Catalyst Design
From Molecular to Industrial Level

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Synthesis of mannitol from inulin using a magnetic catalyst

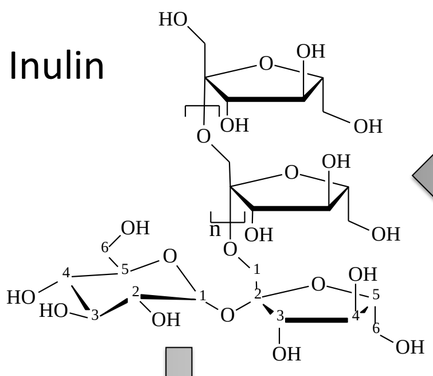
PP-V-12

Ratkevich E.A. [1], Manaenkov O.V.[1], Matveeva V.G.[1], Nikoshvili L.Zh., Kislitza O.V.[1], Sulman M.G.[1], Bronstein L.M.[2]

1 – Tver State Technical University, Department of Biotechnology and Chemistry, Tver, Russia

2 – Indiana University, Department of Chemistry, Bloomington, IN 47405, USA

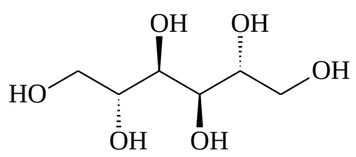
Inulin



16-18 %

Jerusalem artichoke - JA

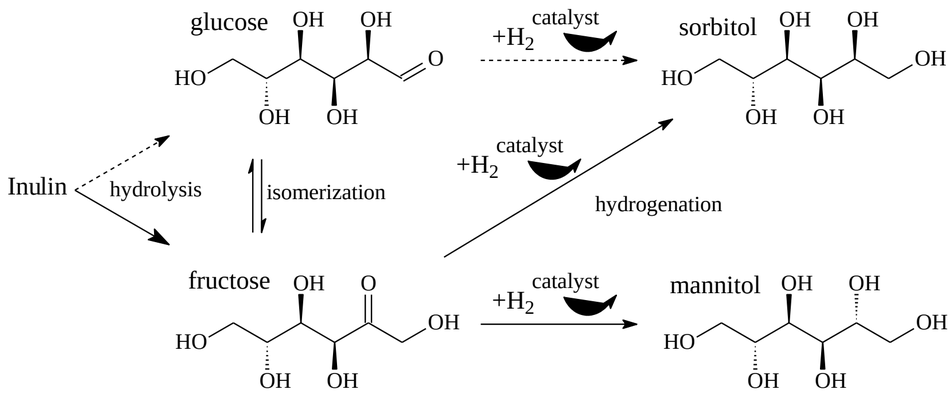
hydrolytic hydrogenation



D-mannitol

There are several methods for mannitol syntheses. It can be obtained by electrolytic reduction of glucose or by hydrogenation of invert sugars, monosaccharides, or sucrose. The shortcoming of the above methods is it uses food sugars, thus interfering with the food supply. This makes the development of novel, effective methods for mannitol syntheses using non-food polysaccharides a high priority.

One of such methods is the hydrolytic hydrogenation of inulin, a polysaccharide which is not digested by humans and which is present in significant amounts in such plants as *Heliánthus tuberósus* (16 – 18 %) and *Cichorium intybus* (up to 20 %).



Catalyst synthesis

1st Stage: Synthesis of Fe_3O_4-SiO_2

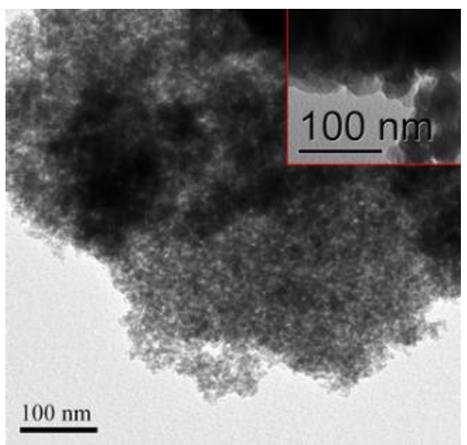
$Fe(NO_3)_3 + SiO_2$ → (250 °C, Ar atmosphere, 5 hours) → Fe_3O_4-SiO_2

