

Electronic Supporting Information

Functionalization of PNIPAAm microgels using magnetic graphene and their application in microreactors as switch materials

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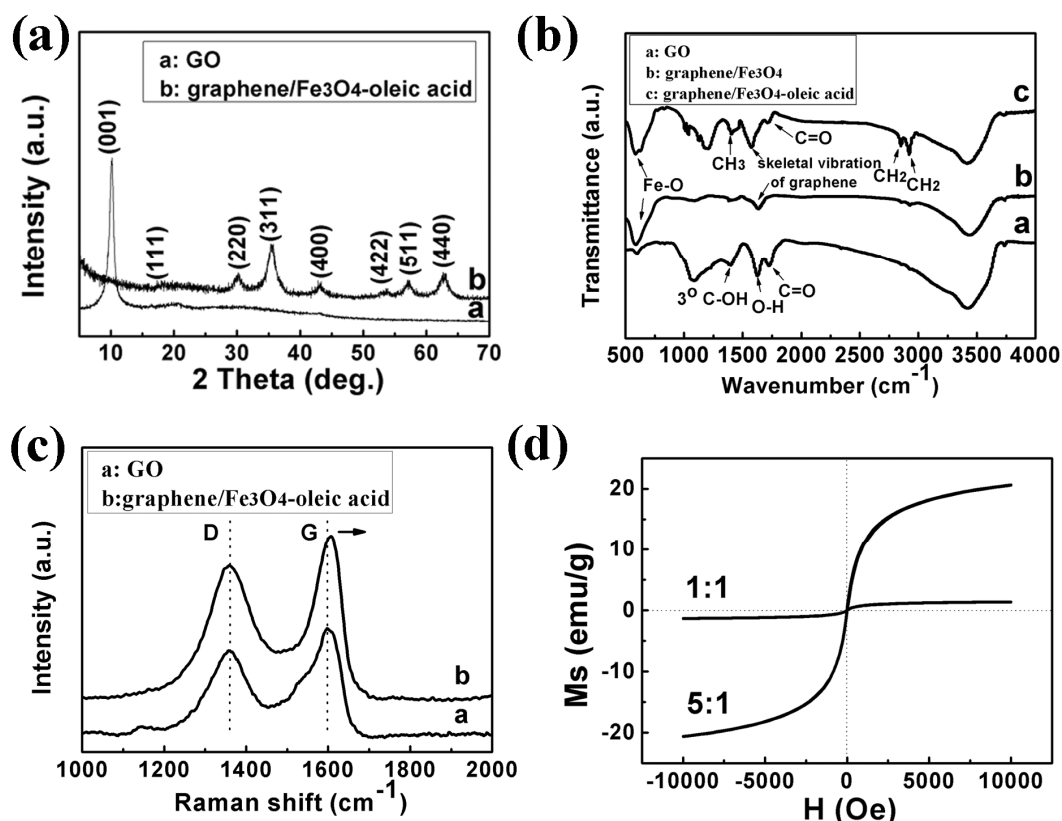


Figure S1 a: XRD patterns of the as-prepared graphene/Fe₃O₄ hybrids and GO; b: FTIR spectra of the as-prepared graphene/Fe₃O₄ hybrids, as-reduced graphene and GO; c: Raman spectra of the as-prepared graphene/Fe₃O₄ hybrids and GO; d: Magnetization curves of the as-prepared graphene/Fe₃O₄ hybrids with different initial iron precursors/GO weight ratios (1:1 and 5:1).

Powder X-ray diffraction (XRD) analysis revealed structural changes occurring during the reduction of graphite oxide (GO). Figure S1A shows the XRD patterns of GO and the graphene/Fe₃O₄ hybrid. The sharp peak at around $2\theta = 10.8^\circ$ (see Figure S1a, line a), which corresponds to the (0 0 1) reflection of GO, almost disappeared in the XRD pattern of the graphene/Fe₃O₄ hybrid (Figure S1a, line b). In addition, all diffraction peaks of the graphene/Fe₃O₄ hybrid can be indexed to cubic spinel Fe₃O₄ (JCPDS Card No. 19-0629), indicating that the layers of GO were exfoliated and the restacking of the as-reduced graphite sheets was effectively prevented.^[1]

