BIODIESEL DRY PURIFICATION USING MAGNETIC POROUS CARBON

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ABSTRACT

This study aims to evaluate the potential of a magnetic porous carbon obtained from phenolic resin/ferrocen/lignin composites, being a lignin a lignocellulosic waste, to be use as adsorbent in biodiesel dry purification. Different concentrations of lignin were incorporated at the matrice composed by carbon and ferrocene and the final magnetic composites was submitted to the adsorption tests to removal glycerol at the crude biodiesel. Samples of crude and purified biodiesel were characterized as density, viscosity, acid index and removal glycerol. The results showed that the magnetic porous carbon removed the free glycerol and decreased the acid index, as well as maintained the biodiesel characteristics, as recommended by ANP920/2023 standards. This study highlighted the potential of lignocellulosic waste in the synthesis of new materials to be used in sustainable processes that contribute to the rational use of potable water.

Keywords: Biodiesel. Adsorption. Magnetic porous carbon. Glycerol. Dry purification.

1 INTRODUCTION

Biodiesel is a renewable and non-toxic biofuel produced from oils and fats using the transesterification process. In this reaction, the triglycerides present in oils react with an alcohol to produce fatty acid mono-alkyl ester and the glycerol as a by-product1. During the transesterification reaction of triglycerides with methanol, approximately 10 wt% of glycerol is produced, as well as intermediate products with mono- and diglycerides. Apart from these, impurities like a catalyst, alcohol and unreacted tryglicerides can result in diverse problems during use of biodiesel, which may include clogging of filters, engine depositing and destruction of fuel properties2.

The process most commonly used in the removal of impurities from biodiesel is known as wet washing, which consumes large volumes of potable water (three liters of water per one liter of biodiesel) and generate large volumes of contaminated liquid effluents. Dry washing using adsorbents is an alternative way to reduce this consume of potable water and effluents3. Comercial adsorbents based on silica and ion exchange resin are effective, but industrially impracticable due to the high cost. Low-cost adsorbents can be developed using agro-industrial waste as lignin with polymeric matrices, producing adsorbent composite with great mechanical and thermal properties.

This study evaluate the performance of a porous carbon produced with Kraft® lignin in different proportions and magnetized with ferrocene in a biodiesel dry purification. The adsorbent efficiency was based on the glycerol removal and free fatty acids reduction from biodiesel produced..

2 MATERIAL & METHODS

The magnetic porous carbon preparation follows the methodology described by Renda4. The phenolic resin was produced from polymerization in acid catalysis by the mixture of phenol and formaldehyde in a molar ratio of 1:3 under stirring magnetic and room temperature for 90 min. After the pre-polymer separation, 3% of ferrocene was added to the mixture and the reaction was performed under mechanical agitation of 10000 rpm for 20 min. In the phenolic resin with lignin, the lignocelulosic waste was used as phenol substituent in proportions of 10, 20 and 30% w/w. The phenolic resins were transferred to aluminum boats and submitted to a thermal treatment up to 1000°C under Argon atmosphere. The magnetic porous carbon obtained was submitted to a BET analysis.

The biodiesel reactions follows the adapted methodology described by Oliveira et al.5 The reaction medium containing refined soybean oil and methanol in a molar ratio 1:6 (oil:alcohol) using KOH 1% m/m as homogeneous catalyst. The reactions were carried out in a jacketed reactor with a condenser under magnetic stirring for 1h and 45 °C. The product obtained was transferred to a decantation funnel for 24h to separate the excess of glycerol. The lower phase containing the methyl esters and residual glycerol called crude biodiesel was submitted to the adsorption tests, to become a purified biodiesel. The crude and purified biodiesel was analyzed as density6, viscosity6, index acid6 and free glycerol7.

The glycerol adsorption tests follows the methodology described by Santos et al.8 The adsorption was carried out in a Erlenemyers containing 20 mL of crude biodiesel and 10 mg/ml of magnetic porous carbon under orbital shaker agitation at 30°C for 1h. After this period, the samples were centrifuged to separate the adsorbent. The supernatant (purified biodiesel) was submitted to the same analysis of crude biodiesel, as described above.

3 RESULTS & DISCUSSION

Figure 1 illustrate the magnetic porous carbon. The BET analysis showed an average pore diameter varying of 40.9 to 52.8 ângstrons for the materials with lignin, indicating that the lignin substitution increase the pore diameter of the pure magnetic porous carbon, which has a value of 35.7 ângstrons.

Figure 1 Magnetic porous carbon.

The performance of magnetic porous carbon pure (0%) and with lignin (10, 20 and 30%) were evaluate in adsorptions tests with crude biodiesel and the results are described in Table 1.

Table 1 Crude and purified biodiesel caracterization.

Properties	Crude Biodiesel	Purified biodiesel				ANP 920/2023
		0 % Lignin	10% Lignin	20% Lignin	30 % Lignin	
Viscosity 40°C (mm^2/s)	3.9	3.9	4.0	4.1	4.1	3.0 to 5.0
Density 20°C (Kg/m^3)	857.08±2.09	899.18±0.52	863.32±1.47	862.57±0.65	862.50± 0.65	850 a 900
Acidity index (mgKOH/g)	0.09±0.02	0.08±0,02	0.05±0.00	0.07±0.01	0.05±0.00	0.50
Free Glycerol (%)	0.0031	0.0017	0.0018	0.0017	0.0015	0.02
Glycerol removal (%)	-	44.83±0.38	42.64±0.68	45.27±1.15	51.41±0.38	-

Table 1 showed that all the biodiesel samples are in accordance with the required values by the ANP 920/2023 standards, and the viscosity and density values were not significant modified by the adsorption process. However, the acidity index and free glycerol were reduced after the dry purification. The magnetic porous carbon with 10 and 30% lignin obtained the higher acidity index reduction, with values of 0.05 mgKOH/g. In addition, all the adsorbent materials were able to remove the glycerol, with higher value of 51.41% reached by the adsorbent with 30% lignin. These results suggesting that the lignin substitution in the phenolic resin not only improves the sustainability of the process, as improve the adsorbent properties of the material.

4 CONCLUSION

Results obtained in this study revealing the potentially of magnetic porous carbon as adsorbent in biodiesel dry purification process. The substitution of phenol by a lignocellulosic waste at the phenolic resin makes the process more sustainable, adds value of the waste and improve the adsorbent properties of the new material. To gain a better understanding of the mechanisms that govern glycerol adsorption, kinetic and thermodynamic studies will be carried out further.

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