

## Support information

# Synthesis and Characterization of Well-defined PAA- PEG Multi-responsive Hydrogels by ATRP and Click Chemistry

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### Synthesis of four-armed core initiator<sup>1</sup>

Pentaerithrol (5.44 g, 0.04 mol) and triethylamine (20.2 g, 0.2 mol) were dissolved in dry methylene chloride (400 mL). Then, 2-Bromoisobutyryl bromide (45.8 g, 0.2 mol) was added dropwise for 1.5 h at 0 °C, and the reaction proceeded at ambient temperature (23 °C) for 48 h. Then, the mixed solution was filtered to remove the salt and the solution was washed with NaHCO<sub>3</sub> solution (weight percent: 5%, 100 ml) and deionized water (100 ml) for three times, respectively. The organic phase was dried by anhydrous MgSO<sub>4</sub> for 24 h, and the raw product was obtained by evaporating the solvent under vacuum. Finally, the product was recrystallized with ethanol for three times and dried under vacuum at room temperature over night. (Yield = 85%) <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>, δ): 4.3 (m, 8H, -C-(CH<sub>2</sub>)), 1.89 (m, 24 H, Br-C(CH<sub>3</sub>)<sub>2</sub>).

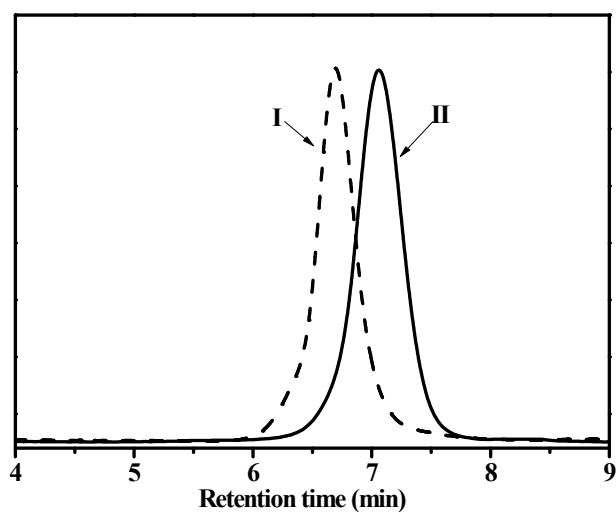
### Synthesis of di-alkyne terminated PEG (DAPEG<sub>45</sub>)<sub>2</sub><sup>2</sup>

PEG (*M<sub>n</sub>* = 4000) (5.00g, 1.25 mmol) was dissolved in dry THF (30 ml), then NaH (0.432 g, 18 mmol) was added to the solution under a dry N<sub>2</sub> atmosphere and stirred for 1 h at 0 °C. Propargyl bromide (0.30 ml, 3.9mmol) was added dropwise into the solution at 0 °C. Then, the reaction lasted 24 h at room temperature. After reaction, the reaction mixture was passed through neutral Al<sub>2</sub>O<sub>3</sub> column, to remove excessive NaH, salt and unreacted propargyl bromide. Finally, the product was obtained from evaporating THF under vacuum. (Yield = 92%). <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>, δ): 4.21 (d, 4H, CH<sub>2</sub>-C), 3.65-3.56 (m, 360 H, -CH<sub>2</sub>-O-), 2.40 (t, 2H, -C-CH).

