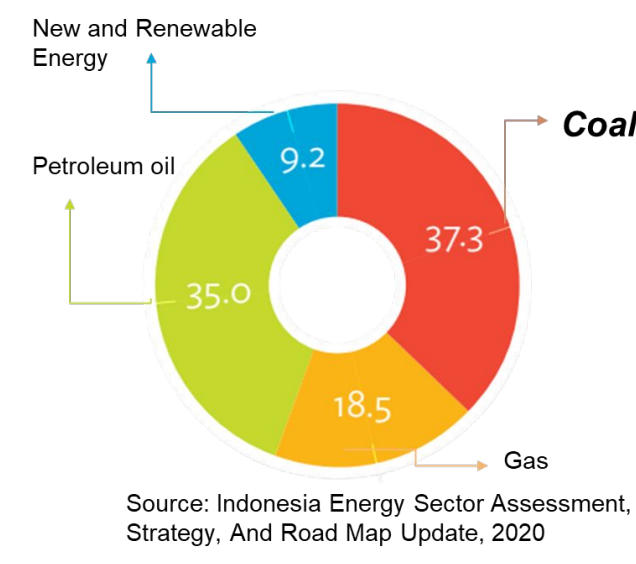
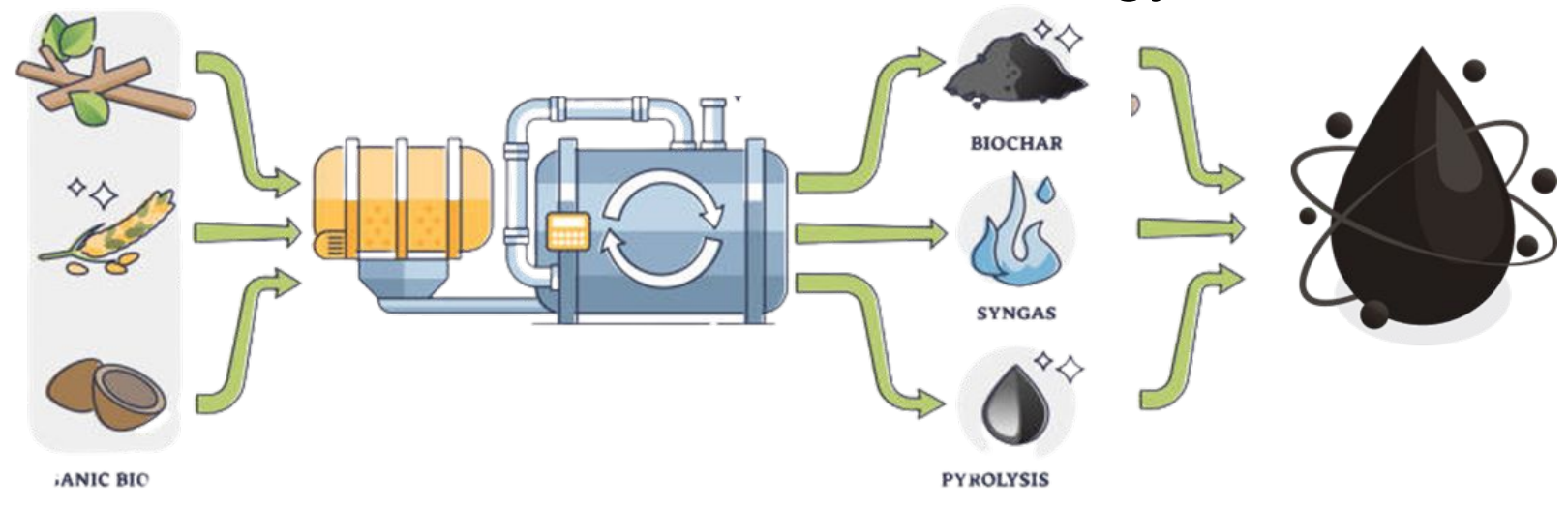


Introduction



As Indonesia crutch to become a world economic megatrend in 2045, the industry sector must be sustainable. Coal, industry main energy, is unfriendly to the environment and non renewable. Biomass can be use as alternative energy which more reliable.



