Production and Characterization of Biochars from Torrefaction of Biomass

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Aim of Study

Alternative fuel

Energy need

Introduction

- **In this study, several biomass species were subjected to torrefaction process and the variations taken place in properties of these biomasses were investigated comparing the fuel characteristics of the parent samples and their biochars.**

MATERIAL AND METHODS

The Properties of Sample

SAMPLES: *Olive milling residue (OMR)*

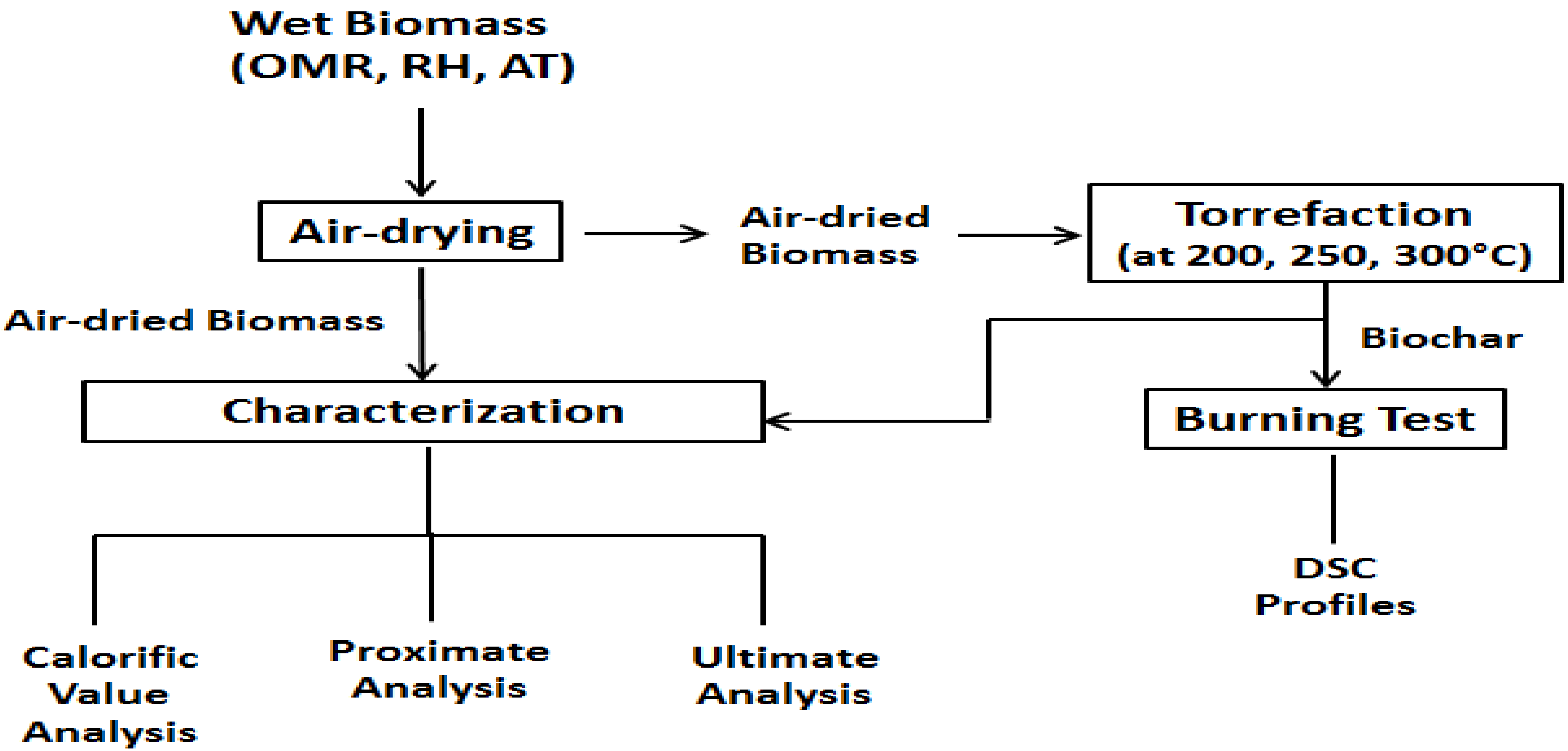
Rhododendron (RH)

Ash tree (AT).

