

Selective Hydrogenation of Sucrose into Sugar Alcohols over Supported Raney Nickel-Based Catalysts

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Abstract: Selective hydrogenation of sugars (e.g. sucrose, cellobiose, glucose, fructose, xylose, arabinose) into sugar alcohols (sorbitol, mannitol, xylitol, arabitol) can be achieved by means of supported Raney Ni-based catalysts. Various supporting materials such as the layered structure of clay (e.g. bentonite, taeniolite, smectite), metal oxides (e.g. Nb₂O₅, ZrO₂, Al₂O₃), and conventional supports (e.g. carbon, silica, zeolite (JRC-SZ1)) were employed to obtain high performance of supported Raney Ni-based catalysts. The conventional Raney Ni, Raney Ni/AlOH, and Ni-NP with relatively high dispersion exhibited superior catalytic activity compared with the various supported Raney Ni catalysts with the conversion of 100% and hexitols selectivity almost ~99%. The H₂ treatment of Raney Ni/SMT at a temperature of 473–773 K caused the increase in Ni(111) crystallite sizes as the conversion of sucrose with compromised decreased of hexitols product. The presence of acidic co-catalyst such as SnO, amberlyst-15, JRC-SZ1, JRC-Z5-9OH1 on Raney Ni/AlOH catalyst significantly enhanced the formation of glycerol product even though the conversion of sucrose compromised decreased owing to the partial leaching of Ni metal into the reaction mixture.

Keywords: selective hydrogenation; sugars; sugar alcohols; supported Raney Ni; acidic co-catalysts

■ INTRODUCTION

Cellulose, a linear polymer of D-glucose with β -1, 4-glycosidic bonds, can be readily hydrolyzed by mineral acids into glucose, which then can be hydrogenated to sorbitol and other polyols [1]. However, this process is not green and suffers from the common problems associated with the use of liquid acids, for example, corrosion and acid recovery or disposal. In attempts to solve these problems, the direct conversion of crystalline cellulose by using preciously noble metal-based catalysts such as Rh, Ru, Pd, and Pt have been employed [2]. Fukuoka and Dhepe [3-4], Luo et al. [5] recently showed that liquid acids can be replaced by solid acids for cellulose conversion into sorbitol and mannitol, but at relatively low yields, most likely owing to the robust structure of crystalline cellulose and its limited accessibility to the surface of acid sites. Alternatively, sugar alcohols (sorbitol or mannitol) can be synthesized from disaccharides (e.g.

sucrose or cellobiose) and monosaccharides such as glucose or fructose via hydrogenation using heterogeneous catalysts.

In published works, Raney nickel-based catalysts are one of the most common applied-catalysts for the aqueous phase hydrogenation of sugars to sugar alcohols [6-12]. One of its most important drawbacks is its pyrophoricity. In the presence of hydrogen and in many cases volatile organic solvents its application requires rigorous safety measures and is easily deactivated due to carbon residue on the surface or sintered under severe reaction conditions [12]. To reduce the pyrophoricity of Raney Ni, Petro and co-workers prepared non-pyrophoric Raney Ni (R-Ni NP) composited with gibbsite and bayerite. This catalyst was prepared in a similar way to the conventional Raney Ni, with the exception that much less NaOH (~1/10) was used for leaching of Al and consequently, much fewer waste

chemicals were generated for disposal. The R-Ni NP catalyst showed the same or higher catalytic activity than that of the conventional Raney Ni in liquid phase hydrogenation of nitrobenzene [13]. The pyrophoricity of Raney Ni catalyst could be also eliminated by removal of adsorbed hydrogen or by addition of metal co-promoters (e.g., Fe, Mo, Cr, Sn, P, and B) [12,14-15]. It was found that the addition of metal co-promoters not only reduced the pyrophoricity but also enhanced the activity and stability astonishingly. Gallezot et al. studied the promoted-nickel with molybdenum, chromium, iron, and tin for hydrogenation of glucose to sorbitol. Among the studied catalysts, tin promoted skeletal Raney Ni catalysts exhibited better stability than that of the unpromoted Raney Ni during the same period reaction time [12]. Li et al. reported the amorphous nickel-boron (Ni-B) alloy catalysts promoted with chromium, molybdenum, phosphor, and tungsten for hydrogenation of sucrose and it was found that tungsten-promoted Ni-B demonstrated the highest [14-15]. In our previous work, we have reported the effective production of sorbitol/mannitol from hydrogenation of sucrose and cellobiose over highly dispersed nickel nanoparticle supported on aluminum hydroxide (NiNPs/AlOH) catalysts with a high yield of sorbitol ca. > 96%. The catalysts were also stable and reusable for at least five consecutive reaction runs without any significant loss of its activity and selectivity [16]. Raney Ni supported on various clay type supports exhibited high activity for the total hydrogenation of biomass-derived furfural to tetrahydrofurfuryl alcohol [17].