Bioslurry, biomass based fuel, is alternative sustainable energy. As energy, its efficiency need to be determined by fuel combustion characterization using single droplet combustion. Combustion characteristics of fuel influenced by viscosity and density (Ghurri and Keun, 2019).

Objective

- 1 Evaluate the effect of viscosity and density to bioslurry combustion characteristics.
- 2 Evaluated combustion characteristics are droplet diameter, ignition delay time, and flash point.

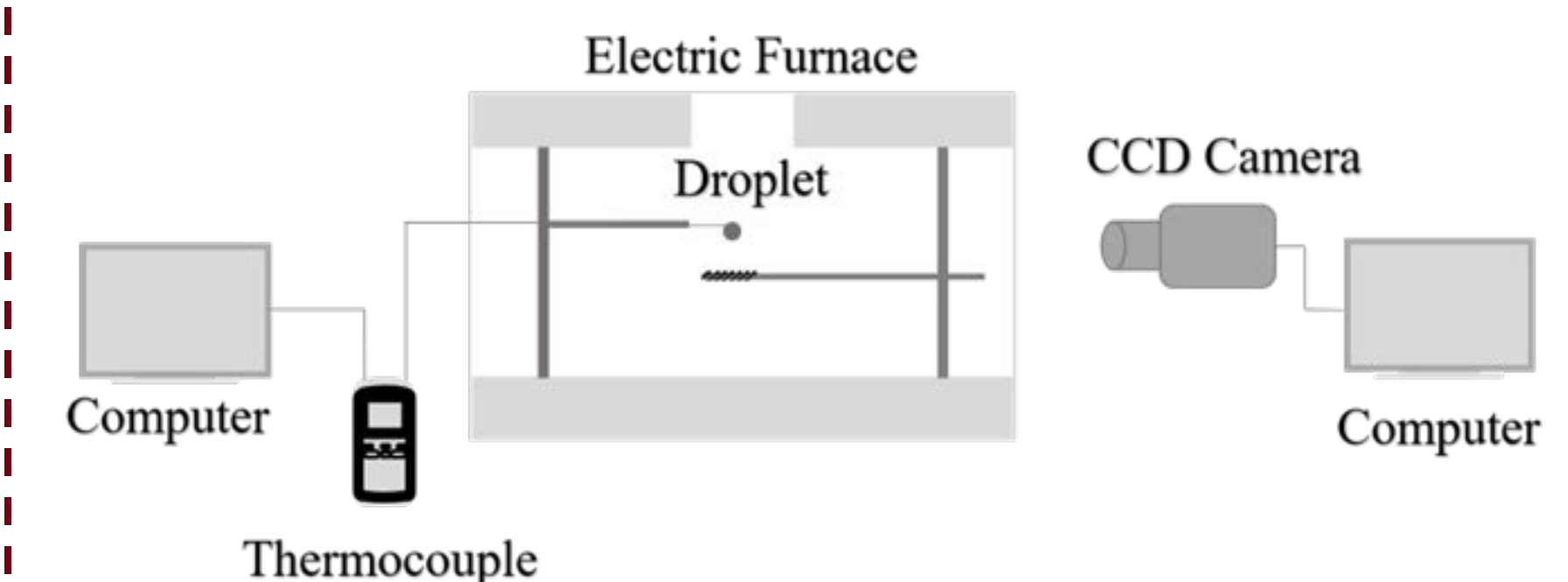
Material

- Slurry fuel in this research made from pyrolysis products on 500 degree celcius (biochar, and pyrolysis oil). Biomass that use in this research are bagasse, corn stalks, and rice husks.
- Slurry fuel in this research have 4 different biochar concentrations : 15%, 20%, 25%, and 30%.
- Purpose of using varying materials and concentrations are to clarify difference between density and viscosity

