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Dual Electric and Magnetic Responsivity of Smart Fluids Containing Multilayered Magnetite-Embedded Core/Shell Silica/Titania Nanoparticles Having an Outermost Silica Shell

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FT-IR spectra of nanoparticles in the range of 1700 – 900 cm^{-1}

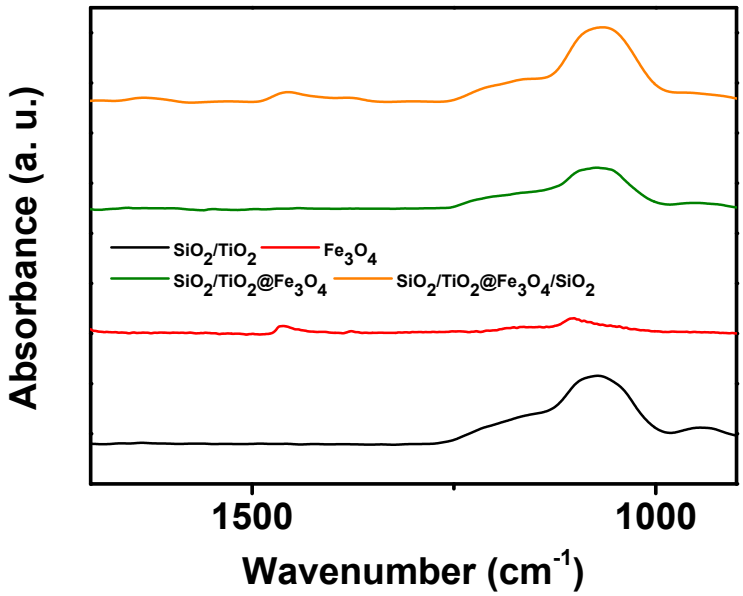

Fig. S1 Fourier transform-infrared spectra of SiO_2/TiO_2 core/shell, Fe_3O_4, $SiO_2/TiO_2@Fe_3O_4$ and $SiO_2/TiO_2@Fe_3O_4/SiO_2$ nanoparticles in the ranges of 1,700 to 900 cm^{-1}.

Dielectric constant (ε') curves of various nanoparticles

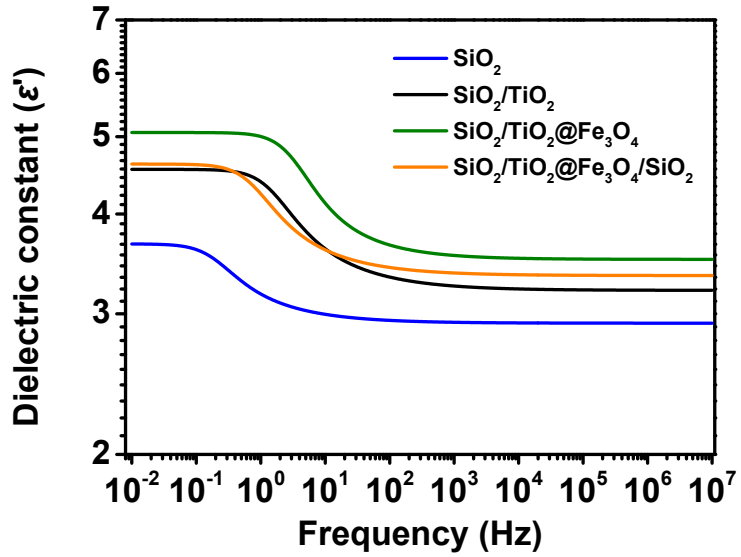

Fig. S2 Dielectric constant (ε') of various nanoparticles dispersed in silicone oil (20.0 vol%) as a function of electric field frequency (f).

Detailed dielectric properties of various nanoparticles

Table S1 Dielectric parameters of nanoparticles dispersed in silicone oil (20.0 vol%)[a]

Nanoparticles	ε_0	ε_∞	$\Delta\varepsilon = (\varepsilon_0 - \varepsilon_\infty)$
SiO_2	3.67	2.92	0.75
SiO_2/TiO_2	4.55	3.21	1.34
$SiO_2/TiO_2@Fe_3O_4$	5.06	3.51	1.55
$SiO_2/TiO_2@Fe_3O_4/SiO_2$	4.62	3.35	1.27

[a] Dielectric properties were measured by the impedance analyzer (Solatron-1260) and dielectric interface (Solatron-1296).

