The complex research on the technical conditions of energy application of wood pyrolysis bio-oil

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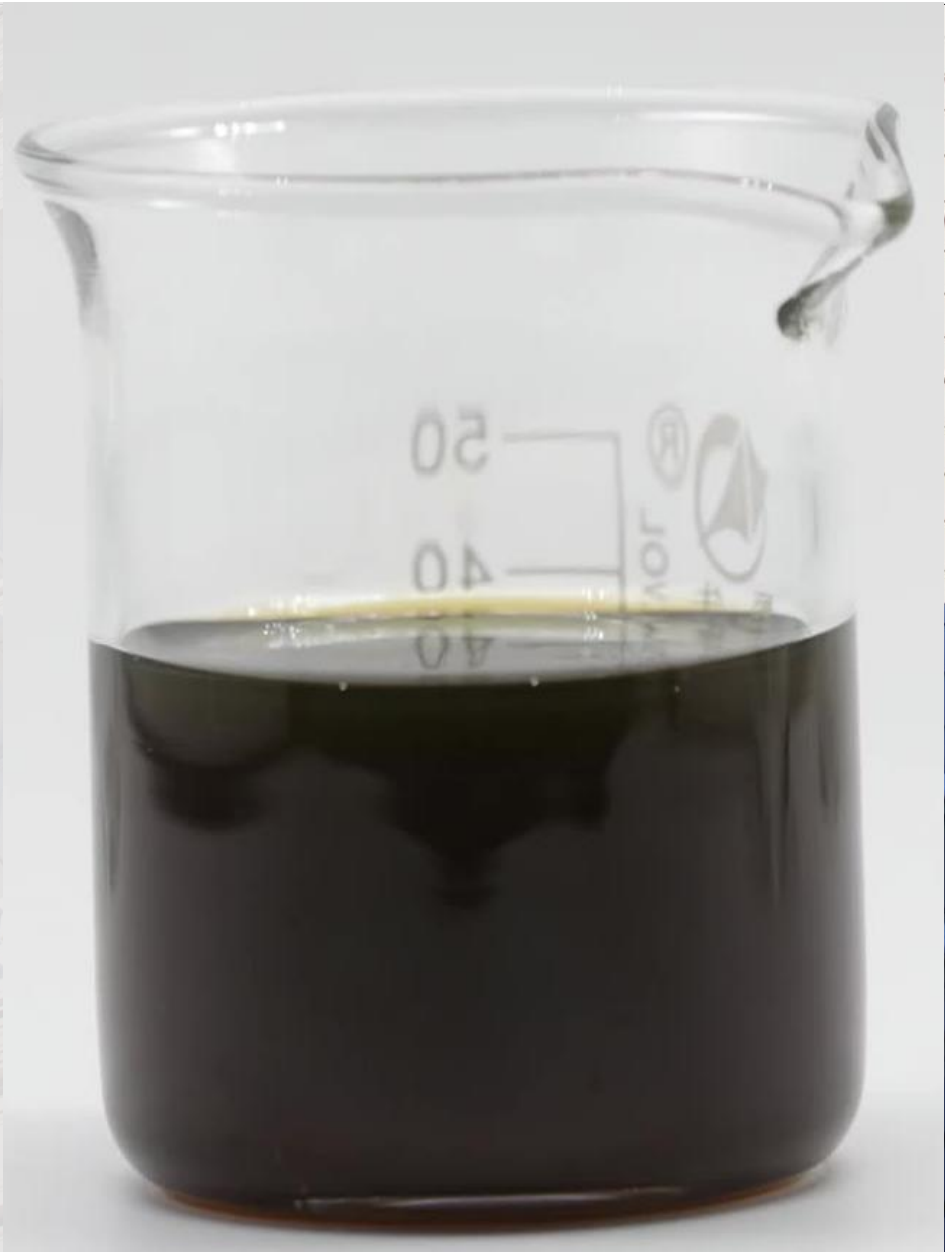
Pyrolysis bio oil

Introduction

The substitution of fossil fuels on the biomass at different appliances is the most feasible and industrially-ready technological solution for the decreasing of overall carbon dioxide emissions.

Pyrolysis oil is one of the most promising option for traditional fuel oil substitution in energy sector.

Pyrolysis bio oil (PBO) – liquid hydrocarbon fraction obtained during thermal conversion of biomass in atmosphere of inert or poorly reactive gas.



PBO sample origin and characterization

The PBO sample studied was obtained from Siberian Biougol (Tomsk region, Russia) industrial-scale activated char production facility. The facility utilizes slow pyrolysis operational principal in residual air atmosphere.

