

Supporting Information

Hybrid Nanocomposite Hydrogels with High Strength and Excellent Self-Recovery Performance

Jia Yang¹, Lin Zhu¹, Xiaoqiang Yan¹, Dandan Wei¹, Gang Qin¹, Baozhong Liu¹,
Shuzheng Liu¹, Qiang Chen^{1, *}

¹ School of Materials Science and Engineering, Henan Polytechnic University,
Jiaozuo, China, 454003

* Corresponding author: qiangcheneric@163.com

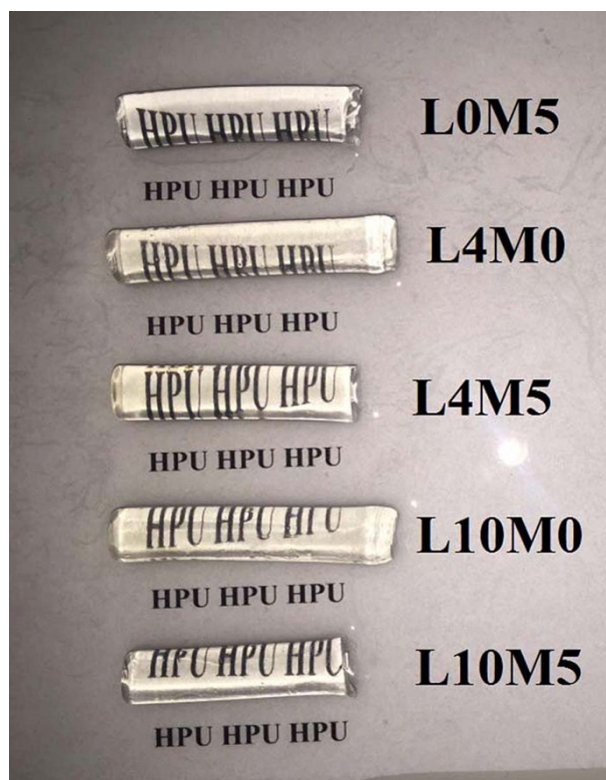


Figure S1. Photos of as prepared physical, chemical and hybrid cross-linked hydrogels.

Table S1 Mechanical properties of physical, chemical and hybrid cross-linked hydrogels. Data represent mean $\pm$ standard deviation. Statistical analysis of compressive properties was done using oneway ANOVA and a LSD's multiple comparison post-test. * $p < 0.05$ compared with L0M5 gel.

Gel sample	Fracture strength (MPa)	Elongation (mm/mm)	Elastic Modulus (kPa)	Fracture energy (MJ/m ³)
L0M5	0.034 $\pm$ 0.003	3.553 $\pm$ 0.164	32.151 $\pm$ 0.414	0.082 $\pm$ 0.013
L4M0	0.062 $\pm$ 0.003	60.517 $\pm$ 1.394*	35.919 $\pm$ 0.540*	2.847 $\pm$ 0.186*
L4M5	0.222 $\pm$ 0.021*	31.766 $\pm$ 0.861*	45.512 $\pm$ 0.084*	4.142 $\pm$ 0.269*
L10M0	0.188 $\pm$ 0.028*	65.044 $\pm$ 2.823*	47.316 $\pm$ 0.664*	6.626 $\pm$ 1.192*

L10M5	0.454±0.019*	50.629±0.282*	72.636±0.961*	9.811±0.672*
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Table S2 Effect of MBA concentration on mechanical properties of PAAm/Laponite hydrogels with Laponite concentration of 4 w/v%. Data represent mean $\pm$ standard deviation. Statistical analysis of compressive properties was done using oneway ANOVA and a LSD's multiple comparison post-test. *p < 0.05 compared with the gel without the MBA.

