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Supporting information

Synergistic catalysis of binary alkalis for recycling of unsaturated polyester under mild conditions

Wenli An,[a] Xiong-Lei Wang,[b] Yang Yang,[a] Huaxiu Xu,[a] Shimei Xu,[a] and Yu-Zhong Wang[a]*

[a] *Collaborative Innovation Center for Eco-Friendly and Fire-Safety Polymeric Materials(MoE), State Key Laboratory of Polymer Materials Engineering, National Engineering Laboratory of Eco-Friendly Polymeric Materials (Sichuan), College of Chemistry, Sichuan University, Chengdu 610064, E-mail: xushimei@scu.edu.cn*

[b] *.College of Chemical Engineering, Sichuan University, Chengdu 610064, China.*

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Conversion mechanism

To explore the degradation mechanism and composition of UP-gel, thermogravimetric analysis (TGA) and element analysis (EA) for dried UP-gels with different molar ratios of DETA to NaOH were used to investigate contents of sodium and total nitrogen (ammonium nitrogen and amide nitrogen) in the UP-gel. To tell the content of ammonium nitrogen from amide nitrogen, acidified UP-gel was prepared for EA measurement by treated with 0.1 mol$\times$L^{-1} hydrochloric acid and then dried.

The residue of UP at 700^{o}C was nearly zero, indicating that UP was composed of pure organic chemicals (Figure S3). The TG residues at 850^{o}C of UP-gels were sodium carbonate. The compositions in UP-gels with different molar ratios of DETA to NaOH at 850^{o}C were shown in Table S2. The generation rate of sodium carboxylate groups, ammonium carboxylate groups and amide groups were defined by the equation (1-3) respectively. There are four ester bonds in each structural unit of UP, so the amount of ester group is calculated as 4/538.8 (mol/g).

$$\begin{aligned}\text{Generation rate of ammonium carboxylate} &= \frac{\text{the amount of sodium carboxylate (mol)}}{\text{the amount of ester group (mol)}} \times 100\% \\ &= \frac{2 \times \text{the content of sodium carbonate (g/g)} \ /106\ \text{(g/mol)}}{4/538.8\ \text{(mol/g)}} \times 100\% \\ &= 2.541 \times \text{the content of sodium carbonate} \end{aligned} \quad (1)$$

$$\begin{aligned}\text{Generation rate of ammonium carboxylate} &= \frac{\text{the amount of sodium carboxylate (mol)}}{\text{the amount of ester group (mol)}} \times 100\% \\ &= \frac{1/3 \times \text{the content of ammonium nitrogen (g/g)}/14\ \text{(g/mol)}}{4/538.8\ \text{(mol/g)}} \times 100\% \\ &= 3.207 \times \text{the content of ammonium nitrogen} \end{aligned} \quad (2)$$

$$\begin{aligned} \text{Generation rate of amide} &= \frac{\text{the amount of amide (mol)}}{\text{the amount of ester group (mol)}} \times 100\% \\ &= \frac{1/3 \times \text{the content of amide nitrogen (g/g)}/14(\text{g/mol})}{4/538.8\,(\text{mol/g})} \times 100\% \\ &= 3.207 \times \text{the content of amide nitrogen} \end{aligned} \quad (3)$$

Adsorption isotherm and kinetics

In order to understand the adsorption mechanism, adsorption data was fitted by the Langmuir(4) isotherm models.

$$\frac{C_e}{q_e} = \frac{1}{q_{max} K_L} + \frac{1}{q_{max}} \times C_e \quad (4)$$

where the constant K_L is related to the energy of adsorption ($L \times mg^{-1}$), q_{max} is the Langmuir maximum adsorption capacity ($mg \times g^{-1}$), C_e ($mg \times L^{-1}$) is the equilibrium solute concentration.

It is of significant importance to evaluate the adsorption rate for developing the theoretical researches and guiding the practical application projects. A pseudo-second model (5) was used to describe the adsorption kinetic.

$$\frac{t}{q_t} = \frac{1}{k q_e^2} + \frac{1}{q_e} \times t \quad (5)$$

where k is the pseudo-second order rate constant ($g \times mg^{-1} \times min^{-1}$), q_t and q_e are the adsorption capacities ($mg \times g^{-1}$) at t and at equilibrium time (min) .

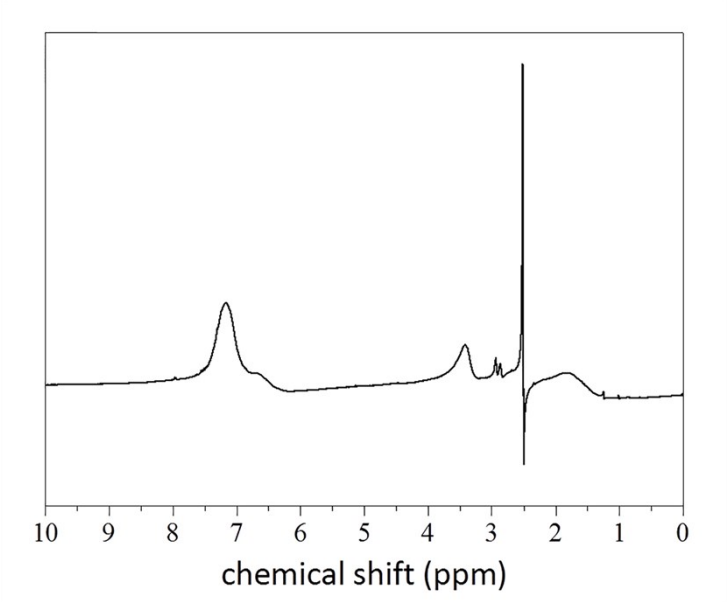

Figure S1 ^{1}H-NMR of SMA.

