Electronic Supplementary Material (ESI) for RSC Advances.

Potential application of carbohydrate biomass in hydrometallurgy: One-pot reduction of metal oxides/salts under mild hydrothermal conditions

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SUPPORTING INFORMATION

This supporting information includes 22 figures. There are in total 13 pages.

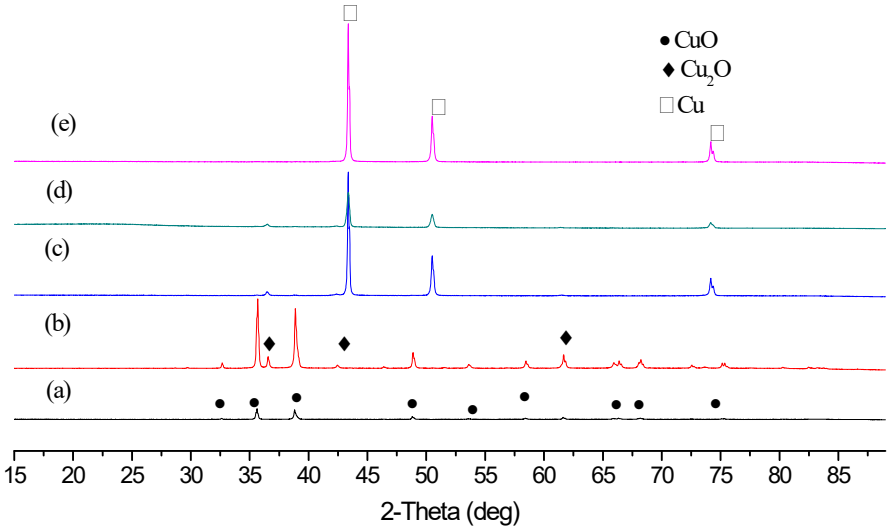

Figure S1 XRD patterns of solid products after reactions of glucose and CuO for 3 h at different temperatures: (a) CuO; (b) 150 °C, 0.4 M NaOH; (c) 220 °C, 0.4 M NaOH; (d) 250 °C, without NaOH; (e) 250 °C, 0.4 M NaOH

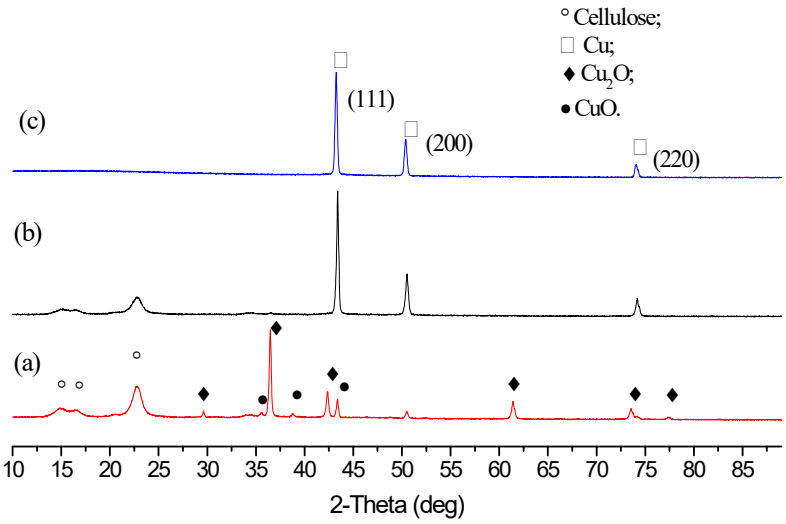

Figure S2 XRD patterns of solid products after reactions of cellulose and CuO with (a) 220 °C, 0.4 M NaOH, 1.5 h; (b) 250 °C, 0.4 M NaOH, 1.5 h; (c) 250 °C, without NaOH, 3 h.

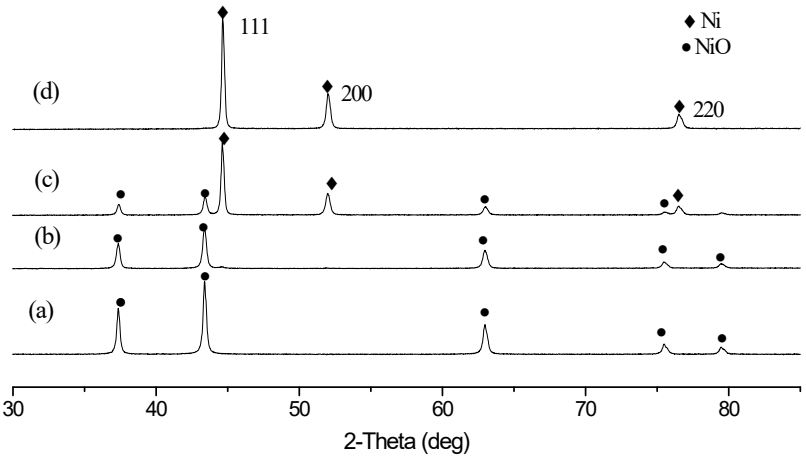

Figure S3 XRD patterns of solid products after reactions of glucose and NiO with different reaction conditions: (a) 250 °C, without NaOH, 6 h; (b) 220 °C, 2.5 M NaOH, 6 h; (c) 250 °C, 2.5 M NaOH, 4 h; (d) 250 °C, 5 M NaOH, 4 h.

