

# Characterization of *Spirogyra* Using TG/DTG and Bomb Calorimeter for Energy Application

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## ABSTRACT

Biomass is usually considered as different types of garbage or waste materials having varied composition potential to utilize in the useful forms of energy as a substitute of conventional fossil fuels. Algal biomass has multi facet application in research and development such as source of nutrients, biochemical, cosmetics and biofuels. However, this newly developed energy source even not met its full potential due to low thermal efficiency, especially for the power generation. In present study, freshwater algae *Spirogyra* taken as source of biomass and analyzed for TG (Thermogravimetric) and calorific values analysis. We found the calorific value is 2129.4 Kcal/Kg and TGA results show that algal biomass decrease rapidly after reaching the temperature over 300°C. The result obtained in this paper may be used in future as reference material for algae based biomass for energy application.

**Key words:** *Spirogyra*, Algal Biomass, Calorific Value, TG.

## 1. INTRODUCTION

Post industrial revolution has not only increased the demand of energy but also polluted the environment manifold. There is a significant increase of emission of CO<sub>2</sub>, SO<sub>x</sub>, NO<sub>x</sub> and particulate matter in the environment due to anthropogenic activities. In the present scenario clean and emission less energy is not only a choice but also a compulsion under obligation of Kyoto protocol to curb the emission of various GHGs. To deal with global warming and avoid dangerous climate change, keeping the temperature below 2°C is also desirable under the Paris agreement. All these concerns may be addressed by introducing renewable energy resources. (1.) Renewable energy comprises solar, wind, hydropower, tidal waves and biomass energy. Algal biomass mainly composed of cellulose, hemicellulose and lignin. Biomass is usually considered as different types of waste materials having varied composition that may be utilized as a substitute of conventional fossil fuels. Composition wise it is constituted of carbon, nitrogen, hydrogen, oxygen and sulphur. Biomass energy is not only clean source of energy, but also considered as fuel substitution of fossil fuels having the same benefits in terms of operation and improving environmental benefits of energy generation. As an energy source biomass can be used directly or indirectly converted into other energy forms through various routes namely biochemical & thermochemical. Besides that biomass resources have more potential than other renewable energy in terms of sustainability. The 1<sup>st</sup> and 2<sup>nd</sup> generation fuels, consisting of maize, cereal crops and soybeans, are environmentally friendly but conflict with food supply. Algae come under 3<sup>rd</sup> generation food mainly composed of lipids, proteins and small fraction of cellulose and are different from its feedstock of a crop food (2.).

The algal application of energy generation was initiated by U.S. government in 1960 and commonly known as ASP (Aquatic Species Program), for the development of algae based technology. It was further extended in Hawaii, just after the period of oil crisis and mid-east war. The Japanese government also started the project in time period of 1990-96 with the innovative idea of CO<sub>2</sub> fixation. These projects concluded with valuable results like new strains development for lipid

production, principle of aquaculture and photo bioreactor design. In 21<sup>st</sup> century, continuous efforts are mainly focused on how to grow algae in large aquaculture and make the economic balance. (10)

In India, algae projects started in 2011 in collaboration of nine premier research institutes led by CSMCRI (Central Salt Marine and Chemical Research Institute) with the development of algae biodiesel with traditional biodiesel. Recently, Algae has gained attention other than biomass to overcome the problem of low performance and efficiency. For increasing efficiency algae must be pretreated before used in the energy system or transformed into another phase. Although production of biodiesel has shown that harvesting procedure and lipid production put the environment at risk and cost energy waste. Some studies use fermentation processes, which are anaerobic in nature in which sugars are converted into cellular energy and thereby produce ethanol and carbon dioxide as metabolic waste products. Anaerobic digestion essentially occurs in absence of oxygen and mediated by microorganisms to convert biomass into biogas, but it still needs lots of development in terms of yield and efficiency. (11)

In developing countries like India, it's started to gain popularity with the development of technology. Apart from *Jatropha*, some strains of Algae are selected and harvested for obtaining the different products like bio oil, syngas through different processes like liquefaction & gasification. Although different processes are available for conversion of biomass into energy, thermochemical conversion is considered as a one of the promising routes. Thermochemical conversion includes combustion, gasification, pyrolysis and liquefaction. Combustion is the chemical reaction occurring at high temperature to convert biomass into useful energy products in presence of oxygen. Recently research is going on for the production of biodiesel through the pyrolysis process. Although very few studies about combustion behavior of algae have been reported, mostly studied about microalgae *Chlorella* species. The combustion behaviors are analyzed through thermogravimetric (TG) analysis, of biomass in different oxygen concentrations and N<sub>2</sub>/O<sub>2</sub> ratio (12, 13).