MBA concentration (mol%)	Fracture strength (MPa)	Elongation (mm/mm)	Elastic Modulus (kPa)	Fracture energy (MJ/m ³)
0	0.062±0.003	60.517±1.394	35.919±0.540	2.847±0.186
0.01	0.146±0.005*	41.038±4.682*	38.998±0.952*	3.249±0.338
0.03	0.198±0.008*	32.173±2.454*	41.984±0.895*	3.882±0.460*
0.05	0.222±0.021*	31.766±0.861*	45.512±0.084*	4.142±0.269*
0.07	0.169±0.008*	18.499±0.771*	46.511±0.914*	1.825±0.170*
0.1	0.091±0.013*	7.051±1.123*	51.047±0.248*	0.377±0.097*

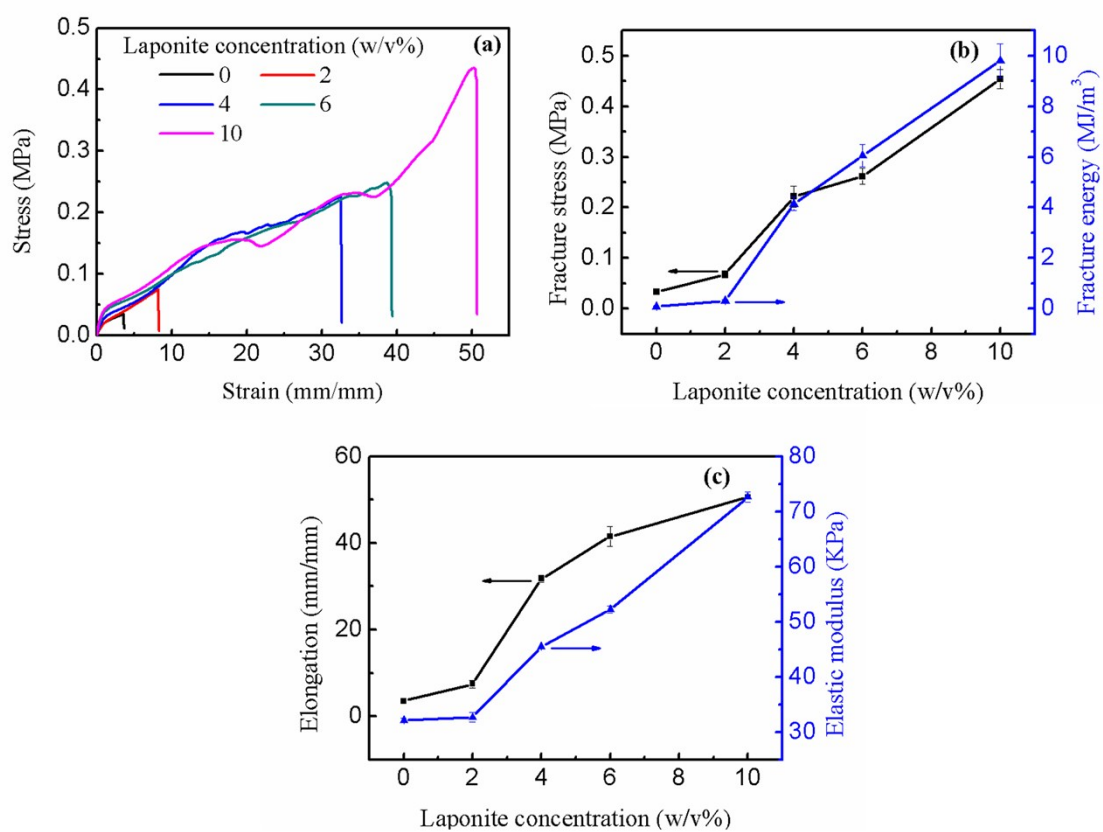


Figure S2. Effect of Laponite concentration on mechanical properties of PAAm/Laponite hydrogels with MBA concentration of 0.05 mol%.

Table S3 Effect of Laponite concentration on mechanical properties of PAAm/Laponite hydrogels with MBA concentration of 0.05 mol%. Data represent mean $\pm$ standard deviation. *p < 0.05 compared with the gel without the Laponite.

