

Supporting Information

Controlled Movement of Complex Double Emulsions via Interfacially Confined Magnetic Nanoparticles

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1. Supplementary Figures and Videos

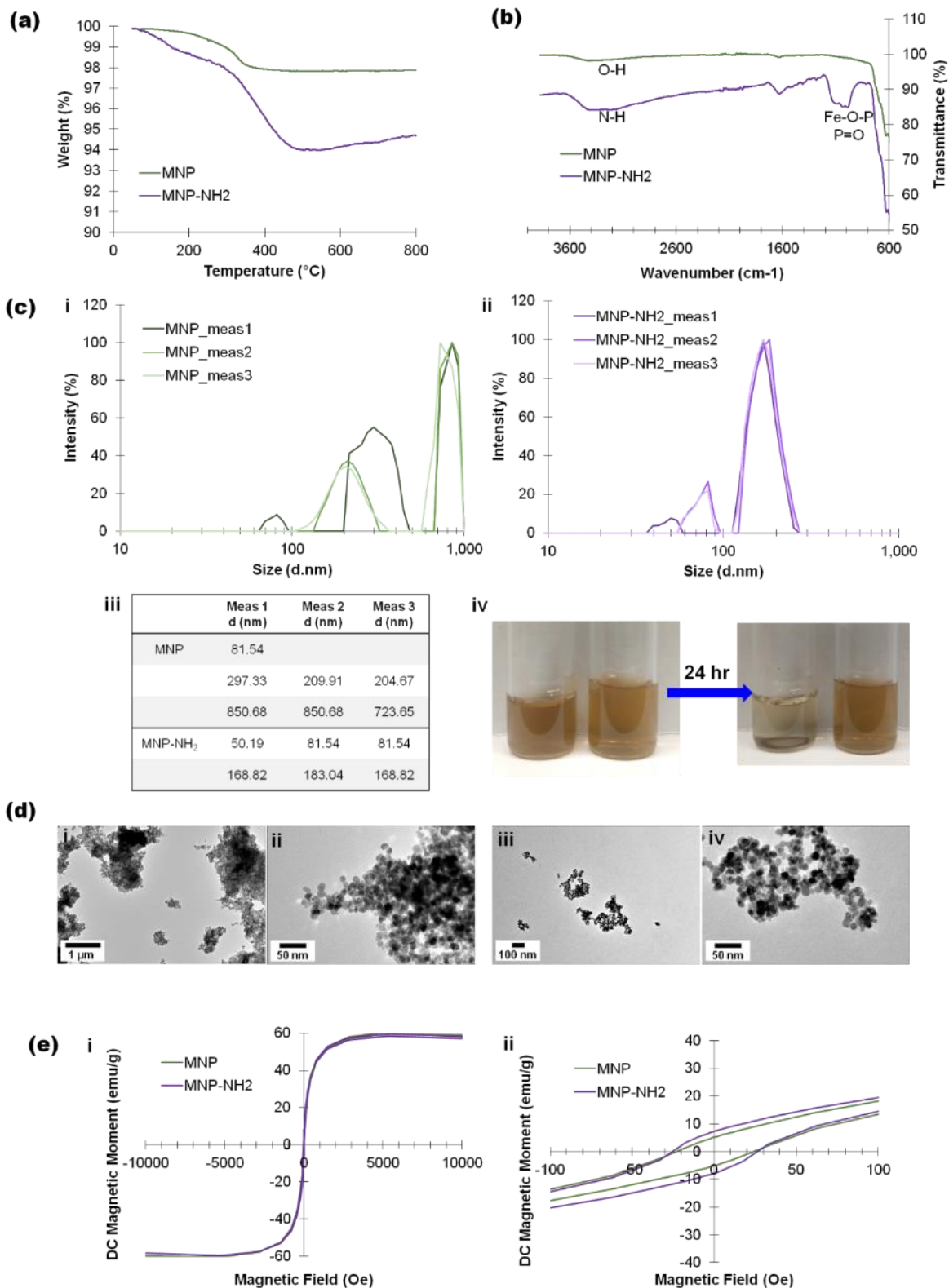


Figure S1. Characterization of MNP and MNP-NH₂: **(a)** TGA measurements; **(b)** FTIR spectra; **(c)** DLS scans: i) MNP, ii) MNP-NH₂, iii) summary of diameters, iv) settling of MNP and MNP-NH₂ overtime; **(d)** TEM images of MNP (i, ii) and MNP-NH₂ (iii, iv); **(e)** Magnetic measurement showing i) full loop and ii) zoomed in to show coercivity.

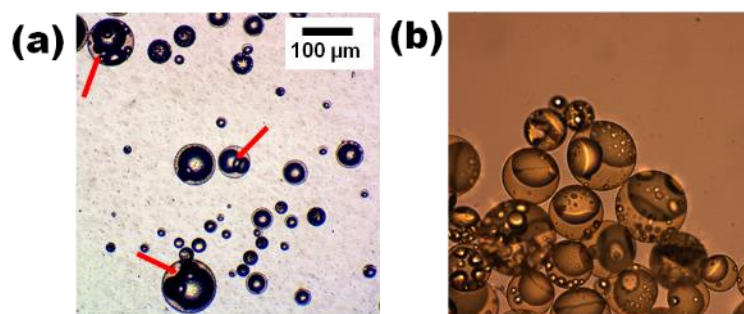


Figure S2. Incomplete phase separation was observed with MNP-NH₂ attachment in water: (a) top-view with highlighted areas of incomplete phase separation and (b) side-view of HC/FC/W double emulsions.

