Electronic Supplementary Information for

Fabrication of pH-Sensitive Graphene Oxide-Drug Supramolecular Hydrogels as Controlled Release System

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1. Synthesis of Graphene Oxide and Characterization

Graphene oxide was synthesized from graphite powder ($<30 \mu$ m) by a modified Hummer's method.¹⁻³ At first, 1.0 g of graphite powder was dispersed in A 7:1 (v:v) mixture of concentrated H₂SO₄/H₃PO₄ (117:17 mL) and it was cooled to 0 °C. Next 6.0 g of KMnO₄ was slowly added to this mixture so that the temperature was $<20^{\circ}$ C during the KMnO₄ addition steps. Then it was mixed well and transferred to a 50 °C water bath and stirred for 12 h. After that, the reaction was cooled to room temperature and poured onto ice with sufficient 30% H₂O₂. The mixture was filtered and washed with 0.05mol/L HCl aqueous solution (250 mL) to remove metal ions followed by washing with 200 mL of water to remove the acid. The resulting solid was diluted to make a GO aqueous dispersion. Finally, it was purified by dialysis for two weeks to remove the remaining metal species and other ions.

The successful formation of exfoliated graphene oxide (GO) in water has been confirmed using a UV/vis absorption spectroscopy and atomic force microscopic (AFM) study. In the UV/vis absorption spectrum, the presence of two peaks at 230 and 300 nm suggests the formation of graphene oxide (Fig. S1). An AFM study of GO indicates that GO sheets have an average thickness of 1.01 nm (Fig. S2). Raman spectrum (Fig. S3) shows two peaks at 1586 and 1352 cm⁻¹ corresponding to the G and D bands of grapheme oxide, respectively. XPS survey spectrum (Fig. S4) shows the calculated value of C1s/O1s (atomic ratios) was 1.909. It clearly indicates a considerable degree of oxidation. The C1s and O1s XPS spectra are shown in Fig. S5. Curve fitting of the C1s and O1s spectra was performed using a Gaussian-Lorentzian peak shape. The peaks of C1s spectra are assigned to four components that correspond to carbon atoms in different functional groups: the nonoxygenated ring C(C-C), the C in C–O bonds (C-OH), the carbonyl C (C=O), and the carboxylate carbon (O=C-OH). The peaks of O1s spectra are also assigned to C-OH, C=O and O=C-OH groups respectively. This suggests that graphite powder has been completely exfoliated to a single layer of GO and this as-prepared GO has been used for gelation studies.



Fig. S1 UV-Vis absorption spectra of GO (0.1 mg/mL)



Fig. S2 AFM images of GO nanosheets on a mica surface. The thickness of GO sheet was measured to be about 1.0 nm.



Fig. S3 Raman spectrum of GO sheets.



Fig. S4 XPS survey spectrum for graphene oxide. The calculated value of C1s/O1s (atomic ratios) was 1.909.



Fig. S5 The (A) C1s and (B) O1s XPS spectra for graphene oxide.

 Table S1 Calculated proportion of four C-containing components

 according to fitted peaks of C1s spectra

Peak / eV	Assignment	Proportion
C-C (~284.8 eV)	Carbon	35%
C-OH (~286.2 eV)	Hydroxyl, Eooxy	13%
C=O (~287.1 eV)	Carbonyl	44%
COOH (~288.8 eV)	Carboxyl, Ester	8%

2. Gel-sol transition by dropping NaOH



Fig. S6 Photographs of the pH-induced gel-sol transition.

3. Standard calibration curve of MFH



Fig. S7 UV-Vis absorption spectra of MFH with different concentrations. From 1 to 5, the concentrations are 5, 10, 20, 30, 40, and 50 mg/L respectively. Inset: The standard curve represents the linear relationship between absorbance and drug concentrations.



Fig. S8 UV-Vis absorption spectra of MFH with different concentrations in HCl solution (pH=1). From 1 to 4, the concentrations are 1, 5, 10 and 15 mg/L respectively. Inset: The standard curve represents the linear relationship between absorbance and drug concentrations.

4. Release Mechanism



Fig. S9 Zeta potentials at different pH values for negatively charged GO (0.005 wt %).⁴

лIJ	hydrogen bonds electrostatic attraction			ostatic attraction
рп –	GO	MFH	GO	MFH
1	-ОН, -СООН	-NH-, -NH ₂	_	=NH ₂ ⁺ , =NH ₂ ^{+,}
3	-ОН, -СООН	=NH, -NH-, -NH ₂	-COO ⁻	$=NH_{2}^{+}$
5	-OH	=NH, -NH-, -NH ₂	-COO ⁻	$=NH_2^+$
7	-OH	=NH, -NH- , -NH ₂	-COO ⁻	$=NH_{2}^{+}$

 Table S2 Groups that can form hydrogen bonds and electrostatic attraction

 in GO and MFH at different pH values

Table S3 Release characteristics of encapsulated MFH from the dried hydrogels

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Samples	k	n	R	Transport mechanism
Freeze dried at pH=1	36.99±1.05	0.26±0.03	0.9772	Fickian diffusion
Freeze dried at pH=3	31.91±1.02	0.10 ± 0.01	0.9766	Fickian diffusion
Freeze dried at pH=5	24.61±1.03	0.29 ± 0.02	0.9914	Fickian diffusion
Freeze dried at pH=7	34.74±1.04	0.16 ± 0.02	0.9655	Fickian diffusion
Air dried at pH=1	44.44 ± 1.06	0.22 ± 0.04	0.9433	Fickian diffusion
Air dried at pH=3	25.47±1.11	0.23±0.06	0.8799	Fickian diffusion
Air dried at pH=5	24.46±1.03	0.27±0.02	0.9891	Fickian diffusion
Air dried at pH=7	30.60±1.08	0.22 ± 0.05	0.9201	Fickian diffusion

under different methods at different pH values

All the values were obtained according to three parallel experiments.

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