Herein, we extend our investigation on the aqueous phase hydrogenation of sucrose into sorbitol or mannitol in the presence of supported Raney nickel catalysts under mild conditions. Supported Raney Ni catalysts were synthesized according to the procedure that has been reported elsewhere [17]. The effects of supports, H₂-treatment at elevated temperature, and the addition of various acidic co-catalysts on the activity and selectivity during the hydrogenation of sucrose to sorbitol/mannitol were studied systematically.

■ EXPERIMENTAL SECTION

Materials

Raney Ni-Al alloy (50 wt.% Al and 50 wt.% Ni) was purchased from Cica Reagent, Kantou Chemical, Ltd. Nb₂O₅, ZrO₂, TiO₂, active carbon (AC, $S_{\text{BET}} = 815 \text{ m}^2\text{g}^{-1}$), sodium hydroxide (NaOH), sucrose, cellobiose, glucose, fructose, xylose, and arabinose were purchased and used as received from Wako Pure Chemical Industries, Ltd. Lithium-taenolite (TN), sodium-Bentonite (BNT), lithium- hectorite (HT) and smectite SA (SMT) were donated by Kunimine Industries Co. Ltd. SiO₂ ($S_{\text{BET}} = 200 \text{ m}^2\text{g}^{-1}$) was purchased from Japan Aerosil Co. Microcrystalline of cellulose was purchased from Sigma Aldrich and used as received.

Instrumentation

The prepared catalyst was characterized by means of powder X-ray diffraction on a Mac Science MXP3 instrument using monochromatic CuK α radiation ($\lambda = 0.15418 \text{ nm}$). It was operated at 40 kV and 20 mA. The experimental conditions corresponded to a step width of 0.02° and a scan speed of 2°/min. ICP-AES (inductive-coupled plasma-atomic emission spectroscopy) measurements were performed on an SPS 1800H plasma spectrometer of Seiko Instruments Inc. (Ni: 221.7162 nm).

The BET surface area (S_{BET}) and pore volume (V_p) were measured using N₂ physisorption at 77 K on a Belsorp Max (BEL Japan). The samples were degassed at 473 K for 2 h to remove physisorbed gases prior to the measurement. The amount of nitrogen adsorbed onto the samples was used to calculate the BET surface area via the BET equation. The pore volume was estimated to be the liquid volume of nitrogen at a relative pressure of approximately 0.995 according to the Barrett-Joyner-Halenda (BJH) approach based on desorption data [18].

The reactant and products in the reactor (glucose, fructose, xylose, arabinose, and mannitol) were analyzed by using a JASCO RI-930 HPLC using an internal standard method. HPLC was performed with a Shodex KS-801 column (H₂O eluent), refractive index (RI)

intelligent detector, the pressure of 17 kg/m², a column temperature of 343 K and a flow rate of 0.6 mL/min. Analyses of sorbitol, glycerol, ethylene glycol and ethanol were performed by using an NH₂ column-Inertsil (Acetonitril-H₂O eluent) using an internal standard method, refractive index (RI) intelligent detector, the pressure of 45–50 kg/cm², a column temperature of 313 K and a flow rate of 1.0 mL/min.