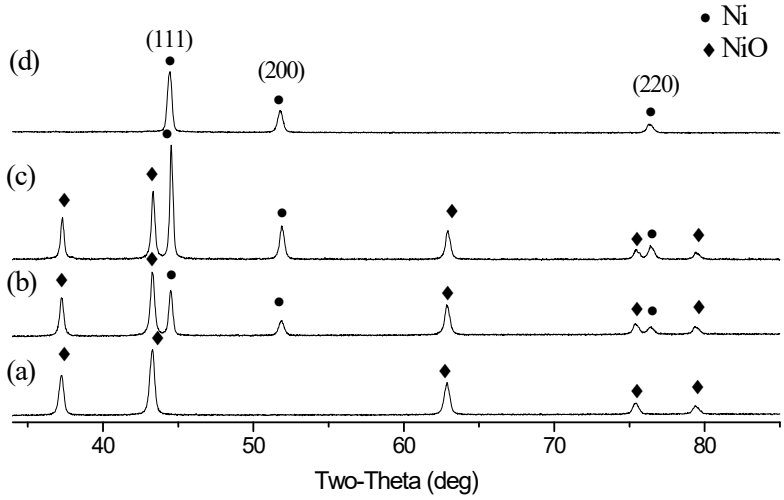

Figure S4 XRD patterns of solid products after reactions of cellulose and NiO at 250 °C ((a) without NaOH, 6 h; (b) NaOH 2.5 M, 3 h; (c) NaOH 5 M, 3 h; (d) NaOH 5 M, 4.5 h).[1]

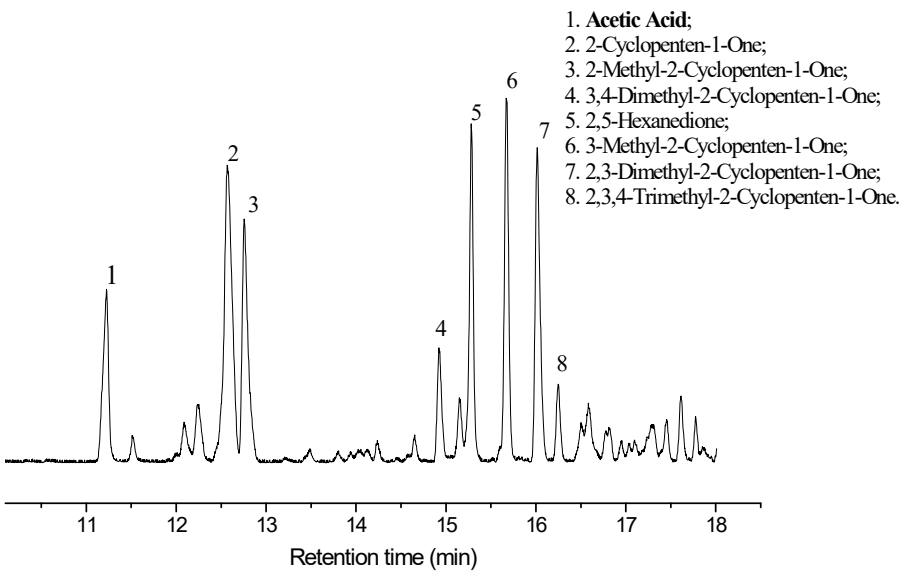

Figure S5 GC-MS chromatogram of the sample after the reaction of glucose and CuO (250 °C, 0.4 M NaOH, 3 h).

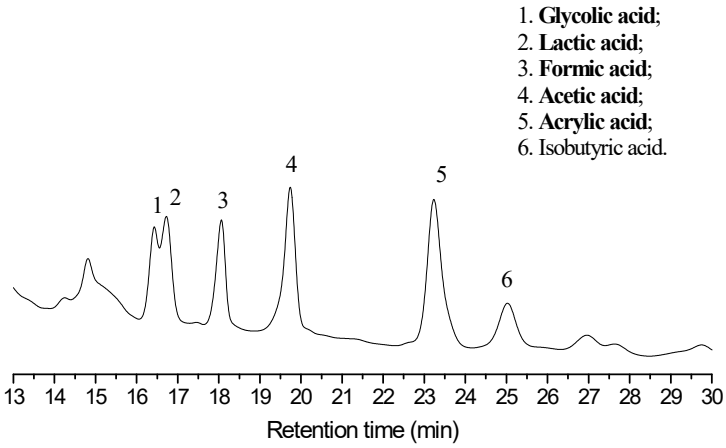

Figure S6 HPLC chromatogram of the liquid sample after the reaction of glucose and CuO (250 °C, 0.4 M NaOH, 3 h).

