Fe_3O_4/Mn_3O_4 core/shell nanoparticles: interface-controlled exchange coupling

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Bi-magnetic core-shell nanoparticles have had a sustained interest during the last decades owing to their unique magnetic properties and the wide range of potential applications.[1] The morphology (such as core diameter, shell thickness, and shape), constituent materials, and their interface are key in determining the final properties, thus, precise determination of these parameters is essential for understanding and adapting their functionalities. Here, we present the in-depth study of exchange coupled Fe_3O_4/Mn_3O_4 and Mn_3O_4/Fe_3O_4 core/shell nanoparticles using a wide range of advanced techniques. High-resolution electron microscopy and synchrotron techniques have revealed that the interface sharpness can be controlled by the synthesis parameters, to occur either through a gradual composition change or an abrupt transition between both materials.[2-4] This difference leads to a significantly different magnetic properties of the system. In cases of a gradual interface, the system mimics the behaviour of traditional exchange-spring magnets.[5] Conversely, when an abrupt interface is present, a distinctive antiferromagnetic coupling between both materials emerges.[6,7] This leads to a range of new phenomena such as a reorientation of the magnetization of the Mn_3O_4 counterpart, from antiparallel to parallel, at high magnetic fields or an exchange bias that changes from negative to positive for large cooling fields. Finally, due to the interface coupling between the Fe_3O_4 and Mn_3O_4 a sizable enhancement of the transition temperature, to above room temperature, of the Mn_3O_4 moiety has been observed, which is ascribed to a magnetic proximity effect.[8]

References

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