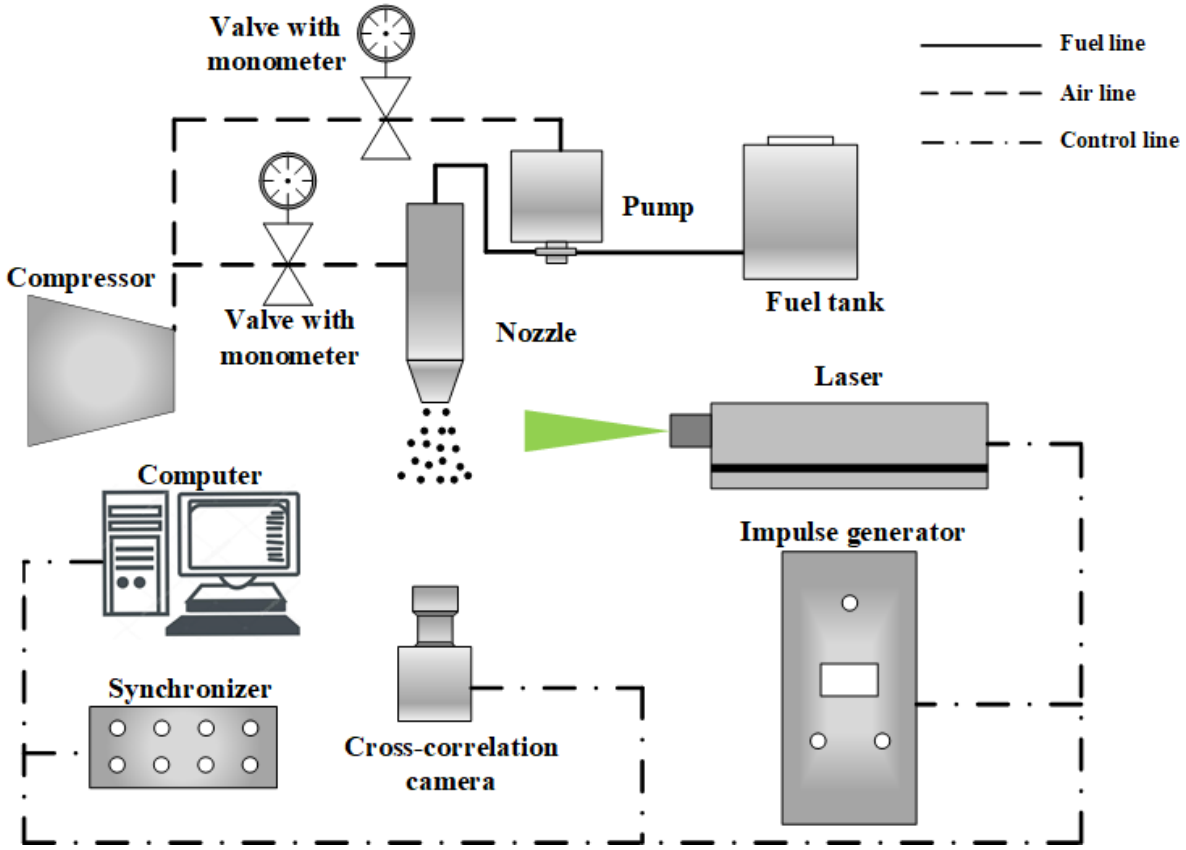
The sample characterization was performed accordi to following standards:

- Density – ISO 12185:1996;
- Viscosity – ISO 3104:1994;
- Pour point – ASTM D97-17b;
- Flash point – ISO 2592:2000;
- Moisture and ash content – ISO 6245:2001.