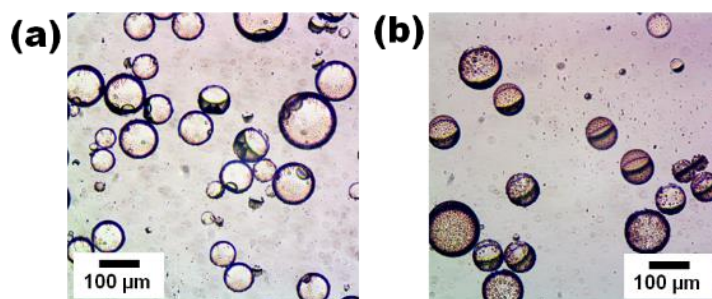


Figure S3. Attachment of MNP-NH₂ in the presence of 0.1 wt% Tween-20 during emulsification: (a) Some phase separation and incomplete coverage at the FC/W interface was observed directly after emulsification; (b) After allowing for a longer reaction time with overnight mixing, better attachment was observed at the FC/W interface; however, non-specific attachment of MNP-NH₂ at the HC/W interface (no imine formation) was also observed.

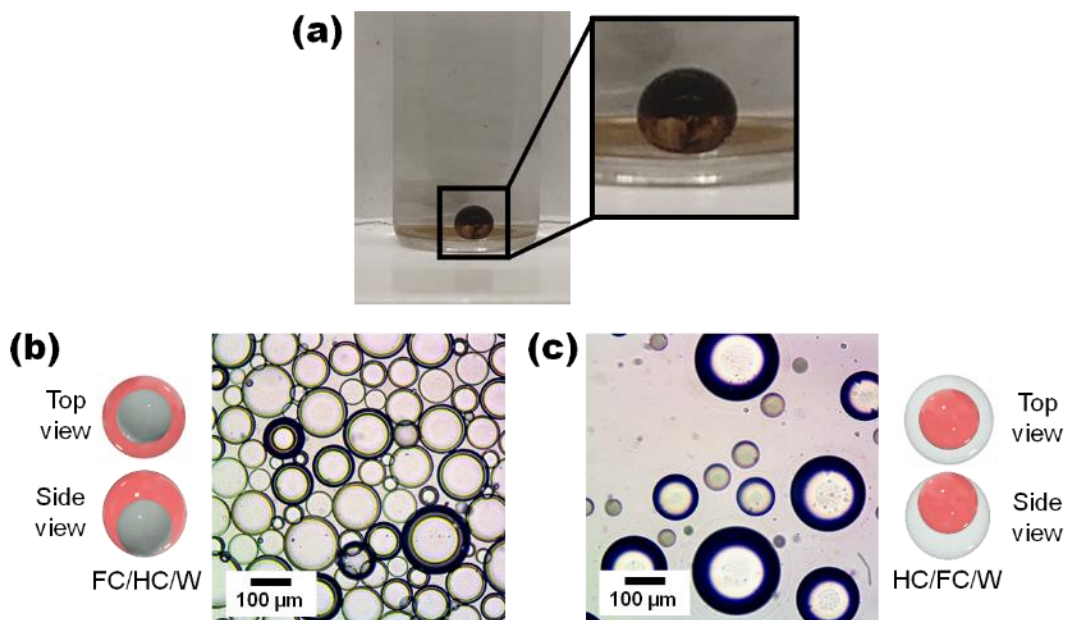


Figure S4. Control studies for MNP and MNP-NH₂ attachment without imine formation: (a) Instant coalescence was observed when attempting emulsification of Hydrate **1** enriched HC/FC dispersed in 1 mg/mL MNP in water. The MNP preferentially attached to the HC/W interface, signifying minimal interaction between unfunctionalized MNP and Hydrate **1**; No MNP-NH₂ attachment was observed in the absence of Hydrate **1** with 1 mg/mL MNP-NH₂ in (b) 0.01 wt% Tween-20 or (c) 0.01 wt% Zonyl continuous phases.