In 2014, Lopez-Gonzalez (14) reported that certain microalgae like *chlorella vulgaris*, *Scenedesmus almeiensis* and *Nannochloropsis gaditana* are potential biomass for combustion application through TGA-MS-DSC analysis. In this study, we analyze the *Spirogyra* in TG/DTG and bomb calorimeter to provide the detail information of algal biomass mainly for combustion application.

## 2. MATERIAL AND METHODS

To analyze algal biomass for energy production, we have selected *Spirogyra* based on their chemical composition. & specialties in energy application analyzed through TG/DTG and bomb calorimeter.

**2.1 Biomass Selection:** Algae has explored for decades mainly due to energy application. For that we have to analyze chemical composition through proximate and ultimate analysis. However, the quantity & potential in biomass for energy production is also important for energy production. Therefore, in this study, we selected *Spirogyra sp.* that has been used in multi-application, production of energy is one of them. Recently, it has been reported that *Spirogyra sp.* having potential for producing biodiesel (15). The algal biomasses are collected from ponds nearby the Meerut district Uttar Pradesh, India. The collected algal biomasses are kept for sun drying and powdered for further use.

**Table 1: The lipid percentage of algae and microalgae**

Microalgae/Macroalgae species.	Lipid (% Dry wt.)
<i>Spirogyra</i>	20-32
<i>Monallanthus salina</i>	>20
<i>Nannochloropsis sp. (fresh water)</i>	20-35
<i>Nannochloropsis sp.(sea water)</i>	31-68
<i>Neochloris oleoabundans</i>	35-54
<i>Botryococcus braunii</i>	25-75
<i>Chlorella sp.</i>	28-32
<i>Phaeodactylum tricornutum</i>	20-30
<i>Nitzschia sp.</i>	45-47
<i>Cylindrotheca sp.</i>	16-37
<i>Cryptocodinium cohnii</i>	20

<i>Dunaliella primolecta</i>	23
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## References [3-9]

**2.2 Calorific Value Detection:** The calorific value of algal biomass is determined by evaluation of gross calorific value (GCV) of prepared sample. It measures the energy content of a unit mass sample in a bomb calorimeter. In this method calorific value is determined by burning a weighed biomass sample under controlled condition in an oxygen bomb calorimeter.

**2.3 TG/DTG Analysis:** The algae sample in powder form kept in oven (40°C. overnight before testing the starting temperature is 90°C for around 30 minutes mainly for drying purpose of the biomass and keep the moisture within limit. Finally temperature increased up to 900°C to analyze the thermal stability and oxidative stability of sample.