The reduced mechanism of GO to reduced graphite sheets was also studied through the fourier transform infrared spectra (FTIR) spectrum and Raman spectrum. In Figure S1b, the FTIR spectrum of the intermediate product, graphene sheets, confirms reduction of GO sheets. Absorptions due to the C=O group (1725 cm⁻¹) and the tertiary C-OH group (1400 cm⁻¹) are decreased obviously in intensity and the absorption at 1635 cm⁻¹ (O-H groups) is absent. A new absorption band that appears at 1580 cm⁻¹ may be attributed to the skeletal vibration of the graphene sheets and another new absorption band at 2930 cm⁻¹ is also observed, which indicates an asymmetric CH₂ stretch in poly(sodium 4-styrenesulfonate) (PSS).^[2] As the Fe₃O₄ nanoparticles were synthesized with the oleic acid modification, more new absorption bands appear in the FTIR spectrum of the final product, graphene/Fe₃O₄ hybrids. The bands at 2920, 2850, 1710 and 1410 cm⁻¹ are attributed to the symmetric

CH₂ stretch, the asymmetric CH₂ stretch, the stretching vibration of C=O and the CH₃ umbrella mode in oleic acid, respectively.^[3] And the band at 588 cm⁻¹ which corresponds to the vibration of the Fe–O bonds in Fe₃O₄ is also observed.

Figure S1c shows the Raman spectra of GO and the as-prepared graphene/Fe₃O₄ hybrids. Both spectra show the existence of the G band and D band, which are E_{2g} vibrational mode in plane and A_{1g} breathing mode, respectively.^[4] For GO, the G band is located at 1597 cm⁻¹, while for the reduced graphene hybrid the G band moved to 1607 cm⁻¹, which was mainly caused by stress.^[5] At the same time, the intensity of the D band of graphene/Fe₃O₄ hybrids increases compared to that of GO, which can be due to the defects introduced in to the reduced GO during preparation.^[4] In addition, the intensity ratio of the D and G band (*I_D/I_G*) changes from 0.78 to 0.85, indicating a decrease in the average size of the sp² domains upon the reduction of GO.

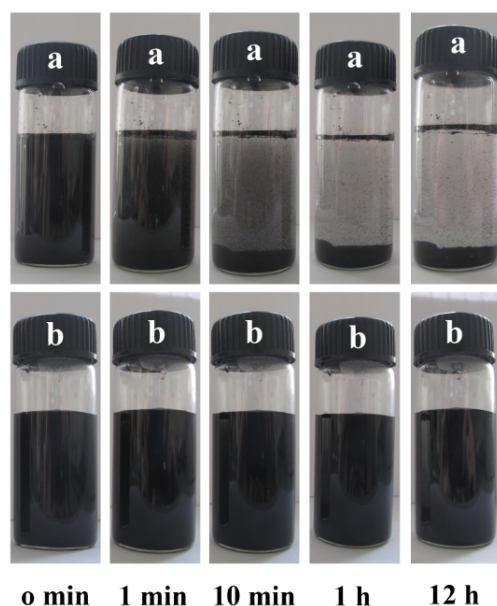


Figure S2 Photographs for the dispersivity of our previous products^[6] (a) and the as-prepared graphene/Fe₃O₄ hybrids (b) in water.

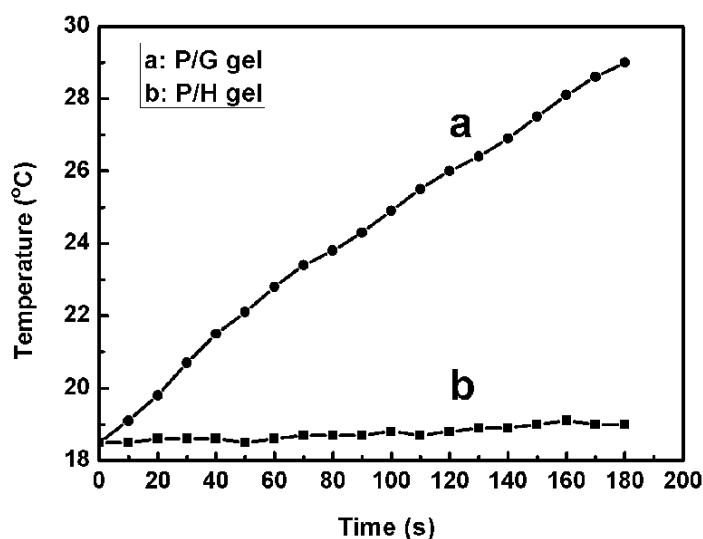


Figure S3 Temperature change curves of the hydrogels exposed to the NIR laser.

Figure S3 shows the temperature change curves of different hydrogels exposed to the NIR laser. In contrast to the P/H gel sample, the P/G gel with 20 mg ml⁻¹ of graphene/Fe₃O₄ shows a rapid increase of temperature when exposed to the laser within a short time.

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