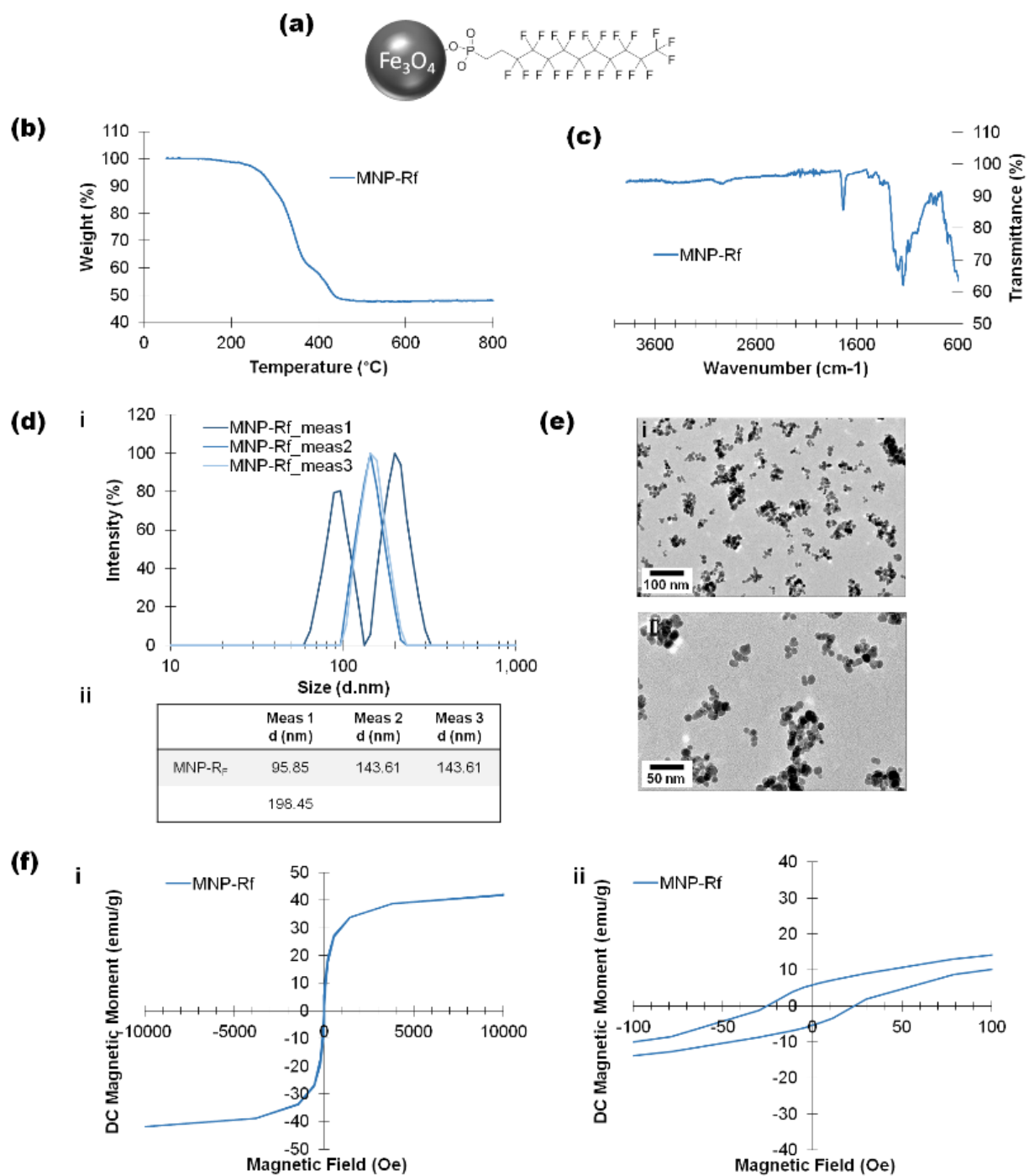


Figure S5. Characterization of MNP-R_F: **(a)** MNP- R_F functionalization; **(b)** TGA measurement; **(c)** FTIR spectra; **(d)** DLS scans: i) MNP-R_F and ii) summary of diameters; **(e)** TEM images of MNP-R_F; **(f)** Magnetic measurement showing i) full loop and ii) zoomed in to show coercivity.

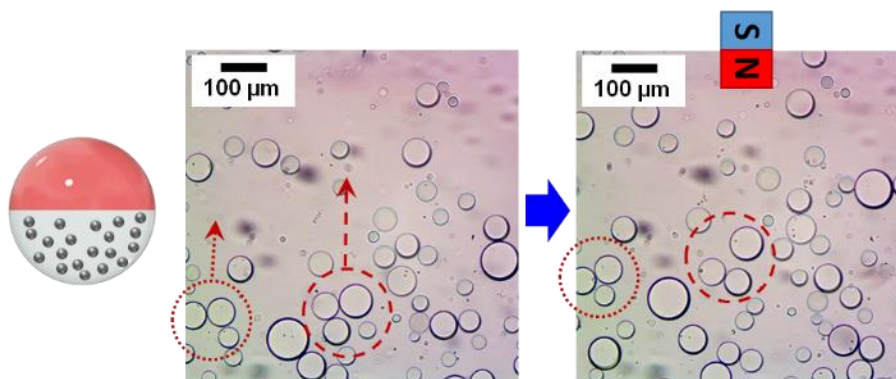


Figure S6. Janus emulsions with MNP-R_F dispersed in the FC in an unconfined state exhibited translation movement towards the magnet, but did not demonstrate the change in orientation shown with interfacially confined magnetic nanoparticles.

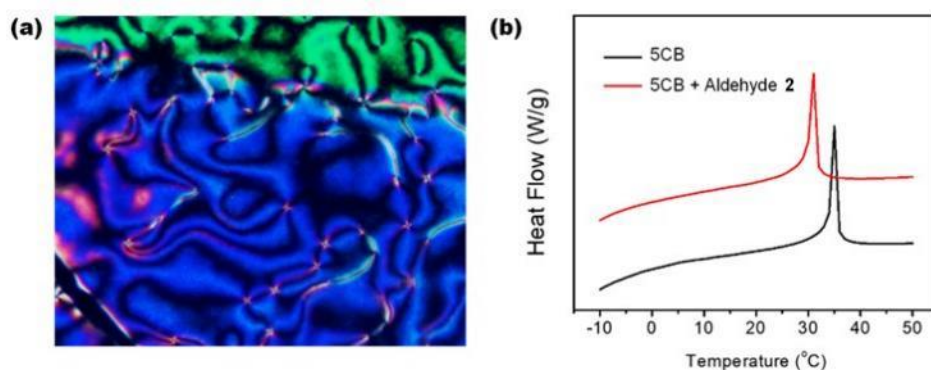


Figure S7. Aldehyde **2** was found to be nicely and readily soluble in the isotropic and nematic phase of 5CB: (a) POM texture of a solution of Aldehyde **2** in 5CB (100 mM) with no evidence of phase separation. (b) DSC traces (Exo down, 10 °C/min) of 5CB with 0 mM and 100 mM of Aldehyde **2**.

