mechanical properties. Over and above the effort to make magnetic hydrogels for the drug release shed light on the embedding of MNPs into the hydrogel (Fig. 13). This process includes the following steps:

1. Synthesis of the MNP hydrogel and characterization
2. Encapsulation of drugs in the MNP hydrogel
3. Intravenous injection of the magnetic hydrogel (this point becomes very easy if the hybrid magnetic hydrogels are thixotropic)
4. Targeting to the pathological site via an applied static magnetic field (SMF) gradient
5. Release of drug from magnetic hydrogel via alternating magnetic field (AMF).

Magnetic hybrid hydrogels with functionalized $CoFe_2O_4$ MNPs covalently bonded to a carboxymethylcellulose (CMC) polymer were prepared (Barbucci et al. 2011). The $CoFe_2O_4$ MNPs were modified with an aminopropyl silane to introduce amino groups onto the surface of metal oxide NPs as nano-crosslinkers, which were also bound to the carboxylic groups of the CMC polymer via amide bonds (Fig. 14). The injectability of the hydrogel through a syringe is a witness of its thixotropic nature, this characteristics facilitates the introduction of such materials at the site of application. Steady state flow tests were performed on the hydrogels before and after the passage through a syringe. The yield stress represents the stress that is necessary to overcome the rigidity of the structure, namely to initiate flow. During the steady state flow test, the sample is subjected to an increasing shear stress. In Fig. 15, the shear rate is plotted as a function of the shear stress. The results of the test are reported for the native hybrid hydrogel, for the hydrogel immediately after being squeezed and for the squeezed hydrogel after one hour of rest. A decrease in the yield stress for the hydrogel immediately after squeezing compared to that of the native one was observed. After 1 hr of rest, the squeezed hydrogel showed the same yield stress of the native one. This demonstrates that the material recovers the initial characteristics after a suitable period of time, even maintaining the chemical structure after the passage through the syringe.

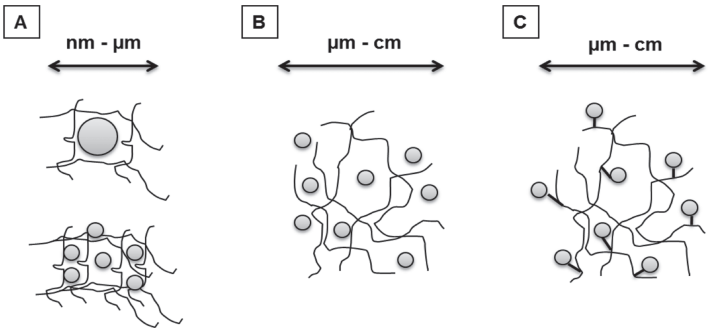

Fig. 13. Combination of nanoparticles and hydrogel to form new functional materials. Three structural designs: (a) micro- or nano sized hydrogel particles stabilizing inorganic or polymer nanoparticles, (b) nanoparticles non covalently immobilized in a hydrogel matrix, and (c) nanoparticles covalently immobilized in hydrogel matrix.