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A new scale for optimized cryogenic magnetocaloric effect in $ErAl_2@Al_2O_3$ nanocapsules

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The $ErAl_2@Al_2O_3$ nanocapsules with $ErAl_2$ core and Al_2O_3 shell were synthesized by modified arc-charge technique. The typical core-shell structure of the nanocapsules was confirmed by high resolution transmission electron microscopy and X-ray photoelectron spectroscopy. Transmission electron microscopy analysis shows the irregular sphere of the nanocapules with an average diameter of 26 nm. Magnetic investigation revealed the Curie temperature of $ErAl_2@Al_2O_3$ nanocapsules at 20 K and the typical superparamagnetic behavior between blocking temperature and Curie temperature. Based on the blocking temperature and average diameter, the magnetocrystalline anisotropy constant of $ErAl_2@Al_2O_3$ nanocapsules was estimated to illustrate the magnetic contribution to the $-\Delta S_M$. The large $-\Delta S_M$ of 14.25 J/(kg K) was obtained under 50 kOe at 5 K. A vital parameter β was introduced in the present work to scale the optimized magnetic characteristics and the optimized mechanism was discussed in detail according to classical superparamagnetic theory. The results demonstrate that the optimal $-\Delta S_M$ will be obtained when the magnetic parameter β is close to the theoretical coefficient.

Keywords: Nanocapsules; Magnetocaloric effect; Superparamagnetic property; Cryogenic refrigeration