2nd Stage: Synthesis of Ru-Fe_3O_4-SiO_2

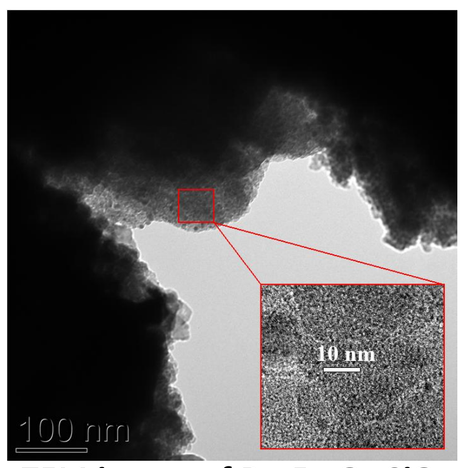
Fe_3O_4-SiO_2 + $Ru(acac)_3$ → (300 °C, Ar atmosphere, 3 hours) → Ru-Fe_3O_4-SiO_2

3rd Stage: Reduction of Ru-Fe_3O_4-SiO_2

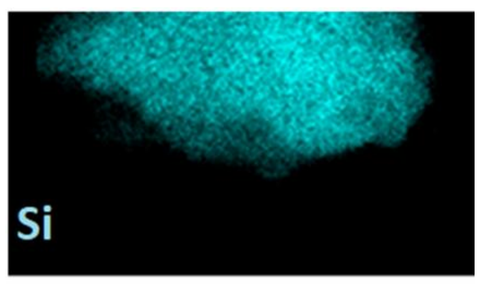
Ru-Fe_3O_4-SiO_2 → (300 °C, H_2 atmosphere, 2 hours) → Ru-Fe_3O_4-SiO_2