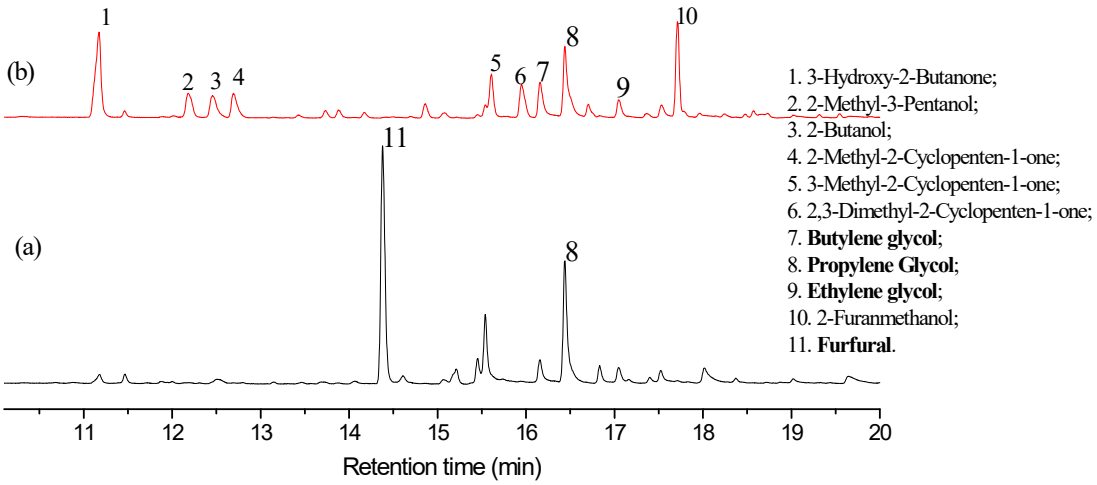

Figure S7 GC-MS chromatograms of samples after reactions of cellulose and CuO without (a) and with 0.4 M NaOH (b) (250 °C, 1.5 h).

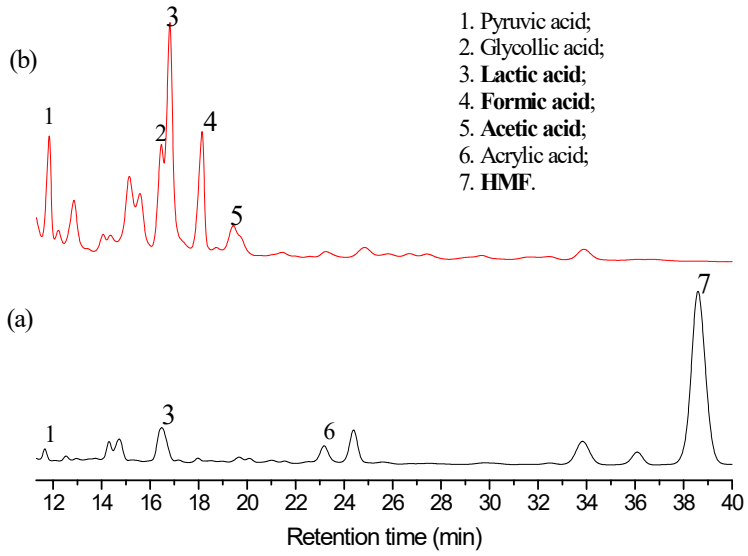

Figure S8 HPLC chromatograms of liquid samples after the reaction of cellulose and CuO in the absence (a) and presence (b) of 0.4 M NaOH (250 °C, 1.5 h).