Locations of the Biomass Samples Production

OMR **RH** **AT**

The flowchart of the experiments



After milling

Thermal Experiments Conditions

Sample Cell : Alumina (cylindrical)

Amount of sample : 10 mg

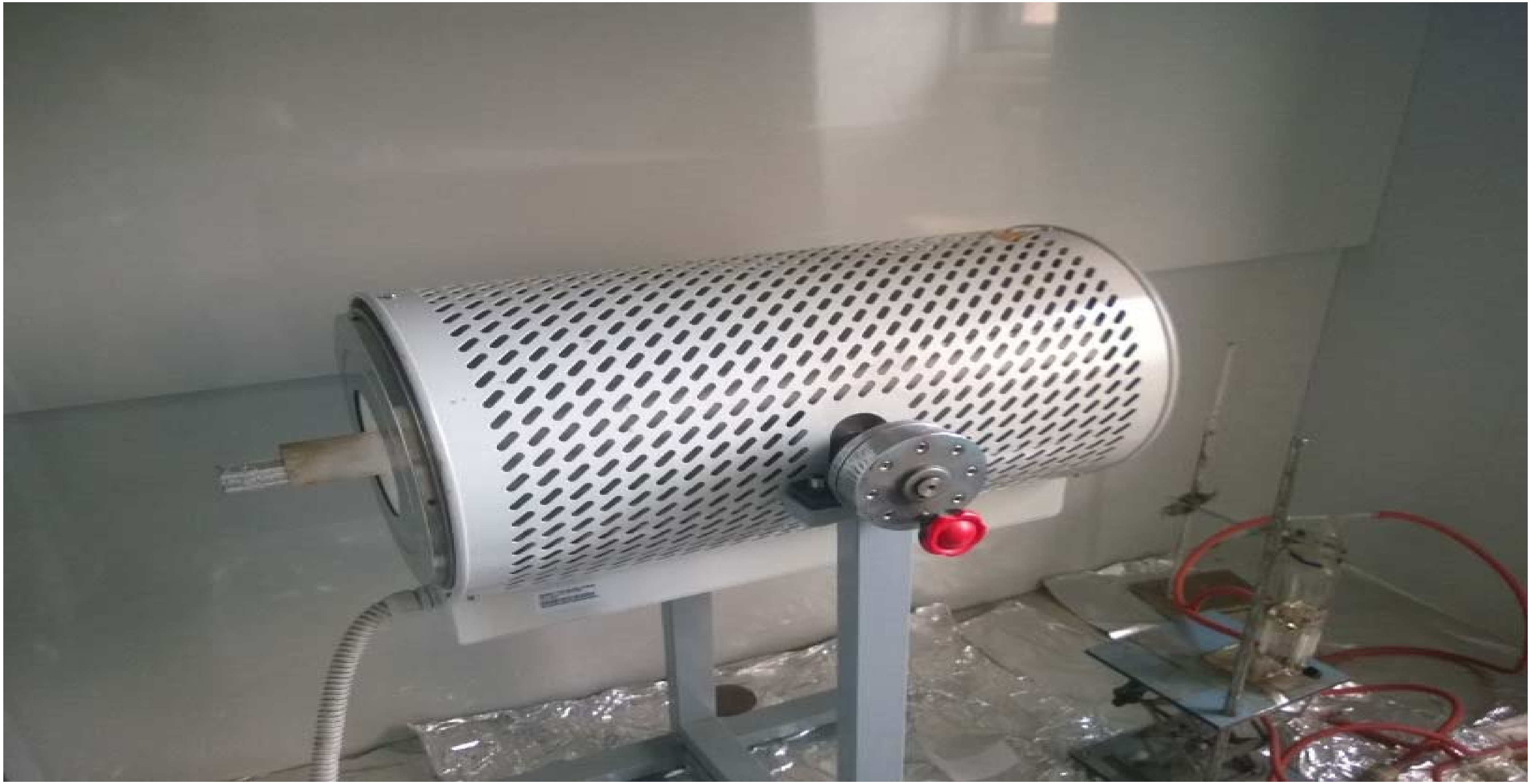
Particle sizes of sample :   under 250 µm

