Remote magnetic heating of smart thermoresponsive PNIPAM-Fe_3O_4 nanocomposites

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The interest on biocompatible smart materials for medical applications has been growing progressively in the last decade.

In particular hydrogels based on PNIPAM (poly N-isopropyl acrylamide) are considered an advance for drug delivery due to their peculiar thermal response. PNIPAM undergoes a reversible phase transition from a swollen hydrated state to a shrunken dehydrated state when heated in water above a critical temperature that is about 32°C (Lower Critical Solution Temperature, LCST)

Magnetic functionality has been recently added to PNIPAM hydrogels and magnetic cores coated with PNIPAM shells have been synthesized in order to induce the PNIPAM shrinkage by controllable high-frequency magnetic field [1].

In particular, our approach in this field refers to reverse composite- hydrogels consisting in PNIPAM-co-acrylic acid hydrogels used as templates for the deposition of magnetic nanoparticles [2]. Non coated and superparamagnetic (SPM) magnetite (Fe_3O_4) nanoparticles, with a narrow size distribution around 8 nm, have been used in order to assure effective magnetic functionality and biocompatibility for remote magnetic manipulation of in-vivo applications.

Similarly to the core- shell hydrogels, the reverse composite-hydrogels easily undergo to LCST under high-frequency magnetic field.

From the TGA profile of the various reverse composite-hydrogels we found that there is a limit for the loading of magnetite nanoparticle (MNP). This limit is achieved using a starting MNP/NIPAM ratio bigger than 2% (w/w).

The LCST of the fully loaded composite-hydrogels has moved to temperatures around 40°C with an average diameter decrease of ≈ 20%.

Remote magnetic heating has been successfully achieved by application of an alternating RF magnetic field (B=27 mT and f=260KHz) to the thermoresponsive PNIPAM-magnetite nanocomposites. The observed temperature increase overcomes the LCST where the MNP/NIPAM nanocomposites shows thermal shrinking, making this system suitable for externally controlled drug delivery .

References

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