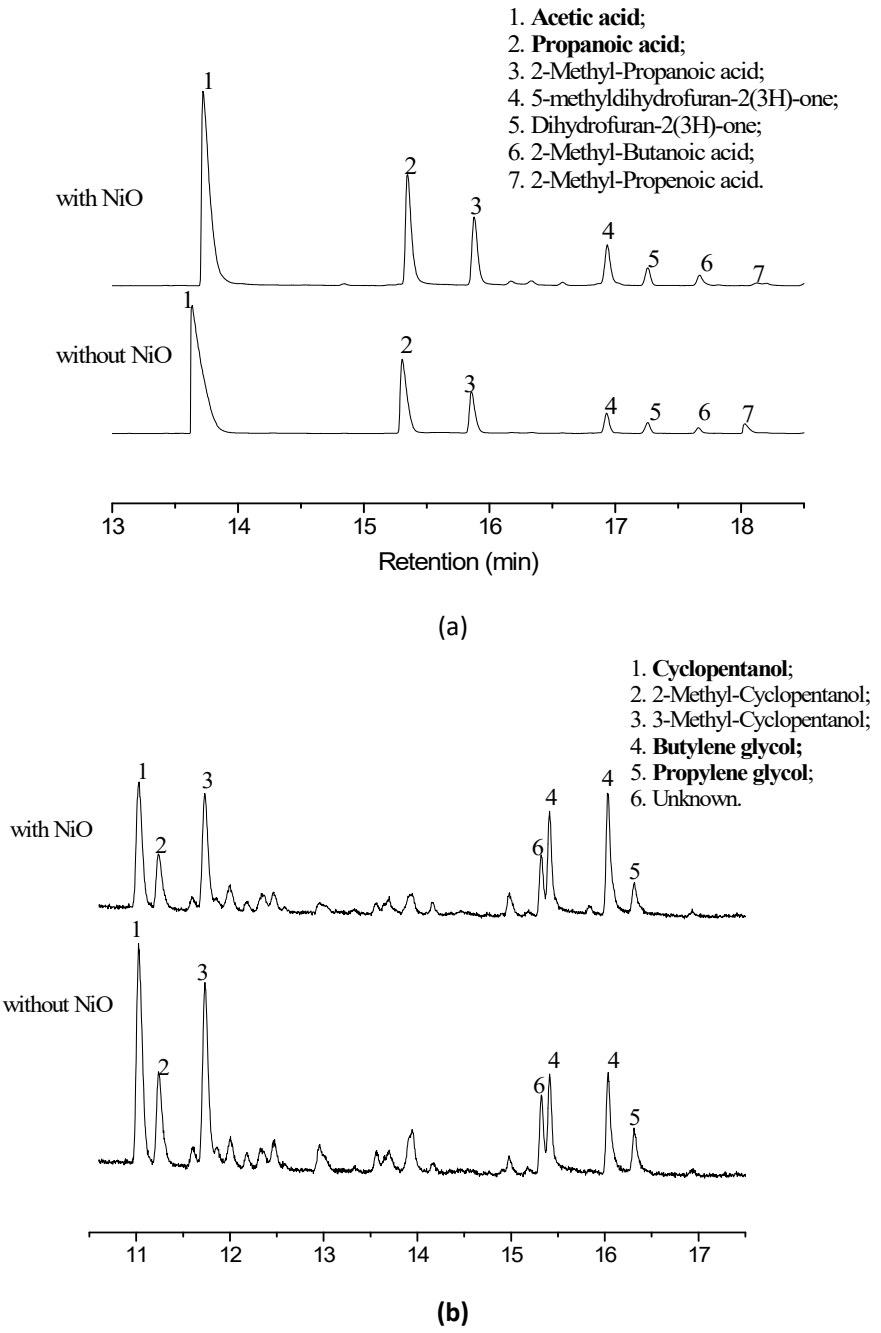

Figure S9 GC-MS chromatograms of samples with (a) adjustment of pH by using HCl and (b) without adjustment of pH after the reaction of glucose with and without NiO (250 °C, 5 M NaOH, 4 h).

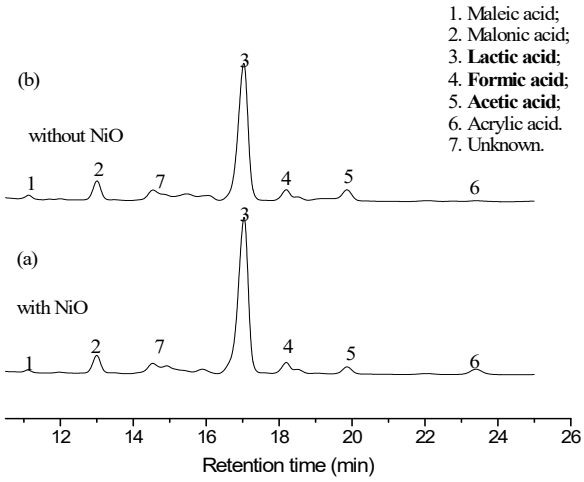

Figure S10 HPLC chromatograms of liquid samples after the reaction of glucose with (a) and without (b) NiO (250 °C, 5 M NaOH, 4 h).