Atmosphere : Dynamic Dry Air, Nitrogen (100 ml/min)

Heating : The sample was heated in a cylindrical alumina crucible from ambient from 700 ^{0}C with a linear heating rate of 10 ^{0}C .min.-1 Enough hold time was given at the final temperature to allow the sample to get an unchanged weight.

DSC curves were obtained.

Torrefaction experiments were implemented in a horizontal tube furnace by heating milled samples under nitrogen atmosphere from ambient up to temperatures of 200, 250, and 300ºC at a constant heating rate of 10ºC/min. For this, a horizontal tube furnace containing a silica tube with a diameter of 15 cm and a length of 72 cm was used. The radiation zone where heating is applied is just in the center of the silica tube and has a length of 5 cm. A PID controller performs the temperature control of the furnace. For each experiment, Approximately 10 g of milled biomass was put into silica crucibles and then the crucible was placed through the radiation zone of the cold furnace. Oxygen was purged out of the system by nitrogen flow, and then temperature was increased from ambient to the mentioned temperatures with a heating rate of 10ºC/min under nitrogen flow at 100 mL/min, and the sample was kept at these final temperatures for 60 min in order to get the torrefied biomass (biochar). Torrefaction-related variations in the fuel properties were interpreted. Burning tests were done using TA Instruments SDT Q600 model thermal analyzer.



Tube Furnace

Experimental Study
omr samples

AFTER TORREFACTION 300 c

BEFORE

4869 KCAL/KG

6065 KCAL/KG

YIELD %25

Experimental Study
RH samples

BEFORE

4438 KCAL/KG

After Torrefaction 300 c

4632 kcal/kg **yield % 4.4**

Experimental Study
AT samples

BEFORE CARBONIZATION

4117 KCAL/KG

AFTER TORREFACTION 300 C

5272 kcal/kg

Yield % 28

Results and Discussion

Biomass samples are rich in cellulose and hemicellulose, while lignin contents are relatively low.

Accordingly, volatile matter yields are disproportionally higher than fixed carbon contents.

Furthermore, ash tree is very poor in ash yield that is a superior nature of this sample over the others.

Table 1. Analysis Results of Biomass Samples (as received basis)