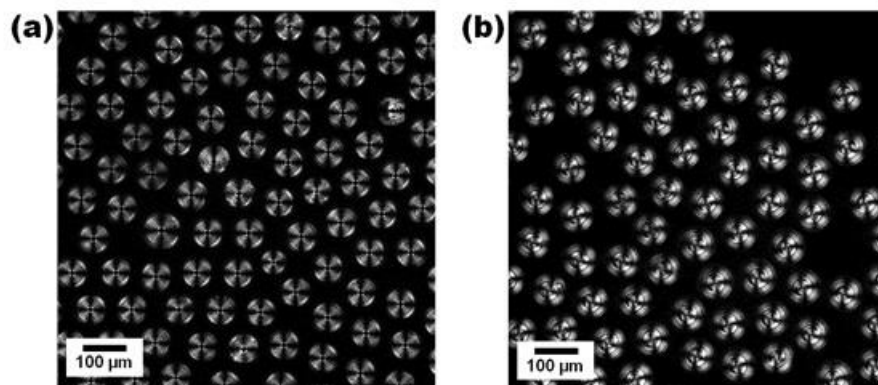


Figure S8. Confocal microscopy images of the fluorescent labelling control experiments for LC single droplets with (a) radial and (b) monopolar organizations.

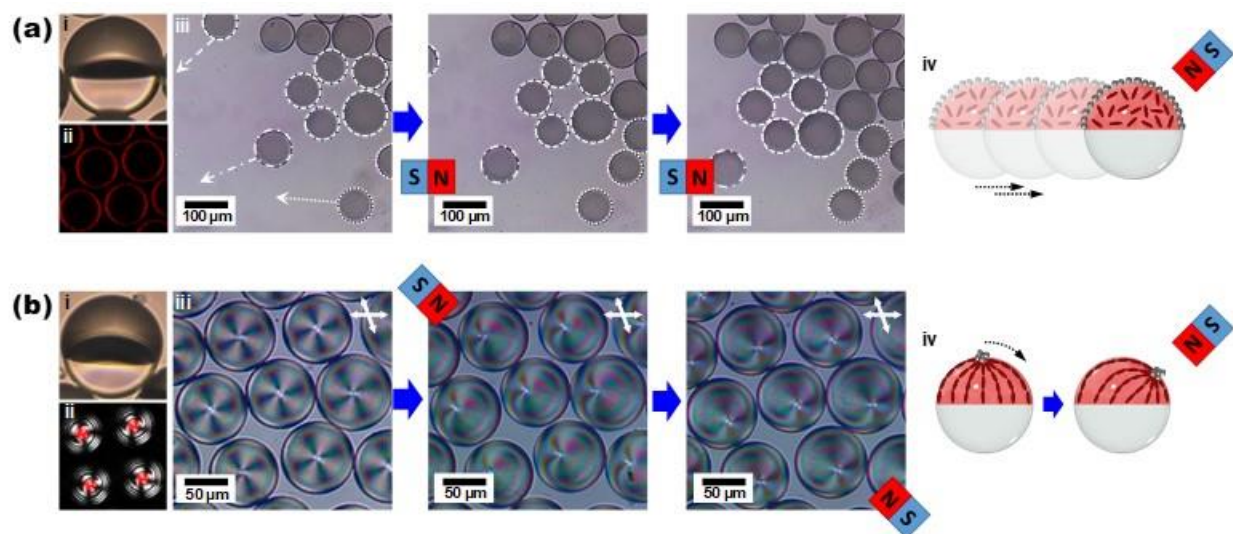


Figure S9. Magnetic response of MNP-NH₂ functionalized LC droplets with monopolar organizations at (a) 40 °C and (b) 25 °C: i) Side-view microscopy images, ii) confocal microscopy images, iii) polarized light optical microscopy images, iv) schematic representations.

2. Materials and Characterization Techniques

2.1 Materials

4-dodecoxy-benzaldehyde (2),¹ 4-Cyano-4'-(3-perfluoro-octyl-propyl)biphenyl (**CB-R_F**),² and 4,4'-bis(tetra(ethylene glycol)monomethyl ether)biphenyl (**CB-diTEG**)² were prepared following previously reported procedures (Figure S10). Commercial reagents were used as received without further purification: Tween-20, Zonyl FS-300 (Zonyl, 40 wt% in water), diethylbenzene, 5(6)-Carboxytetramethylrhodamine succinimidyl ester, (3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-heneicosafuorododecyl)phosphonic acid, 2-aminoethylphosphonic acid, 2,4,6-trinitrobenzenesulfonic acid (TNBS, 5 w/v% in water), l-valine (Sigma-Aldrich); 2-trifluoromethyl-3-ethoxyperfluorohexane (HFE-7500), 1H,2H,2H-perfluorooctanal hydrate (**1**) (SynQuest); (Ethoxy)nonafluorobutane (HFE-7200) (TCI); 4-cyano-4'-pentylbiphenyl (5CB) (Synthon Chemicals, Germany); FC-43, trichloroacetic acid (Alfa Aesar); isopropanol (IPA), toluene (Macron); Iron (II) sulfate heptahydrate (FeSO₄), ammonia solution (38-40%), sodium bicarbonate (Mallinckrodt); and Iron (III) chloride (FeCl₃) (Oakwood). Milli-Q water from a Barnstead Nanopure Water System (Thermo Fisher Scientific) was used for the preparation of the emulsion continuous phases. Neodymium magnets (N48-N52) of dimensions 2 x 3 cm and 0.5 x 7 mm (diameter x height) were used in droplet manipulation studies.

