

Supplementary Information

Dual T_1/T_2 MRI contrast agent based on hybrid SPION@coordination polymer nanoparticles

by Borges et col.

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S1. Mossbauer characterization of CPP-Fe nanoparticles

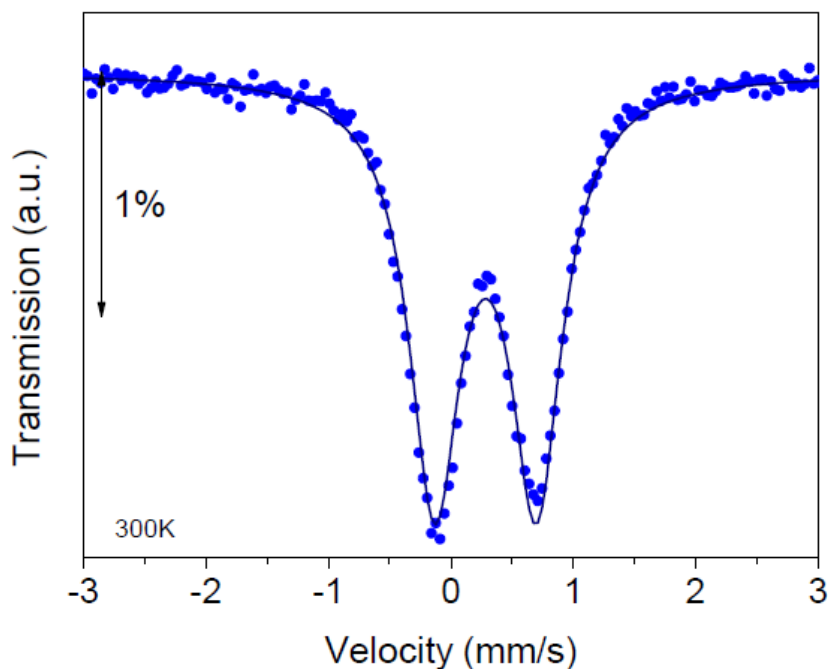


Figure S1: Mössbauer spectra for **CPP-Fe** at 300 K. Experimental data (dots), and computer fitted spectrum (solid line) for high-spin Fe(III). Hyperfine parameters of the fitting of the Mössbauer spectra at 300 K showed the isomer shift relative to the metallic iron (δ_{Fe}), quadrupolar splitting (ΔE_Q) and the full width at half maximum (Γ). The spectrum was fitted to a single doublet with a $\Delta E_Q = 0.83 \pm 0.01$ mm/s and $\Gamma = 0.5$ mm/s. The fitting was centered at an isomeric shift $\delta = 0.39 \pm 0.01$ mm/s attributed to high-spin Fe(III) ions.

S2. SPIONs characterization

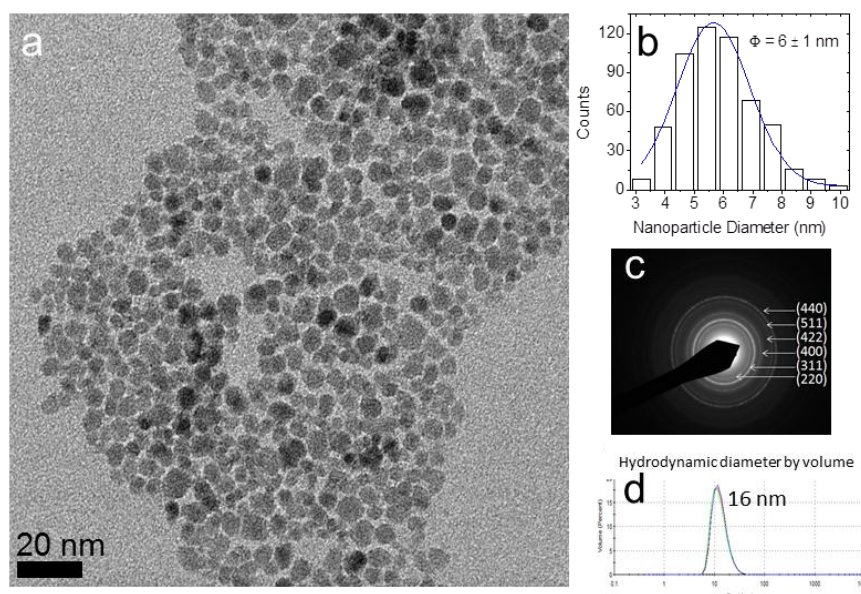


Figure S2a. a) TEM image of the synthesized SPIONs, b) Diameters size histogram of SPIONs determined by TEM, c) Selected area electron diffraction pattern of SPIONs and d) Volume-weighted hydrodynamic diameter distribution of SPIONs dispersed in MQ H₂O determined by dynamic light scattering.