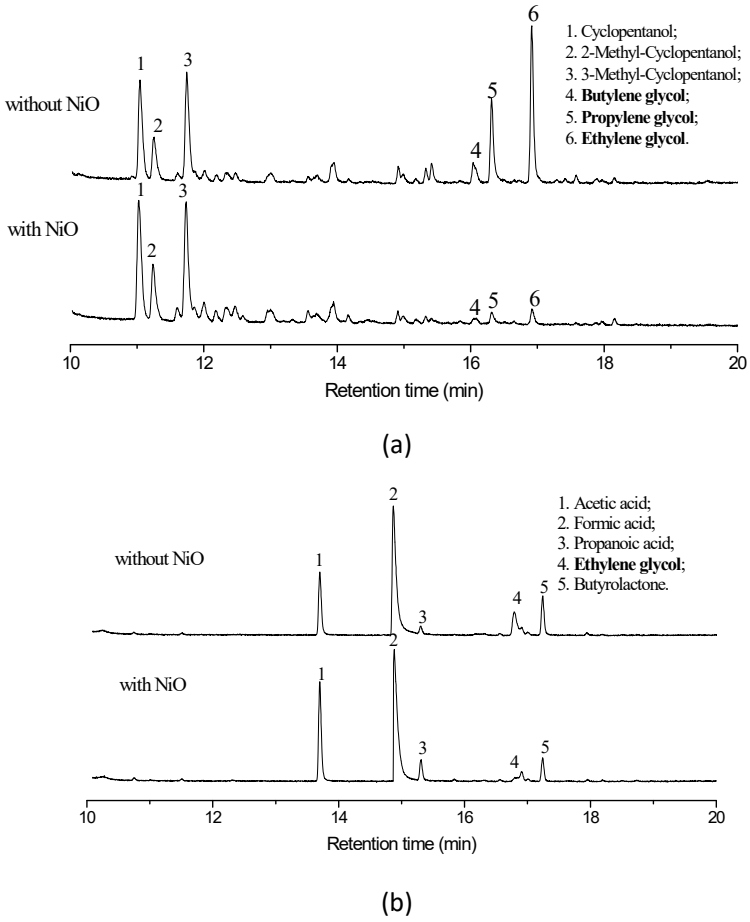

Figure S11 GC-MS chromatograms of samples without (a) and with (b) adjustment of pH using HCl after the reaction of cellulose in the presence and absence of NiO (250 °C, 5 M NaOH, 4.5 h).[1]

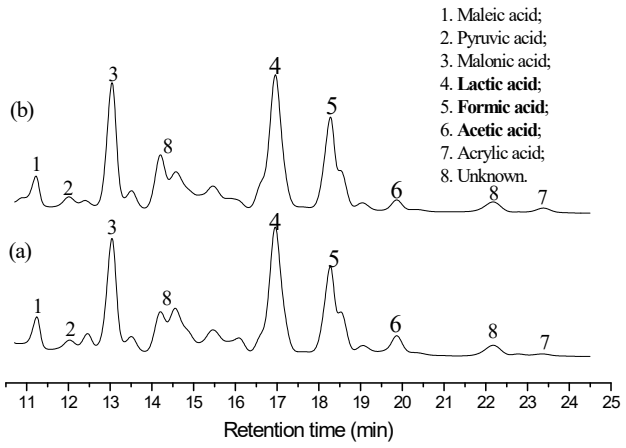

Figure S12 HPLC chromatograms of liquid samples after reactions of cellulose in the presence (a) and absence (b) of NiO (250 °C, 5 M NaOH, 4.5 h).[1]

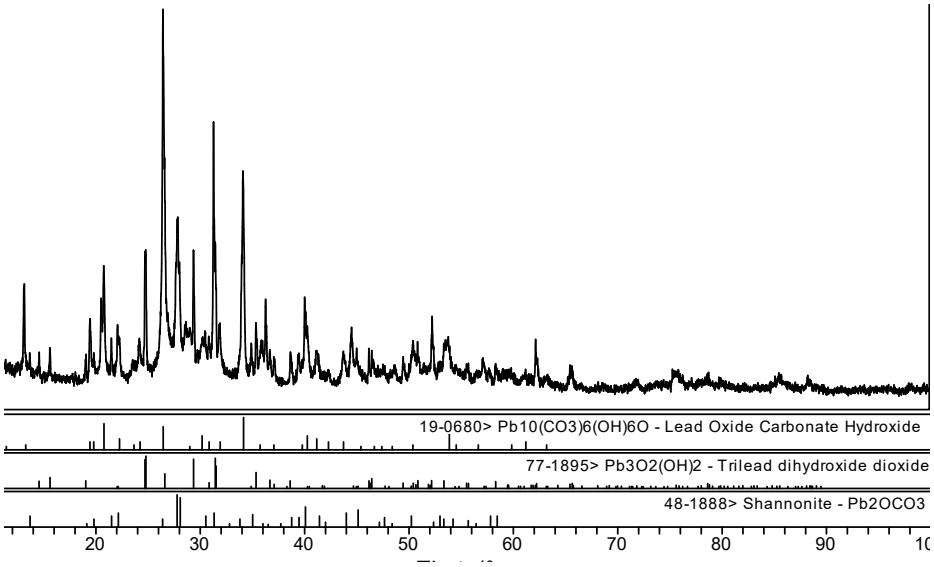

Figure S13 XRD patterns of solid products after the reaction of 0.4 M glucose and 0.2 M PbO_2 (250 °C, 1 M NaOH, 6 h).