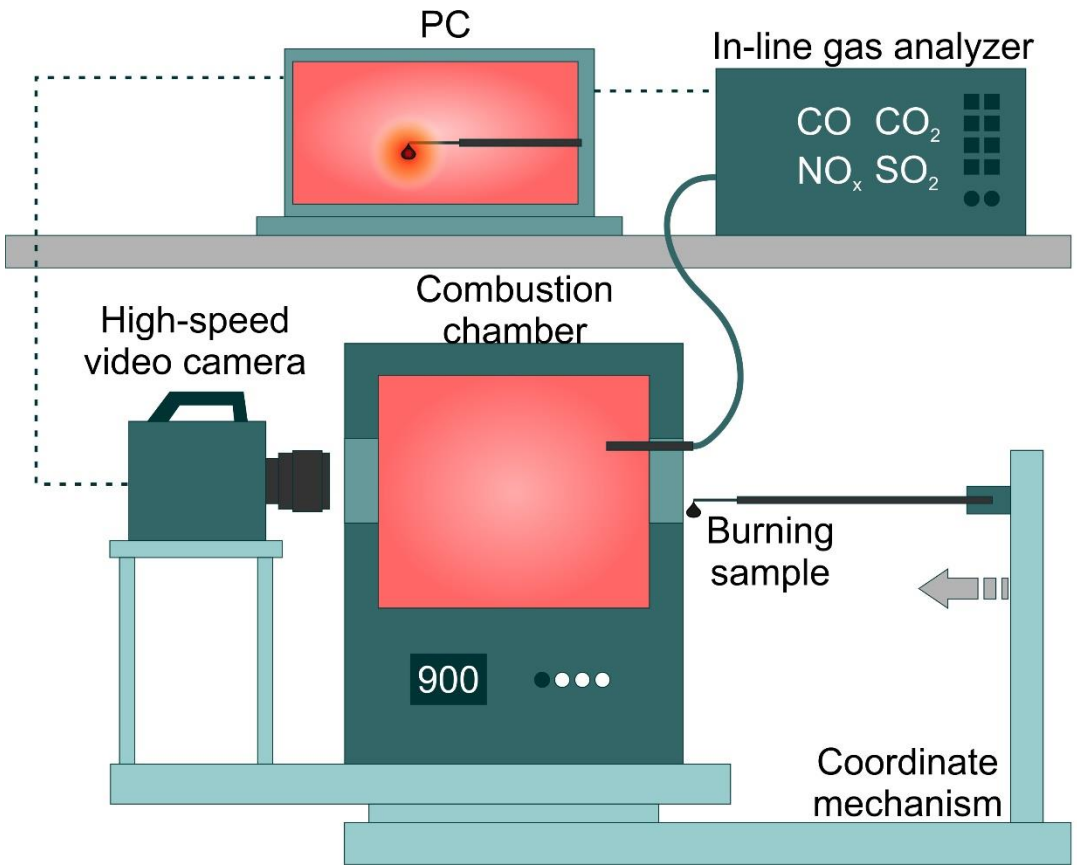
Fractional analysis was performed using **ARNS-1E distillation apparatus**, functional analysis – **Agilent 6890N**, elemental analysis – **Flash 2000 CHNS analyzer**, pH value – **SevenCompact pH meter S220** .