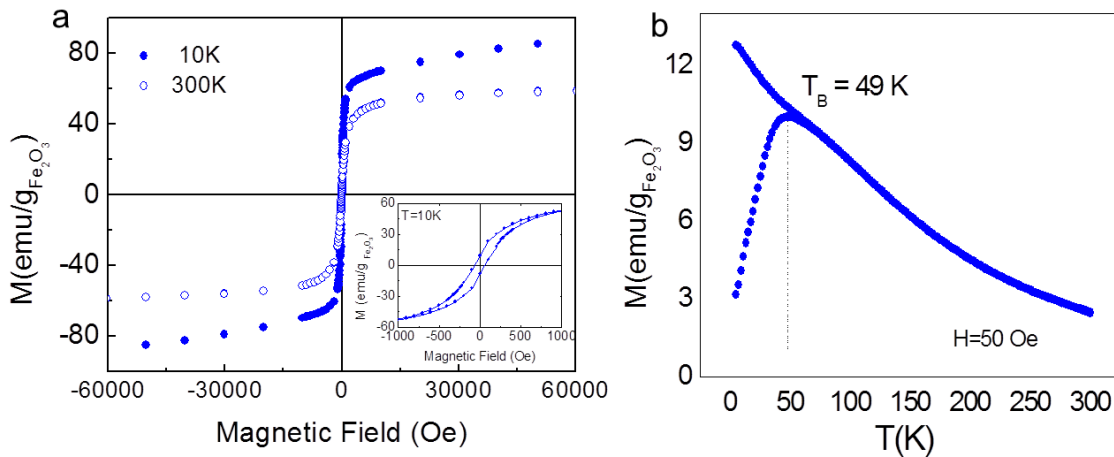


Figure S2b. a) Magnetization curve of SPIONs measured at 10K and 300k. Inset is the hysteresis loop in low magnetic field region measured at 10K, b) ZFC-FC curve of SPIONs obtained at a magnetic field of 50 Oe.

S3. Concentration effect: *SPIONs versus CPP-Fe nanoparticles*

Different batches of **SPION@CPP-Fe** nanoparticles were synthesized by using different amounts of the SPIONs (0.1, 0.3, 0.5 and 0.9 mM) added with the iron salt to the bix and caffeic acid ligands ethanolic solutions under sonication. The different **SPION@CPP-Fe** nanoparticles were checked by STEM to observe the encapsulation rates. In general, low concentration of SPIONs affords low encapsulation rates and high concentration of SPIONs results in agglomeration of the hybrid nanoparticles. The best encapsulation rates and nanoparticles dispersion was achieved for the sample starting from an initial concentration of SPIONs of 0.3 mM.

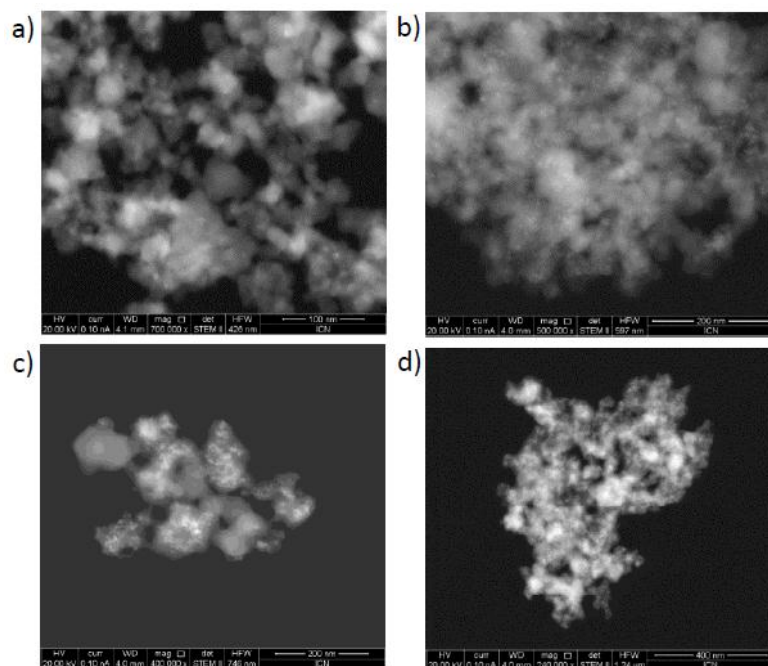


Figure S3: STEM images for **SPION@CPP-Fe** nanoparticles obtained with different concentrations of SPION NPs. a) 0.1 mM, b) 0.3 mM, c) 0.5 mM, and d) 0.9 mM.