The sugar conversion (mol %) and the product yield (mol %) were evaluated on a carbon basis [19], as shown below:

Sugars conversion (mol %):

$$X = \left(1 - \frac{\text{sucrose conc. in product}}{\text{sucrose conc. in the loaded sample}} \right) \times 100\%$$

Product yield (mol %):

$$Y = \frac{\text{moles of carbon product}}{\text{moles of carbon in sucrose introduced}} \times 100\%$$

Product selectivity (mol %):

$$S = \frac{\text{mol of each reaction product}}{\text{mol total of liquid product}} \times 100\%$$

Procedure

Preparation of supported Raney Ni catalysts

The supported Raney-Ni catalysts were prepared by simple synthetic procedure according to our previous report [17]. Active carbon (AC), silica (SiO₂), Nb₂O₅, zeolite (JRC-SZ1), and ZrO₂, and various clay materials such as lithium taeniolite (TN), lithium hectorite (HT), and Na-bentonite (BNT, Kunipia F type) were employed as support materials. Raney Ni was prepared by leaching Ni-Al alloy using a concentrate aqueous solution of NaOH at room temperature for 2 h and then washed with deionized water and ethanol until the filtrate was neutralized then the clay was added slowly and stirred for overnight at room temperature. The mixture was transferred into a sealed-Teflon autoclave reactor for hydrothermal treatment at 423 K for 2 h. The solvent was removed by simple centrifugation then dried under vacuum for overnight. Prior to safety use (pyrophoricity), the supported Raney-Ni-clay was examined by heating up under air and it was found to be nonpyrophoric. In the case of Raney Ni, the catalyst was stored in H₂O and used as slurry to prevent the oxidation with air during

handling. In addition, metal oxides or acidic co-catalysts were added by simple mixing at room temperature without further treatment.

Hydrogenation of sugars

A typical reaction of sugar was carried out in the following manner. Sucrose solution (mmol sucrose/Ni metal = ~85; 0.35 mmol of sucrose) was used as a reactant in an autoclave reactor system of Taiatsu Techno (a Pyrex tube was fitted inside of a sus316 jacket to protect the vessel from corrosion in acidic media). After H₂ was introduced into the reactor (initial pressure of H₂ was 1.0-3.0 MPa) at room temperature, then the temperature of the reactor was raised to the prescribed one in the range of 383–453 K for 24 h. The reaction products were analyzed by using JASCO RI-930 HPLC using internal standard method. HPLC was performed by Shodex KS-801 column (H₂O eluent), refractive index (RI) intelligent detector, pressure 16–17 kg/m², column temperature 70 °C and flow rate 0.6 mL/min.

RESULTS AND DISCUSSION

Catalyst Characterization

The XRD patterns of Raney Ni supported on various metal oxides such as Nb₂O₅, ZrO₂, SiO₂, zeolite (JRCZ) and active carbon (AC) are shown in Fig. 1. The specific diffraction peaks at 2θ of 44.6, 51.3, and 76.2° which can be recognized as the identical diffraction peaks of Ni(111), Ni(200), and Ni(220) phases are clearly observed [20]. In the case of clay supported Raney Ni catalysts that were also employed in this work, the physico-chemical properties and XRD patterns were already reported previously [17].

To evaluate the effect of nickel crystallite sizes on the activity and selectivity in the conversion of sucrose, the as-prepared R-Ni/SMT was treated under a hydrogen atmosphere at a temperature of 473–773 K for 1 h and the XRD patterns of H₂-treated R-Ni/SMT are shown in Fig. 2. The diffraction peak of Ni species at 2θ = 44.6; 51.2 and 76.3° that can be recognized as the diffraction peaks of Ni(111), Ni(200), and Ni(220) (111) intensified as the increase of temperature resulting the increase of crystallite sizes of Ni(111) owing segregation

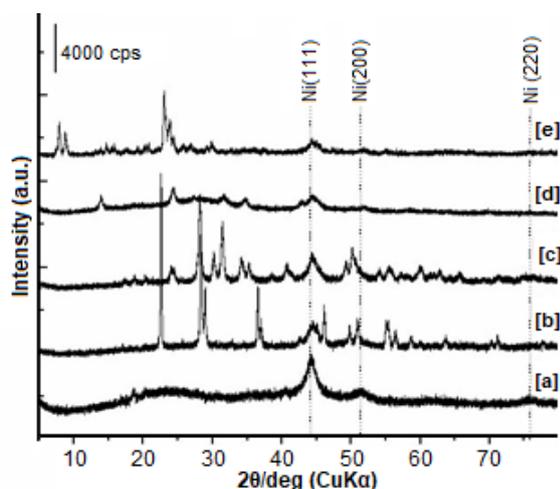


Fig 1. XRD patterns of Raney Ni catalysts on various supports of (a) active carbon (AC), (b) Nb₂O₅, (c) ZrO₂, (d) SiO₂, and (e) Zeolite (JRC-SZ1)

