ICCEIB 2018

Paper ID: A410

Cobalt Supported Alumina Catalyst for Oxidation of Glucose to Gluconic Acid Under Mild Reaction Conditions

*P. X. Ng,[1] M. A. Deraman,[1] A. S. Haji Saud,[1] G. P. Maniam,[1,2] M. H. Ab Rahim[1]**

[1]Faculty of Industrial Sciences & Technology, [2]Central Laboratory, Universiti Malaysia Pahang, 26300 Gambang, Pahang, Malaysia.
**Corresponding author: mohdhasbi@ump.edu.my*

EXTENDED ABSTRACT

Glucose is one of the most essential carbohydrate feedstock for the production of industrial chemicals [1]. One of the important and valuable chemical as a starting feedstock to produce gluconic acid [2, 3]. On the rise of industries and new applications of gluconic acid, further increase in demand is expected to continue rising in future [4]. As the commercialize biochemical route is not recyclable, possesses negative impacts to environment and other drawbacks, many researchers have put much attention towards catalytic oxidation of glucose to gluconic acid with the use of selective heterogeneous catalyst. However, the selective oxidation of glucose is quite challenging as to the activity of catalyst and low conversion. These pose difficulties in designing process, operation and production at industrial scale [5].

The current study is focusing on converting the D-glucose into D-gluconic acid with the aid of γ-alumina based and TS-1 based catalysts loaded with Cobalt. These catalysts were prepared by incipient wetness impregnation method. The catalysts synthesized were characterized via XRD, N_2-physisorption, TGA, UV-NIR, FT-IR, and Hammett test in order to study its physico-chemical characteristics. The catalytic oxidation of D-glucose with H_2O_2 as oxidant was carried out using glass reactor under ambient pressure. The D-gluconic acid produced was qualitatively and quantitatively analyzed by means of HPLC, FTIR and titration method. Optimization of reaction was carried out by conducting a series of experiment in variation of D-glucose concentration, reaction temperature, pH, and amounts of H_2O_2 (i.e. molar ratio in relation to D-glucose).

As a results, the 5 wt.% Co/Al_2O_3 catalyst exhibited highest catalytic activity of 2.1×10^{-2} mol mol(Co)$^{-1}$ s^{-1} under mild reaction conditions (60 °C, pH 9). The conversion of D-glucose successfully achieved more than 80%, independent of D-glucose concentration used in variation (10 wt.% to 30 wt.%) and total amount of H_2O_2 (i.e., 1.0 equivalent in relation to D-glucose by molar ratio), with constant stirring rate at 1000 rpm. The selectivity to D-gluconic acid was found to be exceptionally high which exceeded 99% under most applied reaction conditions throughout the course of study. Moreover, the catalyst activity increased with rising D-glucose concentration up to 30 wt.%. From the findings, the catalyst activity was as well found to be increasing with a rise in reaction temperature, prominently highest activity was attained at 60 °C. The apparent activation energy in the range of 30–60 °C was determined to be 15 kJ mol^{-1}, which is comparably lower that the apparent energy (approximately 48 kJ mol^{-1}) found for D-glucose oxidation with H_2O_2 over the Au/Al_2O_3 catalyst [6]. A weakly alkaline

condition around pH 9 is still most suitable for D-glucose oxidation, no matter with the use of H_2O_2 or O_2 as oxidants.

Further on, it was noticed that the heterogeneous Co/Al_2O_3 catalyst can be easily regenerated and reused with optimal catalytic performance at each cycle of study. These in turn suggests that the proposed catalyst can be used to meet the industrial need to synthesis D-gluconic acid from renewable D-glucose source. In a nutshell, the use of Co/Al_2O_3 may be a new approach in organic chemistry, more specifically employed in D-glucose conversion to D-gluconic acid with H_2O_2 as oxidizing agent, which is generally environmental friendly.

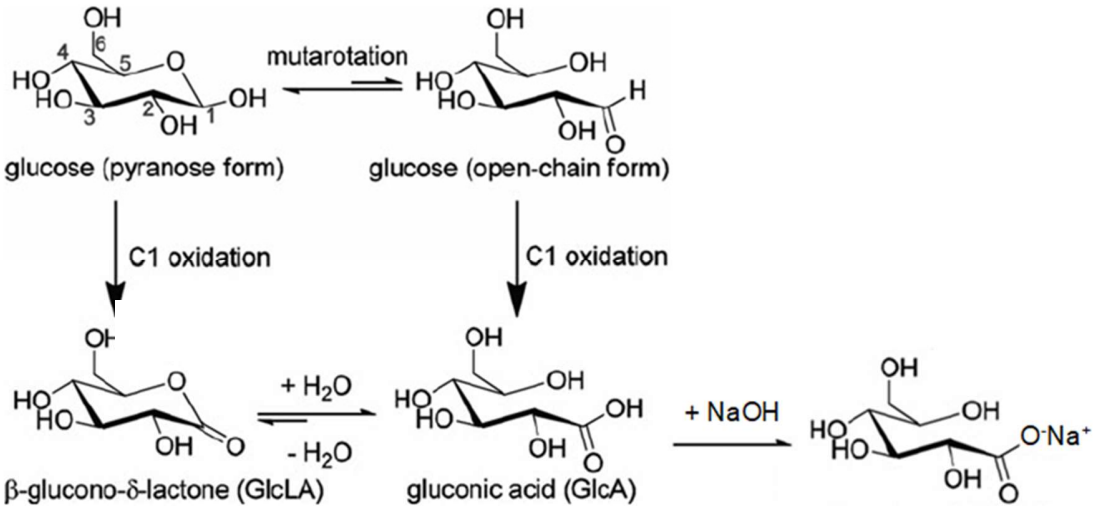

Fig. 1: Proposed reaction mechanism of D-gluconic acid from D-glucose and H_2O_2 and sodium D-gluconate with addition of NaOH solution

Keywords: Cobalt catalyst; Glucose oxidation; Hydrogen peroxide; Selective oxidation; Gluconic acid.

Acknowledgment

The authors would like to thank Universiti Malaysia Pahang for Internal Grants Scheme (RDU 1703277).

References

[1] X. Zhang, K. Wilson, A.F. Lee, Chemical reviews, 116 (2016) 12328-12368.
[2] P.N. Amaniampong, Q.T. Trinh, K. Li, S.H. Mushrif, Y. Hao, Y. Yang, Catalysis Today, (2017).
[3] C. Megías-Sayago, S. Ivanova, C. López-Cartes, M. Centeno, J. Odriozola, Catalysis today, 279 (2017) 148-154.
[4] N. Purane, S. Sharma, P. Salunkhe, D. Labade, M. Tondlikar, J. Microb. Biochem. Technol, 4 (2012) 92-95.
[5] I. Dencic, J. Meuldijk, M. de Croon, V. Hessel, in From a review of noble metal versus enzyme catalysts for glucose oxidation under conventional conditions towards a process design analysis for

continuous-flow operation, Akadémiai Kiadó, co-published with Springer Science+ Business Media BV, Formerly Kluwer Academic Publishers BV, (2012).
[6] R. Saliger, N. Decker, U. Prüße, Applied Catalysis B: Environmental, 102 (2011) 584-589.