Dispersion stabilities of $SiO_2/TiO_2@Fe_3O_4/SiO_2$ nanoparticle

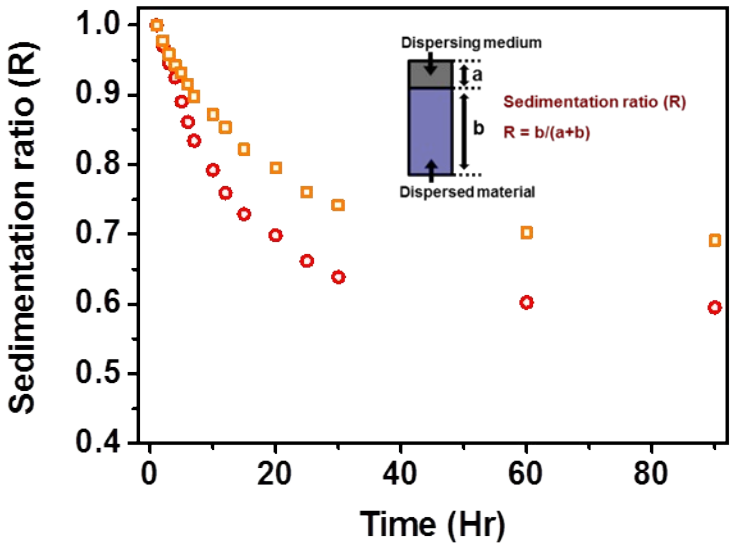

Fig. S3 Dispersion stabilities of Fe_3O_4 and $SiO_2/TiO_2@Fe_3O_4/SiO_2$ nanoparticles dispersed in silicone oil with the concentrations of 20.0 vol% [inset: definition of the sedimentation ratio (R)].

Practical OM observation of fibril-like structure formation under various conditions of external fields

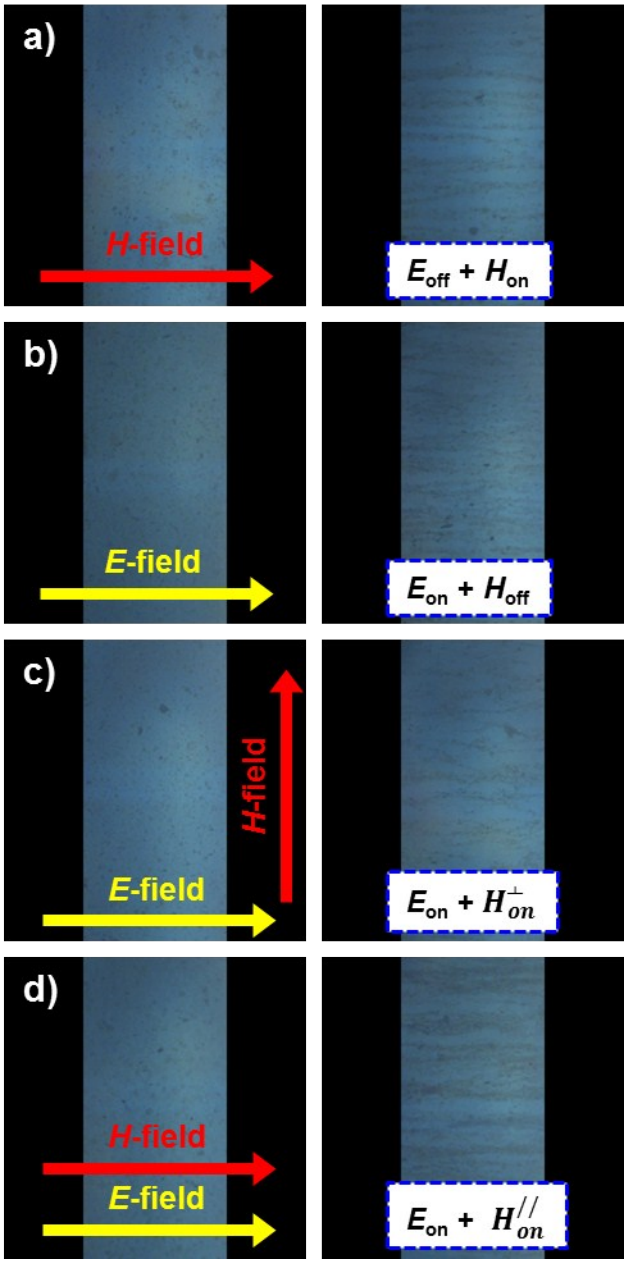

Fig. S4 OM observation of the practical fibril-like structure formation of $SiO_2/TiO_2@Fe_3O_4/SiO_2$ nanoparticles-based EMR fluids under various conditions: a) only *H* field (0.2 T), b) only *E* field (3.0 kV mm^{-1}), c) *E* + *H* fields in perpendicular direction, and d) *E* + *H* fields in parallel direction.