Literature Review

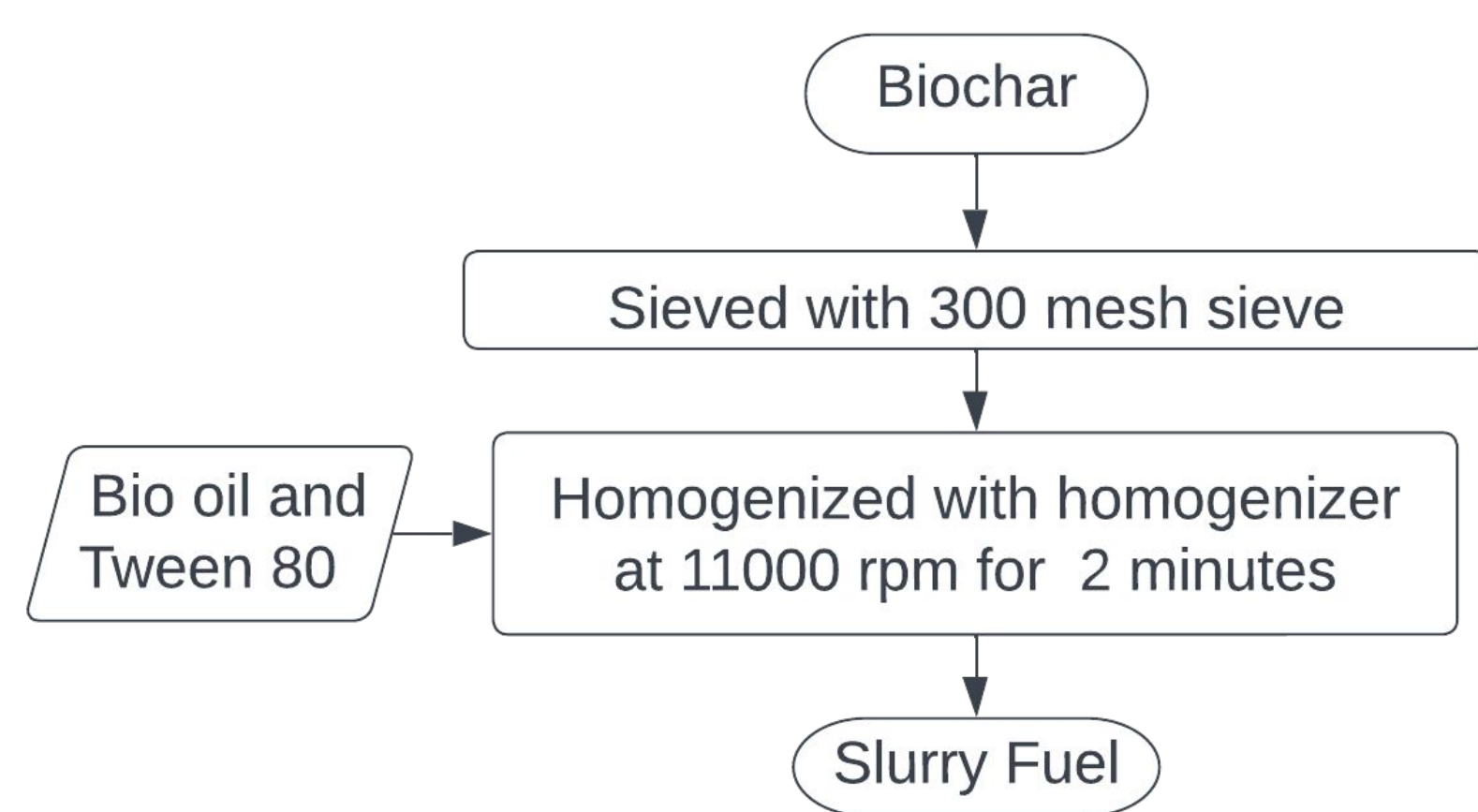
- Viscosity is a measure of resistance for its free flow, flunced fuel atomization during injection. In this research, viscosity test used AND Vibro Viscometer SV 10
- Density related to mass of a unit volume of a material substances, and indicates the quality of fuel. In this research density test by piknometer.
- Single Droplet Combustion is idealised model for burning fuel in single droplet.

