Supporting Information for

Hybrid-Dimensional Magnetic Microstructures on 3D Substrates for Remote-Control and Ultrafast Water Remediation

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Figures

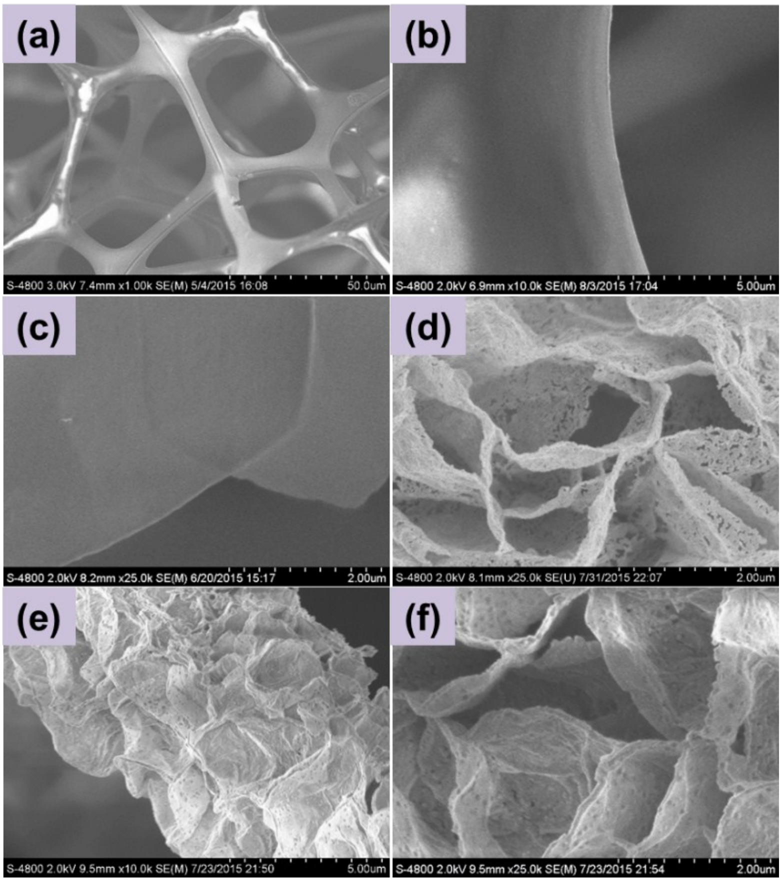

Figure S1. The SEM images of (a,b) pristine MF, (c) MF-C, (d) MMF, and (e,f) MM-RSF.

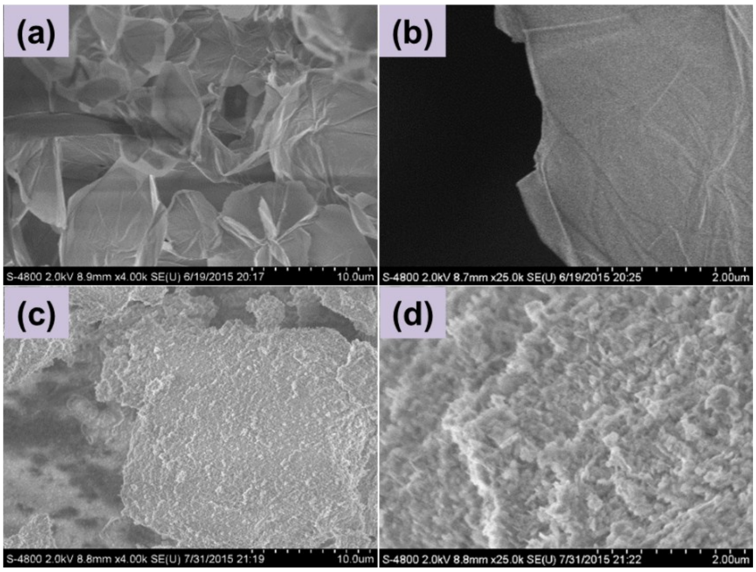

Figure S2. The SEM images of cobalt (II) hydroxide derived from (a,b) slowly precipitation by epichlorohydrin and (c,d) rapidly precipitation by KOH.