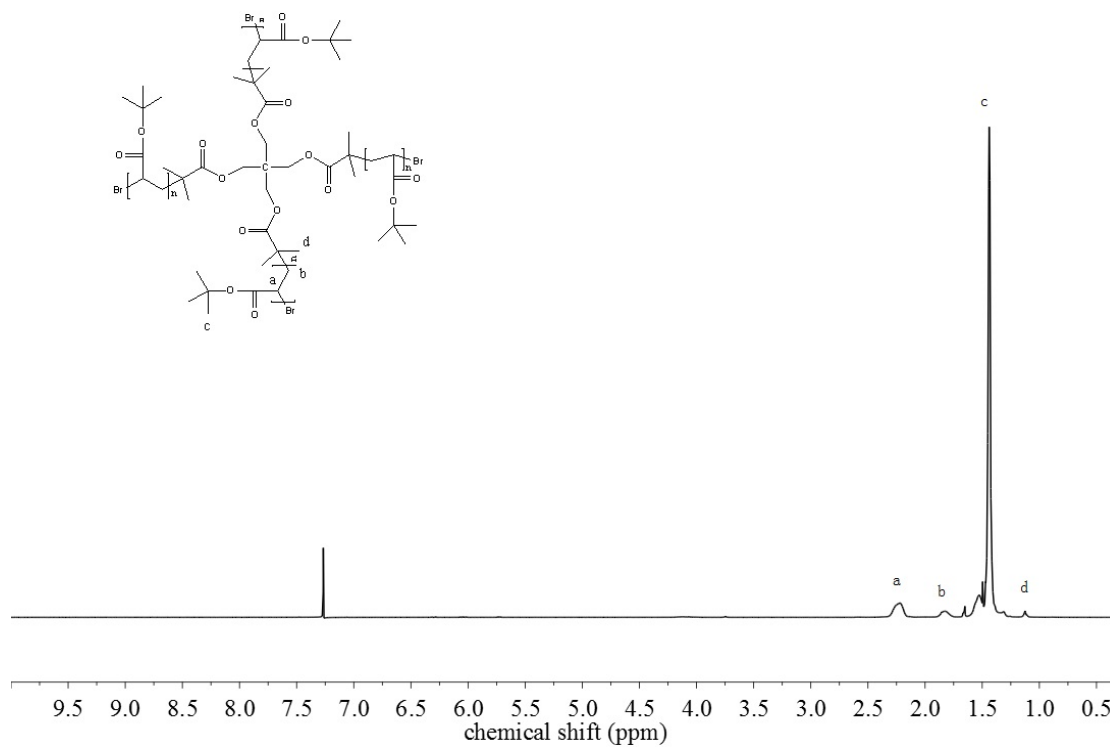
### Thermal behavior

Fig. S4 shows the Thermo gravimetric analysis (TGA) traces of hydrogels gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub>, gel-(PAA<sub>78</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub> and gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>56</sub>)<sub>4</sub> contained different Ca<sup>2+</sup> DC. A three-step degradation was observed in all samples. The first decomposition stage in the range of 215-300 °C was attributed to the destruction of carboxylic groups and CO<sub>2</sub> evolution of PAA segments which lead to the formation of inter- and intra-molecular anhydride.<sup>3, 4</sup> The weight loss of gel-(PAA<sub>78</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub> in the first step at was 22% compared to 18% in gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub> and 14% in gel-

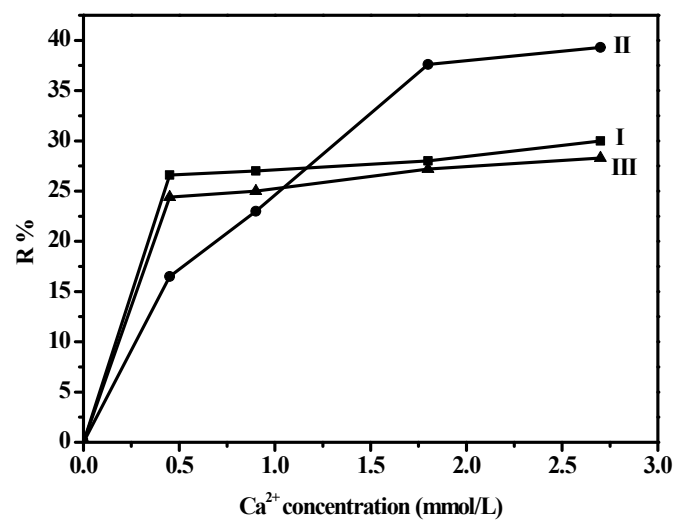
(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>56</sub>)<sub>4</sub>, which is consistent with the relative amounts of acrylic acid in the hydrogel.<sup>5</sup> The second stage at 350-420 °C corresponded to the decomposition of PEG chains in gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>56</sub>)<sub>4</sub> and gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub> which decomposed faster than gel-(PAA<sub>78</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub>, due to the higher PEG content. The third stage higher than 600 °C, the final Ca<sup>2+</sup> residue of three hydrogels were 15%, 12%, 9%, respectively, which corresponded to the Ca<sup>2+</sup> DC in hydrogels.



