High Output Ruthenium-Catalyzed Hydrogenation of Hexoses

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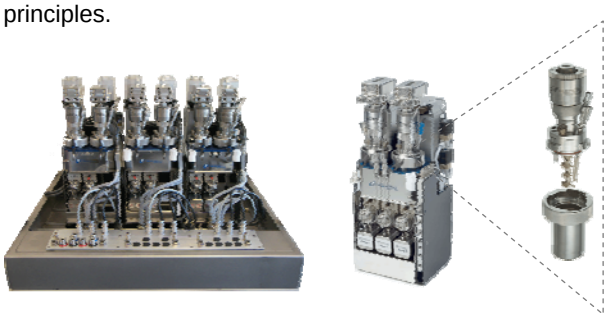
Introduction

Catalytic hydrogenation of D-glucose to D-sorbitol is an industrially important reaction as the product sorbitol is a versatile chemical intermediate. It also occurs naturally in many stone fruits and berries from trees of the genus *Sorbus* [1]. Approximately 60% of the produced sorbitol is utilized in processed foods, confections, toothpaste and other personal care products as humectants, stabilizers, softeners, emulsifiers and bodying agents. An additional 16% of the total market for sorbitol is utilized for the production of Vitamin C.

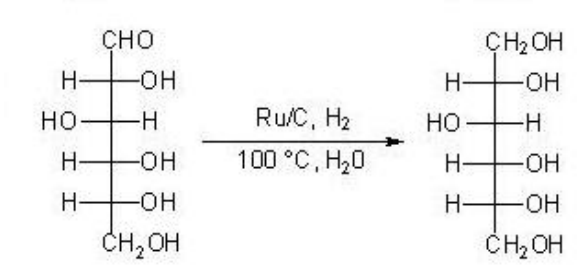
The catalytic hydrogenation of D-glucose has been extensively studied in the literature [2], in particular in pressure reactors. Chemspeed's Process reactor represents a flexible, modular and scaleable reactor technology for a wide range of pressure applications. The continuing need for improved accuracy in flow measurement of mass related processes such as chemical reactions and thermal transfers has resulted in the incorporation of thermal-type mass flowmeters in Chemspeed MiniPlants (**Picture 1**). This type of flowmeters operate with minor dependence on density, pressure, fluid viscosity. The true mass flow rate is determined *via* a heated sensing element and thermodynamic conduction principles.



Picture 1 MultiPlant, MiniPlant, and Process Reactor

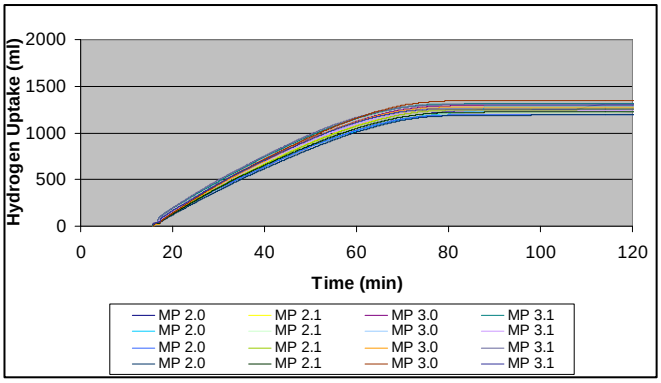
Experimental

The catalytic hydrogenations of D-Glucose to D-Sorbitol were carried out semi-batch in four series of four parallel reactions on a Chemspeed MultiPlant. 13 g of D-Glucose monohydrate (66 mmol) in 54 ml of water were reacted at 100 °C and 40 bar relative hydrogen pressure over 5% Ru/C catalyst (**Scheme 1**).



Scheme 1 Ru-catalyzed hydrogenation of Glucose to Sorbitol

The hydrogen pressure was kept constant at 40 bar relative and the corresponding integrated volumes and mass flows (corresponding to the hydrogen uptake) were monitored and showed excellent reproducibility (**Picture 2**). The possibility of measuring the actual mass flows is nicely complementing all the available data such as, internal and jacket temperatures, pH, stirring speed, stirring power uptake, feed rates, sampling rates and others. Complete data logging assures full traceability and increased sustainable reproducibility.



Picture 2 Hydrogen uptake in Ru-catalyzed hydrogenation of D-Glucose to Sorbitol

Conclusions

The analysis of the hydrogen uptake clearly shows a successful example of high-output reaction parallelization, in which D-Glucose was catalytically reduced to D-Sorbitol within two hours.
A large spectrum of high pressure reaction optimizations and kinetic studies are carried out, e.g. hydrogenations, carbonylations.
Implementing additional available options as autosampler and calorimetry probes for each reactor furthermore allows precise kinetic studies.
This case study of heterogeneous catalyst testing, illustrates the high reproducibility of Chemspeed's parallel process reactors being crucial for high output catalytic process research.

References

[1] Lehninger *Principles of Biochemistry*, Nelson and Cox, Fourth Edition

[2] Hofmann, H., Bill, W. *Chemie-Ing. –Tech.* 1959, *31*, 81; Bizhanov, F.B., Sokol'skii, D.V., Popov, N.I., Malkhina, N.Y., Khisametdinov, A.M. *Kinet. Katal.* 1969, *10* 655; Brahme, P.H., Doraiswamy, L.K. *Ind. Eng. Chem. Process Des. Dev.* 1976, *15*, 130; Wisniak, J., Simon, R. *Ind. Eng. Chem. Prod. Res. Dev.* 1979, *18*, 50; Turek, F., Chakrabarti, R.K., Lange, R., Geike, R., Flock, W. *Chem. Eng. Sci.* 1983, *38*, 275; Déchamp, N., Gamez, A., Perrard, A., Gallezot, P. *Catal. Today* 1995, *24*, 29; Tukac, V., *Collect. Czech. Chem. Commun.* 1997, *62*, 1423.

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