International Journal of Applied Engineering Research ISSN 0973-4562 Volume 14, Number 4 (2019) pp. 942-947

Bio-Oil Produced from Paper Waste and Paper Cup Using Pyrolysis Process

V.Raveendran[1*], V.vigneshwaran[1], V.K.Aravindraman[1] & R.Saravana Sathiya Prabhahar[2]

[1]*Department of Mechanical Engineering, SMK Fomra Institute of Technology, Kelambakkam.*

[1]*Department of Mechanical Engineering, Mepco Schlenk Engineering College, Sivakasi.*

Abstract

The objective of this paper is the utilization of waste into useful liquid products (Bio-Oil).Now a days there is need for alternative fuels due to the depletion of the existing fuels, bio-oil can serve this purpose. In this paper two waste materials have been chosen one is printing paper waste and other is paper cup waste for producing bio-oil. The printing paper waste and paper cup waste is coated with wax ,when they are buried in the ground it take many years to get decomposed, by using pyrolysis process it can be disposed safely without causing any damage to the environment. Bio-oil can be produced from biomass in many ways such as digestion, fermentation, gasification and pyrolysis. Pyrolysis is a thermochemical decomposition process where the material gets decomposed by the application of heat and produces gases by cooling these gases bio-oil will be obtained. The bio-oil obtained from the waste has been tested using FTIR for identifying the groups present in the sample.

Keywords: Bio-oil, Pyrolysis, FTIR, Waste Utilisation

I. INTRODUCTION

Regular world population growth, follow developing and rise of many vitally important life segments. The steady increase in food and clothes production, variable social services, needs in comfort and elements of modern life, brings high demand for energy sector. Many researches are going in the field of new energy sources and extension of renewable energy share, programs in energy efficiency .Bio-fuels could replace fossils in the closest, but indefinite period of this century. It happens because of the positive bio-fuel aspects. Bio-fuel is low emission and environmental friendly source of energy, the biggest part of bio-fuel assortment is cheaper than fossils or at the same price level. Raw material or biomass can be taken from numerous of agricultural, environmental, human life cycle segments. Various wood residues, fats from animal and food industry, straw, crops and corns, fermentation products and municipal solid waste are sources of bio-fuel.

The global bio-fuel production increased around four times from 4.7 billion gallons in 2000 to about 18.5 in 2010, but still averages a small share compare to the world total energy consumption. One more consequence of increased bio-fuel demand has contributed by world food and feed growing prices. EU, USA and Brazil concentrated around 90 percent of the world bio-fuel production. Fortunately, the Asian market is coming bigger every day. Malaysia, Indonesia, China and Japan have been done a lot of successful projects.

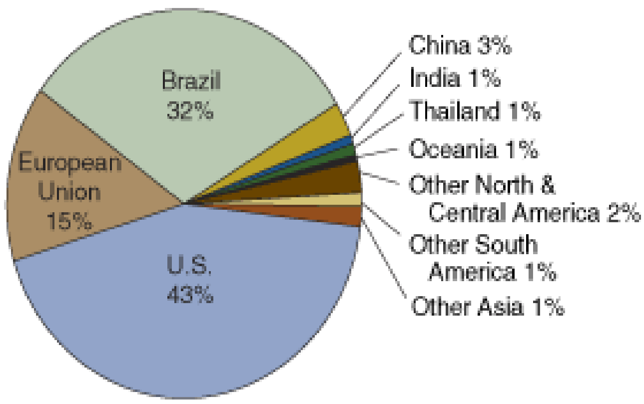

Fig 1. World Bio-Fuel Industry Shares

II. METHODOLOGY AND EXPERIMENTAL SETUP

Methodology

In this proposed work the paper waste is collected from the surrounding printing presses and paper cup has been purchased for carrying out the experiment. The raw material has been made into small pieces of about 30 to 40 mm and the experiment is carried out in the experimental setup. The bio-oil obtained has been tested using FTIR for determining the groups present in the sample.

Experimental Setup

In this the experiment is carried out for two materials at different temperatures from 300 ºC to 500 ºC.The material has been sliced into 30 to 40 mm and then dumped into the lab scale gasifier, when the gasifier is switched on the temperature starts rising and the material inside the gasifier starts decomposing and gases are produced, these gases are allowed to pass through the heat exchanger. In the heat exchanger the gases are cooled and the liquid bio-oil is collected in the conical flask which is kept below the heat exchanger. For attaining a temperature of 300 ºC the set-up took 45minutes and it had kept at that temperature for 30 minutes, similarly the setup took 80 minutes to attain a temperature 500 ºC and kept at that temperature for 30 minutes. During each trial of the experiment the Bio-oil and ash content has been collected.The schematic view of the set-up is shown in figure2.