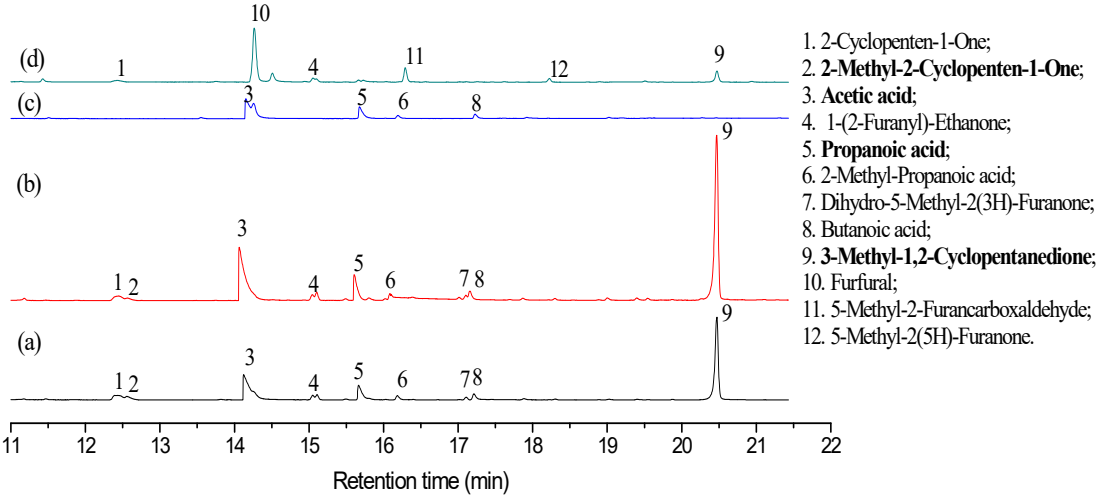

Figure S14 GC-MS chromatograms of liquid samples after the reduction of $CuSO_4$ (a), $CuCl_2$ (b), $Cu(NO_3)_2$ (c) and $Cu_2P_2O_7$ (d) by glucose (160 °C, 6 h).

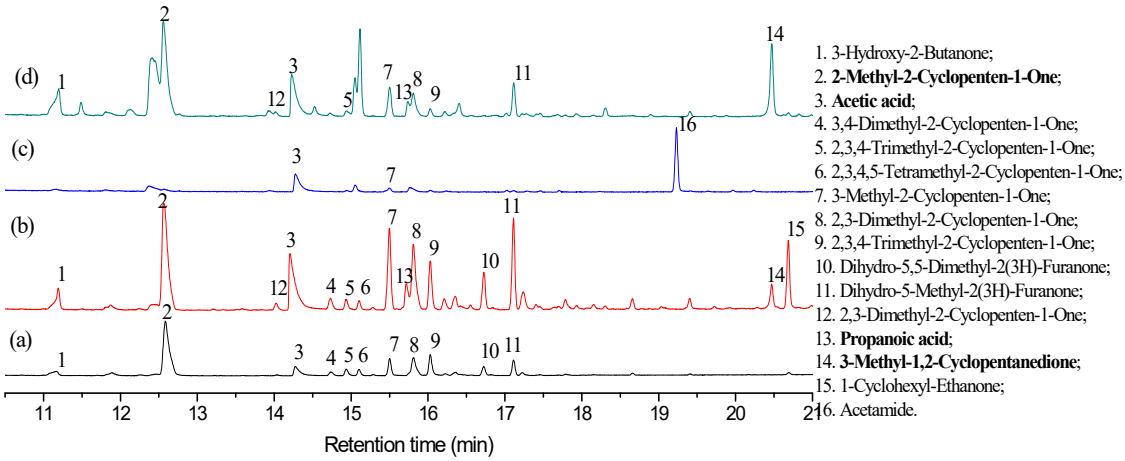

Figure S15 GC-MS chromatograms of liquid samples after the reduction of $CuSO_4$ (a), $CuCl_2$ (b), $Cu(NO_3)_2$ (c) and $Cu_2P_2O_7$ (d) by glucose (250 °C, 3 h).

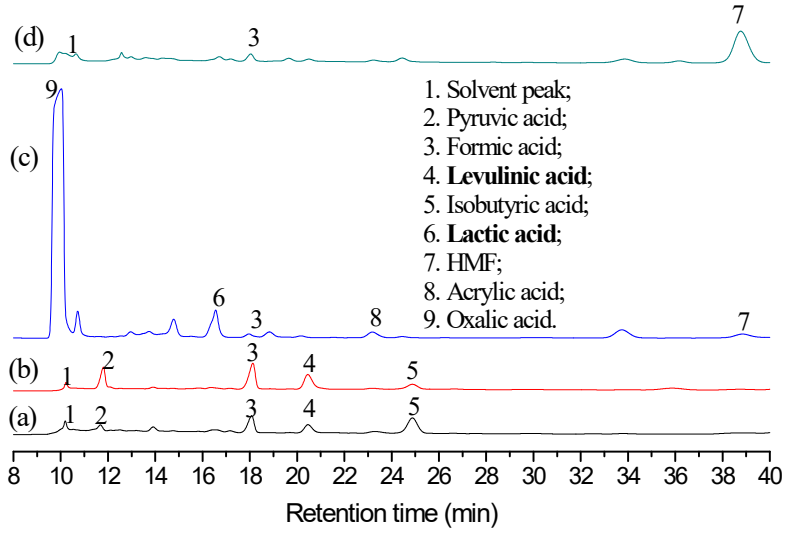

Figure S16 HPLC chromatograms of liquid samples after the reduction of $CuSO_4$ (a), $CuCl_2$ (b), $Cu(NO_3)_2$ (c) and $Cu_2P_2O_7$ (d) by glucose (160 °C, 6 h).