Laponite concentration (w/v%)	Fracture strength (MPa)	Elongation (mm/mm)	Elastic Modulus (kPa)	Fracture energy (MJ/m ³)
0	0.034 $\pm$ 0.003	3.553 $\pm$ 0.164	32.151 $\pm$ 0.414	0.082 $\pm$ 0.013
2	0.068 $\pm$ 0.007*	7.465 $\pm$ 0.910*	32.709 $\pm$ 0.843	0.308 $\pm$ 0.048
4	0.222 $\pm$ 0.021*	31.766 $\pm$ 0.861*	45.512 $\pm$ 0.084*	4.142 $\pm$ 0.269*
6	0.262 $\pm$ 0.016*	41.509 $\pm$ 2.317*	52.252 $\pm$ 0.597*	6.054 $\pm$ 0.437*
10	0.454 $\pm$ 0.019*	50.629 $\pm$ 0.282*	72.636 $\pm$ 0.961*	9.811 $\pm$ 0.672*

Table S4. Dissipation energy of PAAm/Laponite hydrogels at $\lambda=10$ and different recovery time.

t (min)	L4M0 (KJ/m ³)	L4M5 (KJ/m ³)	L10M0 (KJ/m ³)	L10M5 (KJ/m ³)
First loading	58.90	103.64	84.73	123.21
0	16.06	0.68	20.87	9.19
1	18.49	6.16	27.82	13.29
3	38.44	29.52	39.66	47.58
30	40.06	53.09	54.14	74.36
180	45.46	67.73	62.24	89.75
360	49.32	76.68	66.70	94.81

Table S5. Dissipation energy of PAAm/Laponite hydrogels for the same gel specimen in six successive loading with 30 min recovery between two tests at $\lambda = 10$.

Cyclic loading number	L4M0 (KJ/m ³)	L4M5 (KJ/m ³)	L10M0 (KJ/m ³)	L10M5 (KJ/m ³)
1	58.90	103.64	84.73	123.21
2	40.06	53.09	54.14	74.36
3	28.53	40.45	48.64	69.93
4	32.53	31.57	46.98	73.08
5	34.77	27.78	44.63	48.03
6	38.80	24.97	45.06	44.27

Table S6 Fracture Stress (MPa) of healed PAAm/Laponite hydrogels at different healed Temperature. Data represent mean $\pm$ standard deviation. *p < 0.05 compared with the L4M0 gel.

	Healing Temperature of 30 °C	Healing Temperature of 50 °C	Healing Temperature of 80 °C
Gel sample			
L4M0	22.711 $\pm$ 0.577	24.065 $\pm$ 0.721	30.554 $\pm$ 2.234
L4M5	20.632 $\pm$ 3.517	27.432 $\pm$ 1.594	30.968 $\pm$ 0.385
L10M0	35.262 $\pm$ 2.061*	39.944 $\pm$ 0.330*	52.223 $\pm$ 5.055*
L10M5	21.546 $\pm$ 1.346	32.717 $\pm$ 3.956*	44.050 $\pm$ 5.354*

Table S7 Healing efficiency (%) of PAAm/Laponite hydrogels at different healed temperature. Data represent mean $\pm$ standard deviation. *p < 0.05 compared with the L4M0 gel.

Gel sample	Healing	Healing	Healing
	Temperature	Temperature	Temperature
	of 30 °C	of 50 °C	of 80 °C
L4M0	36.446 $\pm$ 0.926	38.618 $\pm$ 1.157	49.031 $\pm$ 3.585
L4M5	9.302 $\pm$ 1.585*	12.367 $\pm$ 0.718*	13.961 $\pm$ 0.173*
L10M0	18.798 $\pm$ 1.099*	21.294 $\pm$ 0.176*	27.839 $\pm$ 2.695*
L10M5	4.743 $\pm$ 0.296*	7.203 $\pm$ 0.872	9.698 $\pm$ 1.179*