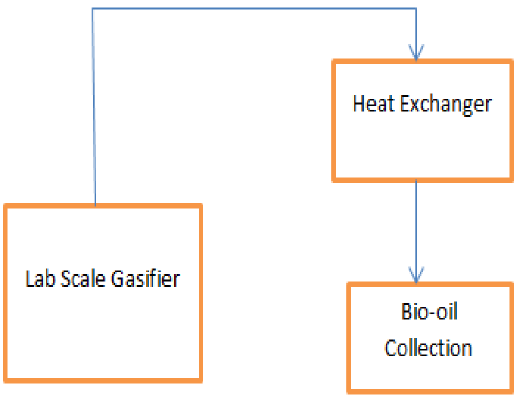

Fig 2. Experimental Setup

III. RESULTS AND DISCUSSION

Proximate Analysis

Proximate analysis is used to find the ratio of combustible to incombustible constituents of a sample. The proximate analysis is carried out according to the ASTM established procedure. The proximate analysis is used to find the moisture content, volatile matter, ash content and fixed carbon present in the biomass sample.

A. Moisture Content

This test measures the total mass of moisture present in a sample by weighing the initial mass of sample and then heating at boiling temperature, without burning. After the weight stabilizes as a final mass, the percentage of moisture present in that sample can be calculated. Moisture content can be determined on a dry basis as well as on a wet basis. In this experiment the moisture content (M.C.) on a dry basis will be used.

Moisture content is defined as:

$$M.C_{Dry} = \frac{\text{Wet Weight} - \text{Dry Weight}}{\text{Dry Weight}} \times 100$$

High moisture contents reduce the thermal efficiency since heat is used to drive off the water and consequently this energy is not available for the reduction reactions and for converting thermal energy into chemical bound energy in the gas. Therefore high moisture content results in low gas heating values.

B.Volatile Matter

Exclusive of the moisture vapour, this test method analyses the percentage of gaseous products in the sample of interest, which are released during the experiment. The calculation is usually obtained as a percent by mass of the total mass of the sample. The amount of volatiles in the feedstock determines the necessity of special measures in order to remove tars from the product gas in engine applications.

C. Ash Content

The ash content is measured by heating the sample in the furnace at 925ºC for about 7 min and the sample is weighed. This weight gives the amount of the ash content. The ashes can cause many problems when they are not properly handled or disposed.

D. Fixed Carbon Content

Solid combustible residue that is the final amount present in a biomass sample after the percentages of moisture, ash, and volatile matter has been determined.

Fixed Carbon Content = 100 – (Moisture content + Volatile Content + Ash Content)

Table I. Proximate Analysis Results of paper waste

Property	Percentage
Moisture Content [M.C] (%)	4.0
Volatile Content [V.M] (%)	62.5
Ash Content [A.C] (%)	32
Fixed Carbon Content [F.C] (%)	1.5
HHV (MJ/kg)	10.024

Determination of Heating Value (Ref)

HHV = 0.3536 FC + 0.1559VM - 0.0078 ASH

= 0.3536(1.5) + 0.1559(62.5) - 0.0078(32)

= 10.024 MJ/Kg

Table I I. Proximate Analysis Results of paper cup waste

Property	Percentage
Moisture Content [M.C] (%)	6.0
Volatile Content [V.M] (%)	78.72
Ash Content [A.C] (%)	14
Fixed Carbon Content [F.C] (%)	1.28
HHV (MJ/kg)	12.615

Determination of Heating Value (Ref)

HHV = 0.3536 FC + 0.1559VM - 0.0078 ASH

= 0.3536(1.28) + 0.1559(78.72) - 0.0078(14)

= 12.615 MJ/Kg

The bio-oil yield at different temperature is shown in the Table III and Table IV

Table III. Bio-Oil Obtained using paper waste

S.No	Temperature (ºC)	Quantity of Liquid (ml)
1	300	9.2
2	350	11.3
3	400	13.8
4	450	14
5	500	8.5

Table IV. Bio-Oil Obtained from paper Cup

S.No	Temperature (ºC)	Quantity of Liquid (ml)
1	300	16.2
2	350	17
3	400	18.4
4	450	17.5
5	500	17

The bio-oil obtained from paper waste is 14 ml at 450◦C and whereas for paper cup waste is 18.4 ml at 400 ºC.The bio-oil obtained is tested using FTIR for determining the groups present in the sample. In the FTIR a laser beam will passed into the sample and the sample used to vibrate and the frequencies are displayed in the system.