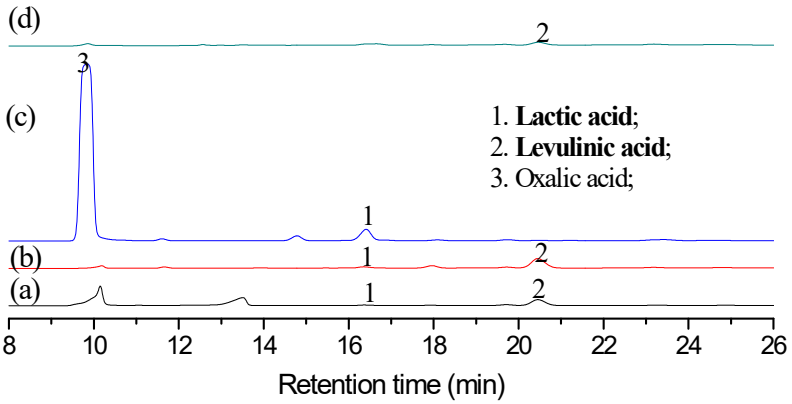

Figure S17 HPLC chromatograms of liquid samples after the reduction of $CuSO_4$ (a), $CuCl_2$ (b), $Cu(NO_3)_2$ (c) and $Cu_2P_2O_7$ (d) by glucose (250 °C, 3 h).

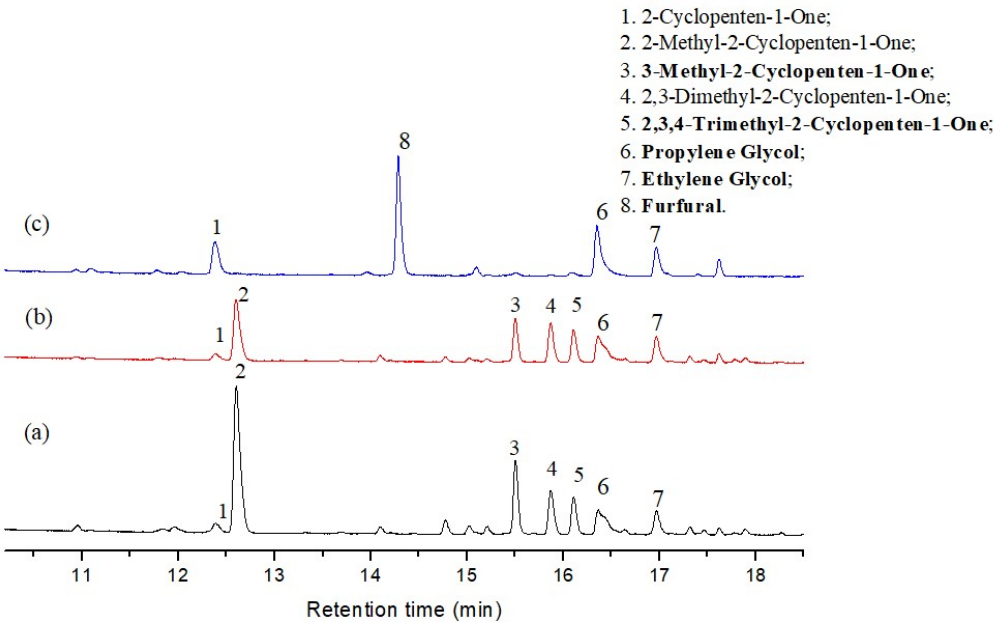

Figure S18 GC-MS chromatograms of liquid samples after reactions of cellulose with $CuSO_4$ (a), $CuCl_2$ (b), and $Cu(NO_3)_2$ (c) (250 °C, 3 h).