S4. Characterization of SPION@/CPP-Fe

S4.1. SEM/STEM

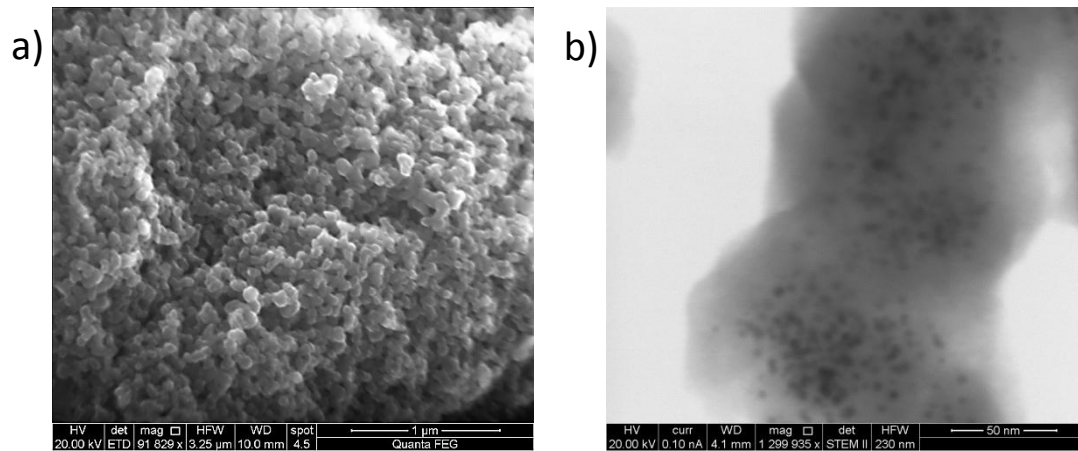


Figure S4a: a) SEM and b) STEM images in transmission mode of **SPION@CPP-Fe** nanoparticles.

