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Effects of Catalytic Flash Pyrolysis with Natural Clay in Chlorella sp.

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Resumo-Abstract

Third-generation biofuels have gained attention as a viable alternative for reducing carbon emissions in the transport sector [1]. Among the various conversion technologies, Catalytic Flash Pyrolysis (CFP) is a prominent and efficient method for converting microalgae into bio-oil, which contains a significant amount of renewable hydrocarbons [2]. However, to make this process more economically and environmentally feasible, research has focused on developing cost-effective catalysts that can enhance the quality of the produced bio-oil [3]. Natural clays, with their unique inorganic composition and structure, present themselves as strong candidates for this purpose due to their potential to provide active catalytic sites during the pyrolysis process [4].This study investigates the impact of CFP, using natural clay, on the composition of volatile compounds in bio-oil derived from Chlorella sp throught PY -GC/MS (Pyrolysis-Gas Chromatography/Mass Spectrometry). *Chlorella* sp. biomass was cultivated in a 10-day process using a BG-11 medium, aerated with a mixture of 10% CO2 and air in a photobioreactor. After cultivation, the biomass was freeze-dried and subjected to Flash Pyrolysis (FP) at 500°C in a quartz tube at a heating rate of 10°C/ms, with a residence time of 20 seconds. The catalytic flash pyrolysis process involved using natural clay as a catalyst, maintaining a 1:5 catalyst-to-biomass ratio, and the pyrolysis vapors were carried by nitrogen gas to the catalyst bed, also at 500°C. The results of the flash pyrolysis of Chlorella sp. showed a bio-oil composition with a significant presence of oxygenated compounds (40.10%), followed by hydrocarbons (33.18%) and nitrogenated molecules (21.22%). The remaining 5.50% of compounds consisted of unidentified elements and other molecules containing nitrogen and oxygen. Due to the high content of nitrogen- and oxygen-containing compounds, the bio-oil produced through flash pyrolysis alone was not suitable for direct use as a biofuel. However, when natural clay was used as a catalyst in the CFP process, there was a significant shift in the bio-oil composition. The relative concentration of oxygenated compounds decreased dramatically to 10%, while the hydrocarbon content rose to 64.01%, making hydrocarbons the dominant component. The nitrogenated compounds remained relatively constant at 21.93%, suggesting that the catalyst did not affect these groups. This shift indicates that the bio-oil generated through CFP is much more suitable for renewable hydrocarbon production, given its higher hydrocarbon content and lower oxygen levels, which improve the overall quality of the pyrolysis bio-oil. Additionally, the natural clay catalyst influenced the specific composition of hydrocarbons by reducing the proportion of aromatic compounds from 68.08% to 56.17% and increasing aliphatic hydrocarbons from 31.91% to 43.82%. This shift toward aliphatic hydrocarbons, particularly alkenes, is likely due to deoxygenation reactions facilitated by the natural clay catalyst. In conclusion, this study highlights that catalytic flash pyrolysis using natural clay as a catalyst significantly improves both the yield and quality of bio-oil from Chlorella sp. by reducing oxygenated compounds and increasing the hydrocarbon content, particularly aliphatic hydrocarbons. This process holds promise for optimizing bio-oil composition and advancing the development of more sustainable biofuels.

Palavras-chave: Chlorella, pyrolysis, clay, catalyst.

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