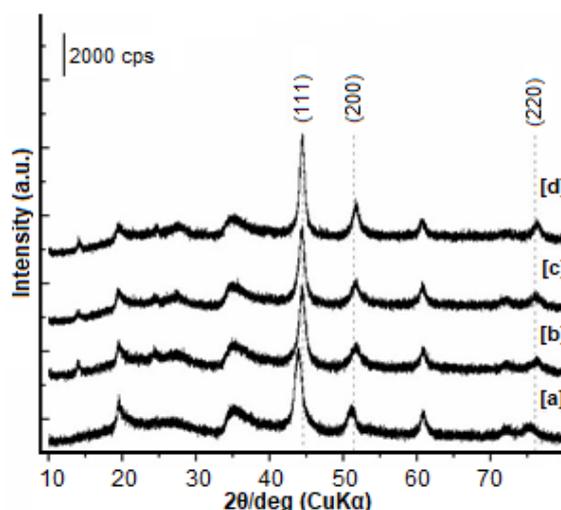
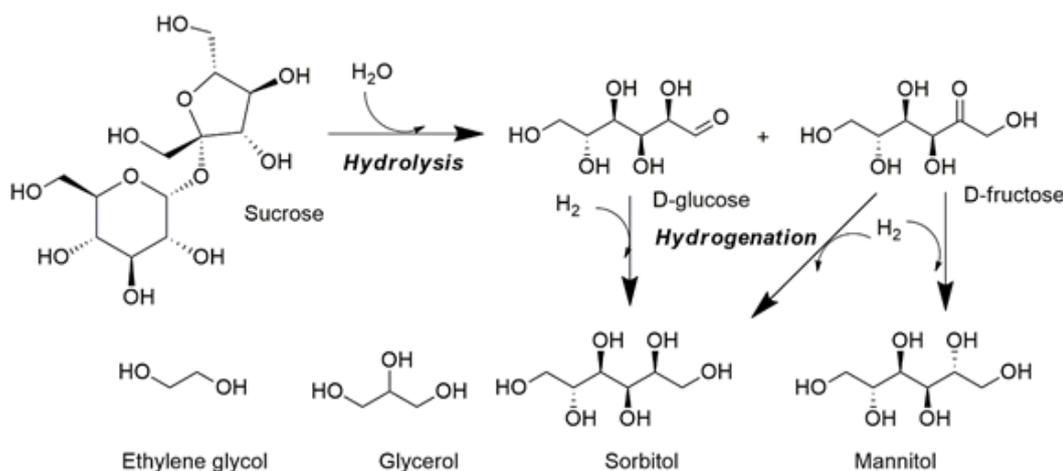


Fig 2. XRD patterns of R-Ni/SMT catalysts after H₂ treatment at (a) 473 K, (b) 573 K, (c) 673 K, and (d) 773 K



Scheme 1. Reaction of sucrose in presence of supported Raney Ni-based catalysts

of Ni species during H₂ treatment at elevated temperature [20]. By using the conventional method of Scherrer equation, the increase of Ni(111) crystallite sizes was from 7.0 nm (untreated) to 11.6 nm (after H₂-treatment at 773 K) (Table 2).

Hydrogenation of Sucrose over Various Supported Raney Ni

In the first experiment, we carried out the reaction of sucrose in water under an H₂ atmosphere in the absence of a catalyst at 403 K for 24 h. The conversion of sucrose was 71% and the yield was 70.6% which consisted of glucose and fructose without the formation of hydrogenated products (Table 1, entry 1). Then, we carried

out the catalytic conversion of sucrose over various supported Raney Ni at identical reaction conditions. The conversion and the yield of glucose, hexitols (sorbitol and mannitol), glycerol and other products over various supported Raney nickel catalysts were summarized in Table 1.