S4.2. EDX

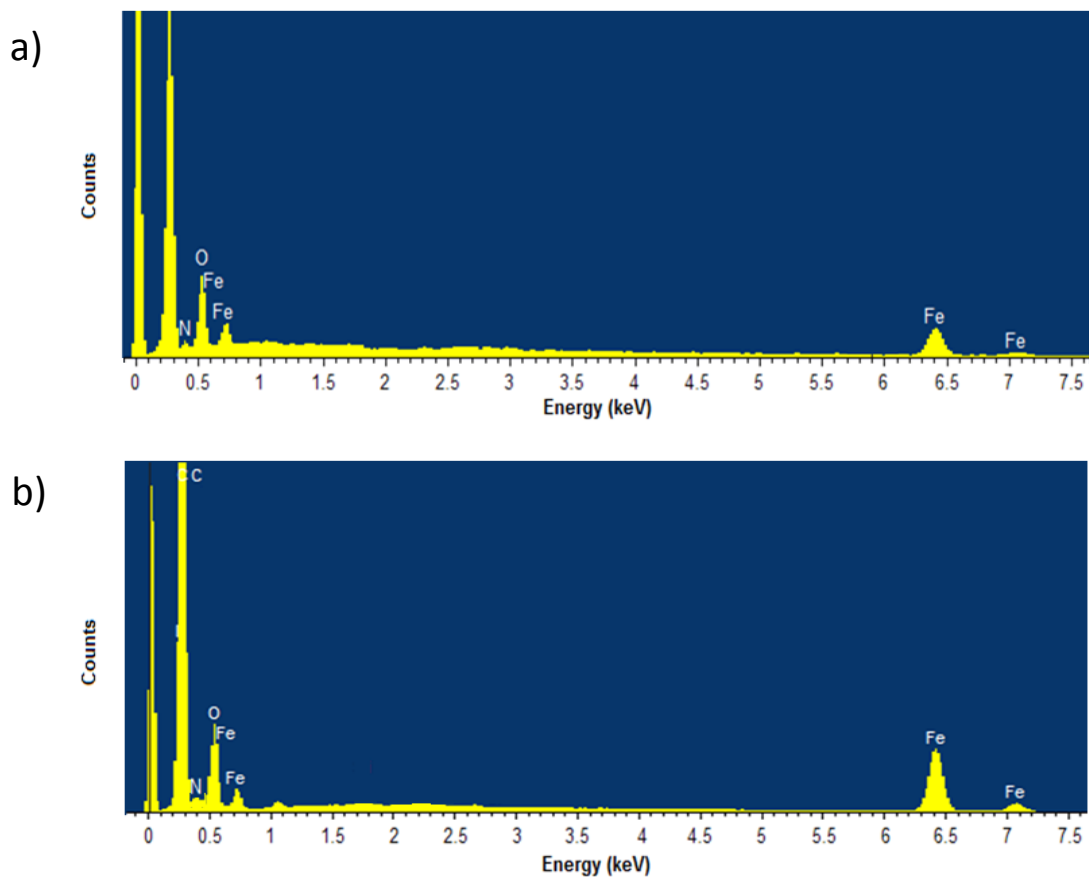


Figure S4b: EDX analysis showing the major elements that compose the nanoparticles for a) **CPP-Fe**, and b) **SPION@CPP-Fe**.

S4.3. DLS

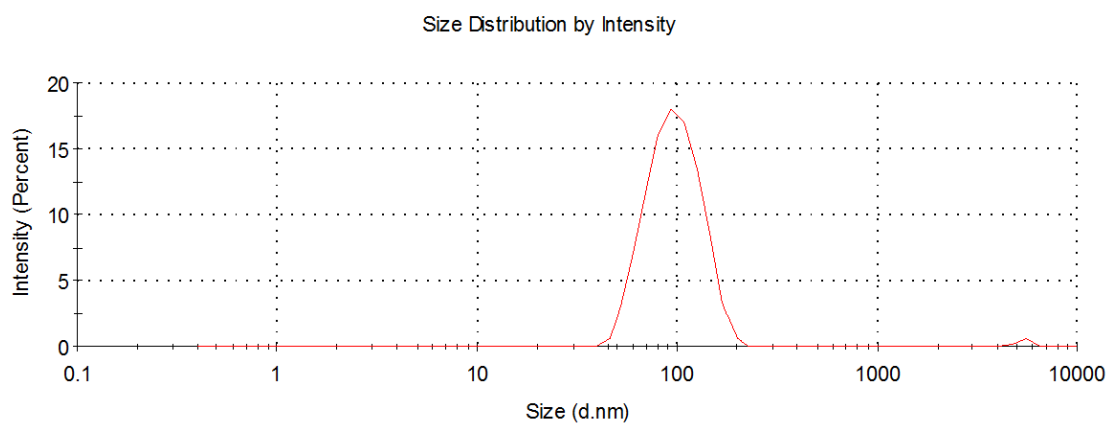


Figure S4c: DLS measurements of **SPION@CPP-Fe** sample used in the present study.

