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Effect of niobia addition on cobalt catalysts supported on alumina for glycerol steam reforming

João Paulo da S.Q. Menezes, Karine R. Duarte, Robinson L. Manfro, Mariana M.V.M. Souza*

Escola de Química- Universidade Federal Do Rio de Janeiro (UFRJ), Centro de Tecnologia, Bloco E, Sala 206, CEP 21941-909, Rio de Janeiro, RJ, Brazil

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Cobalt catalysts were prepared by wet impregnation of three distinct supports: alumina, niobia and 10 wt% niobia/alumina, prepared by wet impregnation of niobia precursor on alumina. Niobia addition decreased alumina acidity, improved catalyst reducibility and reduced the formation of spinel phases ($CoAl_2O_4$ and Co_2AlO_4). The catalysts were evaluated on steam reforming of glycerol for 30 h at 500 °C, GHSV of 200,000 h^{-1} and using a glycerol solution 20% v/v in feed. The best performance was obtained for the catalyst supported on Nb_2O_5/Al_2O_3 (CoNbAl), which presented the highest conversion into gas (90%) and hydrogen yield (65%) during the first 8 h of reaction. All the catalysts suffered deactivation after 24 h of reaction due to coke formation, but the nature of coke (amorphous or graphitic) and its formation mechanism is different for each catalyst. A more in-depth study on the effect of temperature on CoNbAl catalyst performance was conducted in the range from 400 °C to 600 °C, keeping glycerol concentration in feed at 40% v/v of glycerol and GHSV of 200,000 h^{-1}. Hydrogen yield increased from 5% at 400 °C to 15% at 600 °C. A kinetic study was also performed for this catalyst, obtaining an apparent activation energy of 16.2 $kJmol^{-1}$ by Arrhenius equation.

1. Introduction

Fossil fuels are mainly responsible for global warming along the decades, as their use release significant amount of pollutant gases like carbon dioxide. These gases are responsible for severe damage to nature and affect the human health. Furthermore, fossil fuels are non-renewable resources, thus the development of new routes for energy supply based on renewable resources as biomass is essential, as it would reduce the dependence on fossil fuels and minimize environmental issues [1].

In the last decades, research involving renewable sources of energy has been outstanding worldwide. Among the available sources of biomass, oils and fats from plant and animal origin have been largely investigated as strong candidates, because in addition to providing a new stimulus to the production chain of oilseeds, consequently generating millions of direct and indirect jobs, they offer alternatives to economic and socio-environmental difficulties [2].

Biodiesel can be classified as an alternative fuel, derived from renewable source, which can offer socio-environmental benefits when employed in the total or partial replacement of diesel oil. It can be produced through vegetable/animal oils and fats; therefore, this fuel is biodegradable and does not contain aromatic and sulfur compounds. Besides, it enables the decentralized generation of energy and induces strong support for family farming, creating better living conditions in needy regions [3].

Despite its benefits, the main process to produce biodiesel is a transesterification reaction that yields glycerin, considered an unrefined raw product [4]. One ton of biodiesel results in around 110 kg of glycerin, or 100 kg of pure glycerol. Glycerol has many applications as it can be used as feedstock by a variety of industries, however, currently, it has accumulated in the market, becoming a potential pollutant. Thus, it is essential to search for new routes for its conversion into other products of higher value.

The steam reforming of glycerol is an attractive alternative, since it generates hydrogen that can be considered as a future energy vector [5]. Hydrogen is the most abundant molecule of the universe, it can be generated by several processes and its use does not emit significant amounts of pollutants. Currently, most of the hydrogen is produced from non-renewable sources such as natural gas, oil, and coal. Approximately half of the production is obtained through natural gas (48%), followed by heavy oils (29%) and coal

* Corresponding author.
E-mail address: mmattos@eq.ufrj.br (M.M.V.M. Souza).

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