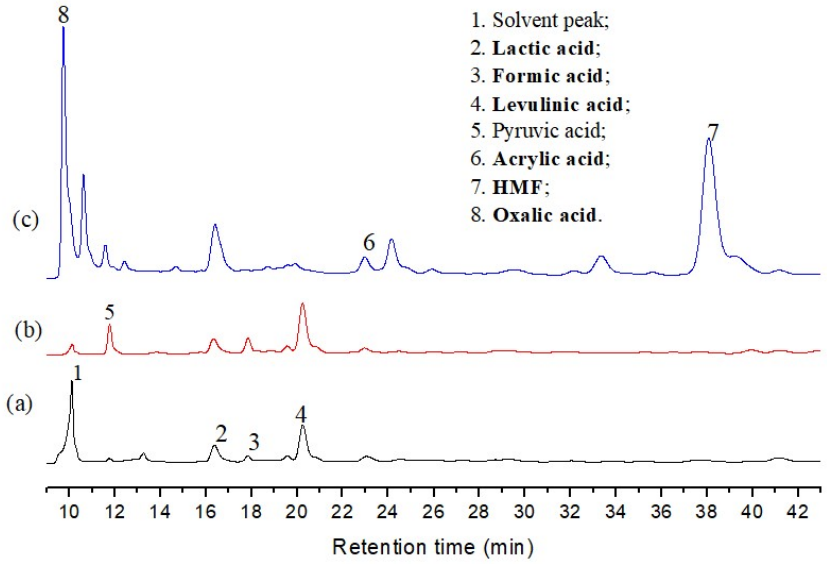

Figure S19 HPLC chromatograms of liquid samples after reactions of cellulose with $CuSO_4$ (a), $CuCl_2$ (b), and $Cu(NO_3)_2$ (c) (250 °C, 3 h).

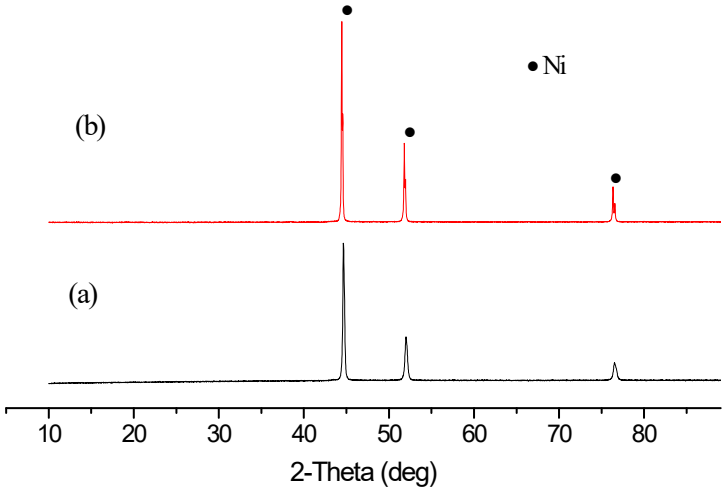

Figure S20 XRD patterns of solid products after the reaction of Ni with 0.4 M (a) and 5 M (b) NaOH (250 ºC, 3 h).

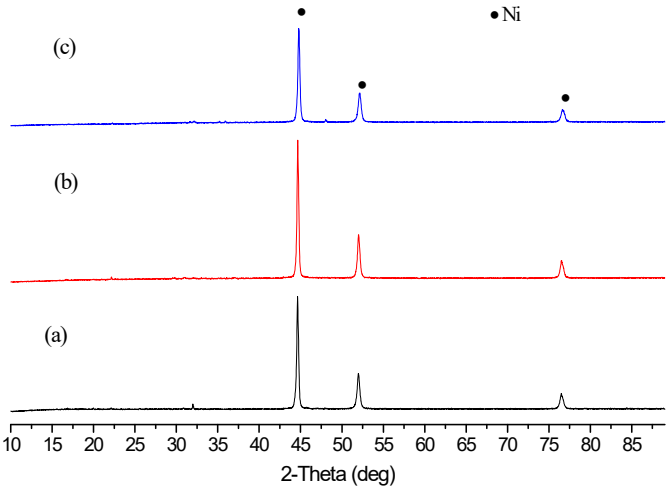

Figure S21 XRD patterns of solid products after reduction of NiO by ethylene glycol (EG) (a), propylene glycol (PG) (b), butylene glycol (BG) (c) (250 ºC, 5 M NaOH, 3 h).

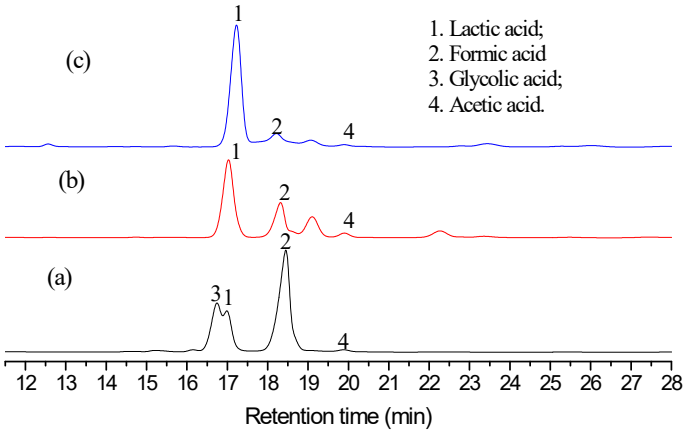

Figure S22 HPLC chromatograms of liquid samples after reduction of NiO by EG (a), PG (b), BG (c) (250 °C, 5 M NaOH, 3 h).

References:

1. Yao, G.; Zeng, X.; Li, Q.; Wang, Y.; Jing, Z.; Jin, F., Direct and highly efficient reduction of nio into ni with cellulose under hydrothermal conditions. *Ind. Eng. Chem. Res.* **2012,** *51* (23), 7853-7858.