A schematic diagram of the apparatus used in the experimentation of single droplet combustion

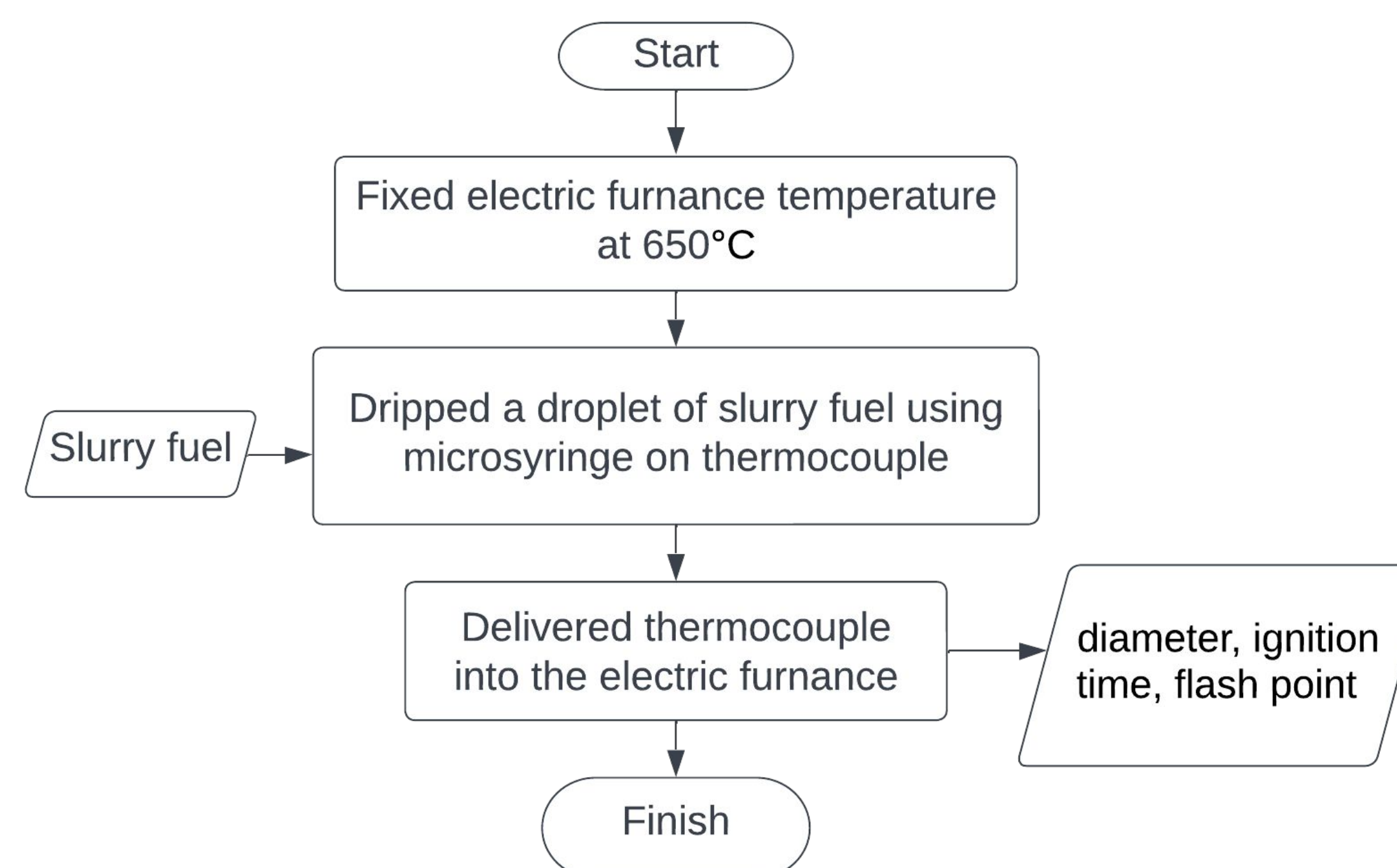


Methods

1. Bioslurry fuel sample preparation