The conventional Raney Ni and Raney-Ni supported on aluminum hydroxide (Raney Ni/AlOH) catalysts demonstrated high conversion of sucrose (> 99%) and gave ~98% hexitols yields (entries 2 and 3) and high yield of hexitols remained even after the reaction time was extended to 24 (entry 4). This result indicates that Raney Ni/AlOH catalyst did not facilitate the further

Table 1. Results of sucrose hydrogenation over various supported Raney Ni catalysts^a

Entry	Catalyst	Conversion ^a (%)	Yield ^a (%)	Selectivity ^b (%)		
				Hexitols ^c	Glycerol	Others ^d
1 ^e	No catalyst	71.0	70.6	0.0	0.0	0.0
2	Raney Ni	99.1	97.1	84.0	0.0	16.0
3	Raney Ni/AlOH	99.2	98.5	98.5	1.5	0.0
4 ^f	Raney Ni/AlOH	>99	99.6	99.4	0.0	0.6
5	R-Ni/BNT	68.0	64.0	90.0	5.2	4.8
6 ^g	R-Ni/HT	72.0	65.0	87.2	1.1	11.7
7 ^h	R-Ni/TN	81.6	78.4	82.2	5.2	12.6
8 ^g	R-Ni/SMT	78.0	76.0	90.0	9.0	1.0
9 ^g	R-Ni/SiO ₂	78.8	67.0	86.8	4.4	8.8
10	R-Ni/Nb ₂ O ₅	87.8	73.2	72.8	6.2	21.0
11	R-Ni/ZrO ₂	83.4	76.5	80.0	4.0	16.0
12	R-Ni/AC	92.0	90.0	95.0	3.7	1.3
13	R-Ni/JRC-SZ1	78.8	76.5	55.0	37.4	7.6
14 ⁱ	Ni-NP	>99	98.0	94.0	0.0	6.0

^a**Reaction conditions:** substrate/Ni = 85; sucrose, 0.35 mmol; H₂O, 5 mL; H₂, 2.0 MPa; temp., 403 K; time, 24 h. ^bTotal yield of liquid products included hexitols and C_n-alcohol (n=3). ^cHexitols (sorbitol + mannitol). ^dOther products are included terminal diols C2-C4 according to GC-MS analysis. ^eThe products were glucose and fructose without the formation of hydrogenated products. ^fThe catalyst was hydrothermally treated at 423 K for 2 h. ^gReaction time was 8 h. ^hReaction time was 16 h. ⁱThe catalyst was synthesized using the colloidal method and after H₂ treatment at 673 K.

conversion of sorbitol into glycerol or other small products and these results are consistent with the previous report [17]. Over various supported Raney Ni catalysts both the as-prepared and after H₂ treatment at 573 K, the conversion of sucrose and yields of hexitols were around 78–85% (entries 5–12). On the other hand, zeolite (JRC-SZ1) supported Raney Ni converted sucrose into hexitols, glycerol, and other products with the selectivity of 55, 37.4, and 7.6%, respectively (entry 13). It seems likely bifunctional catalyst whereas Raney Ni as the hydrogenation agent while JRC-SZ1 as a Brønsted acid site that required for the C-C cleavage [21]. In addition, unsupported nickel nanoparticle catalyst showed similar activity and selectivity to the Raney Ni/AlOH (entry 14). Therefore, it can be concluded that the conventional Raney Ni, Raney Ni/AlOH, and Ni-NP with relatively high dispersion exhibited superior catalytic activity compared with the various supported Raney Ni catalysts. Among clay-supported Raney Ni catalysts, R-Ni/SMT catalyst exhibited relatively higher activity and selectivity within the reaction time of 8 h (entry 8). Therefore, this catalyst was selected for further investigation of the effect

of H₂ treatment, reaction temperature, the addition of acidic co-catalysts, and the hydrogenation of various sugars.

Hydrogenation of Sucrose over H₂-Treated R-Ni/SMT Catalysts

To evaluate the effect of nickel crystallite sizes on the activity and selectivity in the hydrogenation of sucrose, the catalytic reactions over both the as-prepared and H₂-treated R-Ni/SMT were performed, and the results are summarized in Table 2.

