Ensuring the future affordability of wind turbines, computers and electric cars

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Technologies from wind turbines to electric vehicles rely on critical materials called rare-earth elements. These elements, though often abundant, can be difficult and increasingly costly to come by. Now, scientists looking for alternatives have reported in ACS' journal *Chemistry of Materials* a new way to make nanoparticles that could replace some rare-earth materials and help ensure the continued supply of products people have come to depend on.

Rare-earth elements have unique characteristics that make them very useful. For example, the world's strongest magnets are made with neodymium. A little too powerful for your refrigerator, these magnets are incorporated into computer disk drives, power windows and wind turbines. But rare earths are challenging to mine and process, and prices can rise quickly in a short period of time. Given the increasing demand for rare earths, Alberto López-Ortega, Claudio Sangregorio and colleagues set out to find substitutes for use in strong magnets.

The researchers used a mixed iron-cobalt oleate complex in a one-step synthetic approach to produce magnetic core-shell nanoparticles. The resulting materials showed strong magnetic properties and energy-storing capabilities. Their approach could signal an efficient new strategy toward replacing rare earths in permanent magnets and keeping costs stable, the researchers say.

More information: Strongly exchange coupled core|shell nanoparticles with high magnetic anisotropy: a strategy towards Rare Earth -free

permanent magnets, DOI: 10.1021/acs.chemmater.6b00623

Abstract
Antiferromagnetic(AFM)|ferrimagnetic(FiM) core|shell (CS) nanoparticles (NPs) of formula Co0.3Fe0.7O|Co0.6Fe2.4O4 with mean diameter from 6 to 18 nm have been synthesized through a one-pot thermal decomposition process. The CS structure has been generated by topotaxial oxidation of the core region, leading to the formation of a highly monodisperse single inverted AFM|FiM CS system with variable AFM-core diameter and constant FiM-shell thickness (~2 nm). The sharp interface, the high structural matching between both phases and the good crystallinity of the AFM material have been structurally demonstrated and are corroborated by the robust exchange-coupling between AFM and FiM phases, which gives rise to one among the largest exchange bias (HE) values ever reported for CS NPs (8.6 kOe) and to a strongly enhanced coercive field (HC). In addition, the investigation of the magnetic properties as a function of the AFM-core size (dAFM), revealed a non-monotonous trend of both HC and HE, which display a maximum value for dAFM = 5 nm (19.3 and 8.6 kOe, respectively). These properties induce a huge improvement of the capability of storing energy of the material, a result which suggests that the combination of highly anisotropic AFM|FiM materials can be an efficient strategy towards the realization of novel Rare Earth-free permanent magnets.

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