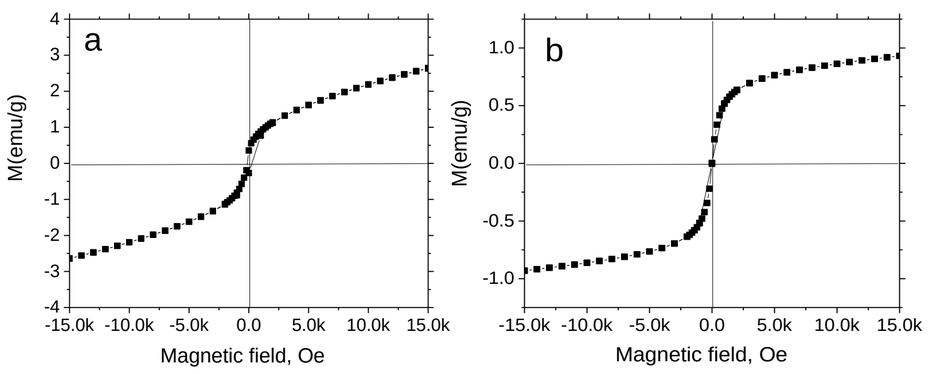
TEM image of Fe_3O_4-SiO_2



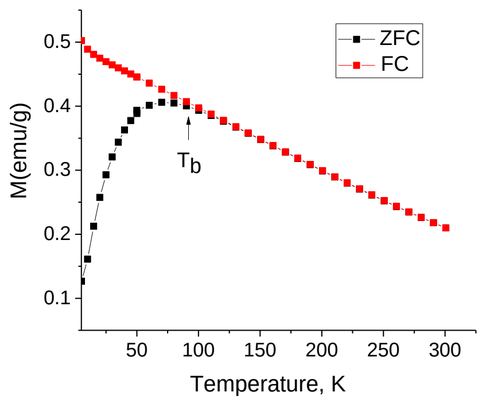
TEM image of Ru-Fe_3O_4-SiO_2



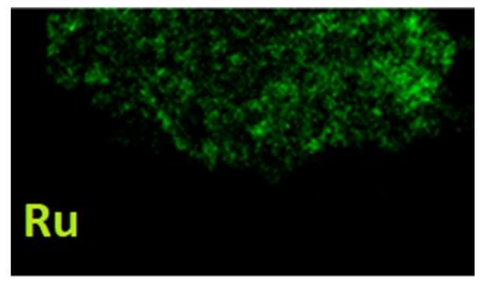
Ru-containing magnetically recoverable catalysts: A sustainable pathway from cellulose to ethylene and propylene glycols / O. V. Manaenkov, J. J. Mann, Y. Losovyj et al. // ACS applied materials & interfaces. — 2016. — Vol. 8, no. 33. — P. 21285–21293.



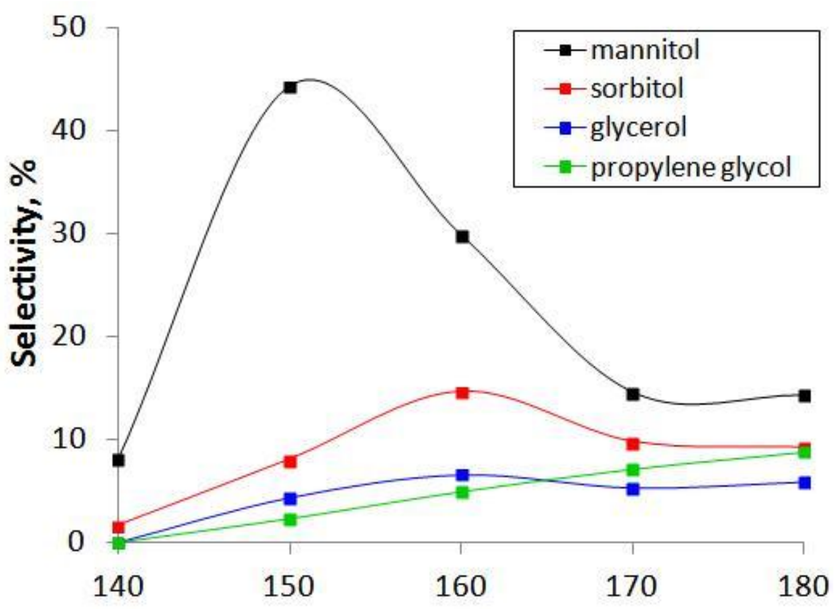
Isothermal magnetization curves of Fe_3O_4-SiO_2 at 5 K (a) and 300 K (b). M(emu/g) is the magnetization.



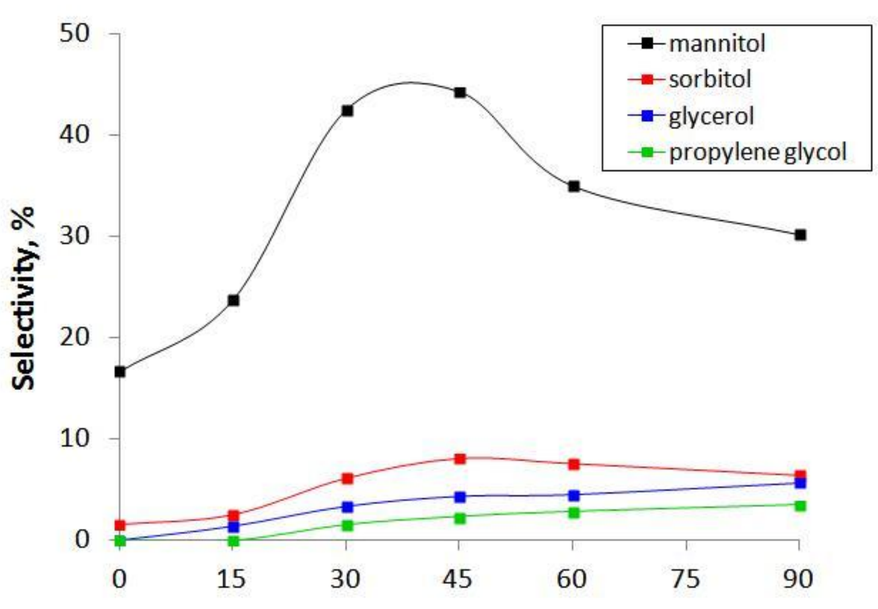
ZFC-FC susceptibility curves of Fe_3O_4-SiO_2



