external magnetic field controls the temperature of a magnetic material. Effective magnetic refrigerants are often difficult to prepare, but now Andy Hor of the A*STAR Institute of

Materials Research and Engineering and the National University of Singapore and his colleagues have created a powerful magnetic refrigerant that is easy to make in the lab.

Compounds with a large magnetocaloric effect typically contain atoms with many unpaired electrons, each of which generates its own tiny magnetic moment. During [magnetic refrigeration](#), an external [magnetic field](#) forces these atomic magnetic moments to line up in the same direction. As the magnetism of the atoms becomes more ordered (which reduces the entropy of the system), the material's temperature rises.

Once the heat has been removed by a flowing liquid or gas, the external magnetic field is reduced. This allows the atomic magnetic moments to become disordered again, cooling the material so that it can be used to draw heat from an instrument, before repeating the cycle.

Magnetic refrigerants commonly use the gadolinium(III) ion (Gd^{3+}), because it has seven unpaired electrons. Most gadolinium complexes are made under harsh conditions or take a very long time to form, which limits their wider application. In contrast, the magnetic refrigerant developed by Hor and colleagues is remarkably easy to make.

The researchers simply mixed gadolinium acetate, nickel acetate and an organic molecule called 2-(hydroxymethyl)pyridine in an organic solvent at room temperature. After 12 hours, these chemicals had assembled themselves into an aggregate containing a cube-like structure of atoms at its heart (see image).

The team measured how an external magnetic field affected this 'cubane' material as the temperature dropped. Below about 50 K, they found that the material's magnetization increased sharply, suggesting that it could be an effective magnetic refrigerant below this temperature.

The scientists then tested the effects of varying the [external magnetic field](#) at very low temperatures. They found that at 4.5 K, a large external field caused an entropy change that was close to the theoretical maximum for the system—and larger than most other magnetic refrigerants under similar conditions.

According to the team, the magnetocaloric effect of magnetic refrigerants has typically been enhanced by creating ever-larger clusters of metal atoms. In contrast, their cubane shows that much simpler aggregates, prepared under straightforward conditions, are promising as magnetic [refrigerants](#).

More information: Wang, P., Shannigrahi, S., Yakovlev, N. L., and Hor, T. S. A. Facile self-assembly of intermetallic [Ni₂Gd₂] cubane aggregate for magnetic refrigeration. *Chemistry – An Asian Journal* 8, 2943–2946 (2013). [dx.doi.org/10.1002/asia.201300838](https://doi.org/10.1002/asia.201300838)

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