Blending of pyrolysis oil with alcohols and diesel

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Pyrolysis oil is a new type of fuel from biomass which presents significant potential for the CO_2-free power and heat generation. Typically during pyrolysis process, 60 – 75 wt. % of the feedstock is converted into pyrolysis oil. The remaining mass is converted to char and non-condensable gases which are combusted and reused for pyrolysis process, biomass drying, heat and power generation. Only few percent of energy is lost in the form of heat. Since the pyrolysis oil is biomass in liquid form it can be easily transported to a place of destination. It can be also stored to cover shortage in electricity or heat during the day or in emergency situation. High energy density, by factor 5-20 higher than the feedstock from which pyrolysis oil is produced, promotes it over conventional biomass. Furthermore, pyrolysis oil does not compete or interfere food chain (second generation of biofuels) and the minerals left from the pyrolysis oil production might be re-used for soil enrichment.

The idea of using pyrolysis oil for energy and heat generation encounters problems resulting from an incompatibility between properties of pyrolysis oil and the designed for fossil fuels combustion devices. High viscosity (≥ 20 cSt at 40^{o}C), delayed ignition time (CN ~ 14), low heating value (LHV ~ 17 MJ/kg), corrosion effect (pH value about 2 – 3) and solid content (generally below 0.2 wt%) make pyrolysis oil a challenging fuel for utilization in modern combustion devices. Significant research work has already been performed on improvement of pyrolysis oil but only few investigations were carried out on utilization of these bio-fuels in modern combustion devices. The latter have shown a major difference in behaviour of pyrolysis oil and fossil fuels during the combustion processes.

In order to improve properties of pyrolysis oil and make it ready for combustion in gas turbines, a blending of pyrolysis oil with alcohol and diesel is performed. Research done by Weerachanchai et.al. see, (Weerachanchai, et al., 2009) have shown promising properties of blends between palm kern bio-oil, alcohol and diesel. Here several blends are investigated with respect to pyrolysis oil.

First results of pyrolysis oil blends with diesel and alcohols (ethanol and butanol), see *Figure 1* and *Figure 2*, done at room temperature, show that pyrolysis oil is miscible and stable with both diesel and alcohol.