S4.4. FT-IR

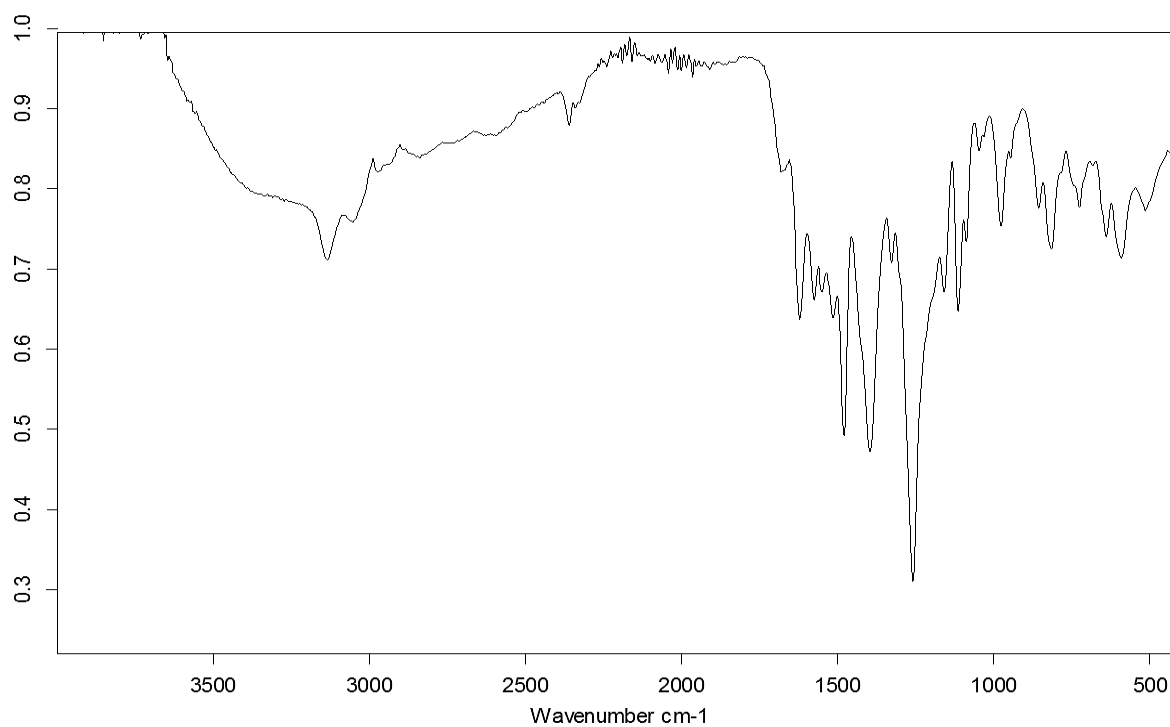


Figure S4d: FT-IR spectrum of **SPION@CPP-Fe** nanoparticles.

S4.5 XRD

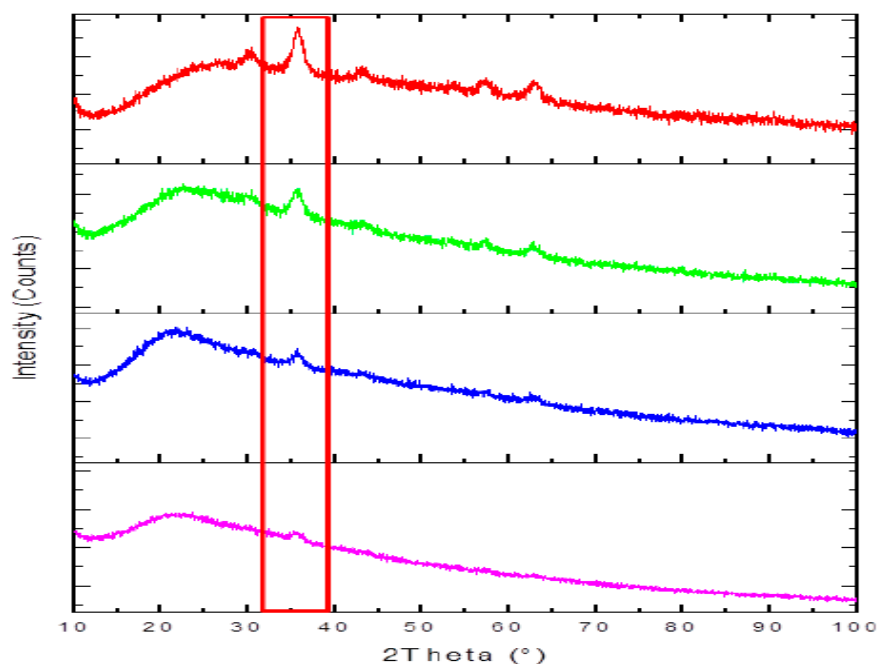
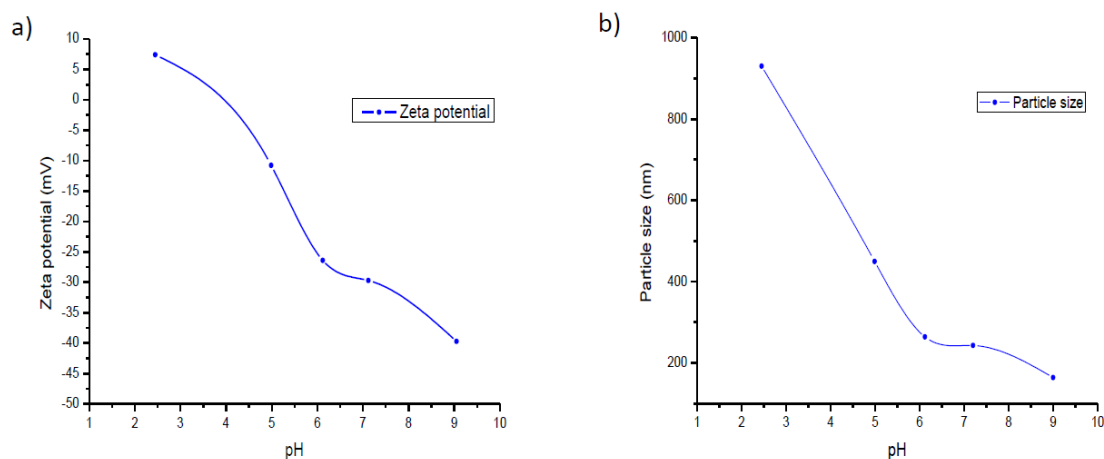


