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Rapid Microwave-Assisted Method for Preparation of Magnetic Nanoparticles for Hyperthermia Treatment

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INTRODUCTION: At the present time, magnetic hyperthermia treatment of cancer gets great attention due to its efficiency and harmlessness. The principle of this method is damaging the tumour cells by the heat generated by application of AC magnetic field on magnetic nanoparticles introduced into the diseased tissue.[1, 2] Since the values of strength and frequency of magnetic field are restricted for therapeutic application, the challenge is preparation of particles of suitable size and shape as well as excellent magnetic properties. Therefore many synthetic strategies for preparation of magnetic nanoparticles were published from which solvothermal methods appear to be ones of the most simple and efficient.[3] However, some aspects of these methods, namely the duration of the synthesis and relatively low yields lead us to use microwave pressurized system by which we are able to prepare particles within few minutes in high yields and simple tune particle properties.

METHODS: Magnetic nanoparticles were prepared by microwave-assisted solvothermal method using CEM Mars 5 pressurized reactor (CEM Corporation). $FeCl_3.6H_2O$ was used as the source of ferric ions, ethylene glycol as a solvent and reducing agent and aqueous NH_3, $(NH_4)_2CO_3$, **NH_4Ac** or NH_4CO_3 served as nucleating agents. Reactants were mixed together, loaded into Teflon vessels and heated in microwave reactor at the required temperature (200, 210, 220 °C) for 30 minutes. The as-obtained product was filtered off and allowed to dry at room temperature. The particle properties were investigated by X-ray diffraction (XRD), scanning electron microscopy (SEM) and vibrating sample magnetometry (VSM).

RESULTS: The XRD analyses confirm that the resulting product is Fe_3O_4 (magnetite or maghemite). As can be seen in Figure 1, particles are uniform, nanosized (around 200 nm) with spherical shape. VSM measurements showed that the saturation magnetization values vary from 8 to 76 emu.g^{-1} depending on synthesis conditions.

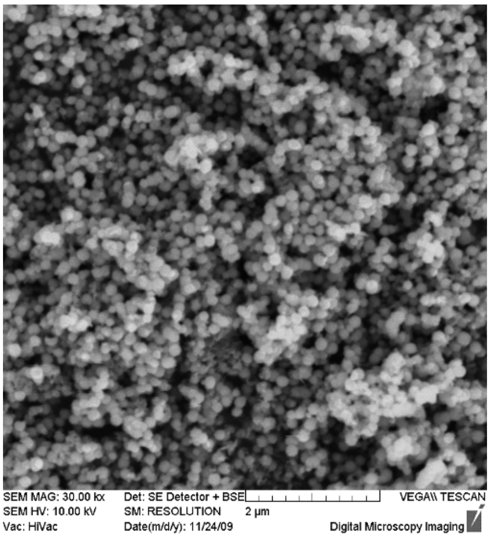

Fig. 1: SEM image of Fe_3O_4 particles prepared with NH_4Ac at 220 °C for 30 minutes.

DISCUSSION & CONCLUSIONS: Microwave-assisted solvothermal synthesis of magnetic nanoparticles presented here is a fast method by which the product can be obtained in 30 minutes with suitable properties. As-prepared particles are uniform in shape, nanosized and exhibit ferromagnetic behaviour. Moreover, particles morphology and magnetic properties can be simply tuned by changing the synthesis conditions, namely, temperature, concentration of ferric ions as well as the type and concentration of nucleating agent. Temperature control of synthesis proved to be appropriate and very sensitive tool for tuning the magnetic properties when NH_4Ac or $(NH_4)_2CO_3$ are used as nucleating agents. However, is not so applicable while using aqueous NH_3, although saturation magnetization is higher than in previous two cases.

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