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Controlling iron-oxide nanoparticle size with nanometer precision to synthesize monodispersed particles: a theoretical and experimental investigation.

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Nanosized iron-based magnets have attracted a great deal of attention in life-sciences and health-care research where they find use in tissue-specific drug delivery, contrast enhancement agents in magnetic resonant imaging (MRI) and cell separation, among others. To improve the efficiency of these nanoparticles (NPs), a very narrow size distribution centering on a small NP size is required, since this directly affects the superparamagnetic behavior. Despite great progress in the synthesis of iron-oxide NPs using thermal decomposition methods, production of NPs with a low polydispersity index is still a challenge. To narrow down the size distribution, size selective precipitation processes have to be performed. In this study we show that, for the first time, the production of monodisperse iron-oxide NPs are indeed possible without employing any post synthesis size-selective procedures. Surfactants oleic acid and oleylamine were used and an experimental and theoretical study on the role of the surfactant ratio to NP size-distribution was carried out. It was observed that at a very specific acid/amine ratio of 3/1, different synthesis procedures may yield truly monodisperse NPs with polydispersity of less than 7%. This acid/amine ratio of 3/1 allowed for the control of the NP size with nanometer precision by simply changing the reaction heating rate. We were able to predict this specific ratio by performing molecular dynamic simulations in advance that revealed a maximization of binding energy at this ratio. HRTEM and XRD were used to confirm the narrow size distribution and hysteresis loops recorded at 300 K and 2 K confirmed the superparamagnetic character of the NPs.

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