Electronic Supplementary Information (ESI)

Emulsion-templated, macroporous hydrogels for enhancing water efficiency in fighting fires

Tao Zhang,[a,b] Zhiguang Xu,[a] Haoguan Gui[a] and Qipeng Guo*[a]

[a]Polymers Research Group, Institute for Frontier Materials, Deakin University, Locked Bag 20000, Geelong, Victoria 3220, Australia. Fax: +61 3 5227 1103; Tel: +61 3 5227 2802; E-mail: qguo@deakin.edu.au

[b]Department of Materials Science and Engineering, Technion−Israel Institute of Technology, Haifa 32000, Israel.

Table of Contents

1. Experimental section

Materials. Acrylamide (AAm), pluronic® P-123, ammonium persulfate (APS), *N,N,N′,N′*-tetramethylethylenediamine (TEMED) and *N,N'*-methylene bisacrylamide (MBAAm) were purchased from Sigma-Aldrich and used without further purification. [2-(Methacryloyloxy)ethyl]trimethylammonium chloride (MTAC) solution (80 wt. % in H_2O) was purified by passing a neutral aluminium oxide column prior to use. The other solvents were analytical and deionized water was used.

Preparation of the hydrogel polyHIPEs. The formulations of HIPEs are listed in Table S1, and the obtained hydrogel polyHIPEs are denoted as HP-*X*-*Y*-*Z*, where *X*, *Y* and *Z* represent the fraction of the dispersed phase, the MBAAm content and MTAC content, respectively.

Typically, HP-*X*-*Y*-*Z* were prepared according to the following procedures. P-123, AAm, MTAC, APS and MBAAm were dissolved into water, and then cyclohexane was added to the aqueous solution on a vertex mixer. After the formation of HIPEs, TEMED was added into the as-obtained HIPEs and mixed for another 2 minutes. The polymerization of HIPEs was conducted at 35 °C for 12 h. The cyclohexane within the polymerized HIPEs was removed by freezing drying, and the polyHIPEs were purified by Soxhlet extraction.

Preparation of reference hydrogels. Reference hydrogels (R-*X*-*Y*, *X* and *Y* stand for MBAAm content and MTAC content, respectively) were also prepared with the same monomer compositions as the corresponding hydrogel polyHIPEs but without P-123 and hexane. After polymerization at 35 °C for 12 h, the as-obtained hydrogels were immersed into water for one week (changing water every day) to remove the unreacted monomers.

Table S1 Formulations of HP-*X*-*Y*-*Z*.

	HP-80-10-00	HP-80-10-20	HP-85-10-20	HP-80-1-20
Continuous aqueous phase				
P-123	1.00	1.00	0.74	1.00
Water	12.58	12.60	9.45	12.60
AAm	5.4	4.20	3.15	4.50
MTAC	0	1.20	0.9	1.46
MBAAm	0.60	0.60	0.45	0.04
APS	0.20	0.20	0.15	0.20
Total	19.78	19.78	14.84	19.77
Dispersed organic phase				
Hexane	80.02	80.02	84.96	80.03
TEMED	0.20	0.20	0.20	0.20
MTAC fraction (wt. %)	0	20	20	20
MBAAm content (wt. %)	10	10	10	1

Characterization. The composition of these hydrogel polyHIPEs was verified with Fourier transform infrared (FTIR) spectroscopy on a Bruker Vertex 70 FTIR spectrometer in transmission model. Dried hydrogel polyHIPEs were ground well with KBr to press into disks for measurement, and the spectra were collected with 32 scans at a resolution of 4 cm^{-1}. The morphologies of dried hydrogel polyHIPEs were observed with Supra 55 SEM with an accelerating voltage of 5 kV, and their surfaces were coated with a thin gold layer before observation. The average diameters of voids and windows were from SEM micrographs (at low magnification) using the software ImageJ (downloaded from http://rsbweb.nih.gov/ij/).

Water uptake. The water uptake was studied by putting a piece of cubic dry hydrogel (polyHIPE) (about 1 cm× 1 cm ×1 cm) with a known weight (m_0) into water. The

weight (m_t) of the hydrogel polyHIPE with time was recorded. The water uptake was calculated by $W_{HP\text{-}T} = (m_t - m_0) / m_0$.

Reducing temperature with hydrogel (polyHIPEs). Three pieces of steel plates (approximately radius of 13 mm and height of 13 mm) were placed on a hot plate to guarantee the three plates exhibiting same temperature. The temperature of hot plate was controlled at 300 ^oC before putting hydrogel onto them. Reference hydrogel and hydrogel polyHIPEs were cut into a round disc with diameter of 15 mm and a thickness of 3 mm. The temperatures of hot plates covered with different hydrogels were monitored every 30 sec with a handheld thermometer (MiniTemp MT4, Raytek®).

Extinguishment performance. 60 mL of ethanol was placed into a round stainless steel pan (with a diameter around 18 cm), and set fire to it. After the fire became stable, water, twice amount (120 g) of swollen reference hydrogel or hydrogel polyHIPEs (HP-80-1-20) was put into fire, and the time used to extinguish fire was recorded. More water or hydrogel was added if ethanol burned again. All the experiments were carried out in a room at 20 ^oC with relative humidity at 65%, door and windows are open to reduce the effect of oxygen concentration.