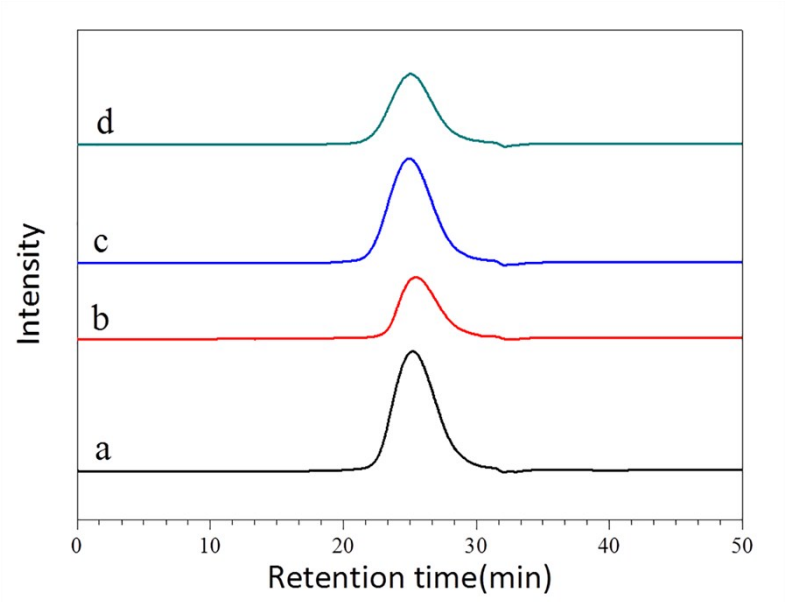

Figure S2 GPC chart of SMA obtained after 3 h (a), 5 h (b), 7 h (c) and 9 (h) of reaction respectively (reaction condition: catalyst (n (DETA & NaOH), 0.2 mol; n (DETA/NaOH), 6/1), atmospheric pressure, 100^{o}C).

Table S1 GPC results of SMA.

Entry	Time/h	Mn	Mw	Mw/Mn
a	3	3127	6724	2.15
b	5	3511	6807	1.94
c	7	4015	8570	2.13
d	9	3895	8662	2.22

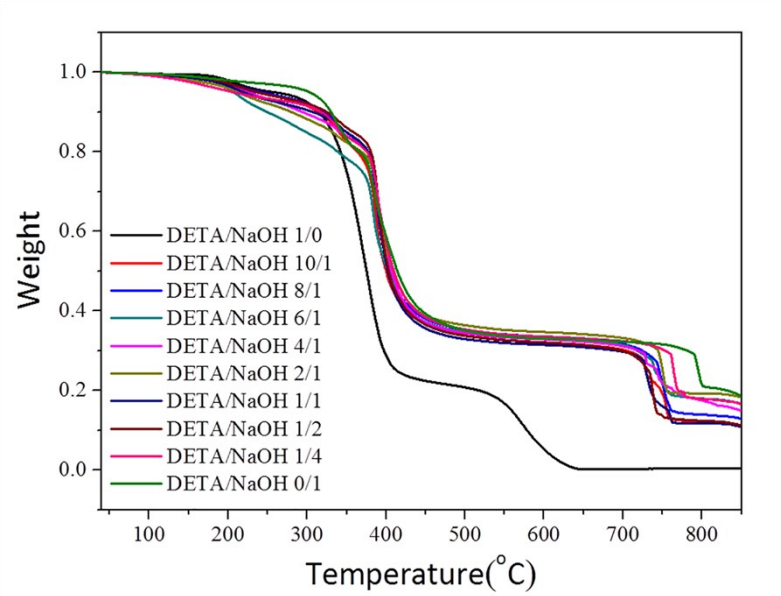

Figure S3 TG curves of UP-gels with different molar ratios of DETA to NaOH.

Table S2 The result of TGA and element analysis.

content/wt%	DETA/NaOH（mol/mol）									
	1/0	10/1	8/1	6/1	4/1	2/1	1/1	1/2	1/4	0/1
Sodium carbonate (TGA)	0.506	11.217	12.949	16.73	14.956	18.329	10.913	11.207	16.599	18.593
Total nitrogen of UP-gel	1.49	2.23	2.62	6.26	5.44	4.53	3.67	2.32	2.37	--
Amide nitrogen of UP-gel	1.03	0	0	0	0	0	0	0	0	--

Table S3 Parameters of Langmuir isotherm model for the adsorption of MB and Cu^{2+}.

Adsorbate	Langmuir		
	q_{max}	K_L	R^2
MB	775.2	0.4243	0.9999
Cu^{2+}	171.5	0.2148	0.9978

Table S4 Pseudo-second order rate constants for MB and Cu^{2+} adsorption on UP-gel.

Adsorbate	Pseudo-second order model		
	q_e	k	R^2
MB	153.8	9.165×10^{-4}	0.9990
Cu^{2+}	121.8	2.043×10^{-3}	0.9998