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Commercial basic resins as efficient heterogeneous catalyst for the isomerization of glucose to fructose

AUTHORS
Maia MONTAÑA / UNIVERSIDAD REY JUAN CARLOS, CALLE TULIPAN S/N, MÓSTOLES
Miriam EL TAWIL / UNIVERSIDAD REY JUAN CARLOS, CALLE TULIPAN S/N, MÓSTOLES
Daniel MARTÍNEZ / UNIVERSIDAD REY JUAN CARLOS, CALLE TULIPAN S/N, MÓSTOLES
José IGLESIAS / UNIVERSIDAD REY JUAN CARLOS, CALLE TULIPAN S/N, MÓSTOLES
Jovita MORENO / UNIVERSIDAD REY JUAN CARLOS, CALLE TULIPAN S/N, MÓSTOLES

PURPOSE OF THE ABSTRACT

During the last decade, the valorization of lignocellulose biomass has become a crucial strategy to obtain platform chemicals through more sustainable pathways. The isomerization of glucose to fructose is an essential step in biorefineries schemes for the valorization of the carbohydrate fraction into a great variety of bioproducts like hydroxymethylfurfural (HMF) and 2,5- furandicarboxylic acid (FDCA) [1,2]. Nowadays, commercial processes for the isomerization of glucose to fructose occur through enzymatic routes, but using enzyme cocktails presents several drawbacks (high cost, very limited operating conditions, etc.) that could be overcome by chemo-catalytic transformations. In this work, selective isomerization of glucose into fructose was investigated using commercial basic resins at low temperature, to contribute a feasible, sustainable, and economical process.

Isomerization of glucose to fructose was studied using 4 commercially available basic anion resins as solid catalysts [3]. Amberlite IRA-900 and Amberlyst A-26 (strong basic resins) and Amberlite IRA-67 and Amberlyst A-21 (weak basic resins) have been tested. Tests were carried out in a round-bottom flask with a magnetic stirrer and using water as reaction media. The experiments were performed for 120 min starting from a 10 wt % glucose aqueous solution, using a mass glucose/resin ratio = 1, and varying the reaction temperature in the range 40-80°C. At the end of each reaction, the final solution was filtered through 0.22 ?m pore filter, and the liquid products were analyzed by HPLC with an Aminex HPX-87P column working at 80°C and using water as the mobile phase (flow rate of 0.5 mL/min). Detection was performed by RI. Catalytic results were presented as glucose conversion, fructose and mannose yield, and fructose selectivity.

The bar plot (Figure 1) shows the influence of the temperature in the isomerization reaction for all the materials after 60 min. As expected, the conversion of glucose and yield of fructose increase with reaction temperature, obtaining the maximum conversion value with A-26 catalyst at 80 ºC (62%). Regarding fructose production, the strong resins (IRA-900 and A-26) exhibited higher yields of fructose than the weak ones (IRA-67 and A-21), achieving the highest fructose yield with the solid IRA-900 at 80 ºC (28 %). This result indicates that strong resins show high activity, and it can be associated with the basic strength of the anionic groups. Although A-26 presents higher conversion, fructose selectivity is lower than for IRA-900. For this reason, IRA-900 was chosen as the best catalyst to continue the research without a significant loss of activity and enhancing the selective transformation of glucose into fructose.

Figure 2 represents the IRA-900 catalytic activity from 0 to 120 minutes at 40, 60, and 80ºC. At low reaction temperatures high conversion of glucose was not achieved whereas at 60ºC the conversion increases up to ~48%. An increase in reaction temperature above 60ºC reduced the glucose conversion, whereas the maximum fructose yield remained almost constant after 60 min (around 27-28 % for both temperatures). Afterward, scarce variations of fructose amount were observed. Changes in resin structure at 80ºC could be responsible for the fast conversion standstill. It is also remarkable the increase of the fructose production rate noted by raising the reaction temperature.

In conclusion, very promising performance was obtained for IRA-900 catalyst at 60ºC and 80ºC after short reaction times (60 minutes), achieving fructose selectivity higher than 75 % and fructose yield of 27 % in the isomerization reaction.

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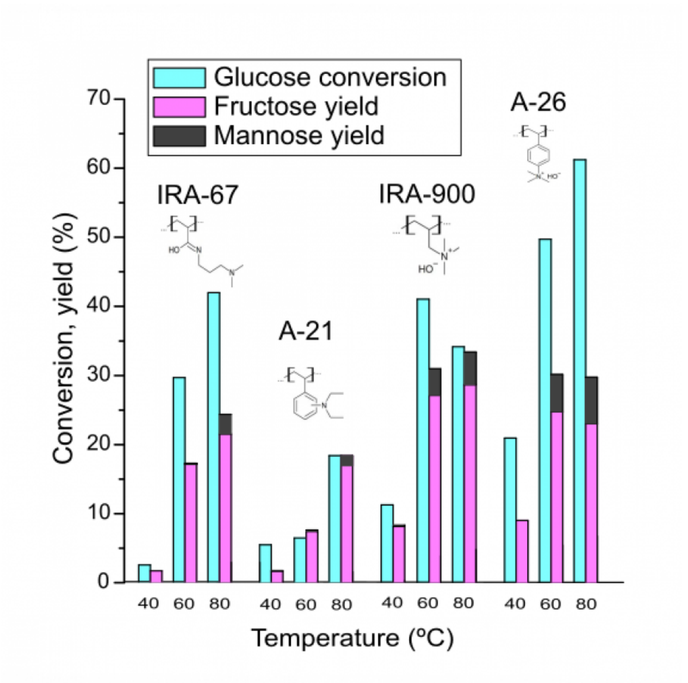
FIGURES



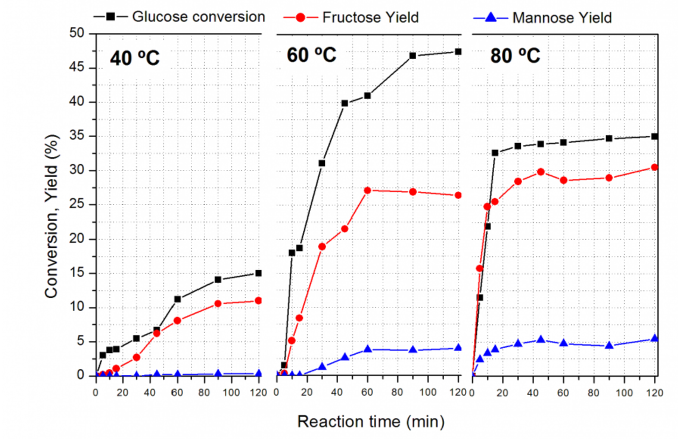


FIGURE 1

Figure 1

Catalytic results to glucose isomerization for basic anion resins.

Reaction conditions: 60 min, 10% wt of glucose in aqueous solution, cat. loading 10% wt.

FIGURE 2

Figure 2

Effect of reaction temperature: catalytic activity vs reaction time for IRA-900.

Reaction conditions: 10% wt of glucose in aqueous solution, cat. loading 10% wt.

KEYWORDS

Glucose | Fructose | Isomerization | Basic resins

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