Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C. This journal is © The Royal Society of Chemistry 2017

Supporting Information

Liquid crystalline phases from polymer functionalized ferri-magnetic Fe₃O₄

nanorods

B. Klöckner,^a P. Daniel,^b M. Brehmer,^a W.Tremel^b and R. Zentel^{*a}



Figure S1: ¹H-NMR of reactive ester block copolymer P(MMA-*b*-PFPMA). The ratio between the PMMA block and the PFPMAblock was determined to be 9.1:1 by using ref. 1.





Figure S3: ¹H-NMR of anchor block copolymer P(MMA-*b*-DOPA). The ratio between the PMMA block and the DOPA-block was determined to be about 10:1 by using ref. 1, however this value is uncertain due to the overlap of the signal at 3.56 ppm with the residual water signal at 3.33 ppm.



Figure S4: ¹⁹F-NMR of anchor block copolymer P(MMA-*b*-DOPA) before purification (signals of pentafluorphenol are visible, but no signals for the reactive ester bonded pentaflourophenol, as showed in S2). After purification, no signals are visible anymore.



Figure S5: UV-vis-spectroscopy of block copolymer P(MMA-*b*-DAAM) showing an absorption band around 283 nm corresponding to the absorption of dopamine.



Figure S6: IR spectra of reactive block copolymer P(MMA-*b*-PFPMA) (red) and after polymer analogous reaction block copolymer (PMMA-*b*-DOPA). The successful attachment of the dopamine anchor group can be proven due to complete disappearance of the C=O band of the ester at 1779 cm⁻¹ and the appearance of the C=O band of the corresponding amide at a wavenumber of 1650 cm⁻¹.



Figure S7: X-ray powder diffraction of precursor particles (black) and reflex position of reduced particles (blue). B: Diffraction pattern of reduced particles. Reflexes were assigned to hematite², magnetite³ and iron (0).⁴



Figure S8: TEM images of the as prepared Fe_2O_3 -particles (left) and the reduced particles (labled Fe_3O_4) with a higher magnification image to show the cavities formed by the Kirkendall-effect on the right.

Table S1: Size and magnetic properties of Fe $_3O_4$ nanorods.									
L _{long} /	L _{short} /	ratio	Т _в / К	M _{Sat} /	M _{Sat} /	Remanence	Remanence	Coercitivi	Coercitivi
nm	nm			emu/g at	emu/g at	/ emu/g at	/ emu/g at	ty / Oe at	ty / Oe at
				5 K (5 T)	300 K (5 T)	5 K	300 K	5 K	300 K
428	87	~4,9	>300	2,0	0,8	0,09	0,07	950	450
(27 %)	(16 %)								
340	77	~4,4	>300	53,8	48,8	12	8	150	150
(30 %)	(27 %)								
	And magr L _{long} / nm 428 (27 %) 340 (30 %)	Add magnetic prop L _{long} / L _{short} / nm nm nm / 428 87 (16 %) 340 77 (30 %) (27 %)	Ind magnetic propertiesLong/Lshort/rationmnmnmratio42887~4,9(27 %)(16 %)~4,934077~4,4(30 %)(27 %)~4,4	Ind magnetic properties of Fe ₃ O L _{long} / L _{short} / ratio T _B / K nm nm nm ratio 100 (000) 100 (000) 428 87 ~4,9 >300 200 (27 %) 340 (27 %) ~4,4 >300 (27 %)	Ind magnetic properties of Fe_3O_4 nanorods.L_{long} /L_{short} /ratio T_B / K $M_{Sat} /$ emu/g at 5 K (5 T)42887 (16 %)~4,9>3002,034077 (30 %)~4,4>30053,8	Ind magnetic properties of Fe_3O_4 nanorods.Long/Lshort/ratioTg / KMsat/Msat/nmnmnmratioTg / KMsat/emu/g at 5 K (5 T)soo K (5 T)42887~4,9>3002,00,8(27 %)(16 %)~-soo 53,848,8(30 %)(27 %)~4,4>30053,848,8	Ind magnetic properties of Fe_3O_4 nanorods.L_{ong} / nmL_{short} / nmratioT_B / K L_B / KM_{Sat} / emu/g at 5 K (5 T)M_{Sat} / emu/g at 	Ind magnetic properties of Fe_3O_4 nanorods.Long / nmL_{short / nmratioT_B / KM_{sat / emu/g at 5 K (5 T)M_{Sat / emu/g at 300 K (5 T)Remanence / emu/g at 300 K (5 T)Remanence / emu/g at 300 K (5 T)42887 (16 %)~4,9>3002,00,80,090,0734077 (30 %)~4,4>30053,848,8128	Ind magnetic properties of Fe_3O_4 nanorods.Long / nmL_{short / nmratioT_B / KM_{Sat / emu/g at 5 K (5 T)Remanence emu/g at 300 K (5 T)Remanence / emu/g at 300 K (5 T)Remanence for a mu/g at 300 K (5 T)Remanen

Figure S9: A shows the temperature-dependent magnetic moment of the particles. A-Fe₂O₃ precursor particles (red) exhibit a very small magnetic moment compared to the reduced particles (blue). B shows the magnetic moment against the applied field (Oe). Precursor particles (red) show weak ferromagnetic behaviour while the reduced particles are strongly magentic but show no significant hysteresis.

Figure S10: Size distribution of short and long axis of Fe₂O₃ precursor particles (red) and reduced particles (blue).

References

- 1 Q. Zhang, P. Schattling, P. Theato & R. Hoogenboom, Polymer Chemistry, 2012, 3(6), 1418-1426.
- 2 Pauling L, Hendricks S B, "The Structure of Hematite", Journal of the American Chemical Society 47, 781-790 (1925).
- Claassen A A, "The scattering power of oxygen and iron for X-Rays", Proceedings of the Physical Society, London 38, 482-487 (1926)
- 4 Fe-5Al-20Ni(5to)0.1 ;COD (Crystallography Open Database); 11001087