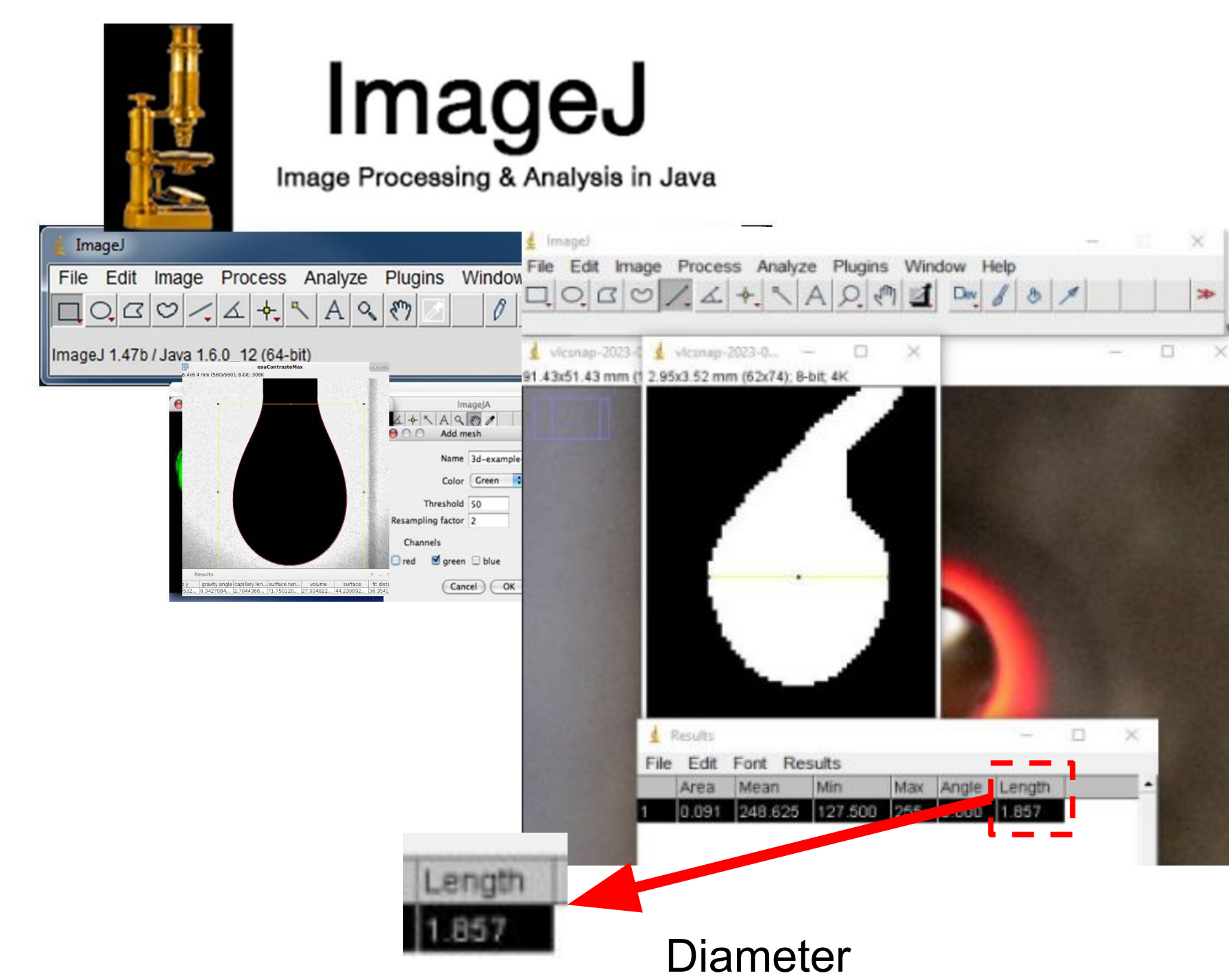


2. Experiment of Single Droplet Combustion



Single droplet combustion method adapted from Zhu et al., (2015).

