

Investigation of pH Effect on Hydrogenation Reaction of Dextrose to Sorbitol using a Mo promoted Sponge Ni catalyst

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Introduction

The hydrogenation of D-glucose to D-sorbitol using a Sponge Ni catalyst is important in the manufacturing process of pharmaceuticals, cosmetics, food products, and Vitamin C [1, 2]. Sponge nickel catalyst are prepared by leaching aluminum from Ni-Al alloys that leads to porous, high surface area, activated, unsupported nickel-based catalysts. Increasing yield efficiency of a customer's catalyst lifespan improves profitability. A high activity must be balanced with the percent sorbitol selectivity and the deactivation environment of the catalyst. In this work we investigate the impact of controlling the initial pH in the manufacturing process of the hydrogenation of D-glucose to D-sorbitol.

During the hydrogenation reaction, the dissolution of nickel ions occurs due to the drop in pH by the production of gluconic acid. The dissolved metal ions makes product purification necessary and additionally results in the loss of active catalyst sites. In this study, the amounts of nickel and aluminum soluble ions have been quantified for each reaction at each pH.

Materials and Methods

The Mo promoted Sponge Ni catalyst was provided by Johnson Matthey Catalyst. The hydrogenation reactions were performed on an HEL automate (4 x 100ml) autoclave reactor at 800 psi and 1,500 rpm. All reactions used a feed stock of 99.9% Glucose (Alfa Aesar) diluted with D.I water to 50%. The pH of each catalyst slurry was tested and adjusted accordingly by adding sodium carbonate or acetic acid to achieve the desired starting pH. The catalyst was recycled nine times for a total of ten hydrogenation reactions. The percent sorbitol selectivity was analyzed using HPLC. The soluble ions in the sorbitol products were determined using ICP analysis.

Results and Discussion

The pH effect on catalytic activity is shown in Figure 1. The evaluation of the data indicates a specific activity for each pH reaction and a relative decrease in activity as the catalyst is used in subsequent reactions. Moreover, the start time of the reaction is directly influenced by the initial pH. The data indicates that decreasing the pH delays the initial start time of the reaction. An initial pH of 8 has more consistent start, end and total reaction times.

A lower starting pH results in higher levels of nickel and aluminum ions in a post-reaction product. HPLC analysis of the product indicates that pH 8 results in improved sorbitol selectivity. Catalyst aging may be characterized by the Al% loss from fresh catalyst. An ICP analysis of the catalyst after the ten hydrogenation reactions (Table 1) indicate the initial pH of 8 has the smallest Al% loss, therefore ages the catalyst the least. The largest Al% loss is when the initial pH is 6, therefore the catalyst ages the most.

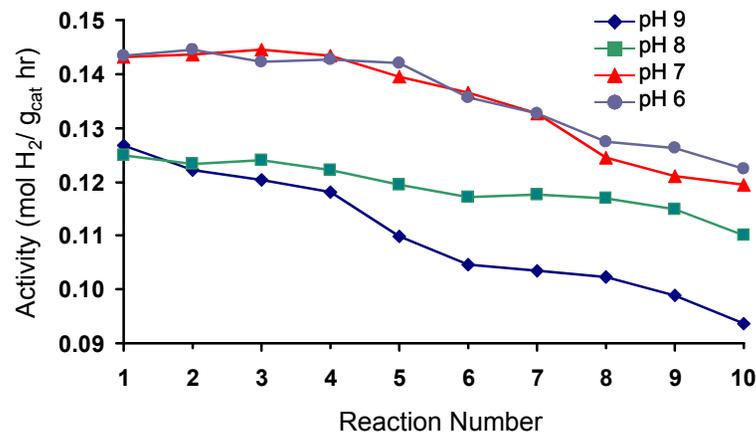


Figure 1. The reaction activity at a specific initial pH

Table 1. Summary of the pH effect on catalyst after ten reactions.

| pH | % Loss of Activity | % Reaction start time | Avg. % sorbitol selectivity | Avg. Ni soluble ions (ppm) | Cat. Al % Reduction |
|----|--------------------|-----------------------|-----------------------------|----------------------------|---------------------|
| 9 | 26.0% | 61.3% | 97.4% | 18.3 | 0.92% |
| 8 | 11.8% | 34.8% | 98.9% | 39.9 | 0.79% |
| 7 | 16.6% | 35.3% | 98.5% | 60.6 | 1.17% |
| 6 | 14.6% | 42.7% | 98.7% | 61.6 | 1.36% |

Conclusions

The pH study reaffirms previous assertions that the initial pH should be adjusted to 8 for Dextrose to Sorbitol reactions. The advantages of an initial pH of 8 are: more consistent catalytic activity, more consistent reaction times (start and ending), decrease of the Ni and Al soluble ions in the post-reaction product, increase the catalyst life, and increase in percent sorbitol selectivity. The regulation of the initial pH for the sorbitol hydrogenation reaction is necessary for the stability of the catalyst and achieving the highest selectivity.

References

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