Magnetocaloric Effect of a Molecular Nanomagnet

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The magnetocaloric effect is the heating or cooling of a material when a magnetic field H is applied or removed. The reduction of magnetic entropy provoked by the field implies an increase of lattice vibrations in an adiabatic process and, consequently, a raise of temperature. It is tied to the alignment of the magnetic moments, decreasing the number of thermally accessible Zeeman states. The most relevant quantities describing the main features of the material as a refrigerant are the isothermal entropy change ΔS_T and the adiabatic temperature increment ΔT_S when a field H is applied. A suitable substance for magnetic refrigeration should have the highest possible values for these magnitudes in the range of the working temperatures. The characterization of a given material can be done with magnetization, with field dependent heat capacity (C_p,H), or with direct measurements of ΔS_T and ΔT_S. We have measured the magnetic cluster $Fe_{14}(ta)_6O_6(OMe)_{18}Cl_6$ in which the 14 Fe^{3+} s=5/2 provide a total spin S=25 [1]. The clusters interact magnetically, ordering at 3 K. The huge spin value together with the magnetic transition provides a record cooling capacity using its magnetocaloric properties in the helium temperature range. The heat capacity of $Fe_{14}(ta)_6O_6(OMe)_{18}Cl_6$ has been measured at various fields between 0 and 6 Teslas. The field dependent entropy curves have been calculated and the magnetocaloric parameters ΔS_T and ΔT_S have been deduced. Isothermal magnetization measurements permit to calculate the isothermal entropy change using the Maxwell thermodynamic relations, and together with the heat capacity data obtain the adiabatic temperature increment. Using the basic features of an adiabatic calorimeter a unique system has been devised to obtain direct measurements of ΔS_T and ΔT_S [2]. It solves the problems of big inaccuracies in the deduction of the magnetocaloric parameters from heat capacity measurements and the inapplicability of the Maxwell relations in first order transitions.

[1] D.M. Low, L.F. Jones, A. Bell, E.K. Brechin, T. Mallah, E. Rivière, S.J. Teat, and E.J.L. McInnes, Angew. Chem. Int. Ed. **42**, 3781 (2003).
[2] M L. Tocado, E. Palacios, R. Burriel, J. Magn. Magn. Mater. **290-291**, 719 (2005).