**Table 2:** The Calorific values of *Spirogyra*, microalgae, fossil fuel & other biomass materials

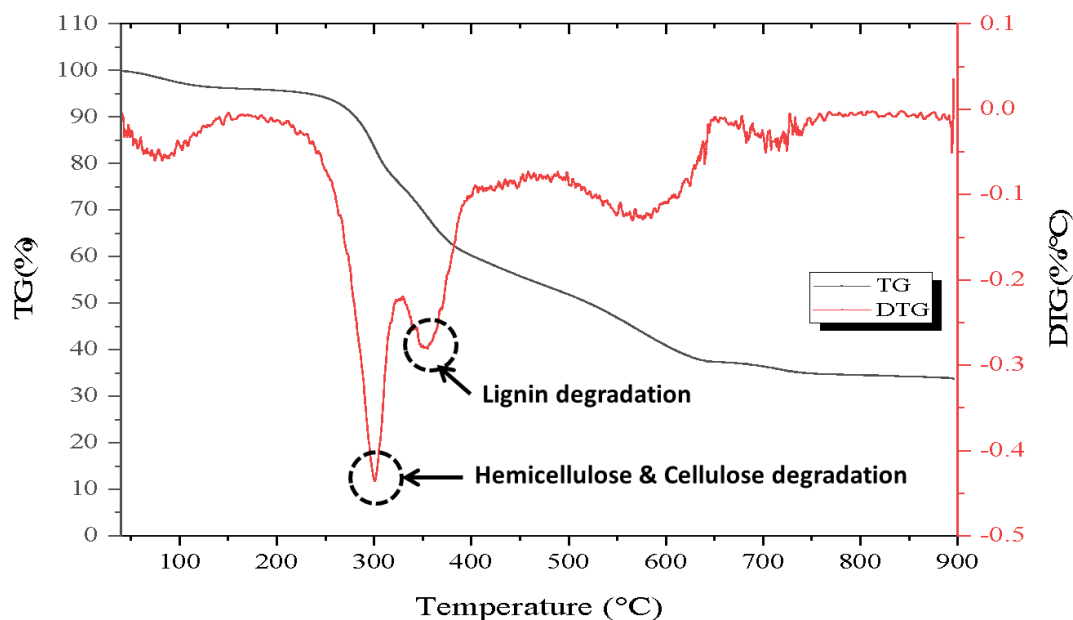
	J/g	Kcal/KG	Types of Biomass	Reference
<i>Spirogyra</i>	8,900.89	2,129.4	Non-food	In this study
<i>Chlorella</i>	21,174.5	5,057.4	Non-food	[18]
<i>Spirulina</i>	20,866.3	4,983	Non-food	[18]
Coal	28,665.6	6,846.7	Fossil fuel	[18]
Diesel	42,000~49,500	----	Fossil fuel	[16]
Coconut	35,000~38,100	----	Food	[16]
Soybean	38,310~39,760	----	Food	[16]
Wood Waste	19,450	4,645.6	Food	[17]
Vege-Oil	33,700	8,049.1	Food	[17]

## 3. RESULTS AND DISCUSSION:

The algal biomass samples were tested for calorific value and TG /DTG analysis.

**3.1 Calorific Value Analysis of *Spirogyra*:** Each sample after drying had been tested for its calorific value. To make analysis comparable and meaningful, examples of fossil fuels like coal & diesel had also been taken as reference. The calorific value of coal & vegetable oil is higher than that of algal biomass. However algal biomass in combination with other biomass can be used to get better results in terms of calorific value.

**3.2 TG & DTG of *Spirogyra*:** The major components of algal biomasses are water, lipid, protein, cellulose & lignin. The TG & DTG curve is shown in figure 1. The sample decreased after 300°C and about 65 % of the sample burnt after 900°C. In the DTG curve, the first peak at 300°C occurs due to cellulose decay and the second peak at 355°C is due to lignin decay of the lignocellulosic biomass.



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114 **Figure: 1 TG & DTG Curves of Spirogyra**

115 **3.3 Discussion:** The calorific value of algal biomass show that potential of algae to be material as biofuel and TG  
116 analysis results show that thermal stability of the biomass behavior in combustion system. According to result calorific  
117 value of *Spirogyra* is not only less than fossil fuel but also less than other microalgae It may due to higher percentage of  
118 lignin in sample biomass, which remains unburnt in samples about 35% even at high temperature. In TG testing  
119 combustion take place in two stages. In first stage almost carbohydrate combusted, in second stage nitrogen and sulphur  
120 combusted as a part of protein degradation. TG analysis result shows the sample decreased rapidly at 300°C and  
121 beyond 650°C the rate becomes almost constant because presence of lignin. DTG (Derivative thermogravimetric) is the  
122 interpretation of weight loss or weight gain over temperature and curve shows that hemicellulose & cellulose degradation  
123 occurs at 300°C and lignin degradation started at 355°C.

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127 **4. CONCLUSION**

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129 In this study, we have analyzed algae biomass *Spirogyra* for knowing the calorific value and TGA to know the heat  
130 behavior of the biomass. Although algae calorific value is not competing with fossil fuel as well as non-food materials but  
131 it have significant lipid percentage 20-28% (Table.1) and may be utilizing for biodiesel production. Besides this, algal  
132 biomass should be mixed with other materials to increase the calorific value for better heat performance. The calorific  
133 value and TG analysis show that algal biomass has potential as a biofuels either alone or in combination with other  
134 biomass for better results. Sometimes the composition of multi component systems results better, when TG coupled with  
135 MS (TG-MS) with rising temperature..  
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