The conversion of sucrose over the H₂-treated R-Ni/SMT increased gradually with the increase of temperature while hexitols selectivity decreased slightly compared with the as-prepared then almost constant at a temperature of 473 K. The increase in conversion might be as the result of the surface activity of reduced/hydride Ni⁰ after H₂ treatment. Alternatively, the increase of Ni(111) crystallite sizes resulted in the more intimate interaction of the molecular reactant and Ni-hydride that facilitate the further reaction of sorbitol into other products.

Effect of Reaction Temperature on Sucrose Hydrogenation

The effect of reaction temperature on the conversion and yield of sugar alcohol in the hydrogenation of sucrose over R-Ni/SMT catalyst was performed and the results are summarized in Table 3.

It can be observed that the conversion of sucrose increased gradually as the increase of reaction temperature. The selectivity of the hexitols product was also decreased smoothly as the selectivity of other products increased, indicating further reaction occurred during the increase of reaction temperature (Table 4, entries 1-5).

Effect of Acidic Co-Catalysts on Sucrose Conversion

The effect of acidic co-catalysts addition to Raney Ni, Raney Ni/AlOH, and R-Ni/SMT catalysts was also evaluated in the hydrogenation of sucrose into hexitols, polyols (glycerol and ethylene glycol). Various acidic compounds such as Nb₂O₅, ZrO₂, SnO, zeolite (JRC-SZ1 and JRC-Z5-9OH1), allophane-SO₃, and amberlyst-15 were added to the reaction mixture and the results are summarized in Table 4.

The addition of Nb₂O₅, ZrO₂, and allophane-SO₃ to Raney Ni/AlOH catalyst did not affect to the product distribution of sucrose conversion (entries 1-3). Interestingly, SnO, amberlyst-15, JRC-SZ1, JRC-Z5-9OH1

Table 2. Results of hydrogenation of sucrose over supported R-Ni/SMT after H₂ treatment at different temperatures

Entry	Temp. (K)	D ^a (nm)	Conv. ^b (%)	Selectivity (%)		
				Hexitols ^c	Glycerol	Others ^d
1	RT	7.0	78.0	90.0	9.0	1.0
2	473	7.6	78.6	89.5	1.6	8.9
3	573	8.3	85.0	89.4	1.9	8.7
4	673	9.6	91.0	89.0	1.6	9.4
5	773	11.6	92.2	85.4	3.6	11.0

Reaction conditions: substrate/Ni = 85; sucrose, 0.35 mmol; H₂O, 5 mL; H₂, 2.0 MPa; temp., 403 K; time, 24 h. ^aCrystallite sizes of Ni(111), calculated by using the Scherrer equation. ^bTotal yield of liquid products included hexitols and Cn-alcohol (n = 3). ^cHexitols (sorbitol + mannitol). ^dOther products are included terminal diols C2-C4 according to GC-MS analysis.

Table 3. Results of hydrogenation of sucrose at different reaction temperatures over R-Ni/SMT catalyst

Entry	Temp. (K)	Conv. (%)	Yield ^a (%)	Selectivity (%)	
				Hexitols ^b	Others ^c
1	403	94	90	95	5
2	423	95	89	95	5
3	433	98	97	83	17
4	443	>99	87	81	19
5	453	>99	96	77	23

Reaction conditions: substrate/Ni = 85; sugar, 0.35 mmol; H₂O, 5 mL; H₂, 2.0 MPa; temp., 403-453 K; time, 24 h. ^aTotal yield of liquid products included hexitols and Cn-alcohol (n = 3). ^bHexitols (sorbitol + mannitol). ^cOther products are included terminal diols C2-C4 according to GC-MS analysis.

Table 4. Influence of acidic co-catalysts on catalytic conversion of sucrose over Raney Ni/AlOH catalyst^{a)}

Entry	Co-catalyst	Conversion (%)	Yield ^a (%)	Selectivity (%)		
				Hexitols ^b	Glycerol	Others ^c
1	Nb ₂ O ₅	53.1	49.0	81.9	10.4	7.7
2	ZrO ₂	57.8	43.2	80.4	7.0	12.6
3	Allophane-SO ₃	84.3	78.6	89.7	6.3	4.0
4	SnO	60.8	56.2	22.6	74.6	2.9
5	Amberlyst-15	39.3	26.9	30.0	65.5	4.5
6	JRC-SZ1	54.1	45.2	27.3	69.0	3.7
7	JRC-Z5-9OH1	50.4	47.0	23.4	74.5	2.1
8	R-Ni/SMT 673K/H ₂ + Amberlyst-15	64.7	45.0	46.2	50.7	3.1
9	R-Ni/SMT 673K/H ₂ + JRC-Z5-9OH1	84.0	77.8	36.6	61.5	1.9
10	Raney Ni + Amberlyst-15	98.0	87.2	42.5	57.5	0.0