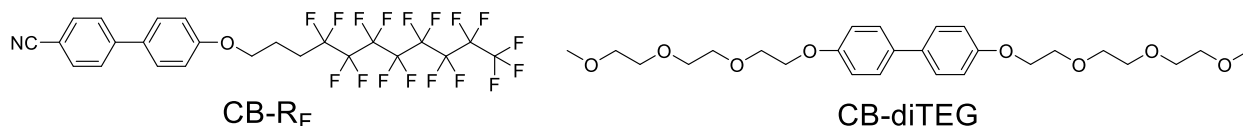


Figure S10: Mesogenic surfactants for the fabrication of stable LC/FC double emulsions.² 4-Cyano-4'-(3-perfluoro-octyl-propyl)biphenyl (**CB-R_F**) and 4,4'-bis(tetra(ethylene glycol)monomethyl ether)biphenyl (**CB-diTEG**) align at the LC/FC and LC/W interfaces, respectively.

2.2 Instrumentation and Characterization Techniques

ATR-FTIR spectra were obtained on a Thermo Scientific Nicolet 6700 FTIR spectrophotometer with a diamond crystal for ATR.

Thermogravimetric analysis (TGA, TA Instruments Discovery TGA1-0075) measurements were conducted with powdered samples (2-5 mg) from 50-800 °C, with a 10 °C/min ramp, under nitrogen. Samples were dried in a vacuum oven overnight at 60 °C to remove residual solvent before measurement.

Differential scanning calorimetry (DSC, TA Instruments Discovery DSC1-0107) measurements were performed with powdered samples (2-5 mg) sealed in aluminum pans. Samples were heated up to 60 °C and cooled down to -20 °C at 10 °C/min, under nitrogen. Three cycles were carried out and data were taken from the second cycle.

Transmission electron microscope (TEM, FEI-Technai) samples were prepared by depositing 1 mg/mL dispersions of nanoparticles in water (MNP and MNP-NH₂) or HFE-7500 (MNP-R_F) onto carbon film- 200 mesh Cu substrates (Electron Microscopy Sciences). The diameter of 100 particles was averaged for the size reported.

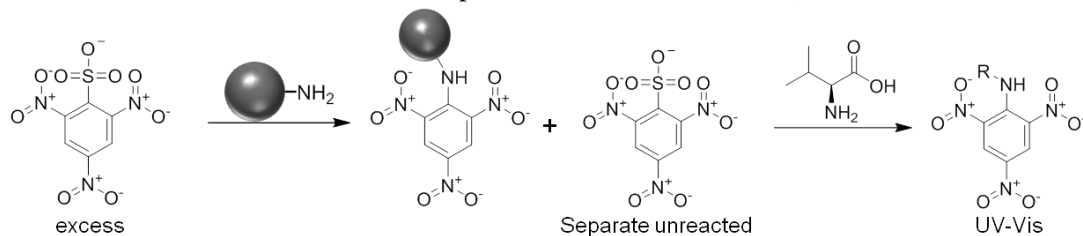
¹ C. A. Zentner, F. Anson, S. Thayumanavan, T. M. Swager, *J. Am. Chem. Soc.* **2019**, *141*, 18048-18055.

² A. Concellón, C. A. Zentner, T. M. Swager, *J. Am. Chem. Soc.* **2019**, *141*, 18246-18255.

Dynamic Light Scattering (DLS, Brookhaven NanoBrook Omni) was utilized to estimate the nanoparticle aggregate size. Measurements on 0.1 mg/mL dispersions of nanoparticles in water (MNP and MNP-NH₂) or HFE-7500 (MNP-R_F) were performed in three successive 3 min measurements, with no delay between the scans.

Magnetic characterization of the nanoparticles and emulsions was performed on Quantum Design MPMS3 QUID Magnetometer equipped with a sealed liquid sample holder. DC scan measurements (4 s) were performed in a loop of the range -10,000 to 10,000 Oe, sweep of 200 Oe/s, and at 300 K. The magnetic moment was corrected to the exact mass of the sample (emu/g). A total volume of 150 μ L of material was tested for each sample. For magnetic emulsion samples, 25-50 μ L of polydisperse double emulsions (10-200 μ m) in 100-125 μ L of continuous phase were measured. The same batch of MNP-NH₂ and emulsions were used for direct comparison of magnetic properties. Studies of emulsions were performed after repeated washings of the continuous phase with fresh aqueous solutions to remove unreacted MNP-NH₂. This ensured the magnetic response was from confined MNP-NH₂ alone.

Quantification of amines on the surface of MNP-NH₂ nanoparticles was accomplished through a modified published literature procedure.³ As outlined in Scheme S1, MNP-NH₂ were reacted with excess 2,4,6-trinitrobenzenesulfonic acid (TNBS), and the unreacted TNBS was quantified by UV-Vis (Agilent Cary 5000). MNP-NH₂ (3-5 mg) were dispersed in 1 mL of 0.1 M sodium bicarbonate solution (pH 8.5). To the MNP-NH₂ dispersion, 2 mL of 0.1 w/v% of TNBS in bicarbonate solution was added. The mixture was stirred at 40 °C in the dark for 1 h. After incubation, the mixture was separated by magnetic decantation and then passed through a 0.4 μ m filter to remove any residual nanoparticles. To measure the unreacted TNBS, a solution of 0.9 mL of the filtered TNBS solution and 0.1 mL of L-Valine solution (40 mM in 0.1 M sodium bicarbonate solution) was prepared. Separately, 0.9 mL of the filtered TNBS solution and 0.1 mL of trichloroacetic acid (1% in 0.1 M sodium bicarbonate solution) were mixed, to be used as the blank in the UV-Vis measurements. Both the sample and blank were stirred at 40 °C for 1 h in the dark. After the 2nd incubation, 5 mL of 0.5 mM HCl was added to each solution, to stabilize the complex. A 10-fold dilution with a 1:5 solution of 0.1 M sodium bicarbonate to 0.5 mM HCl was performed before UV-vis analysis. The absorbance of the solutions was measured at 360 nm against the blank. The amine content on the surface was calculated relative to a calibration curve obtained by using the same procedure described above, including filtration step, except 2 mL of 0.01, 0.02, 0.04, 0.08, or 0.1 w/v% TNBS was added to 1 mL 0.1 M sodium bicarbonate solution (without nanoparticles, $\epsilon = 11470 \text{ M}^{-1} \text{ cm}^{-1}$).