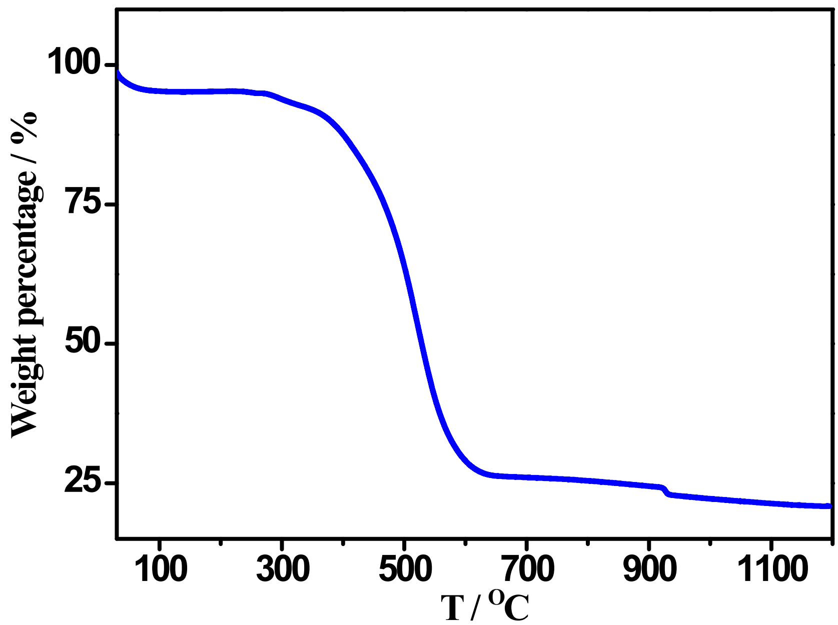

Figure S3. The TG curves of MMF in air, from room temperature to 1200 °C.

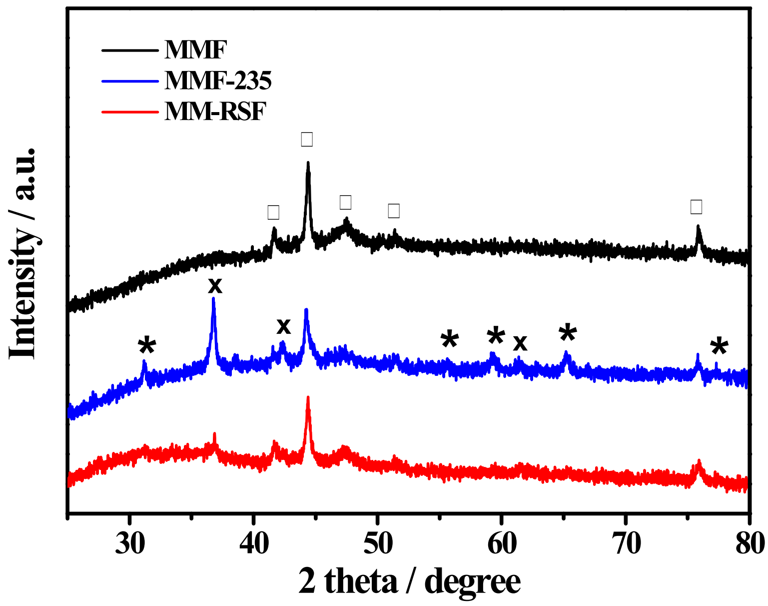

Figure S4. The powder XRD patterns of microstructures on MMF, MM-RSF, and MMF after heating alone in air (MMF-235). The "△", "*", and "x" indicated the peak of cobalt, Co_3O_4, and CoO, respectively. The peaks were assigned according to the PDF#65-9722 and PDF#05-0727 (cobalt, hcp), PDF#15-0806 (cobalt, fcc), PDF#43-1003 (Co_3O_4), and PDF#43-1004 (CoO).

