EUBCE 2019 — 27th European Biomass Conference & Exhibition — 27 - 30 MAY 2019 — LISBON - PORTUGAL

Ricerca di Sistema CNR

Biochar and bioslurry combustion

R. Calabria[1], P. Massoli[1], D. Fabbri[2], C. Torri[2]

ISTITUTO MOTORI
NATIONAL RESEARCH COUNCIL OF ITALY

[1] Istituto Motori, CNR, National Research Council of Italy, Naples, ITALY
[2] University of Bologna - CIRSA, Ravenna, ITALY

CENTRO INTERDIPARTIMENTALE PER LA RICERCA NELLE SCIENZE AMBIENTALI

BACKGROUND – **The utilization of renewable energy and the substitution of the fossil fuels by alternative sources is one of the priority points for a sustainable development. Fuels obtained from biomasses can become a valid alternative to displace fossil fuels, also in the light of stricter environmental constraints. In the outline of alternative liquid fuels, bisolurry can represent an interesting topic as concerns the "fluidification" of solid biomass to be used in power plants and, specially, in small scale energy systems for stationary applications**

FOCUS **Stable and efficient utilization of bioslurry in power plant and small scale energy systems**

OBJECTIVE **Fundamental combustion properties and behavior of droplets of bioslurry**

APPROACH

- Coal/water slurry technology, a suspension of fine coal particles in water, was developed in the former Soviet Union in the '50s of the last century to transport coal from mines to far power plants
- Coal/Water Slurries (CWS) and Coal Oil Slurries (COS) were introduced in the '70s of the last century, in connection to the petroleum crisis, to permit the utilization of coal in power plants designed for liquid fuels
- Bioslurry represents the "green version" of CWS and COS: a fine suspension of biochar in bio-oil to form 100% bio-fuel or in fossil oil (light or heavy) for a mixed bio/fossil fuel
- Bioslurry can represent a viable solution to convert efficiently the energy content of biochar if its utilization efficient and stable is assured. To this aim, the analysis of the combustion properties of bioslurry is the most critical point

MATERIALS AND METHODS

BIOSLURRY

Bio - slurry = Bio (char + diesel)

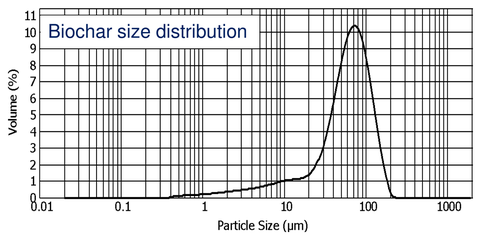
BIO-SLURRY: concentrated fluid mixture of biochar suspended in biodiesel. It is an effective solution to "fluidify" the biomass so as to make it usable in thermoconversion systems based on liquid fuels.

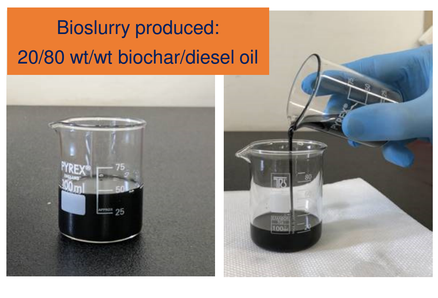
BIOCHAR

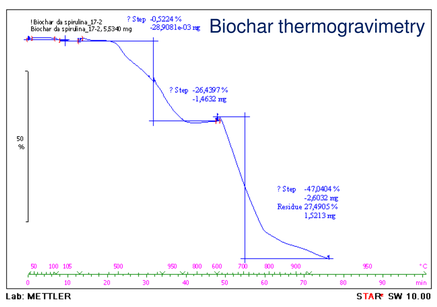
The biochar used to form the bioslurry was produced by multibatch catalytic pyrolysis of algae Spirulina

Biochar elemental composition

Species	N	C	H	S	O*	Ash
A. platensis	7.67	48.2	2.77	< 0.01	4.18	37.1







ACTIVITIES

- **Combustion behavior of droplets of bioslurry formed by different biochar samples in biodiesel**
- **Thanks to a mechanical sieving based on sieve with 200 µm mesh, 125 µm and 50 µm, the sample was divided into four size classes**
- **Two bioslurry were formulated by using biochar particles belonging to the smaller granulometric classes**
- **A third bioslurry was formed for comparison by using algal biomass**

	Biomass	Concentration wt/wt	Size	Acronym
Bioslurry n. 1	Char by pyrolysis multibatch of algae Spirulina	20%	D < 50 µm	$SC_{<50}$
Bioslurry n. 2	Char by pyrolysis multibatch of algae Spirulina	20%	50 µm < D < 125 µm	SC_{50-125}
Bioslurry n. 3	Dehydrate and chopped Botryococcus Brauni algae	20%	N.A.	SA_{BB}

METHOD

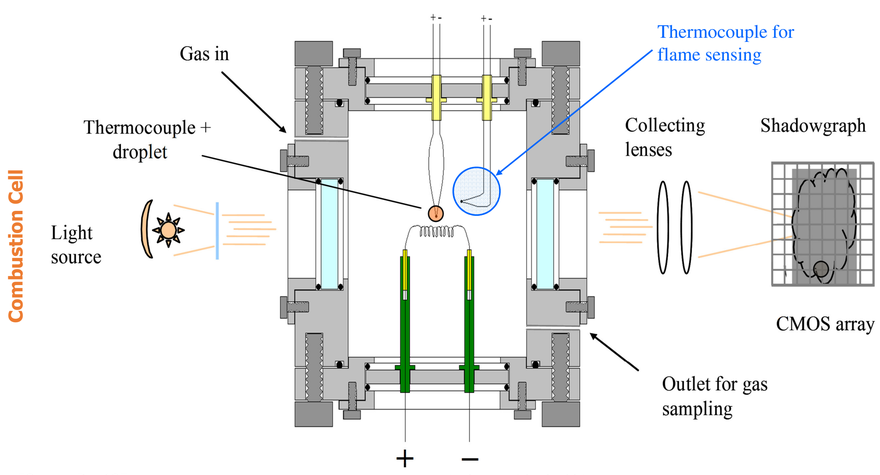
Thermo-optical investigation of the combustion behavior of droplets of bioslurry by high speed shadowgraphy

