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Impact of functionalizing organic molecules on properties of magnetic nanoparticles

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Magnetic nanoparticles (MNPs) have recently attracted much attention for both basic research and application interests. The superparamagnetic behavior of MNP when particle diameter becomes smaller than a few tens nanometers was known yet more than 60 years ago and is a prime property concern in almost all the reports on MNPs today. In applications, the particles need to be functionalized to protect them from oxidation and to make them compatible to the environment. In many cases, especially in biomedicine, the functionalizing materials used are those of organic molecules. Many applications demand the MNP to possess high magnetization. However, the fact that magnetic moment of as-synthesized MNP is reduced from the bulk form value when decreasing particle diameter was realized yet in 1971 by Coey, which is explained to due to the so called spin canting of the outermost layer. The reports on effect of functionalization of MNP by nonmagnetic materials are not coincide with each other although in most of the cases it gives a further reduction of magnetization from that of as-synthesized materials. A very few publications reporting on the improvement of magnetic moment by functionalization have, from one side, made a hope for application researchers, and on the other side, raised an interesting topic for basic research to seek for origin of the effect.

The purpose of this talk is to address the question how organic molecules (OM) can influence the magnetic properties of MNP in general and magnetization in particular. After introducing various methods used for synthesis and different organic materials applied for functionalization of MNP, typical single and multi-core functionalized structures will be reviewed. The MNPs confinement will be introduced as via chemical and physical type regarding the nature of their interaction with OM. Role of the anchoring group will be discussed as to create chemical bonding on the MNP surface, whose the impact depends not only on the type of characteristic molecule groups but also on the protocol of the ligand exchange procedure. As for multi-core composite structures, examples will be overviewed for both small molecule and amphiphilic copolymers. Aside the magnetization, behavior of other magnetic properties such as anisotropy, interparticle interaction or proton relaxability are also discussed. Finally, our preliminary results on improvement of magnetic performance in Fe₃O₄ nanoparticles functionalized by PLA-PEG will be presented.

References

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