3. Image and Data Processing



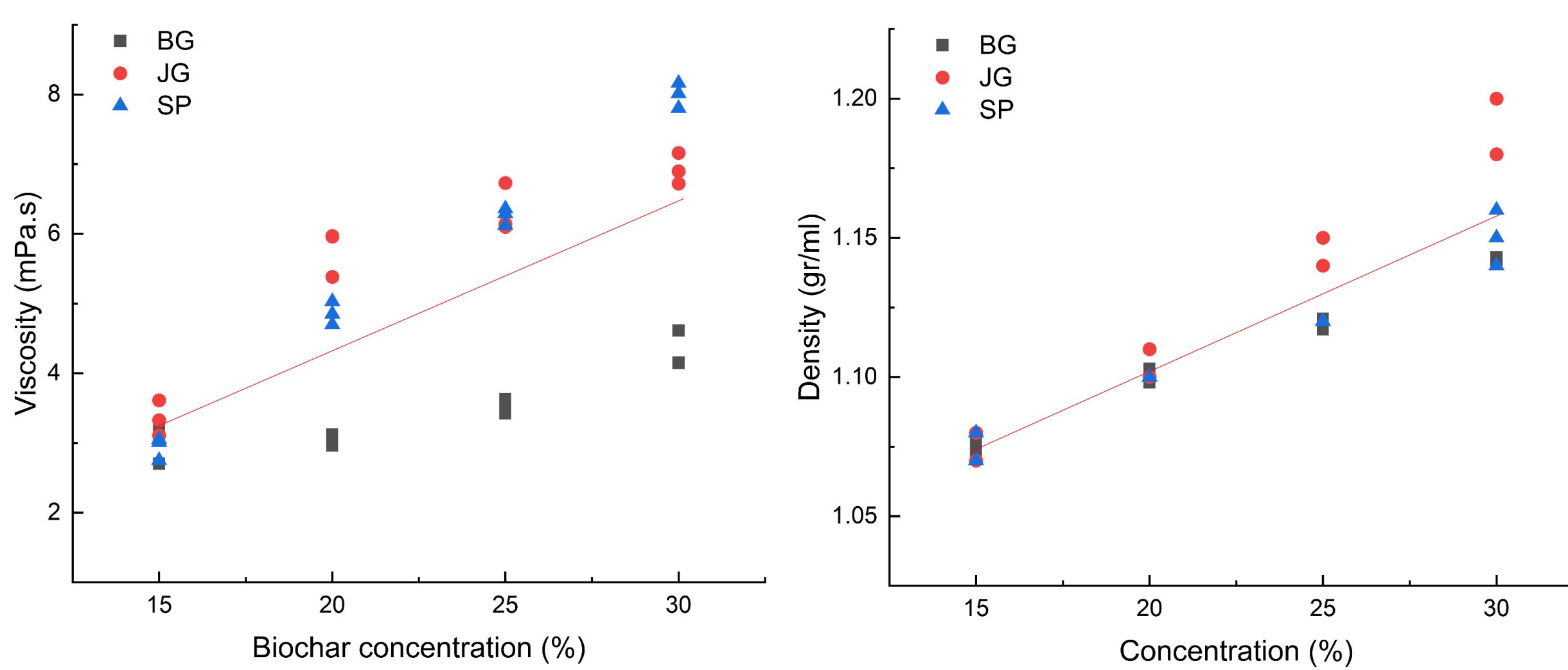
Results and Discussion

1. Table comparison of viscosity and density of Marine Fuel Oil (MFO) and Biochar - Bio oil Slurry Fuel (Bio - SF).

Characteristics	MF0 180	MF0 380	Bio - SF
Viscosity (mm²/dt)	Max 180	Max 380	2.94 – 10.66
Density (kg/m³)	Max 991	Max 991	1703 – 1189
Flash Point (°C)	Min 60	Min 60	> 60

