On the evaluation of the macroalgae Sargassum sp. through different pyrolysis technologies to obtain bio-fuels and other useful materials

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Introduction

The depletion of fossil fuels along with greater environmental awareness motivates the search for new alternatives for these energy sources. One of the most promising alternatives is the pyrolytic conversion of biomass into bio-fuel, especially when it is obtained from urban waste (Velghe et al. 2011) , agriculture (Fu et al. 2010) or industrial residues (Adrados et al. 2012). This is the case of Sargassum sp., a brown macroalgae with unsusual bloom, which can cause severe environmental problems particularly in the tropical seashores, as for example the mexical coastal of Quintana Roo. They massive arrival to the coastal affects not only the marine biology but also conservation activities and tourism. The heterogeneity in the chemical composition of sargassum, the decomposition products in terrestrial environments, the poor control of leachate in groundwater and the generation of toxic emissions into the atmosphere, make it difficult to design strategies for its temporary or final disposal, its productive use being one of the most valued scientific strategies today.

In an effort to address the Sargassum problem this work focused on their utilization as raw material for bio-oil, bio-char and gas generation. An exhaustive analysis of the Sargassum sp macroalgae was initially carried out. In order to study their productive use as bio-fuel and/or biomaterials generation different pyrolysis technologies (conventional, flash ...) were studied in ovens. Diverse pyrolysis conditions will be tested to maximize bio-oil and gas production. In all pyrolysis treatments, the energy potential of the different fractions generated (bio-oil, bio-char and gas) was also determined.

Materials and methods

Two Sargassum samples were collected from the coastal zone of Quintana Roo in México (S1 and S2). They were dryed, grounded and sieved before utilization.

The samples were characterized by different techniques. The thermogravimetric study of the Sargassum sp macroalgae was carried out on a TA Instruments thermobalance (TGA Q5000IR). The determination of carbon, hydrogen and nitrogen in the samples was carried out on the LECO CHN-2000 and S-144-DR automatic equipment. Proximate analysis (moisture, volatile matter, ash) was performed on a LECO TGA 701 thermogravimetric analyzer (LECO Corporation, Groveport, Ohio, United States). The experimental device for pyrolysis includes a Carbolite CTF12/65/550 horizontal tubular furnace and a horizontal tubular furnace of original design equipped with a quartz tubular reactor, a gas mass flow controller and accessories for collecting the liquid and gas phase. The liquid fraction was analyzed by chromatography using an Agilent 7890A chromatograph coupled to an Agilent-MS 5975C mass spectrometer and the gaseous fraction was studied by gas chromatography (Agilent Technologies 3000A and Hewlett-Packard 5890). Transmission electron microscopy (TEM) investigations, including conventional (CTEM),high-resolution (HRTEM), and elemental chemical analysis (EDX) methods, were performed on graphene specimens using an FEI TITAN 80–300 kV instrument (FEI Technology de México S.A., Monterrey, Mexico). It operated at an accelerating voltage of 300 kV. SPECS equipment (SPECS Group, SPECS Surface Nano Analysis GmbH, Berlin, Germany) operating under a pressure of 10−7 Pa with a Mg Kα X-ray source was used for the X-ray photoelectron spectroscopy (XPS) studies.

Results and discussion

The atomic composition of both samples (Table 1), reveals an increased amount (> 1%) of C, O, and K in S1, while S2 exhibit Ca in ots composition, not present in S2.

Table 1: Atomic composition of the Sargassum sp.-based samples S1 and S2

	S1	S2
C	62.1	60.5
O	25.2	24.1
Na	2.3	5.2
Cl	6.0	5.7
S	0.8	1.1
K	3.6	0.9
Ca		2.5

The two samples used in this work were fully characterized by XPS analysis. The C1s XPS curve of both samples (Figure 1), reveals also different distribution of functional groups in the samples, with larger amount of C-O groups in S1.

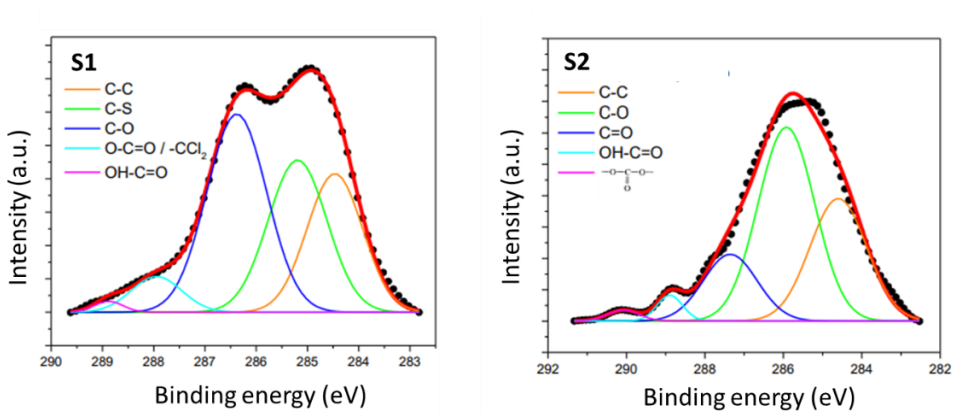

Figure 1: XPS C1s analysis of S1 and S2.

The pyrolysis carried out in both ovens was carried out under the following experimental conditions: 750ºC temperature, 5ºC/min heating ramp, annealing time of 60 minutes and nitrogen flow of 150 ml/min. In order to maximize bio-oil production, lower pyrolysis temperatures (500°C) were also used. It is published that flash pyrolysis at low temperature (500 °C) generates mainly bio-oil (75-80%) and the gas is the minority fraction (4-5%) (Amutio *et al.*, 2013).The analysis of the chemical characteristics, heating value and yield of the pyrolysis fractions (char, bio-oil, bio-gas) were determined demonstrating the efficiency of both pyrolysis processes studied.

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