CONVENTIONAL AND CATALYTIC PYROLYSIS OF PINYON JUNIPER BIOMASS

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Abstract

Pinyon juniper (PJ) woodlands occupy more than 47 million acres in western United States, which include different species of pinyon and juniper trees. The problems caused by PJ woodlands include reduced herbaceous vegetation, crown fires, and soil erosion. Thus, much research has been focused on how to remove these woodlands, but there is no immediate application for this vastly available energy source. Fuel wood remains the most important forest product derived from PJ woodlands. Thus, suitable technology should be adopted to utilize this available energy source. Fast pyrolysis is one of the promising technologies for processing lignocellulosic biomass into value added products. Fast pyrolysis of PJ biomass was carried out in bench scale fluidized bed reactor. The biomass was air dried and finely ground to pass through 1mm sieve prior to pyrolysis. In this study catalytic pyrolysis (with ZSM-5, redmud) was compared with conventional pyrolysis (with sand). The results showed that the pyolysis with sand had maximum bio-oil yield (60 %), but the bio-oil viscosity was high. The pyrolysis with ZSM-5 and redmud had low bio-oil yield, but improved the properties of the bio-oil (viscosity, energy content).

Introduction

Pinyon Juniper woodlands and problems

Pinyon are trees in genus pinus and Juniper are coniferous plants in the genus juniperus. It is estimated that PJ woodlands occupy more than 47 million acres in western United States. PJ woodlands have increased the area occupied by 10-fold in the past 130 years and have the potential to occupy far more area than now. The problem caused by PJ woodlands include reduction of herbaceous vegetation, forest fire and soil erosion. Currently, these woodlands do not have any application other than forest woods.

Problem with Bio-oil

Compared to heavy fuel oil, bio-oils produced from fast pyrolysis are highly acidic, highly viscous, highly unstable, low in energy density and incompatible with petroleum feedstock. Thus upgrading of bio-oil is a necessary process. Bio-oil upgrading is usually done by hydroprocessing and catalytic pyrolysis. Hydroprocessing is an effective method to produce hydrocarbons from bio-oil, but the need for high pressure hydrogen input makes it less attractive. On the other hand, operation at atmospheric pressure, availability of a wide range of catalysts, and no need of external hydrogen make catalytic pyrolysis economically attractive.

Objectives

- Perform pyrolysis of PJ biomass to produce value added products.
- Perform catalytic pyrolysis of PJ biomass to improve the quality of bio-oil.
- Compare the catalytic effect of redmud (industrial waste) and ZSM5 (commercial catalyst).

