ISGC 2022

N°812 / OC
TOPIC(s) : Biomass conversion / Homogenous, heterogenous and biocatalysis

A new life for forestry and agricultural residues: sustainable ethylene glycol production over carbon nanotubes supported Ru-W catalysts

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PURPOSE OF THE ABSTRACT

To help with issues of global environmental problems and diminishing fossil fuel reserves, lignocellulosic biomass is attracting attention as raw-material for the production of green chemicals [1-3]. One of the most interesting routes for biomass valorization is the one-pot hydrolytic hydrogenation into valuable chemicals, such as ethylene glycol (EG) [3]. EG plays an important role in the synthesis of high-value chemicals that have large market demand, such as polymers (e.g. polyester fibers), antifreeze products and cosmetics [4]. Therefore, this work focused on the green direct catalytic conversion of forestry and agricultural lignocellulosic wastes into EG.

In a previous work, a mixture of W and Ru catalysts supported on oxidized carbon nanotubes was found to lead to higher EG production. The modified support contributes to a high surface area acid structure that favors the initial step of cellulose hydrolysis to glucose and suppresses further glucose isomerization to fructose [5]. Following the same approach, that catalytic mixture was evaluated in the one-pot hydrolytic hydrogenation of the different waste lignocellulosic materials listed in Figure 1 [6]. In standard tests, 300 mL of water, 750 mg of ball-milled substrate and 300 mg of each catalyst were introduced into a 1000 mL stainless steel Parr reactor under stirring at 150 rpm. After heating under nitrogen to 205 ºC, the reaction was initiated by switching to hydrogen (50 bar), and the reaction mixture was analyzed by high performance liquid chromatography (HPLC) and total organic carbon (TOC). The properties of the materials and catalysts were characterized by several techniques, such as temperature programmed reduction and desorption, N2 adsorption, ICP, TG, TEM, SEM, EDS, XRD, FTIR, determination of contact angles and elemental analysis. Figure 1 shows the results of waste materials conversion and EG yields after 5 h calculated based on both the total amount of biomass and the holocellulose content. All kinds of biomass materials (softwood, hardwood, herbaceous, etc.) could be converted into ethylene glycol and other polyols. Depending on the lignocellulosic material, the EG yield based on the total amount of biomass varied between 0.8 and 25.2 %. The highest EG yields were obtained for cotton wool and tissue paper, since these materials are almost exclusively composed of cellulose. In general, the woody materials allow obtaining higher EG yields than the herbaceous materials. Apart from the different compositions, the structure of the various biomass samples also played an important role in the production of EG.

Acknowledgments:
This work was financially supported by: Base-UIDB/50020/2020 and Programmatic-UIDP/50020/2020 Funding of LSRE-LCM, funded by national funds through FCT/MCTES (PIDDAC).

FIGURES

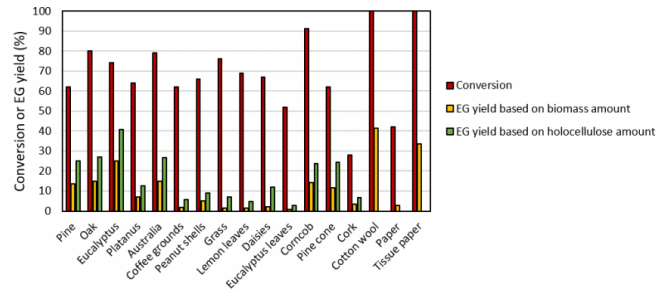

FIGURE 1

FIGURE 2

Figure 1

Catalytic results of waste biomass materials conversion to EG after 5 h of reaction.

KEYWORDS

Agro-forestry residues | hydrolytic hydrogenation | Ru-W catalysts | ethylene glycol

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