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Ethylene glycol production from glucose in batch mode: study of experimental parameters

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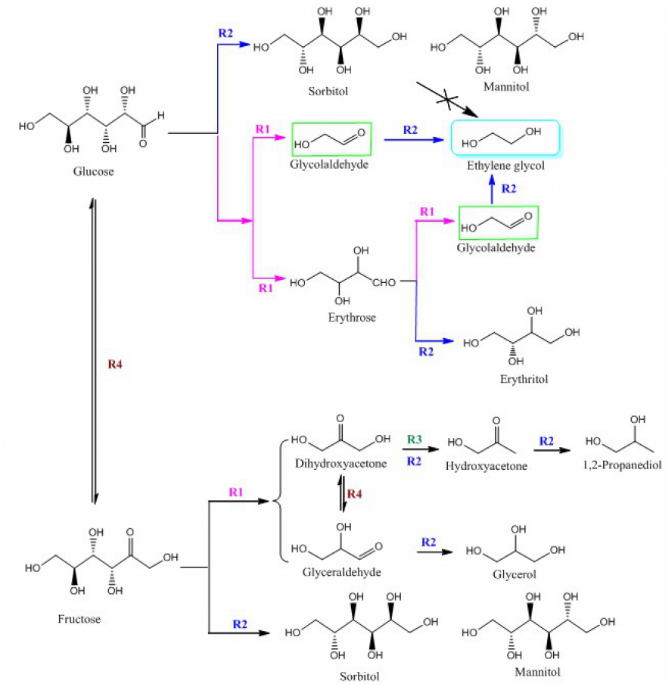
PURPOSE OF THE ABSTRACT

Ethylene glycol is a commodity that is widely utilized in industries such as energy, chemicals, automotive, textiles, transportation, and manufacturing technologies1. This fact has represented an increasing demand for this diol that reached 25 million tons in 20151,2. Currently, the majority of this glycol is obtained by hydration of ethylene oxide. This technology associates the production of this compound with the petroleum industry. Therefore, it is seen as a profitable alternative. Nevertheless, there is an environmental concern that has constituted a great interest in the substitution of fossil-resources. In this aspect, the utilization of biomass for the production of ethylene glycol defines an alternative for an energy-efficient process. The production of ethylene glycol from biomass benefits from the treatment of agricultural wastes. For this purpose, glucose and cellulose are recovered from biological sources and then converted into ethylene glycol and other organic compounds. In accordance with this statement, there is a necessity of evaluating the production of ethylene glycol from renewable sources such as saccharides.

According to the overall results obtained from the literature on the heterogeneous catalytic conversion of glucose, ethylene glycol is synthetized through the formation of Erythrose and/or Glycolaldehyde as intermediates (Figure 1). Four types of reaction are involved in the transformation and are indicated on the reaction scheme: retro-aldolisation (R1), hydrogenation (R2), dehydration (R3) and isomerization (R4). Depending on the nature of the catalysts and reaction conditions, several other compounds can be obtained such as sorbitol, mannitol, erythrose, erythritol, glycerol, glyceraldehyde, dihydroxyacetone, 1,2-propanediol, glycolaldehyde, ethanol, methanol and CO2. According to the reaction scheme, two catalysts are required: one for the retro-aldolisation step and one for the hydration step. In this work, ammonium metatungstate (AMT) is used as a homogeneous catalyst for the first step whereas, a heterogeneous catalyst, Ruthenium 5 % on activated carbon, is used for the second reaction step. The reaction is thus carried out in a three phase medium initially composed of an aqueous phase (water, glucose and AMT, a solid phase (Ru/AC) and a gaseous phase (H2).

This communication reports experimental results obtained for the conversion of glucose into ethylene glycol in a batch or semi-batch equipment (Figure 2). The influence of the most relevant operating conditions (batch or semi-batch mode, feeding rate, residence time, temperature, hydrogen pressure, concentration of catalysts) is discussed.

FIGURES



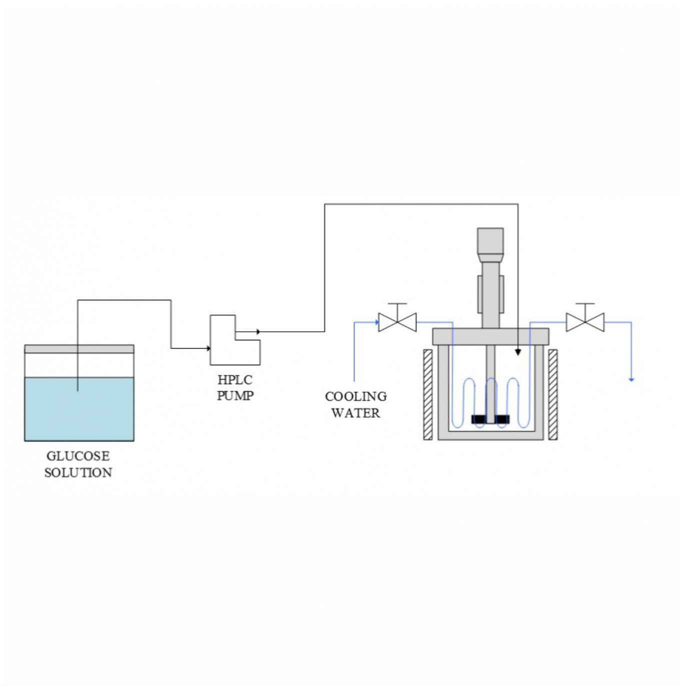


FIGURE 1

Scheme 1: General scheme for the heterogeneous catalytic conversion of glucose using tungstenic catalysts.

R1: Retro-aldolisation; R2: Hydrogenation; R3: Dehydration; R4: Isomerization.

FIGURE 2

Scheme of the semi-batch reactor

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KEYWORDS

Ethylene glycol | glucose | batch reactor | catalysis

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