Bio - SF meet viscosity and flash points standard for MFO

2. Slurry fuel viscosity vs density

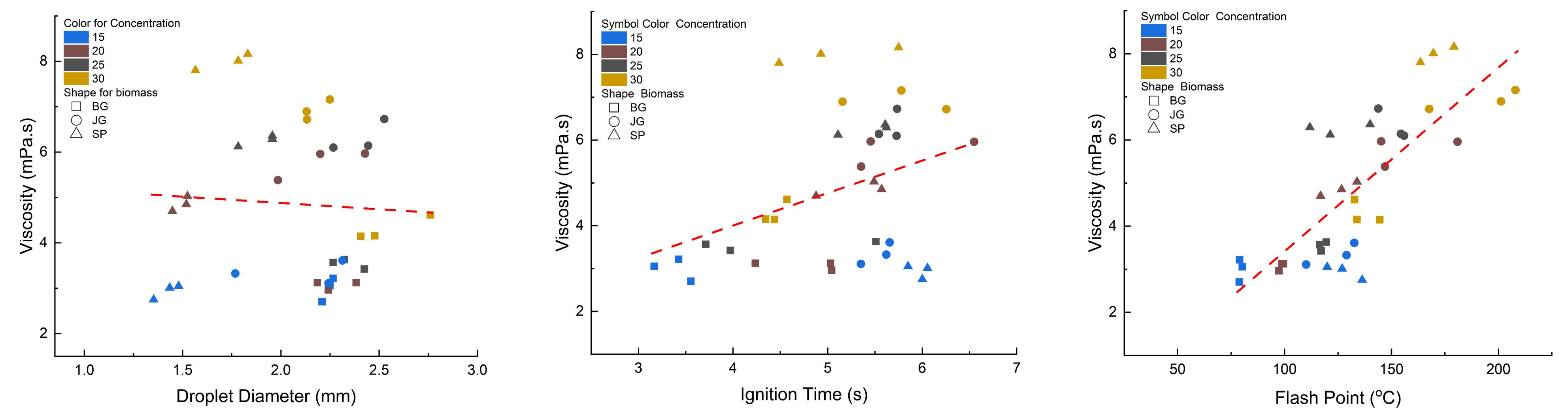


- Highest viscosity is rice husk (SP) slurry fuel with 30% of biochar, and lowest is bagasse (BG) slurry fuel with 15% of biochar.
- Highest density is corn stalks (JG) slurry fuel with 30% of biochar, and lowest is rice husk (SP) slurry fuel with 15% of biochar.

This shows that increment of biochar concentration increase density and viscosity. **Noted** that the highest viscosity does not indicate the highest density.

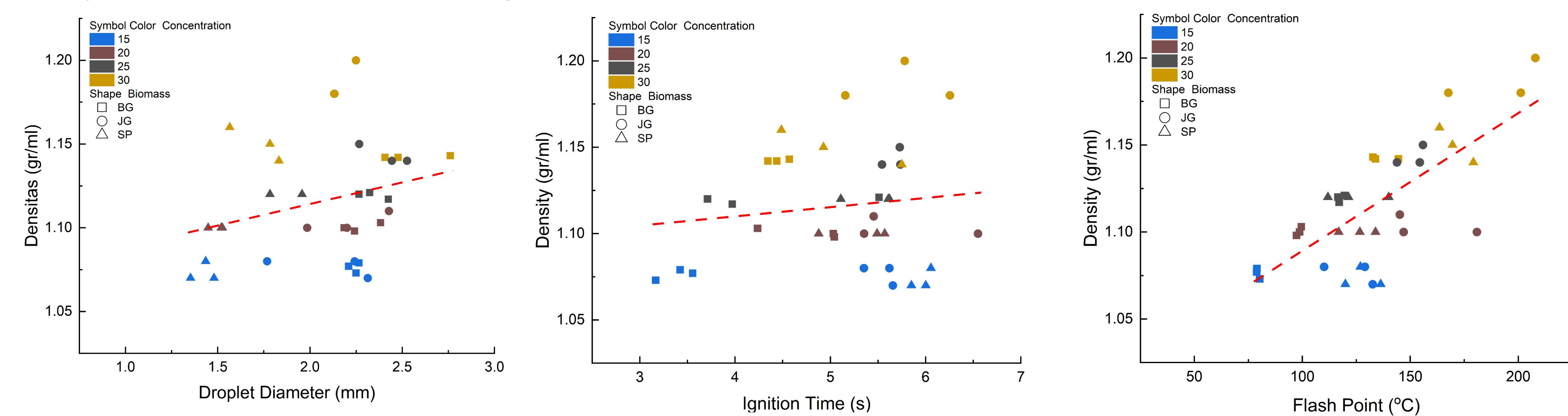
- Density does not affect viscosity, and vice versa (Hack and Thompson, 2011).
- The higher the density and viscosity, the worse the atomization process, and slows the mixing process of air and fuel, this lead to longer delay time, higher flash point, and more difficult to achieve complete combustion process (Ghurri and Keun, 2019).

