

Supporting Information

Active treatment of oily emulsion wastewater by bio-derived tubular micromotors

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Text S1. Detailed information of materials and related characterization apparatus.

Anhydrous ethanol (99.7%), sodium chloride (NaCl, 99%), n-hexane (99%), Tween 80, n-pentanol (98%), 1H,1H,2H,2H-Perfluorodecanethiol (98%), ferrous chloride tetrahydrate ($\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$, 99%), were all purchase from Innochem. Sodium dodecyl sulfate (SDS, 99%), dopamine hydrochloride (PDA, 98%), ferric chloride hexahydrate ($\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$, 99%), dimethyl silicone oil (viscosity 100 cSt), triethylamine (99.5%) and ammonia solution ($\text{NH}_3 \cdot \text{H}_2\text{O}$, AR, 25-28 wt%) were all purchase from Aladdin. Potassium permanganate (KMnO_4 , AR, 99%) and hydrogen peroxide (H_2O_2 , AR, 30 wt%) were purchased from Xilong Science. Tris-HCl buffer (10 mM, PH=8.5) was purchased from Shanghai Yuanye Biotechnology. All chemicals were used without further purification. Experimental water was prepared using a Millipore Simplicity ultrapure water system ($18.2 \text{ M}\Omega \cdot \text{cm}$ at 25°C).

Scanning electron microscopy (SEM) images and energy dispersive X-ray spectroscopy (EDX) mappings were acquired using a field-emission scanning electron microscope (MAIA3 LMH). X-ray photoelectron spectroscopy (XPS) data were collected using an Escalab 250Xi spectrometer (Thermo Fisher Scientific, USA). Thermogravimetric analysis (TGA) was conducted using a Mettler-Toledo TGA/DSC 3+ instrument under an N_2 atmosphere with a heating rate of $10^\circ\text{C}/\text{min}$ from room temperature to 600°C . Chemical composition analysis was performed using a Nicolet iS50 Fourier transform infrared (FTIR) spectrometer (Thermo Fisher Scientific, USA). Contact angles of modified kapok fiber were measured using a Theta Flex optical tensiometer (Biolin Scientific, Sweden). Zeta potential measurements were conducted

using a Zetasizer Nano ZS90 analyzer. All optical images and videos were captured using an OLYMPUS BX43 microscope equipped with a digital camera. The motion trajectory and velocity of micromotors were analyzed using the OLYMPUS CellSens Dimension system.

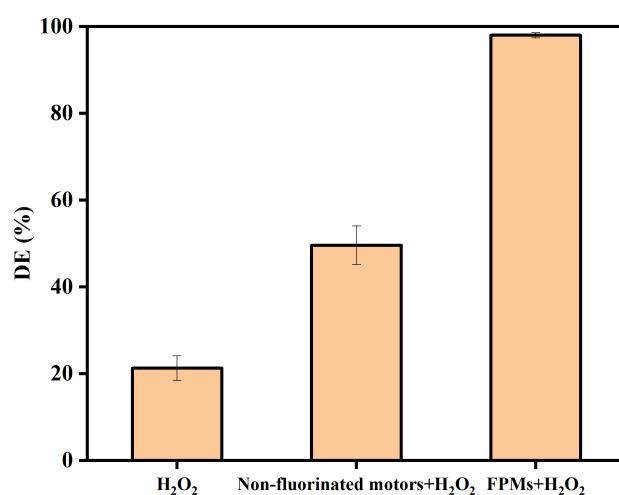


Figure S1. Demulsification efficiencies of different control systems (non-fluorinated motors+ H_2O_2 , FPMs + H_2O_2).

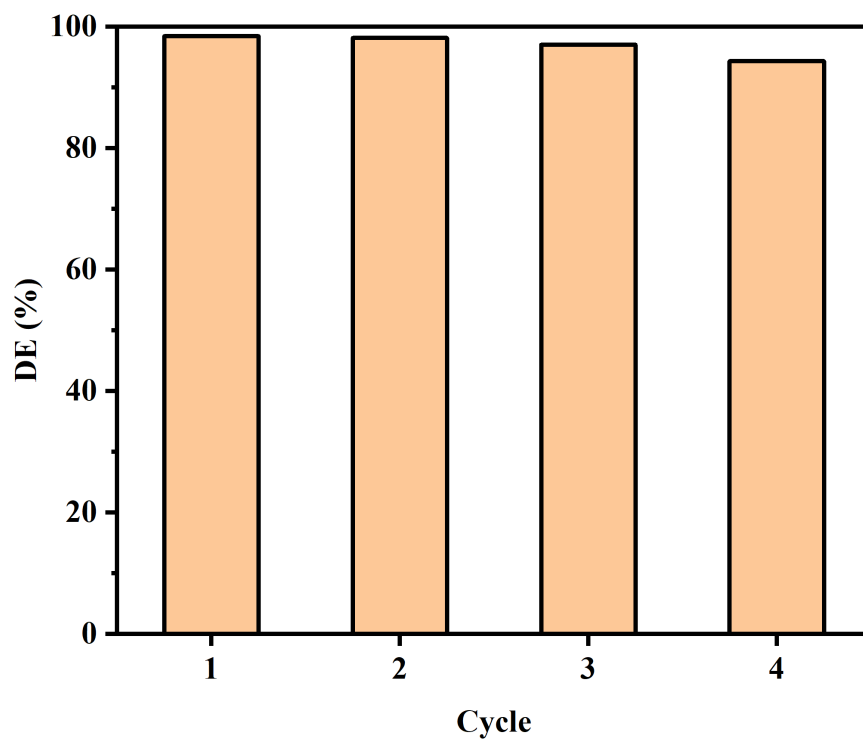


Figure S2. Repeated demulsification experiments of FPMS.

Table S1. ICP-OES analysis of treated water.

Metal ion	Fe	S	Mn
Concentration (mg L ⁻¹)	0.0079	0.2410	1.5040