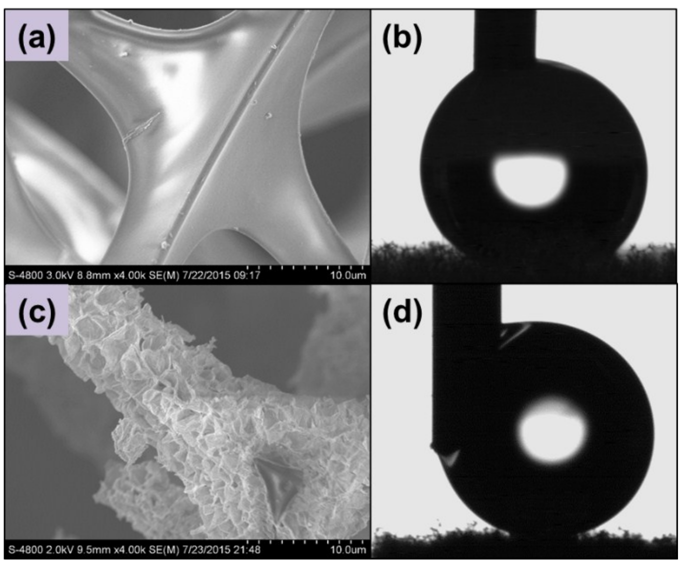

Figure S5. The SEM images and static water contact angle of (a,b) PDMS-coated MF and (c,d) MM-RSF.

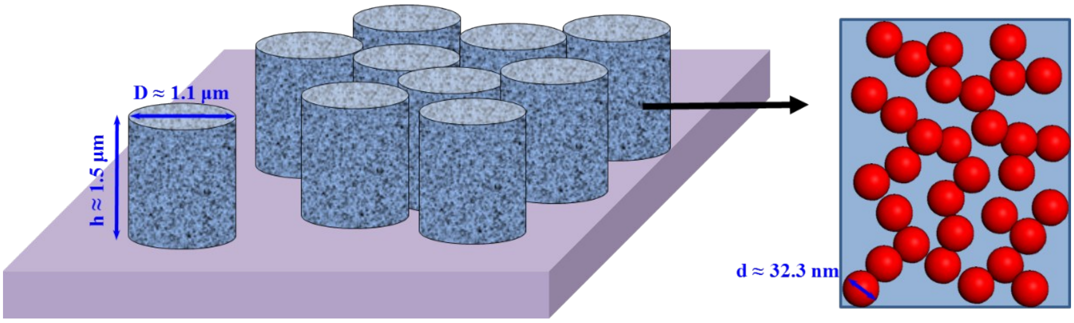

Figure S6 The theoretical model of MM-RSF, representing the 0D/2D hierarchical micro/nano structures on the surface of melamine foam. The 2D sheets vertically and randomly stood on the foam surface and the sheet was composed of 0D cobalt nanoparticles. The 2D sheets are modeled as a series of hollow cylinders (the surface of adjacent cylinders merge together), and the nanoparticles are modeled as spheres.

Roughness is defined as the ratio of the actual area of a rough surface to the geometric projected area. Then the roughness $R_{f,}$ is calculated as follows:

The average size of microstructures were calculated from SEM or TEM images. Given that the average height, diameter and density of hollow cylinders are 1.6 μm, 1.1 μm, and 0.4 μm^{-2}, respectively. The average diameter and density of spheres are 32.3 nm and 320 μm^{-2}, respectively.

