Surface Modification of Iron Oxide Nanoparticles by a Phosphate-based Macromonomer and Further Encapsulation into Submicrometer Polystyrene Particles by Miniemulsion Polymerization

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Nanocomposite polymer particles incorporating magnetic iron oxides such as magnetite (Fe_3O_4) or maghemite (γ-Fe_2O_3) find a wide range of applications, notably in the biomedical field[1]. Among the numerous works which have already been devoted to the synthesis of magnetic particles[2], some examples have been recently reported on miniemulsion polymerization[3-9]. Some of them show very interesting results with an effective and homogeneous incorporation of iron oxide inside particles exhibiting narrow size distribution, together with a high magnetic content[4]. But most of these studies suffer from the following drawbacks: 1) inhomogeneous distribution of the magnetic nanoparticles inside and among the particles and/or 2) polymer particles not incorporating magnetic material and/or 3) residual free nanoparticles or magnetic aggregates in the aqueous phase and/or 4) large particle size distribution and/or 5) limited loading of the particles with magnetic material.
Since the surface of iron oxides is hydrophilic, their successful incorporation into polymer particles using miniemulsion polymerization first relies on an effective surface modification to render iron oxides/polymer compatible. The adsorption of oleic acid is commonly used to favour this incorporation. Its carboxylate head is able to anchor on the surface of iron oxide nanoparticles, while its aliphatic hydrophobic tail ensures steric stabilization as well as compatibility with the solvent. However, with respect to the above mentioned drawbacks and especially those related to inhomogeneous distribution of iron oxides, increasing the compatibility of the magnetic nanoparticles with the polymer may still improve the repartition of iron oxide inside and among the particles. Furthermore, the use of a monomer as the dispersing phase instead of organic solvents such as octane or toluene should also be more appropriate.
The work presented in this paper focuses on the elaboration of submicrometer magnetic polystyrene particles via miniemulsion polymerization. The originality of the system relies on the modification of iron oxide nanoparticles using a non-conventional phosphate-based poly(propylene glycol) methacrylate monomer as stabilizer (PAM200). Phosphate groups are indeed known to strongly link to iron oxides surface, while the methacrylate function should favour irreversible incorporation of iron oxide inside the PS particles through copolymerization with styrene. This surfmer has been evaluated for the elaboration of stable dispersions of magnetic nanoparticles in styrene, dispersions which have been subsequently used for styrene miniemulsion polymerization.

References

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