Reaction conditions: substrate/Ni = 85; sucrose, 0.35 mmol; H₂O, 5 mL; H₂, 2.0 MPa; temp., 403 K; time, 24 h. ^aTotal yield of liquid products included hexitols and Cn-alcohol (n = 3). ^bH = hexitols (sorbitol + mannitol). ^cOther products are included terminal diols C=2-4 according to GC-MS analysis.

Table 5. Results of catalytic conversion of various sugars over R-Ni/SMT catalyst

Entry	Substrate	Conv. (%)	Yield ^a (%)	Selectivity (%)	
				Sugar alc.	Others ^c
1	Sucrose	78	76	90	10
2	Cellobiose	64	60	94	6
3	Glucose	>99	93	95	5
4	Fructose	>99	99	98	2
5	Xylose	>99	98	98	2
6	Arabinose	>99	97	90	10
7	Sorbitol	11	7	0	97

Reaction conditions: substrate/Ni = 85; sugar, 0.35 mmol; H₂O, 5 mL; H₂, 2.0 MPa; temp., 403 K; time, 24 h. ^aTotal yield of liquid products included hexitols (sorbitol + mannitol), xylitol, arabitol, and Cn-alcohol (n = 3). ^cOther products are included terminal diols C2-C4 according to GC-MS analysis.

acidic co-catalysts enhanced drastically the formation of glycerol product even though the conversion of sucrose compromised decreased due to the partial leaching of Ni metal into the reaction mixture (entries 4-7). In the case of R-Ni/SMT 673 K/H₂ and Raney Ni catalysts, similar results were also obtained. A significant improvement of glycerol selectivity was achieved after the addition of amberlyst-15 or JRC-Z5-9OH1 (entries 8-10) and these results are consistent with the Raney Ni/JRC-SZ1 as mentioned before (Table 1, entry 13). Therefore, it can be concluded that the presence of acidic co-catalyst could enhance the catalytic performance of Raney Ni for hydrogenolysis of sucrose.

Catalytic Conversion of Various Sugars

We also intentionally evaluated the catalytic performance of the as-prepared R-Ni/SMT catalyst on hydrogenation of various sugars under the identical reaction conditions and the results are summarized in Table 5.

Sucrose was converted into hexitols (sorbitol and mannitol) with 90% selectivity and a small amount of other products (entry 1). In the case of cellobiose substrate, the conversion was only 64% (94% selectivity of hexitols) and the selectivity to glucose was 6% as other products (entry 2). On the other hand, glucose, fructose, and xylose gave hexitols and xylitol as main products (> 90% yield), respectively (entries 3-6). In addition, R-Ni/SMT catalyst did not active for the conversion of

sorbitol as indicated only 11% conversion and total yield of 7% (entry 7).

CONCLUSION

Selective hydrogenation of sugars (e.g. sucrose, cellobiose, glucose, fructose, xylose, arabinose) into sugar alcohols (sorbitol, mannitol, xylitol or arabitol) can be achieved by means of supported Raney Ni-based catalysts. The conventional Raney Ni, Raney Ni/AlOH, and Ni-NP with relatively high dispersion exhibited superior catalytic activity compared with the various supported Raney Ni catalysts with conversion > 90% and hexitols selectivity almost 95%. The H₂ treatment of Raney Ni/SMT at a temperature of 473-773 K caused the increase in Ni(111) crystallite sizes as the conversion of sucrose with compromised decreased of hexitols product. The presence of acidic co-catalyst such as SnO, amberlyst-15, JRC-SZ1, JRC-Z5-9OH1 on Raney Ni/AlOH catalyst significantly enhanced the formation of glycerol product even though the conversion of sucrose compromised decreased owing to the partial leaching of Ni metal into the reaction mixture.

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