FTIR Test Results for Paper Waste: 2pt

At 300ºC

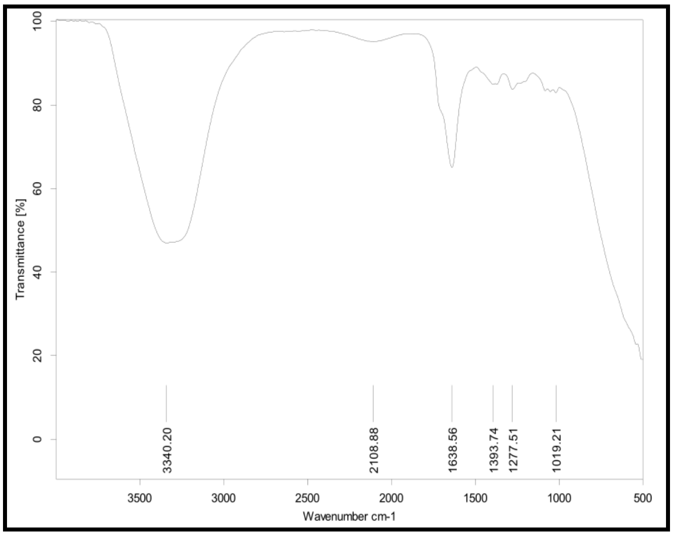

Fig 3. FTIR RESULT at 300ºC

At 350ºC

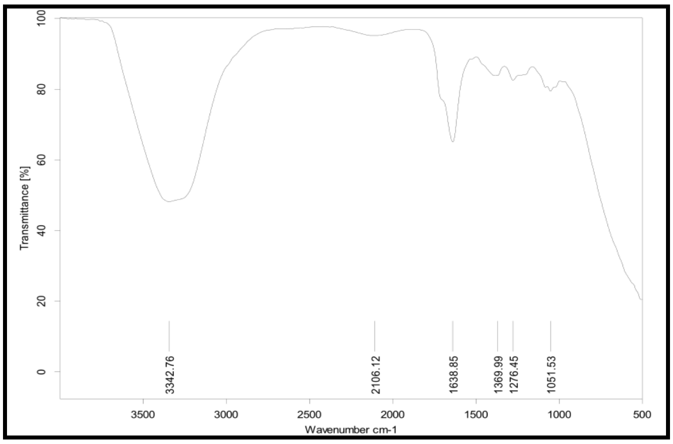

Fig 4. FTIR RESULT at 350ºC

At 400ºC

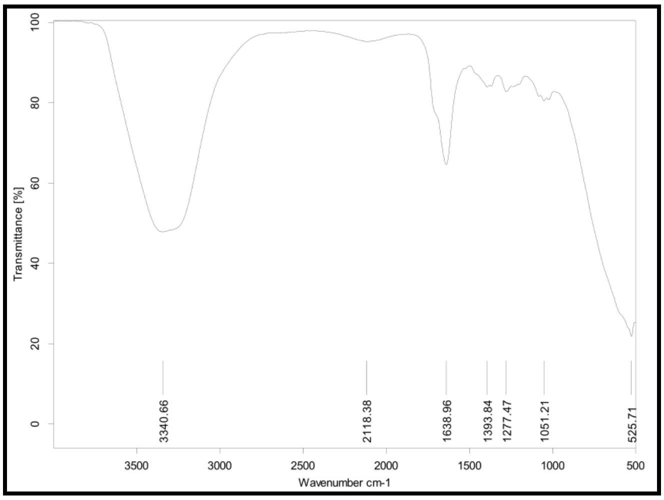

Fig 5. FTIR RESULT at 400ºC

At 450ºC

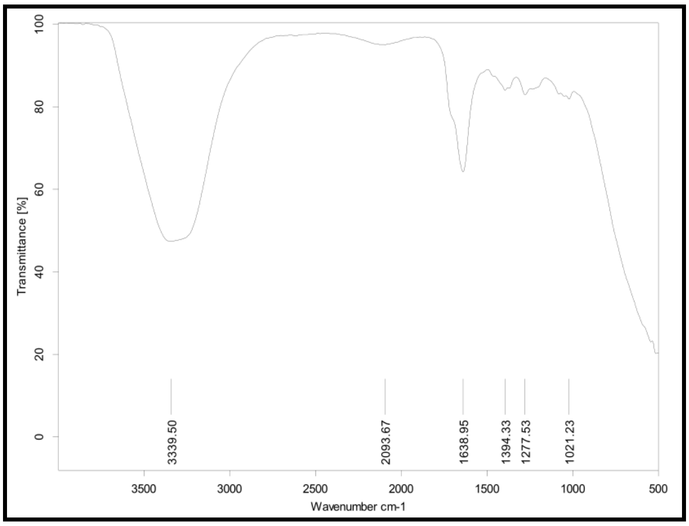

Fig 6. FTIR RESULT at 450ºC

At 500ºC

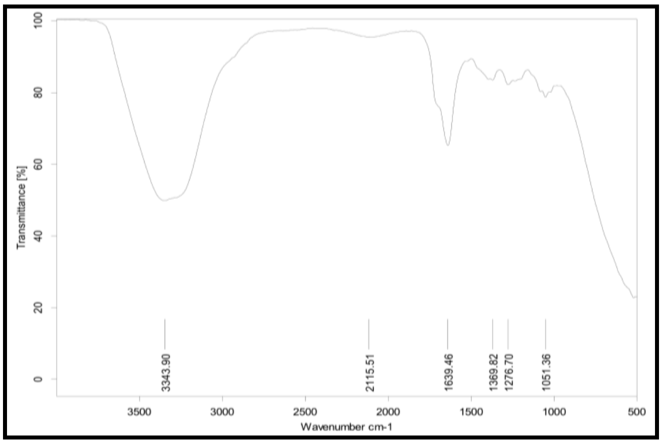

Fig 7. FTIR RESULT at 500ºC

FTIR Test Results for Paper Cup Waste

The FTIR results of paper cup waste is shown in the below diagram

At 300ºC

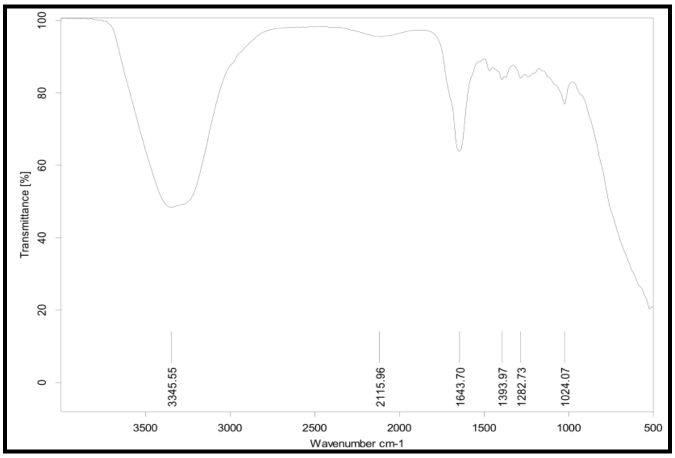