Scheme S1. Schematic for the quantification of amines on nanoparticle surfaces.

Imaging: HC/FC double emulsions were imaged on an AmScope B120C-E1 (equipped with a AmScope MU1003 camera). Liquid crystal double emulsions were investigated by polarized-light optical microscopy (POM) using a Leica DMRXP polarized-light microscope (equipped with a AmScope MU1000 camera) fitted with a Linkam TMS 94 hot stage. Confocal images were taken on a Zeiss LSM 700 laser scanning confocal microscope (Whitehead Institute), with excitation of 554 nm at 20-25% power. Side-view images

³ M. Das, D. Mishra, T. K. Maiti, A. Basak, P. Pramanik, *Nanotechnology*, **2008**, *19*, 415101.

of the droplets were taken using a custom-built horizontal microscope composed of Olympus 10-20x objective, a Thorslabs tube lens (effective focal length = 200 nm), and an Allied Vision Prosilica GT camera. A white screen was placed behind the sample, and the sample was illuminated from the side using a Fiber-Lite MI-152 lamp for bright field images. Polarized-light side-view images were taken using two cross film polarizers from Thorslab. For these experiments, emulsion droplets were deposited into a demountable quartz cuvette (path length: 0.1 or 0.2 mm) from Starna Cells, Inc.

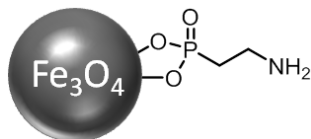
3. Synthesis and Characterization

No unexpected or unusually high safety hazards were encountered in the following syntheses.

3.1 Synthesis of Fe₃O₄ (MNP)

The synthesis was modified from a published literature procedure.³ FeSO₄ (278 mg, 278.01 g/mol, 1 mmol, 1 equiv.) and anhydrous FeCl₃ (324 mg, 162.02 g/mol, 2 mmol, 2 equiv.) were dissolved in 10 mL of argon sparged water. The solution was heated to 80 °C under argon. At temperature, 5 mL of 38-40% ammonia solution was rapidly injected and the mixture stirred for 20 min at 80 °C. The mixture was then cooled to room temperature. The nanoparticles were separated with a magnet, followed by repeated washings with water (3x10 mL). 10 mL of water was added and the pH was neutralized with 1 M HCl. Water washes were repeated again after neutralization (2x10 mL). The Fe₃O₄ nanoparticles (MNP) were dispersed in 5 mL of water (213 mg, 231.53 g/mol, 0.920 mmol, 92%). Characterization of MNP is outlined in Figure S1.

3.2 Synthesis of MNP-NH₂

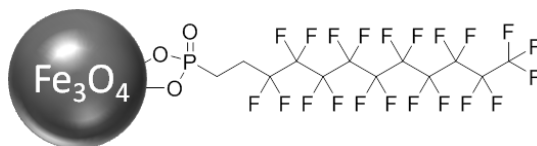


The synthesis was modified from a published literature procedure.³ In a 20 mL vial, 2-aminoethylphosphonic acid (125 mg, 125.06 g/mol, 1 mmol) was added to 10 mL of water. To the solution, a portion of the Fe₃O₄ solution in water was added (~20 mg). The total volume was adjusted to 15 mL and the pH was then adjusted to 6 using 1 M NaOH. The dispersion was tip sonicated (Qsonica Q125, 125 W, 20 kHz) for 1 hr. The dispersion was then stirred at 60 °C for 16-18 hr. The resulting dispersion was separated with a magnet, washed with base (pH 8, 3x10 mL), and then washed with water (2x10 mL). The MNP-NH₂ nanoparticles were dispersed in 3 mL water to give ~5-7 mg/mL solutions. Characterization of MNP-NH₂ is outlined in Figure S1 and compared to MNP below.

3.3 Characterization comparison of MNP and MNP-NH₂:

Quantification of amines using TNBS showed 1.0 ± 0.1 $\mu\text{mol/mg}$ (amine ligand per mg MNP). Control sample with MNP showed only 0.07 $\mu\text{mol/mg}$, demonstrating successful amine functionalization. In TGA studies, an average weight % loss of $4.2 \pm 0.5\%$ was observed across MNP-NH₂ samples (Figure S1a). Appearance of -NH₂, Fe-O-P, and P=O *st.* bands in the FTIR are clearly observed compared to unfunctionalized MNP (Figure S1b). Although both nanoparticles show aggregation in water, MNP-NH₂ displays less aggregation, which was consistent with better dispersibility with amine functionality. In DLS studies, significant aggregation was observed in MNP solutions in water (Figure S1c-i) – aggregates as large as 850 nm were observed. Conversely, MNP-NH₂ aggregates were a maximum of 183 nm (Figure S1c-ii). The aggregation of MNP in water is further demonstrated by the settling of the nanoparticles overtime (Figure S1c-iv). We observed the settling of a 0.1 mg/mL dispersion of MNP in water within 24 hr, whereas a 0.1 mg/mL dispersion of MNP-NH₂ stays dispersed over the same time frame. Although not a measure of aggregate size in solution, TEM studies further demonstrated the increased aggregation of MNP, with aggregates that were significantly greater than 1 μm (Figure S1d-i,ii). The anisotropic nanoparticles of MNP and MNP-NH₂ are 10.5 ± 2.5 and 10.6 ± 2.6 nm in diameter, respectively (Figure S1d). A small decrease in magnetic saturation value was observed with functionalization, from 59.10 to 58.06 emu/g, with no change in coercivity (Figure S1e).