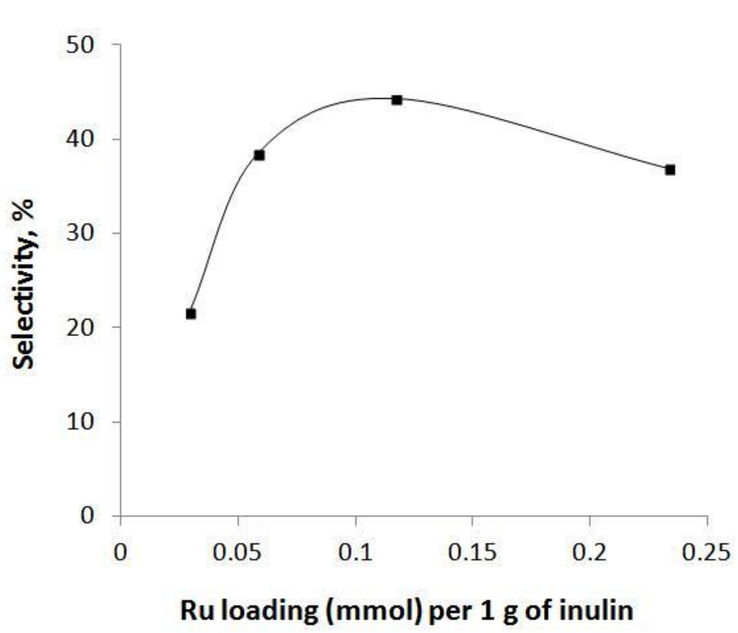
STEM EDS maps of Si, Fe and Ru for Ru-Fe_3O_4-SiO_2.



Selectivity to mannitol, sorbitol, glycerol, and propylene glycol over temperature (0.1167 mmol Ru per 1 g of inulin; 0.3 g of inulin; 0.07 g of catalyst; 30 mL of H_2O; P(H_2) 60 bar, 45 min).



Dependencies of the mannitol, sorbitol, glycerol, and propylene glycol selectivities on time (0.1167 mmol Ru per 1 g of inulin; 0.3 g of inulin; 0.07 g of catalyst; 30 mL of H_2O; P(H_2) 60 bar, 150 °C).



Dependence of the selectivity to mannitol on the Ru/inulin (mmol/g) ratio (0.3 g of inulin; 30 mL of H_2O; 150 °C; P(H_2) 60 bar; 45 min).

Summary

- ✓ The behavior of the Ru-containing magnetically separable catalyst in the conversion of inulin to mannitol was studied.
- ✓ The selectivity to mannitol of 44.3 % was obtained at 150°C, H_2 60 bar, 0.1167 mmol of Ru per 1 g of inulin for 45 min with the catalytic activity of 2.53 h^{-1}.
- ✓ Under these conditions, the inulin conversion reached 100 %.
- ✓ These factors and the catalyst stability under hydrothermal conditions as well as easy magnetic separation make 5% Ru-Fe_3O_4-SiO_2 the catalyst of choice for practical applications in biomass conversion.

Manaenkov O.V., et al. Magnetically recoverable catalysts for the conversion of inulin to mannitol. Energy, 154 (2018) 1-6.

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