Research on Using Seaweeds as Biofuel by Using Vacuum Drying Method

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Received: May 12, 2013 / Accepted: June 03, 2013 / Published: December 25, 2013.

Abstract: Seaweeds carry out photosynthesis to convert inorganic carbon into organic substances, such as hydrocarbons or neutral lipids. And those resulting products can be used as biofuel. The CO₂ fixation ability of seaweeds is much greater than other plants on earth, but directly extracting lipids from seaweeds is quite inconvenient and extravagant. In this study, Vacuum drying method to dry seaweeds to biofuel directly was used which can save cost and energy compared with extract process. It has been tested at 60 °C, 70 °C and 80 °C, respectively under normal atmospheric pressure. The experimental results show that vacuum drying method can save cost and energy observably and the shortest time is also the lowest power cost.

Key words: Seaweeds, biofuel, vacuum drying, CO₂ fixation.

1. Introduction

In recent decades, with the increasing energy demand, the problem of climate change and greenhouse emission from traditional fossil fuels becomes more and more serious, while now renewable energy as a clean energy sources is still the minority of the current total primary energy production. Biomass as one of renewable energy is not only produced from plants, animals, and micro-organisms but also from organic wastes. They usually absorb the CO₂ by photosynthesis or metabolism, so biomass as a new energy source could decrease the CO₂ emission amount greatly. Biomass may become a source of local energy, and microalgae seem to be promising because of their high photosynthetic efficiency, high biomass production, and fast growth [1]. The idea of converting algae to biofuels was first suggested in 1955 [2], and has been pursued more intensely in recent decades [3-7]. As a matter of fact, average biodiesel production yield from microalgae can be 10 to 20 times higher than the yield obtained from oleaginous seeds and/or vegetable oils [8,

9] (Table 1). Some microalgae have high oil content (Table 2) and can be induced to produce higher concentration of lipids (e.g., low nitrogen media, Fe³⁺ concentration and light intensity) [10-14].

However, the most biological producer of oil from microalgae is difficult or impossible used immediately. And also, extract process is complicated and with high cost. In this study, we used low cost process-vacuum drying method, to decrease the biomass cost and make biofuel to be used directly. We also focus on the lowest power cost during the vacuum drying method and calorific value under different moisture content of biomass.

2. Materials and Methods

2.1 Sample Preparation

Compare with the other microalgae, *Chlorella vulgaris* has higher reproductive capacity and cultural method is simpler. However, until the experiment stated, *Chlorella vulgaris* haven't enough quantity to support. We chose *Ceratophyllum demersum* to replace it and began the experiment. Each time 2 g simple is dispersedly put in the bottom of jar, and fixed

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Table 1 Comparison of some sources of biodiesel.

Crop	Oil yield (L/ha)
Corn	172
Soybean	446
Canola	1,190
Jatropha	1,892
Coconut	2,689
Oil palm	5,950
Microalgae ^a	136,900
Microalgae ^b	58,700

a 70% oil (by wt) in biomass.

b 30% oil (by wt) in biomass.

Table 2 Lipid content of some microalgae (% dry matter).

Species	Lipids
<i>Scenedesmus obliquus</i>	11-22/35-55
<i>Scenedesmus dimorphus</i>	6-7/16-40
<i>Chlorella vulgaris</i>	14-40/56
<i>Chlorella emersonii</i>	63
<i>Chlorella protothecoides</i>	23/55
<i>Chlorella sorokiana</i>	22
<i>Chlorella minutissima</i>	57
<i>Dunaliella bioculata</i>	8
<i>Dunaliella salina</i>	14-20
<i>Neochloris oleoabundans</i>	35-65
<i>Spirulina maxima</i>	4-9

into the water bath. Every time preheat the water bath to target temperature. (Fig. 1).

2.2 Drying and Temperature

Before the experiment started, we test the moisture content of original sample every time ($90 \pm 1\%$). The purpose of final moisture content is average 30%. So we tested under 60 °C, 70 °C and 80 °C, respectively, and each temperature condition cost 20 min, 30 min, and 40mins respectively. Under these factors, each of the experiment test has been done at least 10times.

2.3 Analytical Method

In the experiment, we used vacuum pump (N810FT.18, Knf, Japan), weight measurement by electron steelyard (AF-R220, Vibar, Japan), moisture content measurement used electrical moisture meter (MOC63u, Shimadzu, Japan), calorific value measurement used calorimeter (CA-4AJ, Shimadzu, Japan), and power cost measurement used eco keeper (EC-03EB, Elpa, Japan).

Fig. 1 Experimental apparatus.

3. Results and Discussion

Because of vacuum pump's high power, after 5-10mins, the vacuum degree in the jar reaches to 0.080MPa, and become steadily. According to the standard atmospheric pressure (0.101 MPa), the pressure in the bottle is almost 0.020 MPa, under this condition, the boiling point of water is nearly 60 °C, which is the same as the starting temperature of the experiment.

According to Fig. 2, moisture content decreased with the drying time increased obviously. But under different temperature condition, the moisture content

Fig. 2 The relation of time and moisture content on 60 °C, 70 °C, 80 °C.

is quite different. At 60 °C, after 40mins moisture content just under 30%, at 70 °C, after 30mins, moisture content average in 30%, and at 80 °C condition, after 20 min even moisture content was not stable enough, but it was still under 30% (Fig. 3). All the data conform the moisture content under 30% become stably, and decreased with moisture content, the stable of the data increased.

Basically, calorific value was increased with moisture content decreased (Fig. 4), and of course high calorific value means more value in the practical application. But the more moisture content decreased, means the more energy cost we need in biomass production. According to Fig. 5, obviously energy cost was increased with temperature increasing, which because high water temperature needs more energy cost. Under the condition of 60 °C, 70 °C and 80 °C, heating the water (20 °C) to the specified temperature cost 50.4, 102.4 and 168 kJ, respectively. Obviously, the higher of preheating temperature is, the greater of energy consumption it cost. But in order to practical application, we should consider about quantity and continuity test. Under condition of moisture content 30%, 60 °C, 70 °C, 80 °C cost 40 min, 30 min and 20 min respectively. And during these 20-40 min, they had cost average 48.4, 54.4, 36 kJ to keep the temperature at 60 °C, 70 °C and

Fig. 3 The average of moisture content on each temperature.

Fig. 4 The relation between moisture content and calorific value.

Fig. 5 The relation between time and energy consumption.

80 °C, respectively. That means, without preheat energy cost, the shortest time (80 °C, 20 min) spend the fewest power.

4. Conclusions

A vacuum method has been successfully applied to biofuel produce experiment at 60 °C, 70 °C, 80 °C respectively. According to the low pressure condition, seaweeds have been easily drying. Under different condition, energy cost increased with temperature increasing and time consumption. At 60 °C condition total power cost is the lowest, and at 80 °C is the

highest power cost. But without preheat energy spending, the shortest time, 20 min at 80 °C spend the fewest power.

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