Hypothesize the 2D sheet was flat, the A_0, $A_{cyclinder}$ denote the projected area (1μm^2) on the foam and the area provided by the flat hollow cylinders. Then the roughness of the foam (denoted as R_1) can be calculated as follows,

$$R_1 = \frac{A_0 + A_{cylinder}}{A_0} = 1 + \frac{0.4 * \pi * 1.1 * 1.5}{1 * 1} = 3.07$$

Considering the 2D sheet as the substrate, A_S, A_{NPs} denote the projected area (1μm^2) on the sheet and the area provided by the spherical nanoparticles. Then the roughness of the sheet can be calculated as follows,

$$R_2 = \frac{A_S + A_{NPs}}{A_S} = 1 + \frac{320 * 4 * \pi * (0.0323 / 2)^2}{1 * 1} = 2.05$$

Therefore, the total roughness provided by the nanoparticles-composed sheets can be derived as follows

$$R_f = R_1 * R_2 = 3.07 * 2.05 = 6.29$$

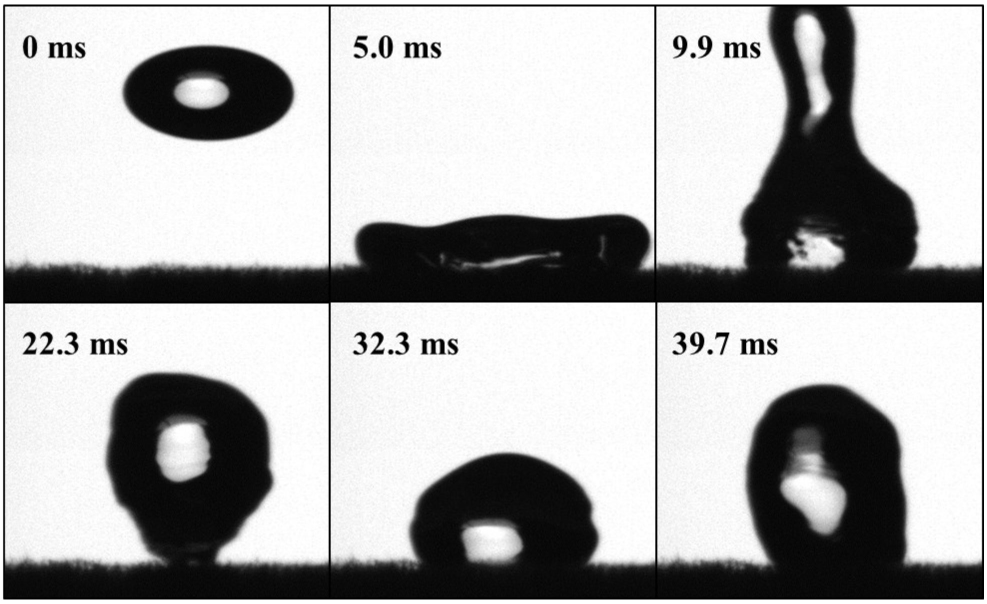

Figure S7. Snapshots of a water droplet impact on the surface of PDMS-coated MF.