Materials and Methods

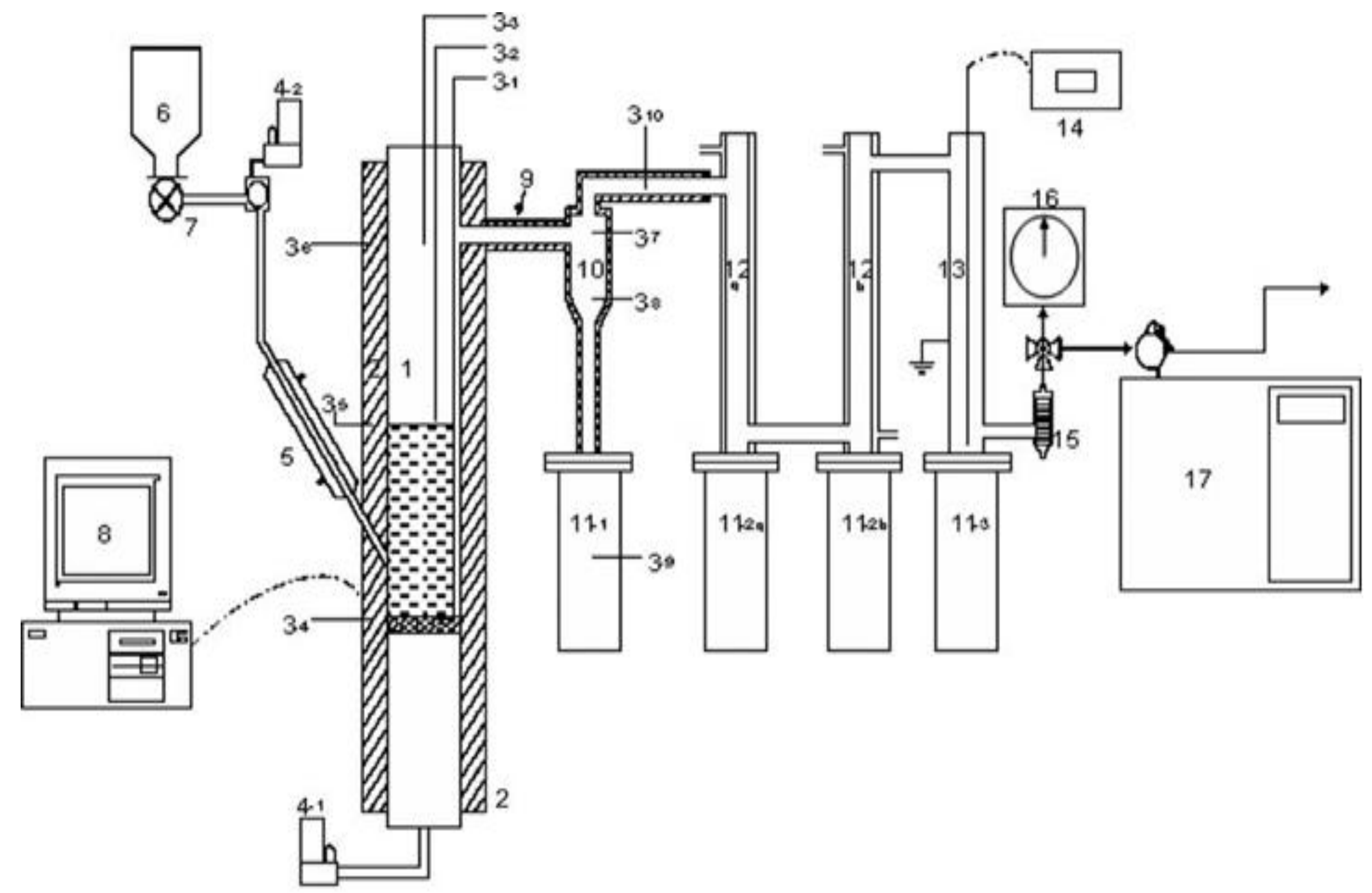

Figure 1: Bench scale fluidized bed reactor

Table 1: Pyrolysis condition

	Sand	ZSM5	Redmud
Temperature (°C)	475	475	475
Feed rate (g/hr)	150	150	150
Flow rate (L/min)	16	5.5	5.5
Particle size (µm)	253.5	137.5	137.5
Sand/catalyst (g)	100	100	100
WHSV (hr^{-1})	1.5	1.5	1.5
Run time (min)	120	120	120