Fig 8. FTIR RESULT at 300ºC

At 350ºC

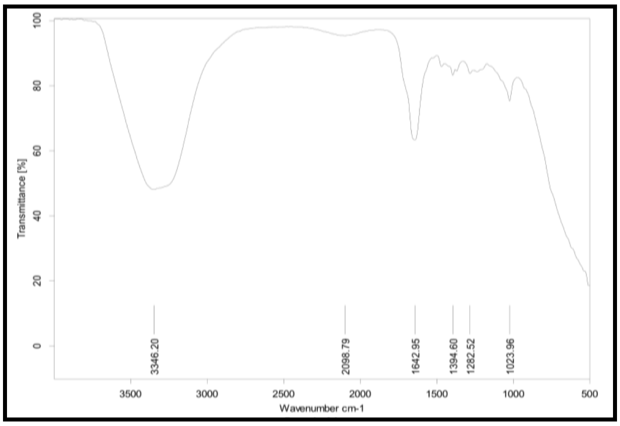

Fig 9. FTIR RESULT at 350ºC

At 400ºC

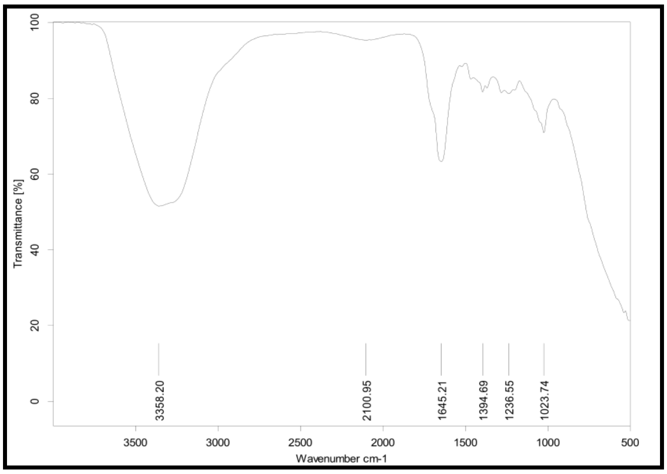

Fig 10. FTIR RESULT at 400ºC

At 450ºC

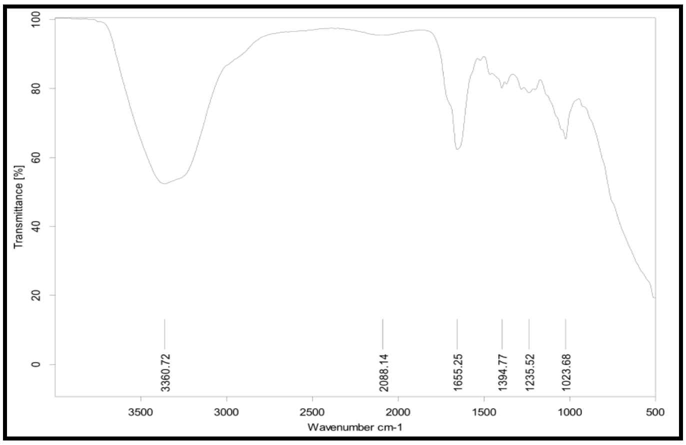

Fig 11. FTIR RESULT at 450ºC

At 500ºC

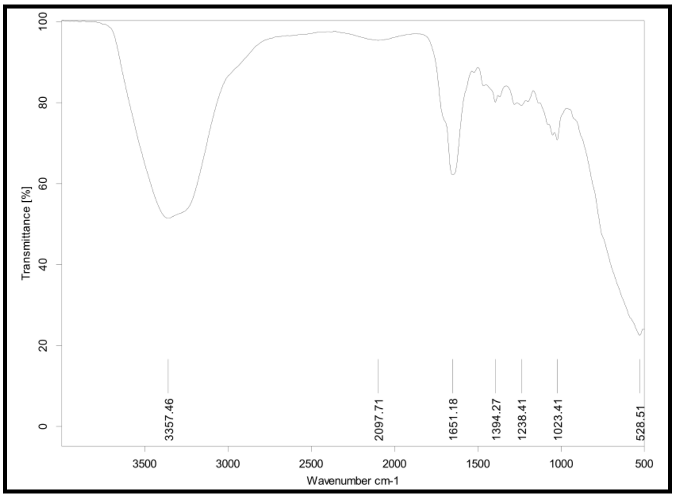

Fig 12. FTIR RESULT at 500ºC

Table V. The FTIR functional groups and the indicated compounds of pyrolysis oils(Ref)

Frequency Range (cm-1)	Group	Class of Compounds
3650-3100	O-H stretching	Polymeric O-H, water impurities
3000-2800	C-H stretching	Alkanes
1775-1680	C=O stretching	Ketones,aldehydes,carboxylic acids
1680-1575	C C stretching	Alkenes
1575-1425	-NO2 stretching	Nitrogenous compound
1425-1325	C-H bending	Alkanes
1300-1175	C-O stretching	Primary,secondary and tertiary alcohols
	O-H bending	Phenol,esters and ethers
1150-1000	C-H bending	Alkanes
950-875	C C stretching	Alkynes
		Aromatic compounds

Table VI. Experimental Result For paper waste

S.No	Temperture (ºC)	Residence Time in min	%Liquid Yield	%Solid Yield	%Gas Yield
1	300	30	20	54	26
2	350	30	24	50	26
3	400	30	28	46	26
4	450	30	30	44	26
5	500	30	18	44	38