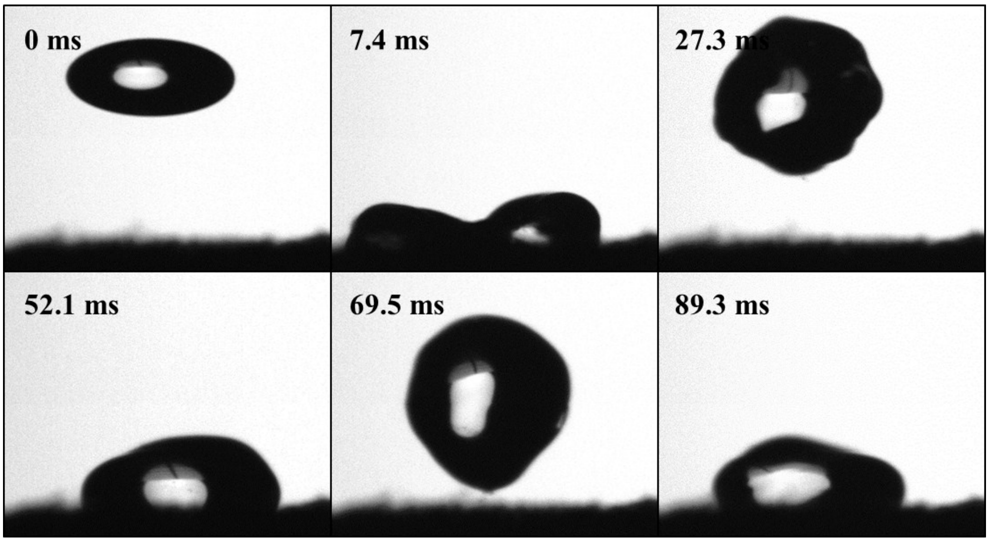

Figure S8. Snapshots of a water droplet impact on the surface of MM-RSF.

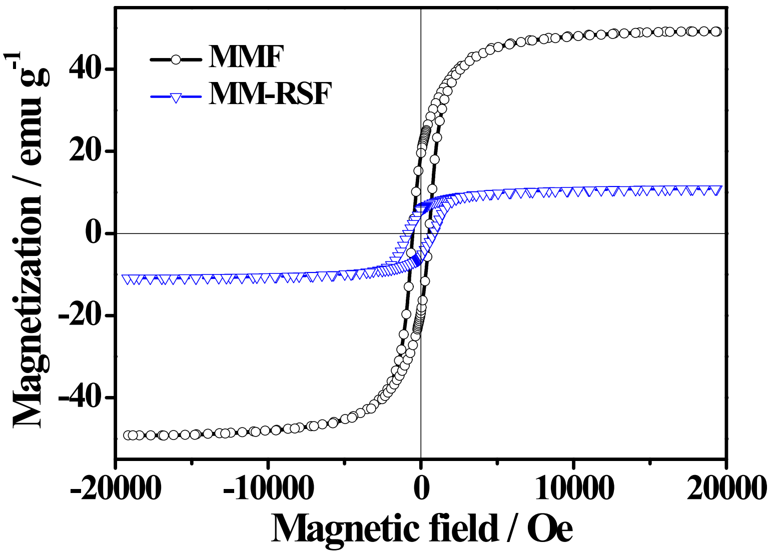

Figure S9. The magnetization curves of MMF and MM-RSF.

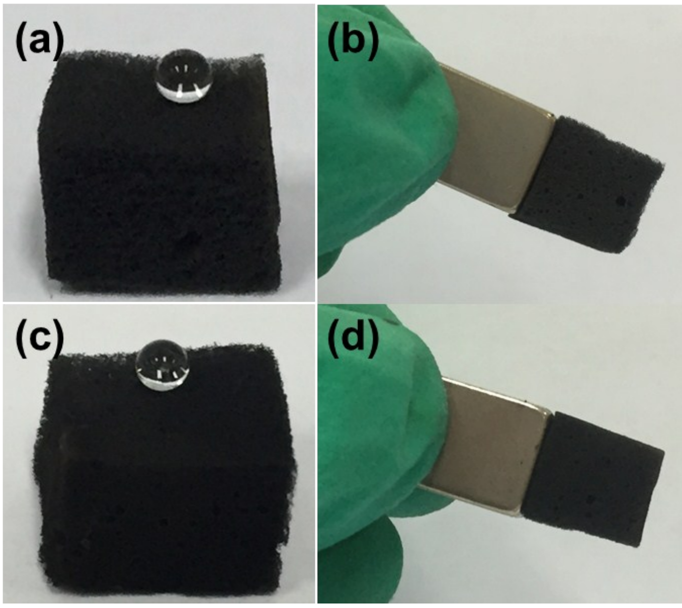

Figure S10. The demonstration of the hydrophobicity and magnetism retention of MM-RSF after (a-b) heating (200°C, 2h) in air and (c-d) cooling (-196°C, 2h) in liquid nitrogen.