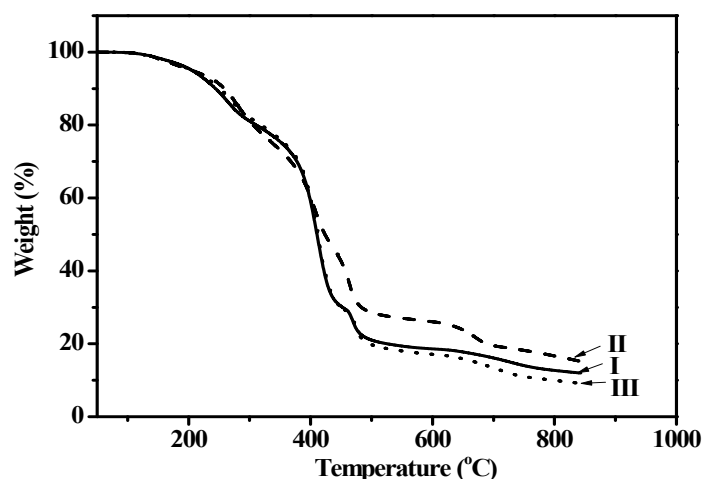
**Fig. S1.** GPC traces of four-armed PtBA prepared by ATRP of I (PtBA<sub>41</sub>)<sub>4</sub> and II (PtBA<sub>78</sub>)<sub>4</sub> initiated by four-armed core initiator in toluene at 60 °C.



**Fig. S2.** <sup>1</sup>H NMR spectrum (400 MHz) of PtBA four-armed polymer in CDCl<sub>3</sub>.



**Fig. S3.** The change of Ca<sup>2+</sup> absorption ratio as a function of initial Ca<sup>2+</sup> concentration for (I) gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub>, (II) gel-(PAA<sub>78</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub> and (III) gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>56</sub>)<sub>4</sub>. (C<sub>0</sub>= 0-2.7mmol/L; t=7 h)



**Fig. S4** Thermo gravimetric analysis (TGA) curves of hydrogels (I) gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub> contained 48% Ca<sup>2+</sup> DC, (II) gel-(PAA<sub>78</sub>)<sub>4</sub>-(PEG<sub>45</sub>)<sub>2</sub> contained 55% Ca<sup>2+</sup> DC, (III) gel-(PAA<sub>41</sub>)<sub>4</sub>-(PEG<sub>56</sub>)<sub>4</sub> contained 46% Ca<sup>2+</sup> DC.

**Table S1. The Solution ATRP of *t*-BA with different conditions**

Entry	[ <i>t</i> -BA] <sub>0</sub> /[Initiator]/ [Cu(I)] <sub>0</sub> /[PMDETA] <sub>0</sub>	Time (h)	Conversion <sup>a</sup> (%)	<i>M</i> <sub>n</sub> (GPC) (g/mol)	<i>M</i> <sub>n</sub> (th) <sup>b</sup> (g/mol)	<i>M</i> <sub>w</sub> / <i>M</i> <sub>n</sub>
(PtBA <sub>41</sub> ) <sub>4</sub>	200:1:4:4	4	73.1%	26700	19400	1.17
(PtBA <sub>78</sub> ) <sub>4</sub>	300:1:4:4	15	92.7%	43700	36300	1.15

<sup>a</sup> calculated by gravimetric

<sup>b</sup> $M_{n(th)} = ([M]_0/[Initiator]_0) \times M_M \times \text{Conversion} + M_{(initiator)}$ , where  $[M]_0$  and  $[Initiator]_0$  are initial concentrations of monomer (*t*-BA) and initiator, respectively.  $M_M$  and  $M_{(initiator)}$  are the molecular weights of monomer (*t*-BA) and initiator, respectively.

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