Results

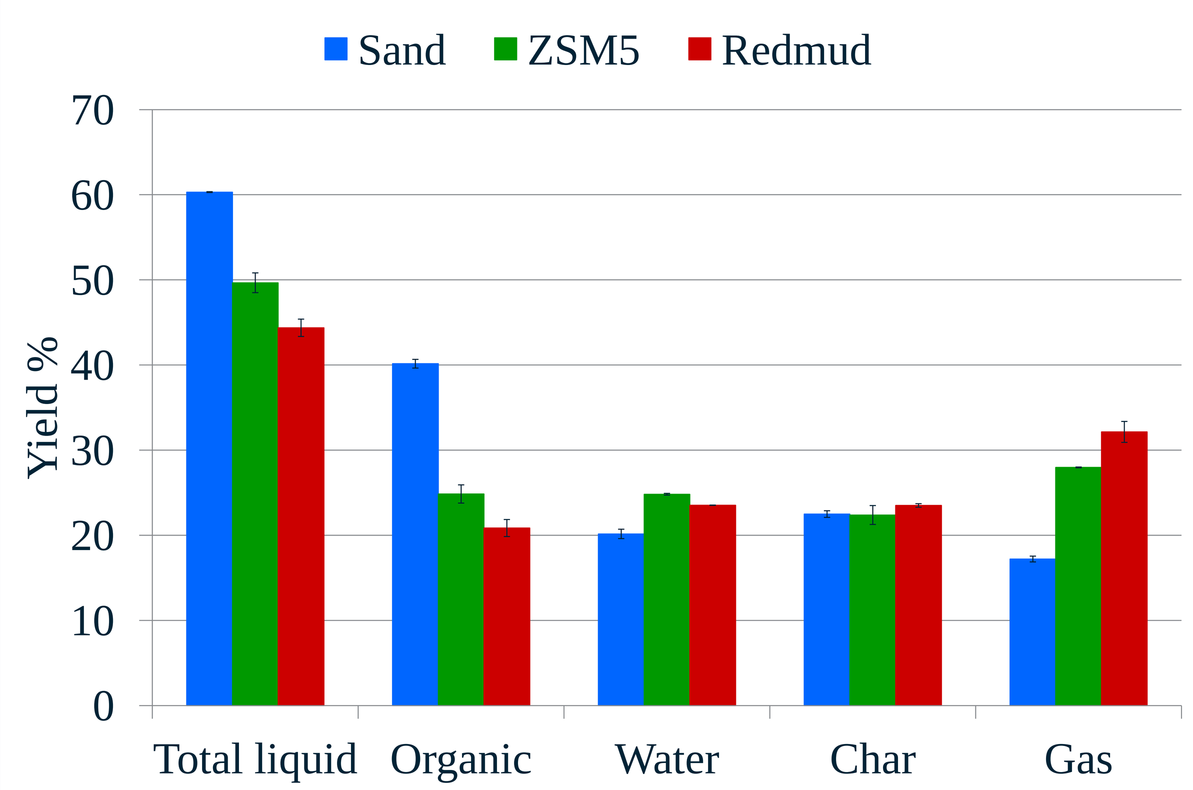

Figure 2: Pyrolysis product distribution

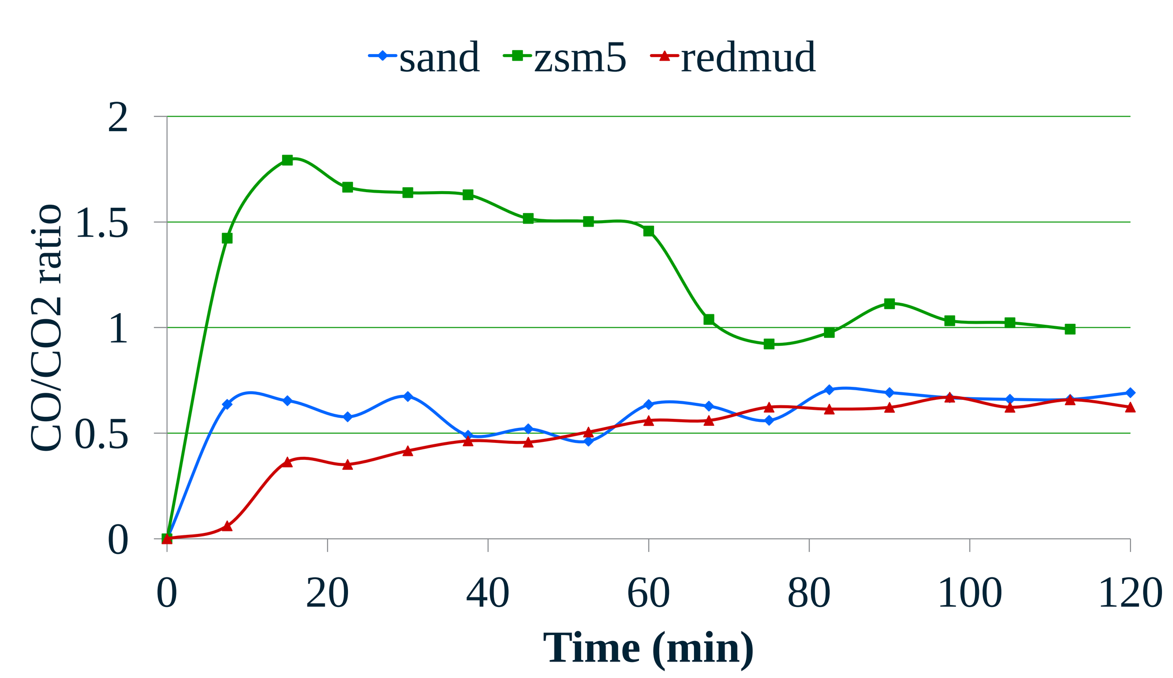

Figure 3: CO/CO2 ratio of sand, ZSM5, redmud pyrolysis

Table 2: Physiochemical properties of ESP oil

	Sand	ZSM-5	Redmud
Water content (wt %)	2.81±0.18	1.72±0.07	1.46±0.08
pH	2.75±0.04	2.89±0.03	3.56±0.03
Dynamic Viscosity (cP)	686.02±27.52	261.61±27.44	96.99±19.54
HHV (MJ/Kg)	24.87±0.37	28.55±0.23	29.46±0.62

Table 3: Gas yields

Gases	Sand	ZSM-5	Redmud
	% yield (N_2 free basis)		
Hydrogen	0.15	0.38	0.57
Methane	0.51	1.09	1.47
Carbon monoxide	5.57	10.98	8.79
Carbon dioxide	9.77	9.16	17.06
Ethane	0.11	0.52	0.38
Propane	0.18	0.53	0.33
N-butane	0.27	1.57	1.43
N-pentane	0.10	0.33	0.19
Total	16.66	24.56	30.22

Discussion

- The study shows that the pyrolysis yield and quality of the bio-oil is affected by the fluidizing medium (sand, ZSM5, redmud).
- Catalytic pyrolysis produced more gases at the expense of the liquid yield.
- The bio-oil produced by catalytic pyrolysis had lower viscosity and higher energy content compared to conventional pyrolysis.
- The bio-oil produced using redmud had the lowest viscosity, and highest energy content.
- The gas analysis showed that the rejection of oxygen from the biomass was carried out mainly through CO on ZSM5 and CO_2 on redmud.

Conclusions

- PJ biomass could be used in fast pyrolysis to produce value added products (bio-oil, bio-char, and gases).
- The results show that redmud, which is an industrial waste from Bayer's process, could be effectively used as catalyst for biomass pyrolysis.

References

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Acknowledgement

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