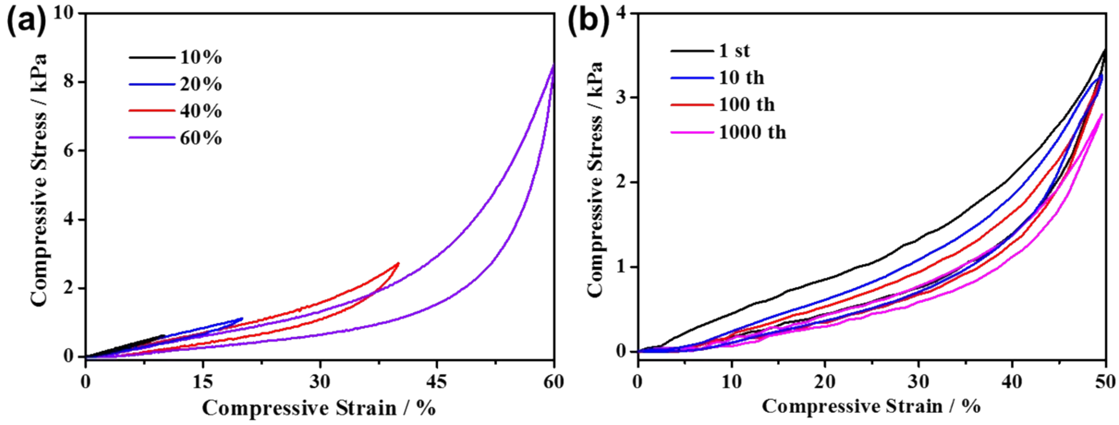

Figure S11. (a) The stress-strain curve of MM-RSF with different strain. (b) The cycling stress-strain curve of MM-RSF (1000 cycles) at 50% strain.

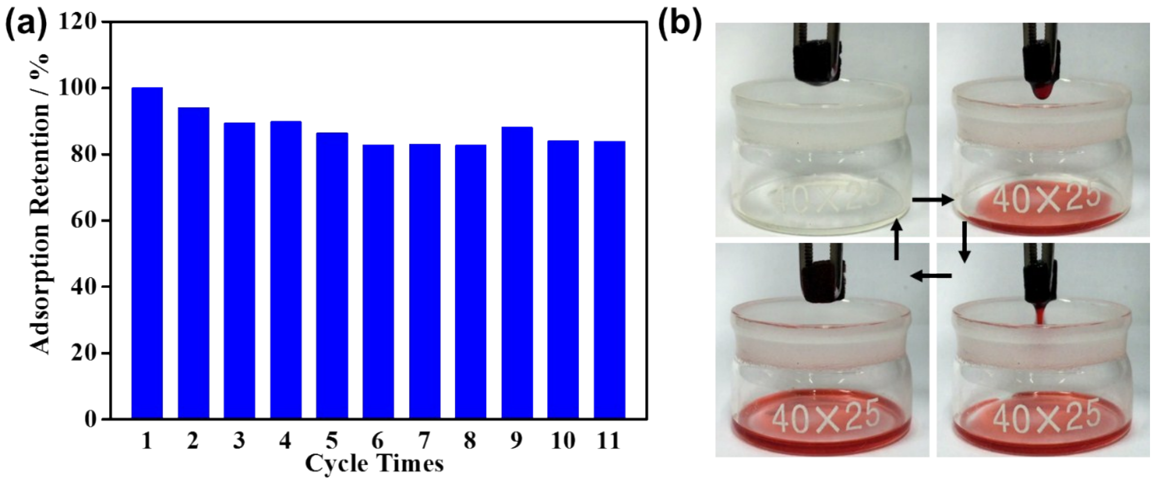

Figure S12. (a) The adsorption cycles of MM-RSF for acetone realized by squeezing regeneration. (b) The demonstration of oil recovery (toluene, dyed by Sudan III) by squeezing the saturated MM-RSF.

Figure S13. The water contact angle (164.2°) of MM-RSF in hexane.