2. FT-IR

The composition of hydrogel polyHIPEs was verified by FT-IR.

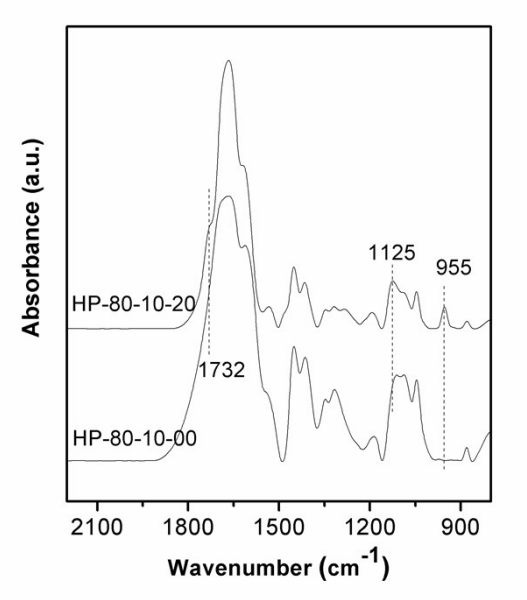

Fig. S1 FT-IR of hydrogel polyHIPEs in the range from 2150-850 cm^{-1}.

3. Porous structures

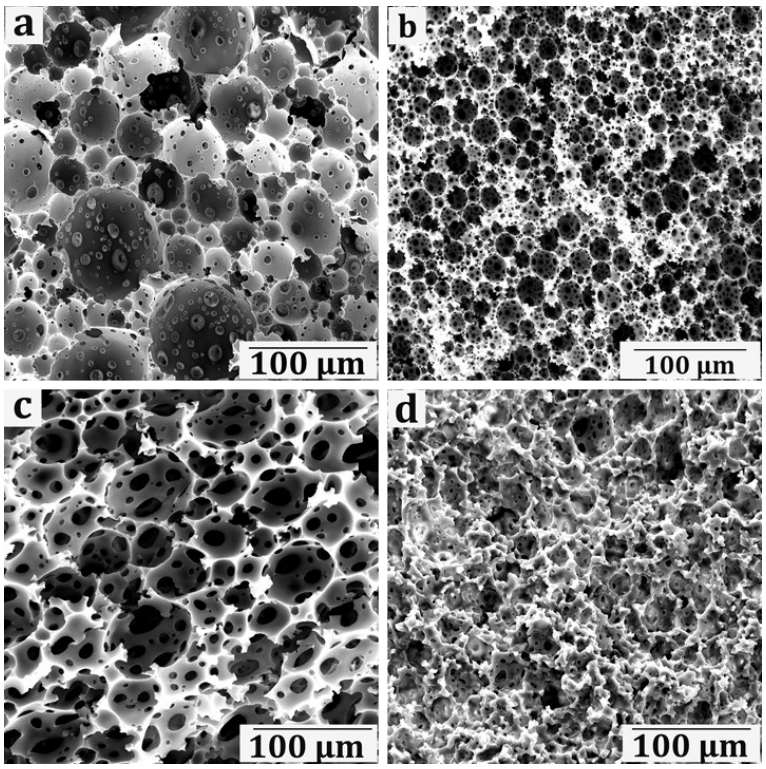

Fig. S2 Interconnected macroporous structures of hydrogel polyHIPEs (SEM): (a) HP-80-10-00; (b) HP-80-10-20; (c) HP-85-10-20 and (d) HP-80-1-20.

4. Mechanical behavior and adhesion of hydrogel polyHIPEs

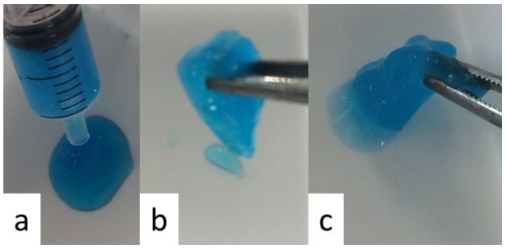

Fig. S3 Photos of HP-80-1-20 showing it to be (a) injectable, (b) and (c) high deformable. The hydrogel polyHIPE was dyed with methylene blue.

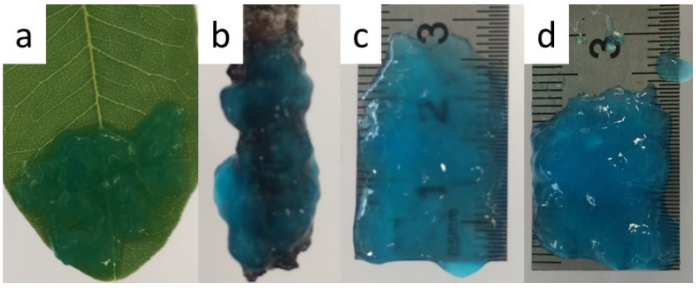

Fig. S4 The HP-80-1-20 adheres onto a vertical smooth leave (a), vertical rough wood (b), a ruler before (c) and after (d) 15 seconds. The hydrogel polyHIPE was dyed with methylene blue.