

Supporting Information

Synergistic effect of graphene oxide and hydroxylated-graphene on the enhanced properties of cement composites

Yundong Pu,^a Sen Yang,^a Meng Qi,^b Kuang Sheng,^a Junfeng Bi,^a Fukun Fan,^a Xiaoya

Yuan^{a,*}

a. College of Materials Science and Engineering, Chongqing Jiaotong University, Chongqing 400074, China.

b. School of Civil Engineering, Chongqing Jiaotong University, Chongqing 400074, china.

1. Figures

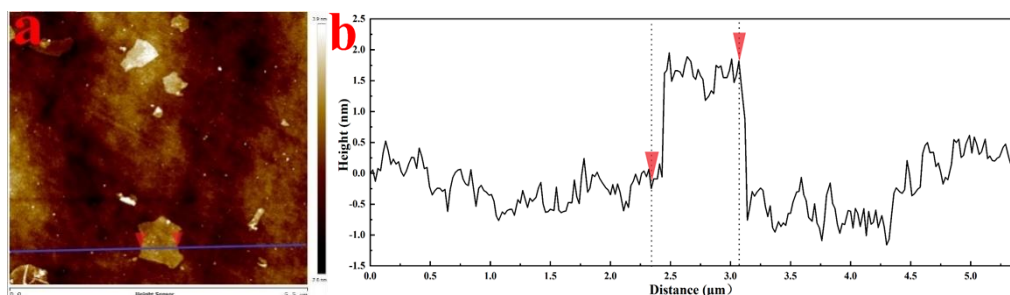


Figure S1. Typical AFM images (a) and the corresponding height profiles (b) of GO.

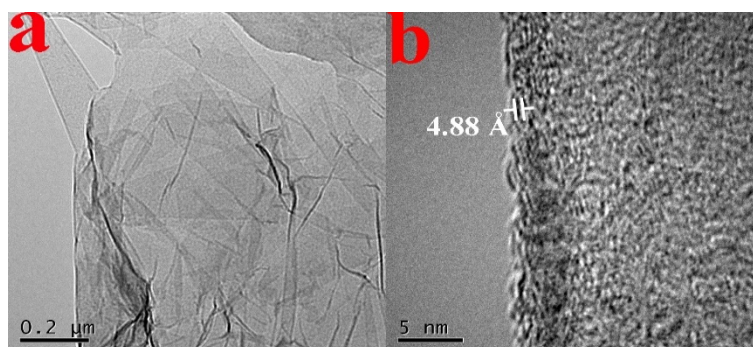


Figure S2. HRTEM images of GO.

* Corresponding author. *Tel.:* +86-23-62789154; *Fax:* +86-23-62789154.

E-mail address: yuanxy@cqjtu.edu.cn (X.Y Yuan)

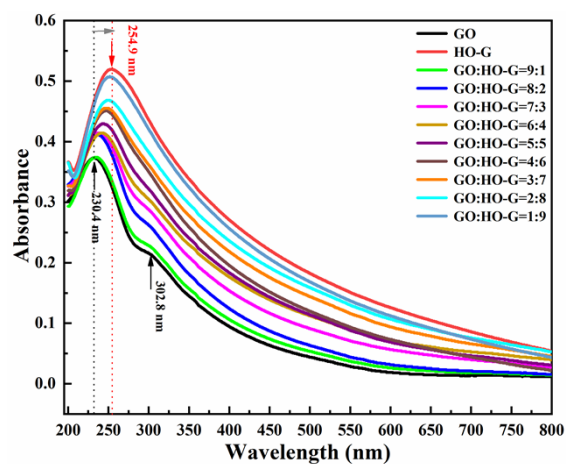


Figure S3. UV-vis spectra of aqueous solutions of different HO-G to GO ratios.

Solution concentration was kept at 10mg/L.

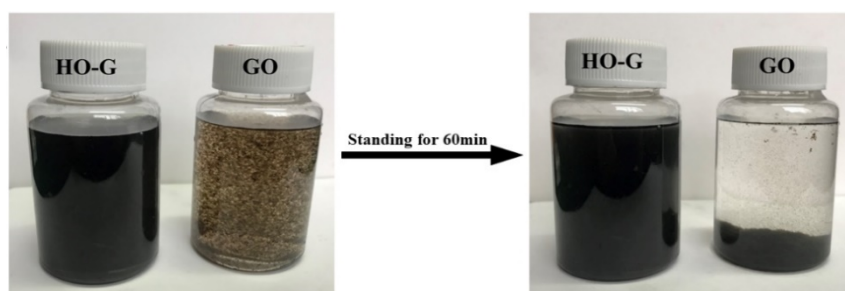


Figure S4. Digital images of HO-G or GO dispersions (1 mg/mL, 5 mL) in saturated $\text{Ca}(\text{OH})_2$ solution (100 mL).

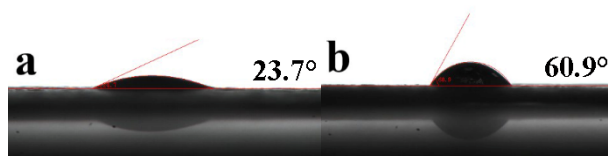


Figure S5. The contact angles of (a) GO, (b) HO-G.

2. Tables

Table S1. Chemical compositions of cement (%).