RESULTS

Fundamental parameters of the combustion of droplets of bioslurry

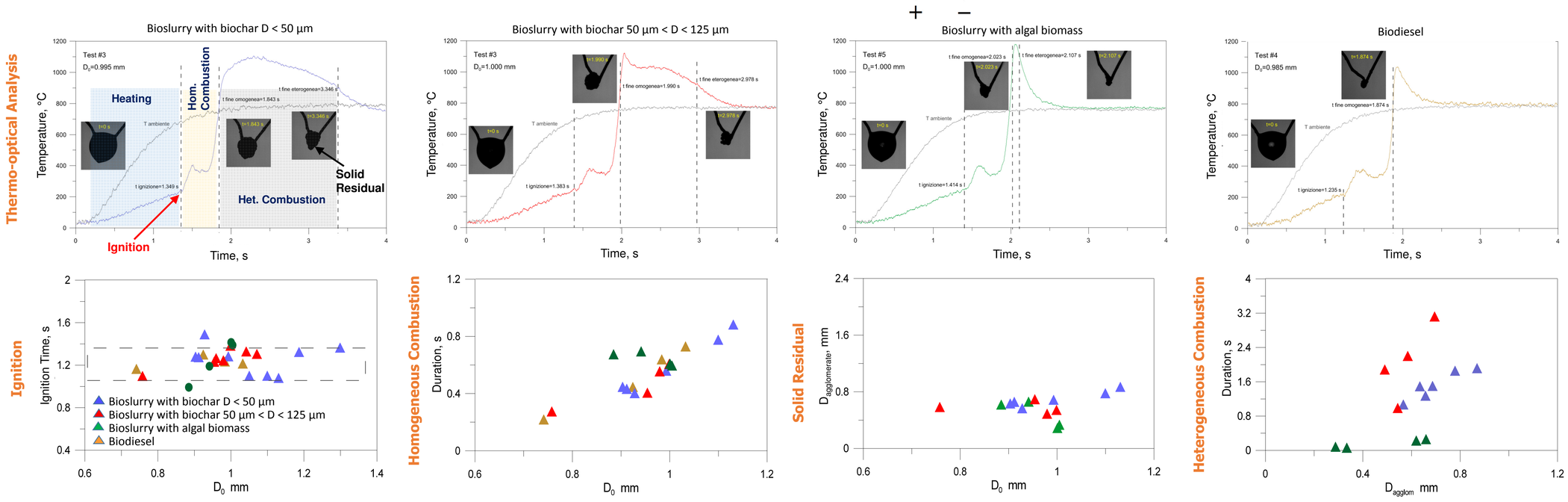
EXPERIMENTAL SET-UP

- A 75 µm wires bare thermocouple was used to hang and measure the temperature of the droplets
- A lateral thermocouple (75 µm wires) was used to sense droplet ignition and flame standing
- A CMOS high-speed camera (Photron Fastcam SA-X2, max acquisition rates of 1 Mfr/s, 1024x1024 pixels, 12-bit) was used to visualize the droplets before and after the ignition, as well as the variation of their size. The acquisition frequency was set at 1,000 frames/sec and full frame resolution
- All the signals were acquired by a LeCroy Waverunner 104MXI-A transient recorder
- The heating of droplets was obtained by a resistive coil placed below the droplets (picture on the right)



Combustion of Bioslurry droplet

RESULTS . . . .



Acknowledgement:

Ministero dello Sviluppo Economico

The project has been partially funded by the Italian Ministry of Economic Development (MiSE) in the framework of the program *Accordo di Programma per la Ricerca di Sistema Elettrico, AdP 2015-2017*

CONCLUSIONS

- **All slurry droplets show significant swelling and sputtering.**
- **Ignition of bioslurry drops is governed by biodiesel fraction: Tign = 230-260 ° C.**
- **The homogeneous combustion of bioslurry formed with biochar is dominated by the behavior of biodiesel. The slurry with algae exhibit a greater homogeneous burning time due to the contribution of the lipidic compounds.**
- **The three bioslurry examined show the formation of a solid carbonaceous residual at the end of the homogenous combustion phase. It is generated by the thermo-chemical transformations that biochar and algae particles undergone during the homogeneous combustion phase.**
- **Considering the excellent ignition behavior and the homogeneous combustion of the analyzed bioslurry, the oxidation of the carbonaceous residual (heterogeneous combustion) remains the most critical aspect.**
- **The duration of heterogeneous combustion is almost inexistent for algae slurry. For biochar slurry, it is double for the slurry formed with larger particles (50µm<D<125µm) with respect to the finer one (D<50µm). From this point of view, the bioslurry with algal biomass is very promising.**
- **However, smaller biochar requires supplementary energy costs due to the greater work for grinding finely the biochar, and greater problems of management and safety, in relation to storage, due to greater propensity to ignition.**