Table VII. Experimental Result For for paper cup waste

S.No	Temperture (ºC)	Residence Time in min	%Liquid Yield	%Solid Yield	%Gas Yield
1	300	30	36	30	34
2	350	30	38	28	34
3	400	30	42	22	36
4	450	30	40	20	40
5	500	30	38	18	44

From the FTIR results the groups present are Alkanes, Primary, Secondary, tertiary alcohol, Phenols, ethers, esters, Polymeric and water impurities. The Bio-oil obtained from paper waste at 400ºC contains aromatic compound at frequency range 525.71, similarly the bio-oil obtained from paper cup waste also contains aromatic compound at frequency range 528.51 at 500ºC, this is the only variation caused and other groups present in the bio-oil samples are same at different temperatures.

IV. CONCLUSION

The bio-oil obtained from paper cup has produced more amount of yield then that of the paper waste, and from the FTIR results it can be concluded that the groups present in the sample are same. The paper cup waste is available plenty from the environment which can be used to produce bio-oil. Many researches has been going on alternative fuels in the recent trends by upgrading the bio-oil produced from the paper waste and paper cup waste can be converted into transportation fuel.

REFERENCE

[1] Pramila Tamunaidu, Subhash Bhatia "Catalytic cracking of palm oil for the production of biofuels:Optimization studies" (2007), Bioresource Technology 98 (2007) 3593–3601.

[2] Mohammad Rofiqul Islam, Momtaz Parveen, Hiroyuki Haniu " Properties of sugarcane waste-derived bio-oils obtained by fixed-bed fire-tube heating pyrolysis" (2010), Bioresource Technology 101 (2010) 4162–4168.

[3] Thana Phuphakrat,Tomoaki Namioka,Kunio Yoshikawa "Tar Removal from Biomass Pyrolysis Gas in Two-Step Function of Decomposition and Adsorption" (2010), Applied Energy 87 (2010) 2203–2211.

[4] Umakanta Jena, K.C. Das, J.R. Kastner " Effect of operating conditions of thermochemical liquefaction on biocrude production from Spirulina platensis" (2011), Bioresource Technology 102 (2011) 6221–6229.

[5] Chaiyan Chaiya ,Prasert Reubroycharoen "Production of Bio-oil from Para Rubber Seed Using Pyrolysis Process" (2012), Energy Procedia 34 (2013) 905 – 911.

[6] 6.)Quan Bu,Hanwu Lei,Shoujie Ren,Lu Wang,Qin Zhang,Juming Tang,Roger Ruan "Production of Phenols and Bio-fuels By Catalytic Microwave Pyrolysis of Lignocellulosic Biomass" (2012), Bioresource Technology 108 (2012) 274–279.

[7] Yingbin Zhuang,Jingxue Guo,Demao Li,Junhai Liu,Naihao Ye "Microwave-Assisted Direct Liquefaction of Ulva Prolifera for Bio-oil Production By Acid Catalysis" (2012), Bioresource Technology 116 (2012) 133–139.

[8] ParinKhongkrapan,PatipatThanompongchart,NakornTippayawong,Tanongkiat Kiatsiriroat "Fuel Gas and Char from Pyrolysis of Waste Paper in a Microwave Plasma Reactor" (2013), Volume 4, Issue 6, 2013 pp.969-974.

[9] Siyi Luo, Chuijie Yi, Yangmin Zhou" Bio-oil production by pyrolysis of biomass using hot blast furnace slag" (2013), Renewable Energy 50 (2013) 373e377.

[10] Jeong Wook Kim , Hyung Won Lee ,In-Gu Lee, Jong-Ki Jeon, Changkook Ryu d,Sung Hoon Park, Sang-

Chul Jung , Young-Kwon Park " Influence of reaction conditions on bio-oil production from pyrolysis of construction waste wood" (2014), Renewable Energy 65 (2014) 41e48.

[11] JigishaParikh, S.A.Channiwala, G.K.Ghosa "A correlation for calculating HHV from proximate analysis of solid fuels ", Fuel 84 (2005) 487–494.

[12] M.N.Islam*,M.N.Islam,M.R.A.Beg "The fuel properties of pyrolysis liquid derived from urban solid wastes in Bangladesh",Bioresource Technology 92(2004) 181-186.

[13] Jae Hyung Choi,Hee Chul Woo and Dong Jin Suh "Pyrolysis of Seaweeds for Bio-oil and Bi-char production",AIDIC Vol 37,2014.