Chemical composition	Test value (%)
Al ₂ O ₃	4.47
SiO ₂	21.5
Fe ₂ O ₃	3.37
CaO	65.84
MgO	3.18
SO ₃	0.3
NaO	0.49
f-CaO	0.78
C ₃ S	58.92
C ₂ S	20.19
C ₃ A	8.12
C ₄ AF	8.21

Table S2. Physical properties of cement.

properties	Test value
Fineness (%)	0.6
Density (g/cm ³)	3.15
Specific surface area (m ² /kg)	350
Standard Consistency (%)	25.6
Soundness (mm)	0.5
Initial Setting Time (min)	132
Final Setting Time (min)	198

Table S3. Gradation of standard sand.

Square mesh size (mm)	Remaining on the sieve (%)
2.0	0
1.6	7 ± 4
1.0	33 ± 4
0.5	67 ± 4
0.16	87 ± 4
0.08	99 ± 1

Table S4. Compressive and Flexural strength of cement mortars with the hybrids of various GO: HO-G ratios at 3, 7 and 28d.

Samples	Compressive strength ^a (Mpa)/Change ^b (%)			Flexural strength ^a (Mpa) /Change ^b (%)		
	3d	7d	28d	3d	7d	28d
PLAIN	29.6/0	37.5/0	46.8/0	10.6/0	10.9/0	12/0
P _{HO-G}	39.1/+32.1	42.9/+14.4	54.1/+15.6	10.9/+2.8	11.1/+1.8	12.4/+3.3
G ₁ H ₉	47.5/+60.5	50.1/+33.6	60.1/+28.4	11.1/+4.7	11.4/+4.6	12.8/+6.7
G ₂ H ₈	46.3/+56.4	50.3/+34.1	56.6/+20.9	11.3/+6.6	11.9/+9.2	12.5/+4.2
G ₃ H ₇	50.3/+69.9	55.0/+46.7	62.5/+33.5	11.3/+6.6	12.1/+11.0	12.9/+7.5
G ₄ H ₆	47.4/+60.1	54.0/+44.0	63.1/+34.8	11.3/+6.6	12.1/+11.0	13.2/+10.0
G ₅ H ₅	54.2/+83.1	56.9/+51.7	65.6/+40.2	12.0/+13.2	13.3/+22.0	14.1/+17.5
G ₆ H ₄	52.2/+76.4	57.9/+54.4	63.0/+34.6	11.7/+10.4	13/+19.3	13.4/+11.7
G ₇ H ₃	49.3/+66.6	54.7/+45.9	59.8/+27.8	12.3/+16.0	13.1/+20.2	13.9/+15.8
G ₈ H ₂	51.7/+74.7	57.7/+53.9	58.6/+25.2	12.2/+15.1	13.3/+22.0	14.1/+17.5
G ₉ H ₁	50.5/+70.6	53.6/+42.9	58.2/+24.4	12.1/+14.2	13.2/+21.1	14.0/+16.7
P _{GO}	36.5/+23.3	46.4/+23.7	54.8/+17.1	12.3/+16.0	13.4/+22.9	14.6/+21.7

a. Average value.

b. Compared to PLAIN.

Table S5. The improvement ratio of the compressive strength of cement mortars with the hybrids of various GO: HO-G ratios at 3, 7 and 28d.

Samples	Improvement ratio of the compressive strength (%)					
	Compared to P _{HO-G}			Compared to P _{GO}		
	3d	7d	28d	3d	7d	28d
G ₁ H ₉	+17.1	+16.8	+11.1	+30.1	+8.0	+9.7
G ₂ H ₈	+15.5	+17.2	+4.6	+26.8	+8.4	+3.3
G ₃ H ₇	+22.3	+28.2	+15.5	+37.8	+18.5	+14.1
G ₄ H ₆	+17.5	+25.9	+16.6	+29.9	+16.4	+15.1
G ₅ H ₅	+27.9	+32.6	+21.3	+48.5	+22.6	+19.7
G ₆ H ₄	+25.1	+35.0	+16.5	+43.0	+24.8	+15.0
G ₇ H ₃	+20.7	+27.5	+10.5	+35.1	+17.9	+9.1
G ₈ H ₂	+24.4	+34.5	+8.3	+41.6	+24.4	+6.9
G ₉ H ₁	+22.6	+24.9	+7.6	+38.3	+15.5	+6.2

Table S6. The improvement ratio of the flexural strength of cement mortars with the hybrids of various GO: HO-G ratios at 3, 7 and 28d.

Samples	Improvement ratio of the flexural strength (%)					
	Compared to P _{HO-G}			Compared to P _{GO}		
	3d	7d	28d	3d	7d	28d
G ₁ H ₉	+1.8	+2.7	+3.2	-9.8	-14.9	-12.3
G ₂ H ₈	+3.7	+7.2	+0.8	-8.1	-11.2	-14.4
G ₃ H ₇	+3.7	+9.0	+4.0	-8.1	-9.7	-11.6
G ₄ H ₆	+3.7	+9.0	+6.5	-8.1	-9.7	-9.6
G ₅ H ₅	+10.1	+19.8	+13.7	-2.4	-0.7	-3.4
G ₆ H ₄	+7.3	+17.1	+8.1	-4.9	-3.0	-8.2
G ₇ H ₃	+12.8	+18.0	+12.1	0	-2.2	-4.8
G ₈ H ₂	+11.9	+19.8	+13.7	-0.8	-0.7	-3.4
G ₉ H ₁	+11.0	+18.9	+12.9	-1.6	-1.4	-4.1