Spraying, ignition and combustion test

Atomization setup

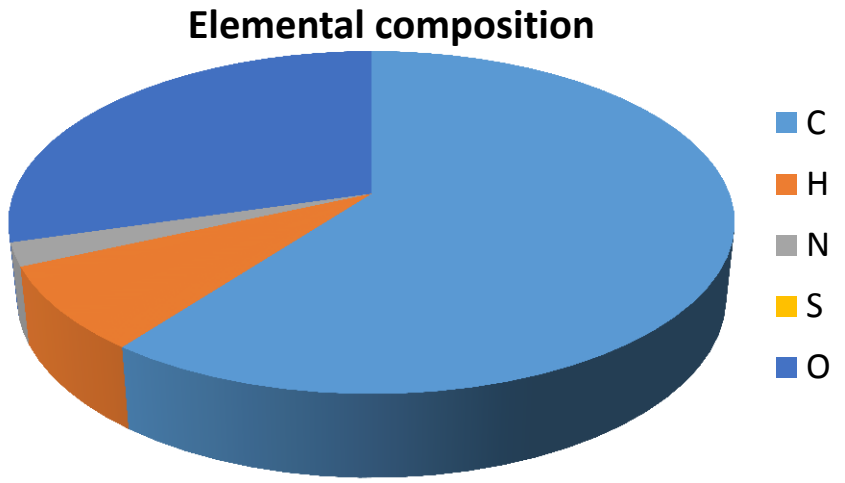


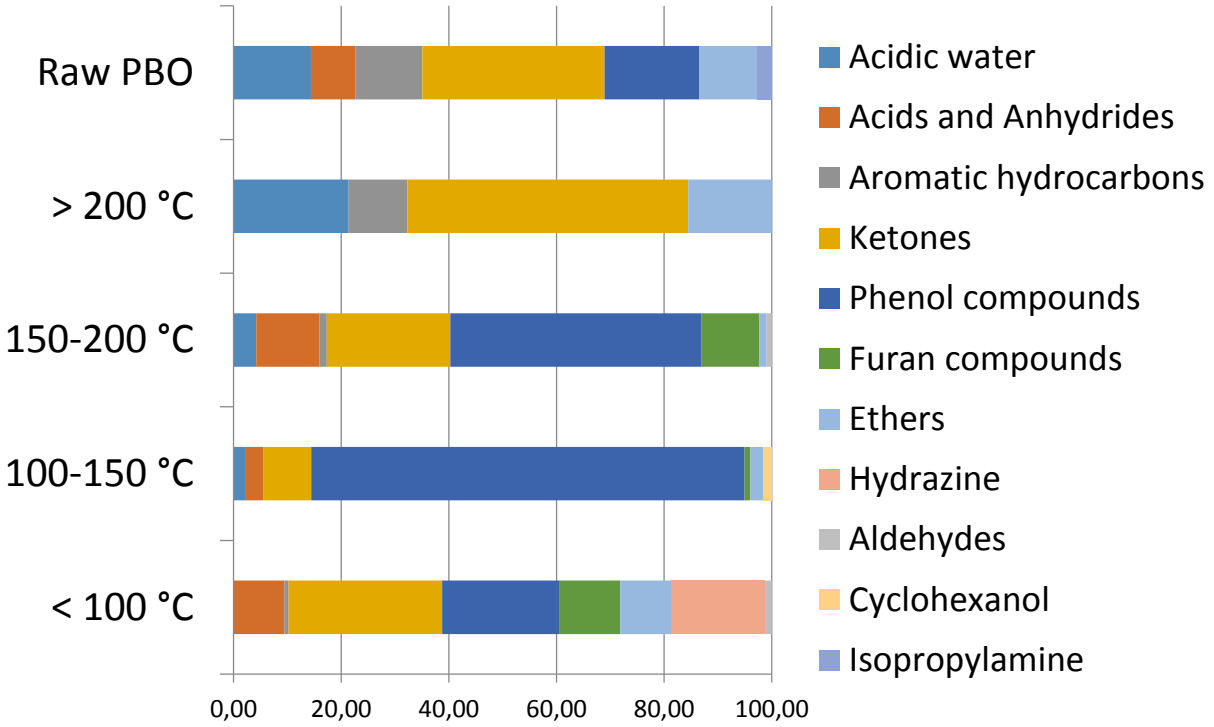
Combustion setup



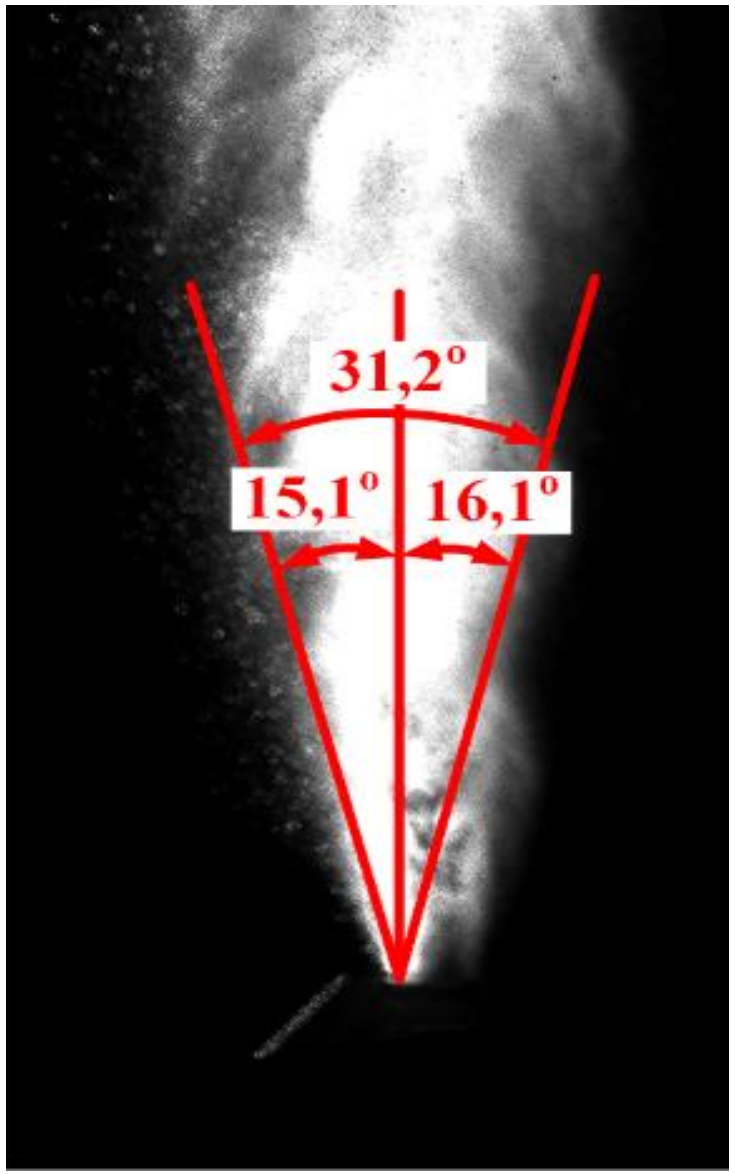
Physical and chemical properties of PBO

Parameter	PBO sample	ASTM Burner Fuel Standard D 7544	
		Grade G	Grade D
Density, kg/m³			
• At 20°C	–	1.1-1.3	1.1-1.3
• At 50°C	1.18	–	–
• At 80°C	1.16	–	–
Dynamic viscosity, mPa·s			
• At 50°C	184.16	n/a	n/a
• At 80°C	29.94		
Kinematic viscosity, mm²/s			
• At 40°C		<125	<125
• At 50°C	154.90	–	–
• At 80°C	25.69	–	–
Pour point T_{pp}, °C	7	<-9	<-9
Flash point T_{fp}, °C	133	>45	>45
Gross calorific value Q_i^a, MJ/kg	25.01	>15	>15
Water content, wt.%	4.5	<30	<30
Ash content, wt.%	1.4	<0.25	<0.25
pH	2.7	n/a	n/a