3.4 Synthesis of MNP-R_F



The synthesis of MNP-R_F was modified from a published literature procedure.⁴ In a 20 mL vial, (3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,11,11,12,12,12-heneicosafuorododecyl)phosphonic acid (157 mg, 628.11 g/mol, 0.250 mmol) was added to 5 mL IPA. To the solution, a dispersion of MNP in IPA (~19 mg in 7.5 mL) was added. The dispersion was sonicated for 30 min at 25 °C. The nanoparticles were separated by centrifugation (10,000 rpm, 5min) and washed with IPA (3x3 mL). The nanoparticles were let air dry to remove most of the residual IPA and 1mL HFE-7500 was added to freshly disperse the MNP-R_F (21.6 mg).

An overall weight % loss of 52.4% was observed in two steps (Figure S5b). The FTIR in the region between 1000-1400 cm⁻¹ has overlapping signals for Fe-O-P, P=O, and C-F *st.* bands (Figure S5c). The DLS measurements in HFE-7500 show smaller aggregates than in MNP and MNP-NH₂, with an average diameter around 145 nm (Figure S5d). TEM studies showed smaller amounts of aggregation compared to MNP and MNP-NH₂ and an average size of 9.9 ± 2.4 nm for the nanoparticles (Figure S5e). In the magnetic measurements, a lower magnetic saturation (42.2 emu/g) compared to unfunctionalized MNP was observed, consistent with significant ligand wt % of MNP-R_F (Figure S5f).

⁴ L. Zeininger, L. Portilla, M. Halik, A. Hirsch, *Chem. Eur. J.* **2016**, 22, 13506-13512.

4. Experimental Procedures

No unexpected or unusually high safety hazards were encountered in the following procedures.

4.1 General procedure for the preparation of HC/FC double emulsions

Polydisperse double emulsions were fabricated by phase separation emulsification and imine formation according to modified published literature procedures.^{1,5} A 1:1 volume ratio of hydrocarbon (HC) and fluorocarbon (FC) were heated above their upper critical temperature (T_c) to form a homogeneous mixture. 25 μ L of the heated HC/FC mixture was added to 500 μ L of continuous phase and vortexed for 5 s to emulsify. Double emulsions were imaged upon cooling and full phase separation of the HC/FC. This bulk emulsification method generated polydispersed droplets with diameters ranging from 10 to 200 μ m as observed by an optical microscopy.

4.2 Immobilization of MNP-NH₂ at the FC/W interface

The continuous phase consisted of 1 mg/mL MNP-NH₂ in water, Zonyl, or Tween-20 aqueous solutions. The dispersed phase was comprised of a 1:1 volume ratio of diethylbenzene and 200 mM Hydrate **1** in HFE-7500. Emulsions were made following the general procedure outlined. Before imaging, the continuous phase was exchanged three times with fresh water or surfactant solution to remove excess MNP-NH₂.

Emulsification without co-surfactants resulted in incomplete phase separation upon cooling (Figure S2). Emulsification in the presence of Tween-20 resulted in either incomplete phase separation at concentrations less than 0.1 wt% or incomplete MNP-NH₂ coverage at the FC/W interface at 0.1 wt% (Figure S3a). Allowing the MNP-NH₂ and Hydrate **1** to react further overnight after emulsification did increase coverage at the FC/W interface, but non-specific attachment of MNP-NH₂ at the HC/W interface was also observed, indicating a preference to align at this interface given time. Therefore, the high energy *in situ* emulsification is necessary to prevent non-specific attachment. The requirement for high energy emulsification to prevent non-specific attachment also prohibited the fabrication of monodisperse droplets. In that method, similar to Section 4.5, monodisperse emulsions were fabricated in co-surfactants first and then MNP-NH₂ was added. Non-specific attachment and < 100% coverage were observed. In addition, low concentrations of MNP-NH₂ (0.1 mg/mL) in the absence of co-surfactants resulted in low surface coverage and droplets coalesced over a few days. Therefore, high concentrations of MNP-NH₂ were necessary for sufficient coverage and droplet stability.

In an optimized procedure, 0.01 wt% Zonyl and 1 mg/mL MNP-NH₂ was used for the continuous phase to achieve HC/FC/W emulsions with MNP-NH₂ immobilized at the FC/W interface. After removing excess MNP-NH₂, morphology change from HC/FC/W to Janus was achieved by exchanging the continuous phase further with 0.5 - 1 wt% Tween-20.

