# Carbon-encapsulated magnetic nanoparticles spontaneously formed by thermolysis route

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Carbon-encapsulated magnetic nanoparticles (CEMNPs) are core-shell structures which posess interesting chemical and physical properties. The small size of the core allows to fabricate single domain ferromagnetic nanoparticles, which have much higher coerciviety and remanence than bulk materials. The carbon shell protects the encapsulated crystallites from the oxidation and further agglomeration. CEMNPs have attracted increasing interest because of their intrinsic physical properties, resulting in a wide range of applications in such fields as magnetic data storage, sensors, xerography, ferrofluids, magnetic resonance imaging, and targeted drug delivery systems.

Carbon arc method and RF thermal plasma torch are the main techniques that allow mass production of CEMNPs. However, both methods need sophisticated equipment what drastically limits their use. Thus, developing of new methods which are simplier and use low-cost materials is of a great importance. We showed recently that thermolysis offers a potential for generating inorganic nanostructures [1, 2]. During the course of self-sustaining highly exothermic reaction, rapid solidification of products creates nanostructures that would be otherwise difficult to make. Herein we propose a new method for producing carbon-encapsulated magnetic nanoparticles by means of the thermolysis. The method is based on dechlorination of $C_2Cl_6$ or $C_6Cl_6$ with $NaN_3$ in the presence of ferrocene, iron or Fe-Nd-B magnetic alloy.

The as-obtained products contained CEMNPs with the diameters 10-40 nm. The products were purified and their composition and morphology was studied by means of SEM, TEM, XRD, and DTA/TG. The magnetic hysteresis loops were also recorded. The nanoparticles exhibit superparamagnetic behaviour with the maximum saturation magnetization of 22 emu/g. This autothermal process has inherent advantages, including the use of low cost materials and the simplicity of the production protocol, and can be also used to obtain other nanoencapsulates.

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[1] A. Huczko et al., *J. Phys. Chem. B.*,**109**, 16244 (2005).
[2] S. Cudziło et al., *Carbon* **43**, 1778 (2005).