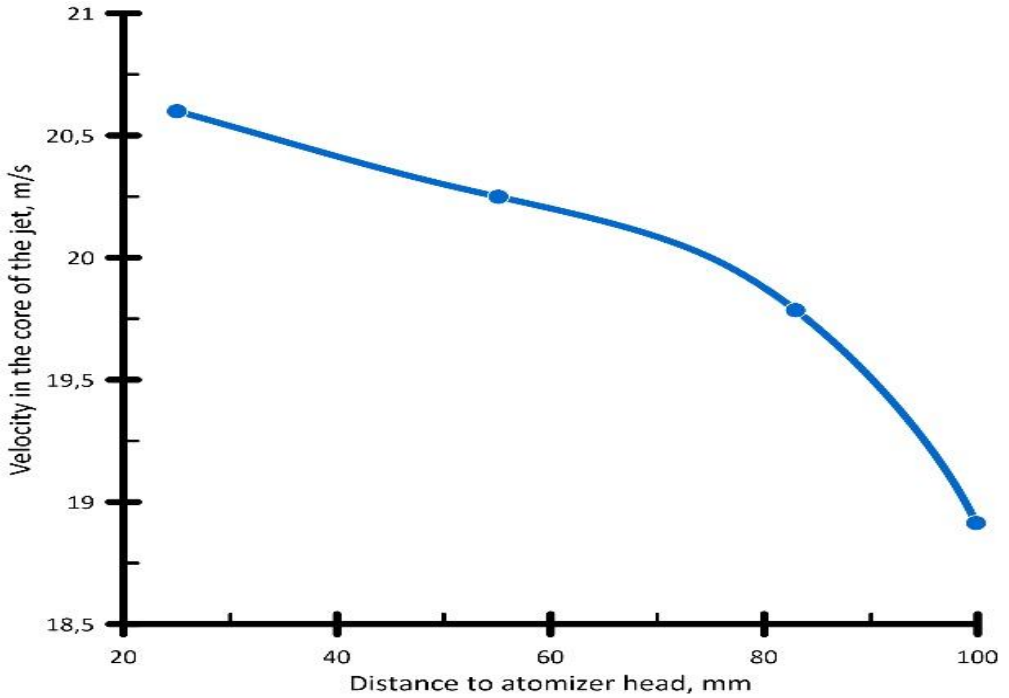




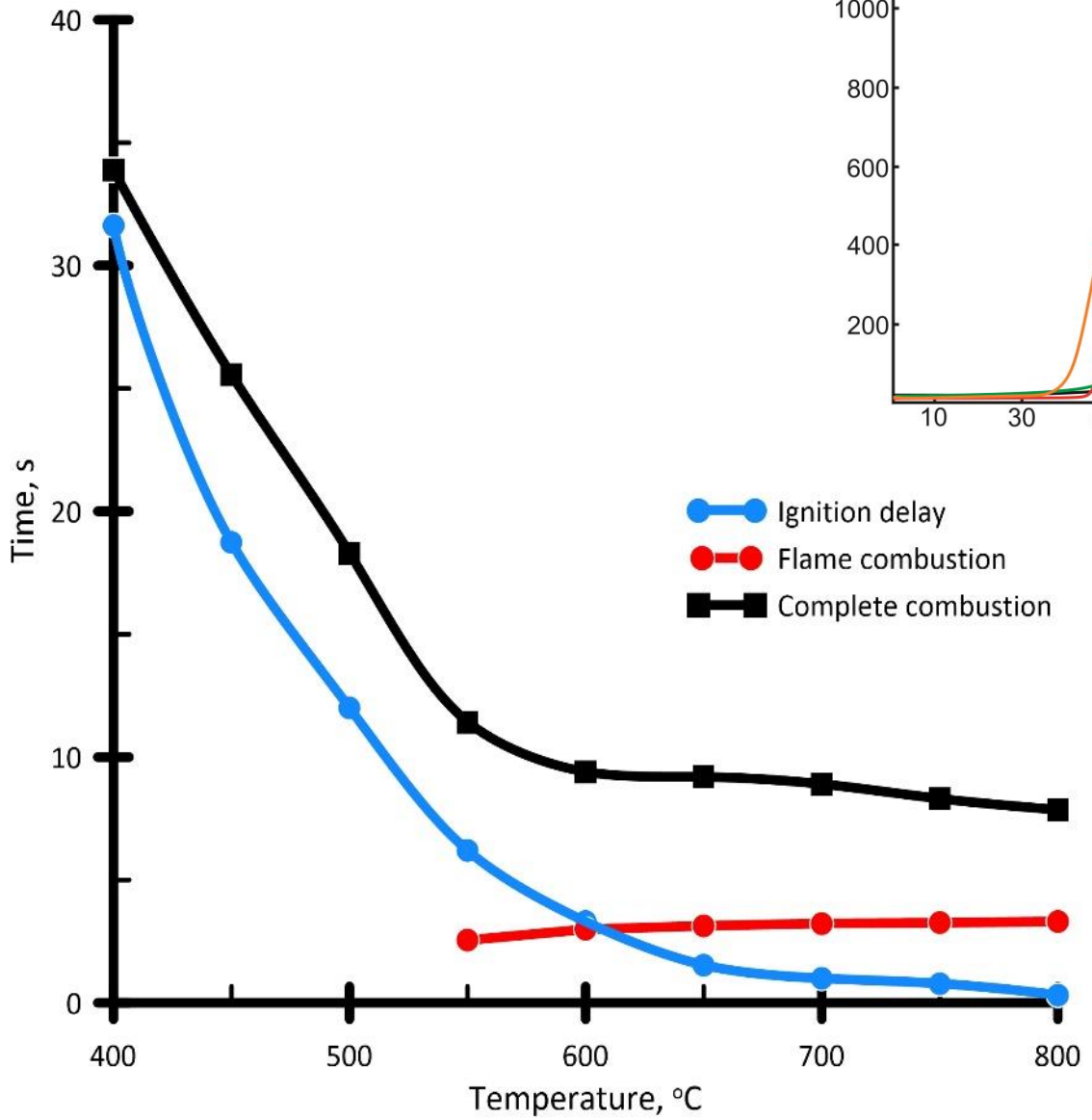
Atomization properties of PBO

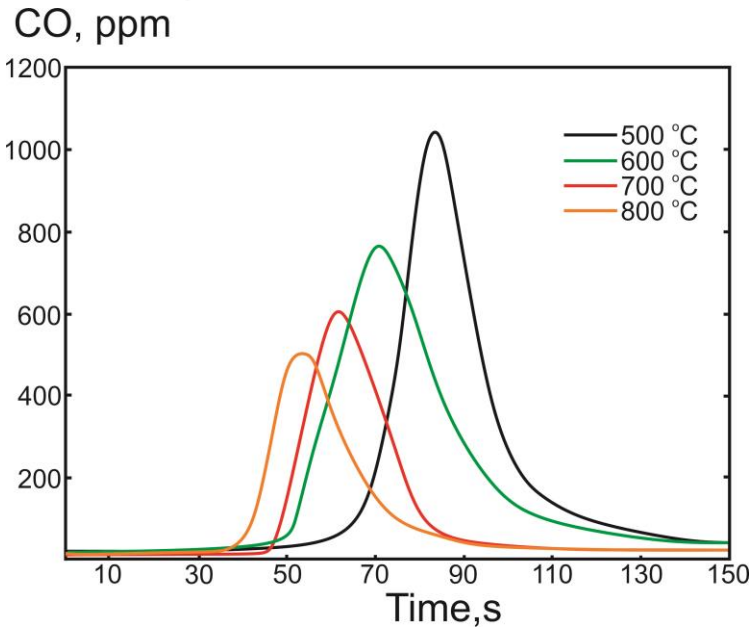


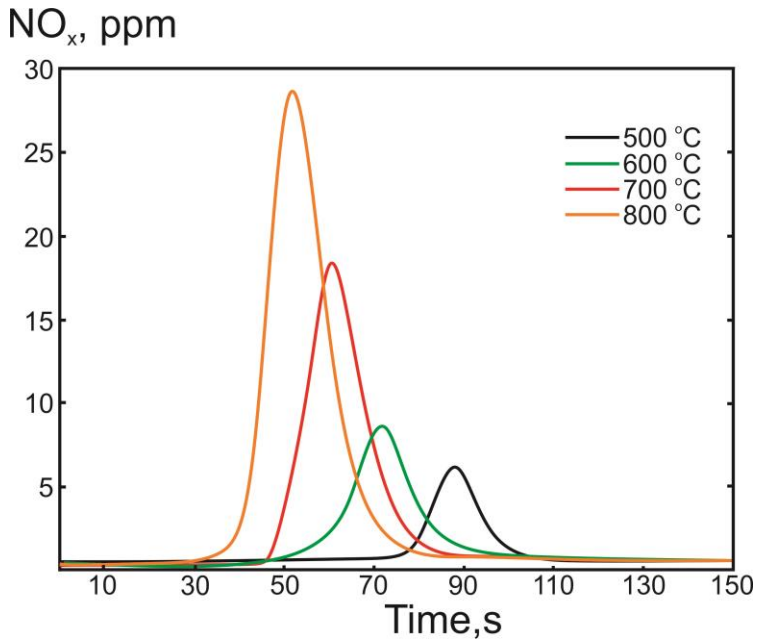
The jet had a fairly uniform structure with droplet size <0.2 mm. The trajectory of the droplets passed in the boundary region of the jet, which were subsequently destroyed due to the aerodynamic resistance of the external environment. This led to the appearance of a cloud of small aerosol particles during the jet disintegration. The high viscosity of the fuel prevented droplets from deformation due to the aerodynamic resistance of the air. Fuel droplets after collision with others, were destroyed into several droplets with smaller size. Their trajectories of movement after primary fragmentation practically did not change and were oriented chaotically. The characteristics of the jet after spraying viscous suspensions deteriorate.