Figure S4e. XRD patterns for **SPION@CPP-Fe**; obtained using different concentration of SPION nanoparticles: a) 0.1 mM (purple), 0.3 mM (blue), 0.5 mM (green), and 0.9 mM (red). The typical signals from SPION increase their intensity respect to the amorphous background from the **CPP-Fe** matrix.

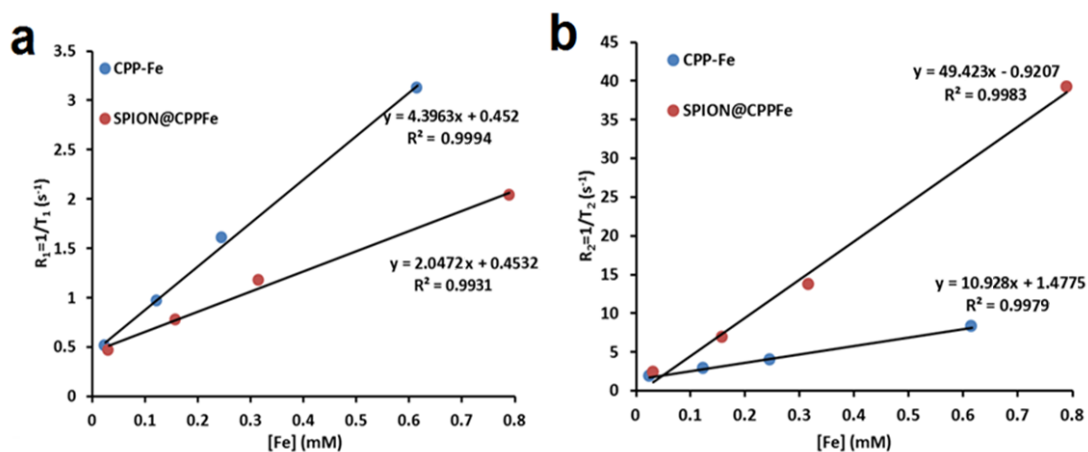
S5. Colloidal Stability of SPION@CPP-Fe and pH dependence



pH	Z-potential (mV)	Particle size (nm)
2.5	7.4	929.7
5.0	-10.8	449.5
6.1	-26.4	264.1
7.2	-29.7	243.0
8.5	-34.3	222.1
9.0	-39.0	164.0
11.2	-35.5	701.1

Figure S5. Evolution of the a) Z-potential, and b) particle size of an aqueous solution containing **SPION@CPP-Fe** nanoparticles (20 mM) with pH. The comparative results indicate that the best dispersion and higher colloidal stability has been achieved at pH 9.

S6. Relaxativity measurements for CPP-Fe and SPION@CPP-Fe.



c

		r_1 (mM s) ⁻¹	r_2 (mM s) ⁻¹	r_2/r_1
T_1	CPP-Fe	4.4	-	2.5
	SPION@CPP-Fe (based total [Fe])	2.1	-	23.5
	SPION@CPP-Fe (based [Fe] from CPP-Fe)	2.8	-	66.2
T_2	CPP-Fe	-	10.9	
	SPION@CPP-Fe (based total [Fe])	-	49.4	
	SPION@CPP-Fe (based [Fe] from SPIONs)	-	185.3	

Figure S6: Relaxativity measurements for **CPP-Fe** and **SPION@CPP-Fe** related to [Fe]. a) Representation of R1 ($1/T_1$) in front of total [Fe]; b) Plot of R2 ($1/T_2$) in front of total [Fe]; c) longitudinal (r_1) and transversal (r_2) relaxation values based on total or relative [Fe]. MR studies were carried out at the joint NMR facility of UAB and CIBER-BBN, Unit 25 of NANBIOSIS, with a 7T horizontal magnet.