Electronic Supplementary Information

Iron-oxide-based twin nanoplates with strong $T_2$ relaxation shortening for contrast-enhanced magnetic resonance imaging

Ruixue Wei,¹ Tiantian Zhou,² Chengjie Sun,¹ Hongyu Lin,¹ Lijiao Yang,¹ Bin W. Ren,¹ Zhong Chen,² and Jinhao Gao*¹

¹State Key Laboratory of Physical Chemistry of Solid Surfaces, The MOE Laboratory of Spectrochemical Analysis & Instrumentation, and The Key Laboratory for Chemical Biology of Fujian Province, College of Chemistry and Chemical Engineering, Xiamen University, Xiamen 361005, China.

²Fujian Key Laboratory of Plasma and Magnetic Resonance, College of Electronic Science and Technology, Xiamen University, Xiamen 361005, China.

*Email: jhgao@xmu.edu.cn
**Fig. S1** A TEM image, HRTEM images and fast fourier transform (FFT) patterns of iron oxide nanoplates with thickness of 3 nm (IOP-3). (a) A TEM image of IOP-3. (b) A side-view HRTEM image of IOP-3, the lattice spacing distance of 0.25 nm and 0.49 nm could be ascribed to the \{311\} plane and \{111\} plane, respectively. The crystal zone could be ascribed to [0\(\bar{1}\)1]. (c) A top-view HRTEM image of IOP-3, the crossed lattice spacing distance of 0.29 nm could be attributed to the \{220\} plane. (d) FFT patterns of (c), showing \{111\} facets of face-centered cubic (FCC) crystals.
Fig. S2 A large-area TEM image of IOP-13.
Fig. S3 (a) X-ray power diffraction (XRD) patterns of IOP-13, the diffraction patterns are in agreement with the magnetite structure (JCPDS NO. 19-0629). Selected area electron diffraction (SAED) patterns (b) and X-ray photoelectron spectroscopy (XPS) (c) of IOP-13 are also consistent with the crystalline nature of magnetite. The peaks of 711.0 and 724.3 eV are assigned to Fe 2p3/2 and Fe 2p1/2 of magnetite.
Fig. S4 The stability of IOP-13 in (a-c) phosphate buffer (PBS, 1×, pH = 7.4) and (d-f) 10% (v/v) fetal bovine serum (FBS) solution. The TEM images of IOP-13 after 7 days incubated with PBS (a) and FBS solution (d). The optical photographs of IOP-13 after incubated with PBS (b) and FBS solution (e). The hydrodynamic diameters of IOP-13 in PBS (c) and FBS solution (f) at different time points.
Fig. S5 Field-dependent magnetization curves (M−H) of IOP-13 at 5 K. The $M_s$ of IOP-13 and IO-34 are 84.4 and 69.7 emu/g, respectively.
Fig. S6 A TEM image of as-prepared Fe₃O₄ nanoparticles (IO-34).
Fig. S7 Field-dependent magnetization curves ($M$−$H$) of IOP-3 seeds at 300 K and 5 K.
Fig. S8 Relaxivity profiles, $T_1$- and $T_2$-weighted phantom imaging at 0.5 and 7 T. (a) $R_1$ and (b) $R_2$ of IOP-13, IO-34, and Feraheme® with different concentrations at 0.5 T, the $r_1$ and $r_2$ values were obtained from the slopes of linear fits. (c) $R_1$ and (d) $R_2$ of IOP-13, IO-34, and Feraheme® with different concentrations at 7 T, the $r_1$ and $r_2$ values were obtained from the slopes of linear fits. (e) $T_1$-$T_2$-weighted phantom imaging of IOP-13, IO-34, and Feraheme® at 0.5 and 7 T.
Fig. S9 Cell viability of SMMC-7721 cells incubated with various concentrations of (a) Fe$_3$O$_4$ nanoplates (IOP-13) and (b) Fe$_3$O$_4$ nanoparticles (IO-34) for 24 h. The results show that the cell viabilities are more than 90% even at the concentration of 100 µg [Fe] mL$^{-1}$, indicating that IOP-13 and IO-34 have no appreciable cytotoxicity and excellent biocompatibility.
Fig. S10 Hematoxylin and eosin (H&E) staining of heart, liver, spleen, lung, and kidney of the mice after administration of IOP-13 at a dose of 20 mg Fe per kg body weight. The mice of the control group were injected with the same volume of 1 × PBS.
Fig. S11  *In vivo* $T_2$-weighted MR false-color images of liver at 7.0 T. (a) $T_2$-weighted MR false-color images in the transverse plane at 0, 0.5, 1, 2, and 4 h after intravenous injection of IOP-13, IO-34 nanoparticles and Feraheme® at a dose of 2 mg [Fe]/kg body weight. (b) $T_2$-weighted MR false-color images in the coronal plane at 0, 0.5, 1, 2, and 4 h after intravenous injection of IOP-13 and IO-34 nanoparticles at a dose of 2 mg [Fe]/kg body weight.
**Fig. S12** *In vivo* $T_2$-weighted MR false-color images of liver tumor at 7.0 T. $T_2$-weighted MR false-color images in the sagittal plane at 0, 0.5, 1, 2, and 4 h after intravenous injection of IOP-13 and IO-34 nanoparticles at a dose of 2 mg [Fe]/kg body weight. Arrows indicate the location of tumor.
Fig. S13 Biodistribution of IOP-13 in mice organs at 2 h and 3 d after intravenous injection (2 mg Fe /kg body weight, \(n = 3\)/group). The iron contents were measured by ICP-MS and the background was subtracted.
Table S1. The $r_1$ and $r_2$ values of IOP-13, IO-34, and Feraheme® at 0.5 and 7.0 T.

<table>
<thead>
<tr>
<th>Sample</th>
<th>$r_1$ (mM$^{-1}$s$^{-1}$)</th>
<th>$r_2$ (mM$^{-1}$s$^{-1}$)</th>
<th>$r_2/r_1$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5 T</td>
<td>7 T</td>
<td>0.5 T</td>
</tr>
<tr>
<td>IOP-13</td>
<td>48.21</td>
<td>0.49</td>
<td>571.21</td>
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<tr>
<td>IO-34</td>
<td>24.93</td>
<td>0.65</td>
<td>161.02</td>
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<tr>
<td>Feraheme®</td>
<td>16.49</td>
<td>2.16</td>
<td>86.85</td>
</tr>
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