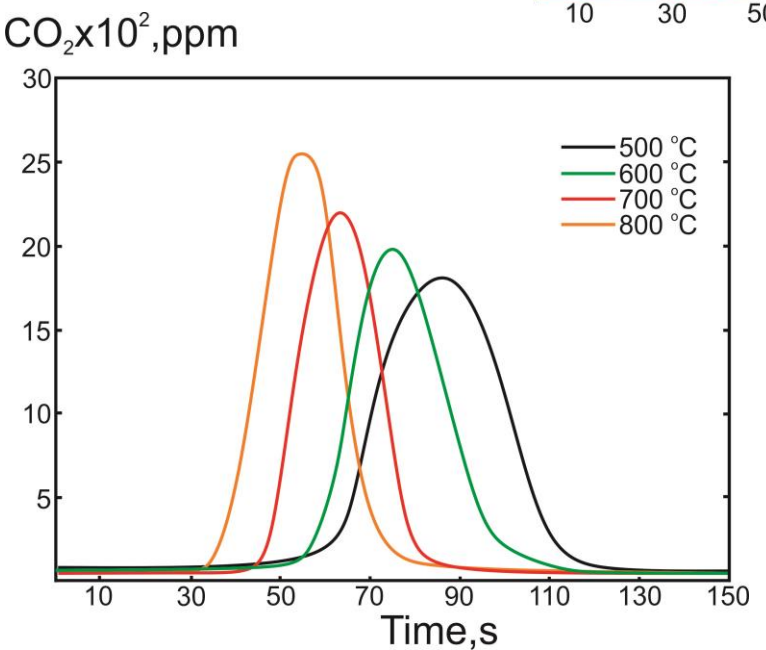


Ignition and combustion PBO









Ignition and combustion PBO

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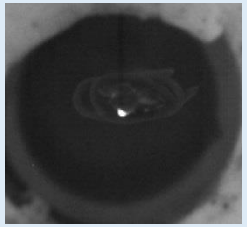
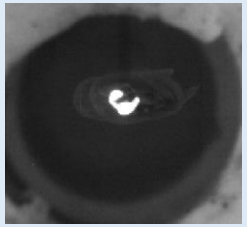
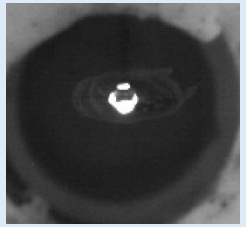
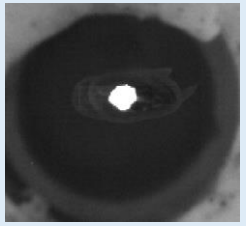
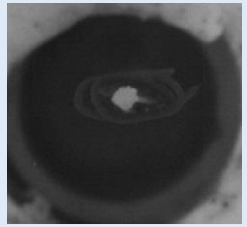
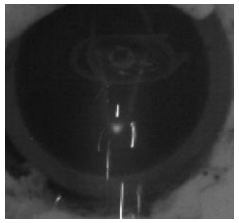
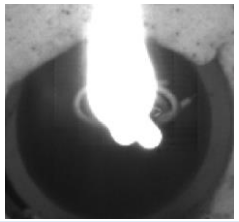
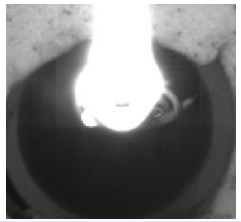
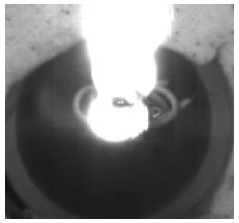
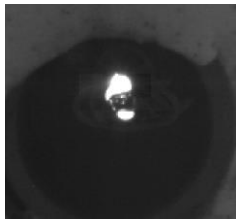
				
Ignition	t=1.44s	t=3.51s	t=9.29s	t=18.66s
600°C				
				
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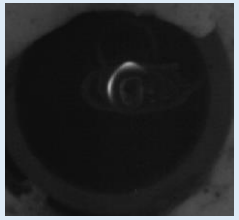
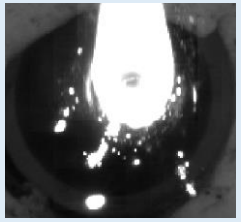
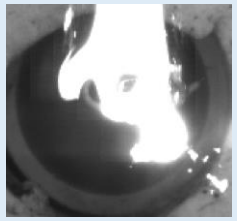
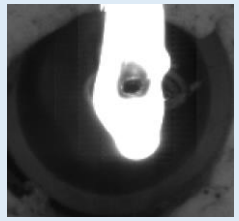
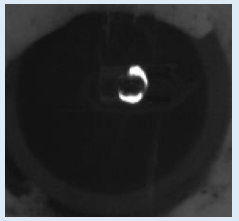
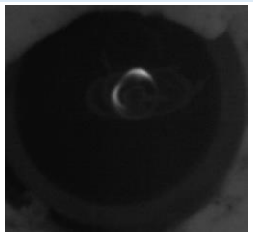
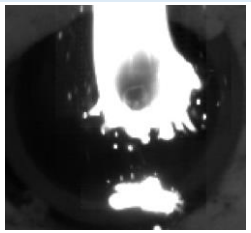
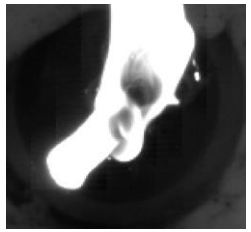
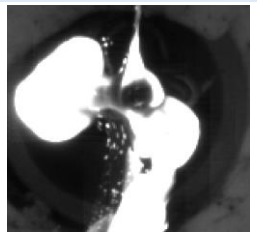
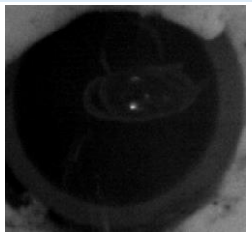
700°C				
				
Ignition	t=0.81s	t=1.62s	t=2.43s	t=3.24s
800°C				
				
Ignition	t=0.81s	t=1.62s	t=2.43s	t=3.24s

Conclusion

The complex research on the physical, chemical, spraying, ignition and combustion characteristics of wood slow pyrolysis bio-oil.

The PBO sample studied was found to be very similar to traditional fast pyrolysis bio oil.

Pyrolysis bio oil sample was found to comply with ASTM D 7544 requirements with three exceptions:

- The high pour point value (7 °C vs -9 °C);
- The high kinematic viscosity (155 mm^2/s vs 125 mm^2/s);
- The high ash content (1,4 wt.% vs 0,25 wt.%).

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ЗА ВНИМАНИЕ!