4.3 Control studies with MNP and MNP-NH₂

Following the procedures outlined, control experiments were performed with MNP and MNP-NH₂. First, double emulsions were made with 1 mg/mL MNP in either water, 0.01 wt% Zonyl, or 0.01 wt% Tween-20. A 1:1 volume ratio of diethylbenzene and 200 mM Hydrate **1** in HFE-7500 was dispersed in the MNP containing continuous phases. In all three continuous phases, coalescence was observed with no stable emulsions. When using water as the continuous phase, the large drop after coalescence showed MNP attachment preferentially at the HC/W interface (Figure S4a). Separately, control studies were performed

⁵ L. D. Zarzar, V. Sresht, E. M. Sletten, J. A. Kalow, D. Blankschtein, T. M. Swager, *Nature* **2015**, 518, 520.

with MNP-NH₂ in the absence of Hydrate **1** to demonstrate if imine formation is necessary for attachment. Double emulsions were made with 1 mg/mL MNP-NH₂ in either water, 0.01 wt% Zonyl, or 0.01 wt% Tween-20. A 1:1 volume ratio of diethylbenzene and HFE-7500 was dispersed in the MNP-NH₂ containing continuous phases. Without surfactants, instant coalescence was observed without significant MNP-NH₂ attachment. In the presence of Zonyl or Tween-20, no MNP-NH₂ attachment was observed (Figure S4b & S4c).

4.4 Control studies with MNP-R_F

Double emulsions were prepared with MNP-R_F dispersed in the FC phase to compare to immobilized MNP-NH₂ emulsions. MNP-R_F (1 mg/mL) was dispersed in HFE-7500&FC43 (9:1). A 1:1 volume ratio of toluene and MNP-R_F enriched FC phase were emulsified in 0.05 wt% Zonyl/Tween-20 following the general procedure outlined. Higher loading of MNP-R_F was prohibitive due to observed incomplete phase separation. MNP-R_F is selectively dispersible in HFE-7500&FC43 over toluene and stays dispersed after emulsification. A stable dispersion was not achieved after heating with diethylbenzene/HFE-7500.

4.5 General procedure for the preparation of LC double emulsions²

Emulsions were fabricated using either bulk emulsification or a microfluidic device, which generates polydisperse or monodisperse droplets, respectively. In a typical bulk emulsification preparation, we emulsified 35 μ L of a solution of 5CB/HFE7200/DCM (1:1:2 volume ratio) with 2.5 wt% **CB-R_F** and 100 mM Aldehyde **2** into 500 μ L of a 0.1 wt% aqueous solution of Tween-20. A vortex mixer at 3000 rpm for 10 seconds was used, and then DCM was slowly evaporated at RT to induce phase separation inside the droplets. This bulk emulsification method generated polydispersed droplets with diameters ranging from 5 to 200 μ m as observed by an optical microscopy. Emulsions were also fabricated using a microfluidic device purchased from Dolomite Microfluidic. A Telos 2 Reagent Chip (100 μ m) was used, and two Mitos P pressure pumps, one for the dispersed phase and one for the continuous phase, were used for controlling the flow rate. The fluids were driven by pressurizing the two individual dispersed and continuous chambers with N₂ providing a pulseless, stable flow to the flow focusing chip (pressures: dispersed phase: 200 mbar; continuous phase: 800 mbar). The average diameter of the monodispersed droplets generated from this setup was 70 \pm 10 μ m as observed by optical microscopy.

To generate LC double emulsions droplets with a radial organization, the dispersed phase (LC/HFE7200/DCM in a 1:1:2 volume ratio with 2.5 wt% **CB-R_F** and 100 mM Aldehyde **2**) was emulsified into a 0.1 wt% aqueous solution of Tween-20. At the LC/W interface, Tween-20 surfactant is adsorbed with its apolar aliphatic chains penetrating into the LC, promoting a radial orientation of the director of the mesophase in the droplet (mesogens align perpendicular to the aqueous phase). Morphology change from FC/LC/W double emulsions to Janus was achieved by exchanging the continuous phase to a solution of 0.1 wt% Tween-20/0.1 wt% Zonyl = 3:1 (v/v).

For the preparation of LC double emulsions with a monopolar organization, **CB-diTEG** was dissolved at 50 mg/mL in the dispersed phase (LC/HFE7200/DCM in a 1:1:2 volume ratio with 2.5 wt% **CB-R_F** and 100 mM Aldehyde **2**). LC complex emulsions were fabricated by the emulsification methods described above in 0.001 wt% pure Tween-20 as the continuous phase. Morphology change from FC/LC/W double emulsions to Janus was achieved by exchanging the continuous phase to a solution of 0.001 wt% Tween-20/0.01 wt% Zonyl = 3:7 (v/v).

4.6 Immobilization of MNP-NH₂ at LC/W interface

Aldehyde **2**-functionalized LC droplets were fabricated by the emulsification methods described above. MNP-NH₂ were attached by pre-dispersing MNP-NH₂ (0.5 mg/mL) in 500 μ L of the corresponding surfactant solution and subsequently adding 40 μ L of pre-formed Aldehyde **2**-functionalized LC droplets with planar or radial alignment. The emulsions were agitated for 24 hr at 150 rpm. Prior to any measurements, the aqueous surfactant solution was exchanged five times to remove the non-reacted MNP-NH₂. LC emulsions did not exhibit magnetic response in control experiments under the same conditions but in the absence of Aldehyde **2**, confirming imine formation is necessary for selective MNP attachment at LC/W interface.

4.7 Fluorescence labelling of the immobilized MNP-NH₂

Fluorescent labelling of the attached MNP-NH₂ was performed by pre-dispersing 5(6)-carboxytetramethylrhodamine succinimidyl ester (1 mg/mL) in 500 μ L of the corresponding surfactant solution and subsequently adding 40 μ L of pre-formed LC droplets functionalized with MNP-NH₂. The emulsions were agitated for 24 hr at 150 rpm. The aqueous surfactant solution was exchange five times to remove the non-reacted dye before recording the confocal microscope images.