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Pyrolysis, combustion and gasification characteristics of *Nannochloropsis gaditana* microalgae

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HIGHLIGHTS

- Pyrolysis, combustion and gasification of marine biomass were evaluated.
- Oxygen concentration enhanced the oxidation stage of the *NG* microalgae.
- N-compounds were evolved in pyrolysis. Sulfur compounds are evolved in combustion.
- Combustion and pyrolysis main gas products evolved during the second step.
- H_2 production during gasification was enhanced by steam concentration.

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ABSTRACT

Pyrolysis, combustion and gasification characteristics of *Nannochloropsis gaditana* microalgae (*NG* microalgae) were investigated by thermogravimetric analysis (TGA). *NG* microalgae pyrolysis and combustion could be divided into three main stages: dehydration, proteins and polysaccharides degradation and char decomposition. The effects of the initial sample mass, particle size and gas flow on the pyrolysis and combustion processes were studied. In addition, gasification operation conditions such as temperature, initial sample mass, particle size, sweep gas flow and steam concentration, were experimentally evaluated.

The evolved gases were analyzed online using mass spectroscopy (MS). In pyrolysis and combustion processes, most of the gas products were generated at the second degradation step. N-compounds evolution was associated with the degradation of proteins. Furthermore, SO_2 release from combustion could be related to sulphated polysaccharides decomposition. The main products detected during gasification were CO_2, CO, H_2, indicating that oxidation reactions, water gas and water gas shift reactions, were predominant.

1. Introduction

Recently, the utilization of biomass for transport fuels, chemical commodities, power generation and reduction of CO_2 emissions is growing interest (Ross et al., 2009). Thus, biomass has the potential of being an important renewable energy source.

Algae are a very promising biomass for the following reasons: a high growth rate, high yield per area, high efficiency in CO_2 capture and solar energy conversion and no competition with food agriculture. In addition, they can be grown in open water (sea water or ponds) and in bio-photo reactors on non-arable lands (Babich et al., 2011).

The generic term microalgae refer to a large group of very diverse photosynthetic micro-organisms of microscopic dimensions. They have received more attention than macroalgae for biofuels production, which can be cultured in ponds or photobioreactors with supply of nutrients or wastewater. Moreover, the production of microalgae does not require of high quality arable land and therefore it does not compete with food crops.

Generally, microalgae varied in their proportions of protein (6–52 wt.%), carbohydrate (5–23 wt.%) and lipid (7–23 wt.%). *Eustigmatophytes* are rich in one or both of the 20:5(n-3) and 22:6(n-3) polyunsaturated fatty acids. According to Ross et al. (2009), microalgae with high lipid content could be a future source of third generation biofuels and chemicals. The oil content itself can be estimated to be 64.4% of the total lipid component. Thus, *Nannochloropsis gaditana* (*NG*) microalgae, belongs to *Eustigmatophytes* microalgae specie, have been proposed as a candidate to carry out this study.

Interest towards the quality and characteristics of bio-oil from microalgae is revived nowadays, due to growing concerns over emissions, energy supply, oil prices and availability (Babich et al., 2011). The conversion technologies for utilizing microalgae

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