Glucose production from hydrolysis of cellulose over a novel silica catalyst under hydrothermal conditions

Catalytic hydrolysis of cellulose over solid acid catalysts is one of efficient pathways for the conversion of biomass into fuels and chemicals. In this study, we synthesized a novel silica catalyst by an evaporation-induced self-assembly method (EISA) and tested its activity for the catalytic selective hydrolysis of cellulose to glucose. This silica catalyst exhibited a higher catalytic activity than other oxides, such as ZrO_2, TiO_2, and Al_2O_3 etc., prepared with the same method. The 73.3% cellulose conversion with 50.1% glucose yield was achieved over this novel silica catalyst under hydrothermal conditions without hydrogen gas (Table 1).

Table 1 *Cellulose conversion and yield of products over different catalysts at 433 K for 12 h[a]*

Entry	Catalyst	Conversion (%)	Yield (%)						
			Cellohexose	Cellopentaose	Cellotetraose	Cellotriose	Cellobiose	Glucose	Unknown products
1	Blank	4.5	1.3	–	–	0.3	0.2	–	2.7
2	ZrO_2[b]	15.8	–	–	–	0.1	0.3	9.0	6.4
3	TiO_2[b]	15.4	1.9	–	0.8	1.0	2.0	2.2	7.5
4	Al_2O_3[b]	17.0	5.3	–	1.2	0.1	1.3	0.1	9.0
5	SBA-15	4.0	1.2	–	0.2	0.3	0.5	1.4	0.4
6	HZSM-5 (25)	12.8	–	1.9	1.5	1.1	0.8	1.6	5.9
7	HZSM-5 (38)	12.3	–	1.9	1.4	1.1	0.8	1.8	5.3
8	SiO_2	73.3	1.8	–	1.0	1.8	4.0	50.1	14.6

a. *Reaction conditions: 12 hr reaction time, 10 mL H_2O, 0.05 g cellulose, 0.15 g catalyst.*

b. *The preparation of catalysts were carried out under the identical experimental conditions to that of entry 8.*

Temperature-programmed desorption of ammonia (NH_3-TPD) using a mass spectrometer (HPR-20, Hiden Analytical, Warrington, UK) was used to characterize the acidic properties of the tested samples. The amount of acid sites was estimated by the conventional acid–base titration method. The results of NH_3-TPD (Fig.1) indicated that the acidic properties of the SiO_2 sample were much stronger than those of the other samples. In addition, the SiO_2 sample presented a much higher acid amount than other samples. The textural properties (BET) indicated that the SiO_2 sample has an appropriate average pore diameter (3.512 nm) that could facilitate the transportation of oligosaccharides and thus enhances the chances of oligosaccharides interacting with acid sites. It is concluded that the synergistic effect between the strong acidity and a suitable pore diameter of silica catalyst is one of the

reasons for its high activity. In addition, the catalyst was recyclable and showed the excellent stability during the recycle catalytic runs.

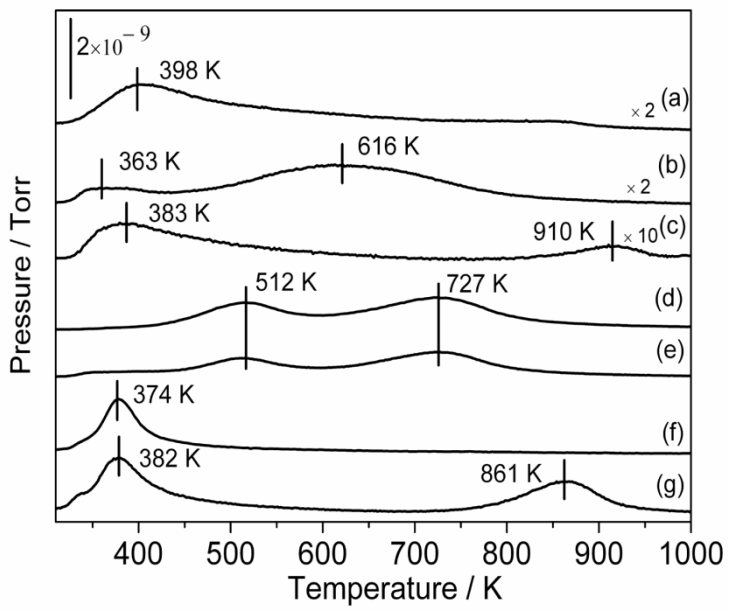

Fig. 1 *Temperature-programmed desorption of ammonia (NH_3-TPD) profiles for various samples of (a) ZrO_2, (b) TiO_2, (c) Al_2O_3, (d) HZSM-5(25), (e) HZSM-5(38), (f) SBA-15, and (g) SiO_2 (EISA).*

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