3. Viscosity effect on initial droplet diameter, ignition time, and flash point



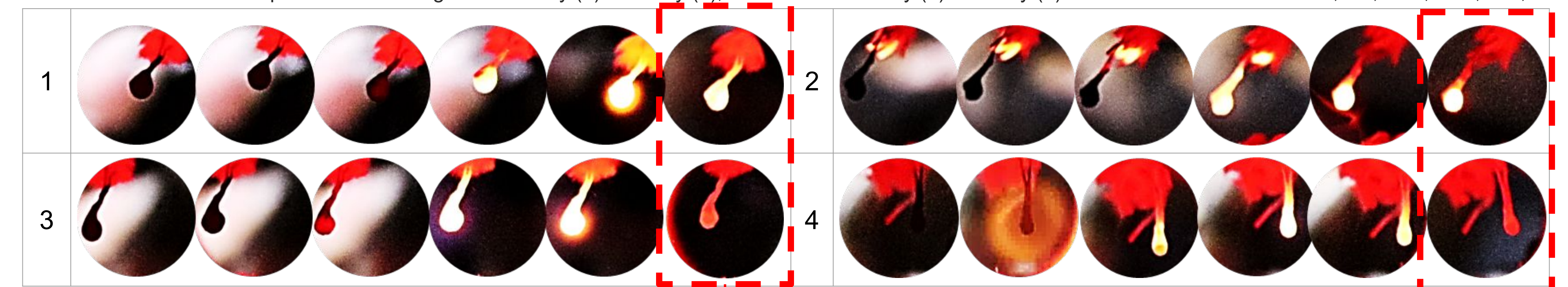
As viscosity increases, ignition time and flash point increase. But there is no significant relationship between droplet diameter and viscosity

4. Density effect on initial droplet diameter, ignition time, and flash point



As density increases, diameter of droplet and flash point increase. But there is no significant relationship between ignition time and viscosity

Visualization of combustion phenomena for highest viscosity (1) - density (3) and lowest viscosity (2) - density (4) inside electric furnace on 0 s, 3 s, 10 s, 15 s, 25 s, 45 s.



Pictures taken by canon 80D with EF-S18-135mm f/3.5-5.6 IS USM.

→ The higher the viscosity and density, the longer the combustion duration ←

Conclusion

Viscosity and density affect the combustion characteristics of bio-slurry fuel. An Increase in viscosity leads to an increment of ignition time, and flash point. An Increase in density leads to an increment in droplet diameter and flash point. Viscosity does not have a significant effect on the diameter of the droplet, and density does not have a significant effect on ignition time

References

- Ghurri, A. and Keun, S.K., 2019, June. Experimental study on combustion characteristics of an indirect injection diesel engine fuelled by biodiesel blends. In *IOP Conference Series: Materials Science and Engineering* (Vol. 539, No. 1, p. 012013). IOP Publishing.
- Hack, A.C. and Thompson, A.B., 2011. Density and viscosity of hydrous magmas and related fluids and their role in subduction zone processes. *Journal of Petrology*, 52(7-8), pp.1333-1362
- Zhu, M., Zhang, Z., Chan, Y.L., Yani, S. and Zhang, D., 2015. An experimental investigation into the droplet and combustion characteristics of single droplets of biochar slurry fuels. *Energy Procedia*. 75 (1): 180-185. Available at: <https://doi.org/10.1016/j.egypro.2015.07.286>