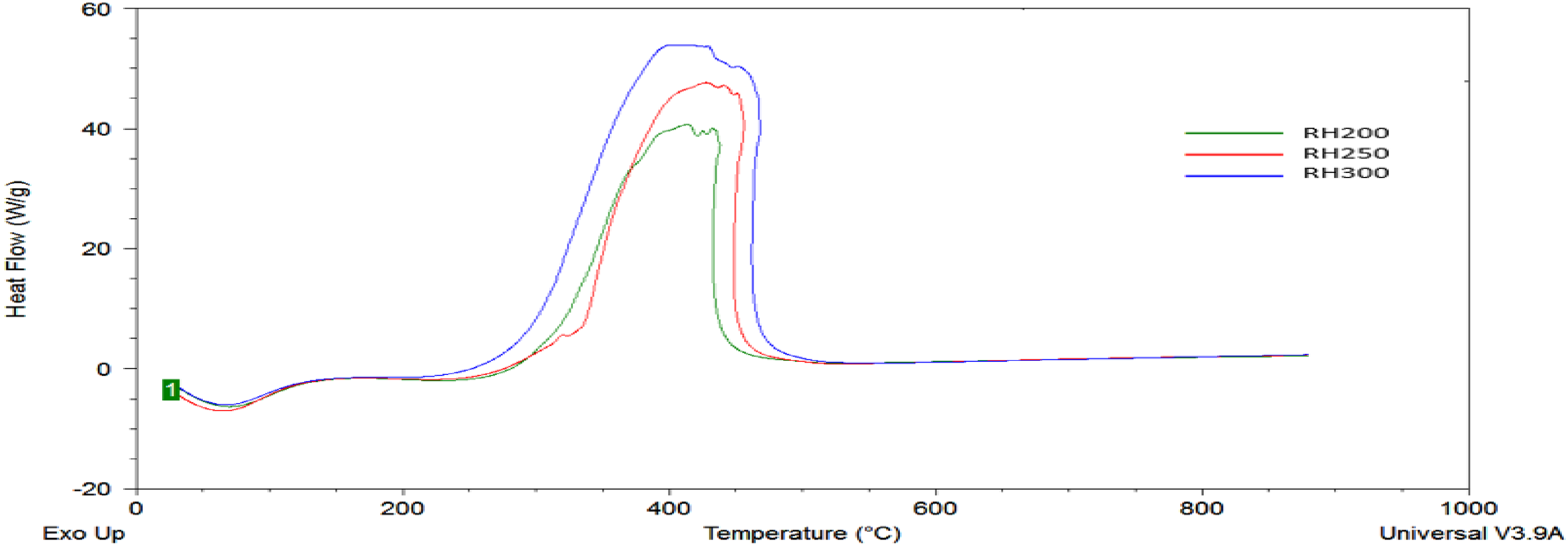
	OMR	RH	AT
Cellulose + Hemicellulose (%)	57.4	85.0	77.4
Lignin (%)	19.9	11.7	15.6
Extractives (%)	22.7	2.7	7.1
Moisture (%)	4.0	5.2	7.6
Volatile Matter (%)	80.1	78.9	80.4
Ash (%)	7.3	8.6	1.1
Fixed Carbon (%)	8.6	7.3	10.9
HHV (kCal/kg)	4869	4441	4117

Table 2. Proximate and Ultimate Analyses Results of Biochars (%)

Sample	M_{ar}	VM_{ar}	Ash_{ar}	FC_{ar}	C_{daf}	H_{daf}	N_{daf}	S_{daf}	O_{daf}	HHV (kCal/kg)
OMR200	3.0	77.6	10.9	8.5	59.4	7.5	1.2	0.6	31.3	4647
OMR250	3.3	73.6	11.6	11.5	64.0	7.7	1.6	0.3	26.4	5306
OMR300	3.0	57.6	26.3	13.1	85.7	8.4	2.2	0.4	3.3	6065
RH200	4.4	80.9	0.4	14.3	51.0	6.3	0.1	0.3	42.3	4618
RH250	3.5	77.9	0.5	18.1	53.6	6.3	0.2	0.3	39.6	4790
RH300	4.4	64.0	1.4	30.2	61.4	6.1	0.3	0.4	31.8	4632
AT200	2.6	84.0	1.6	11.8	n/a	n/a	n/a	n/a	n/a	4436
AT250	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4571
AT300	4.2	69.3	0.4	26.1	57.5	5.8	0.4	0.3	36.0	5272

ar: as received daf: dry-ash-free M: moisture VM: volatile matter FC: fixed carbon

Fig.1. DSC Curves for RH Biochars



It is apparent from these DSC curves that some enhancements in the heat flows during burning of the biochars took place as a function of torrefaction temperature. That is, torrefaction carried out at 300°C showed the highest heat flows. This confirms that torrefaction is capable of producing promising solid fuels in terms of energy giving characteristics during burning.

Conclusions

-Comparison of the properties of biochars and untreated parent biomasses indicated that the ratio of volatile matter to fixed carbon reduced and HHV increased.

-, The HHVs of the biochars are almost comparable with those of high rank coals.

Significant improvements in the fuel properties of biomass through torrefaction.

-Heat flows during burning of the biochars showed that increasing torrefaction temperature caused increase in the heat flows.

-energy intense fuels can be produced from ordinary biomass species thanks to applied thermal pretreatment.

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