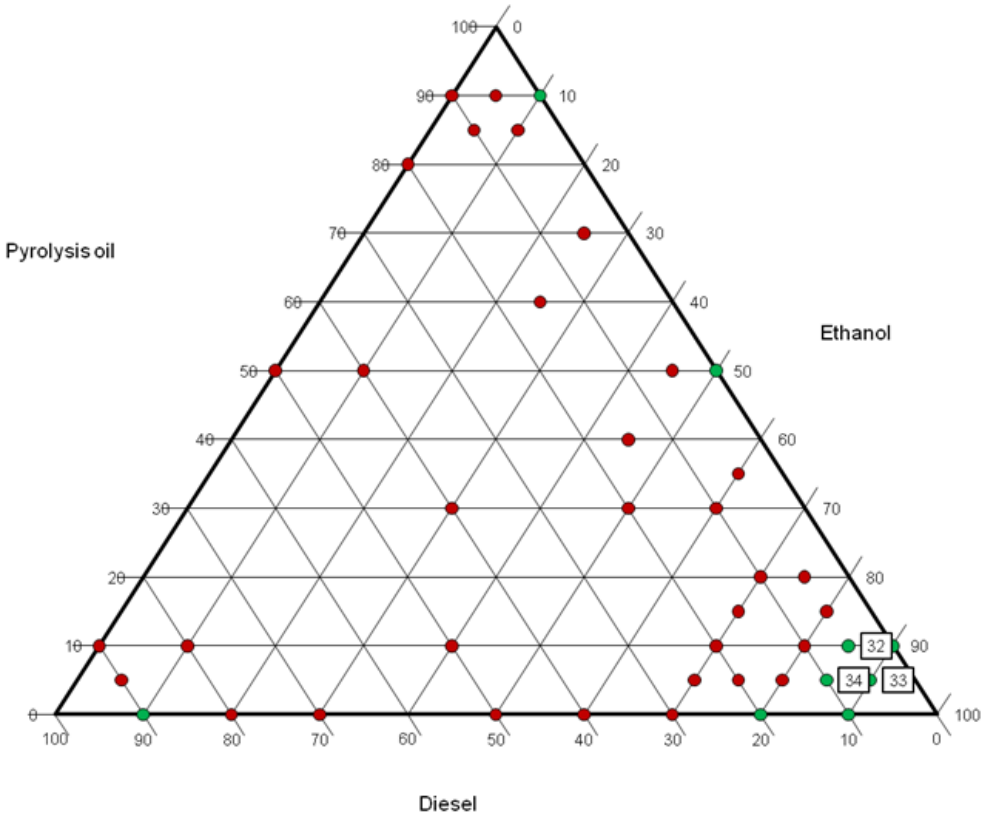

Figure 1: Pyrolysis oil blends (wt%) with ethanol and diesel (red dots – immiscible, green-miscible, HHV is given in rectangles)

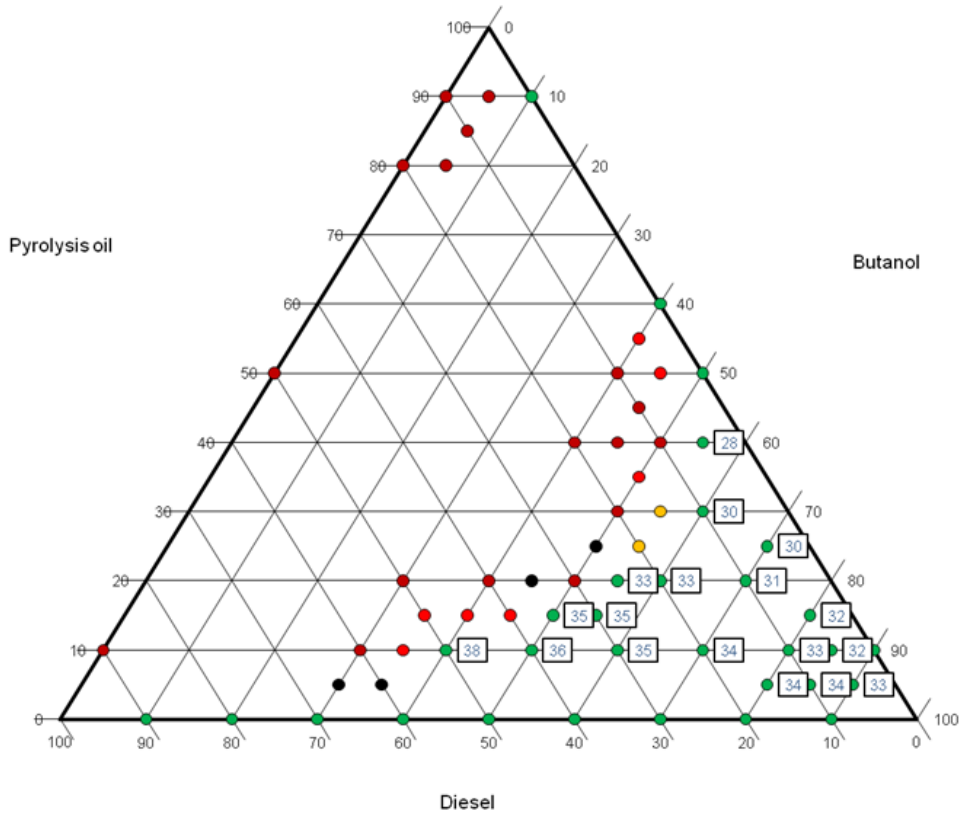

Figure 2: Pyrolysis oil blends (wt%) with butanol and diesel (red dots – immiscible, green-miscible, yellow and black-to be checked, HHV is given in rectangles)

The ratio of miscibility in the ternary system is determined by type of alcohol used as a solvent. The longer chain of aliphatic hydrocarbon in butanol makes it better soluble in diesel and in pyrolysis oil. Properties of alcohol also significantly influence mixture behaviour. Ethanol decreases more rapidly viscosity of the blend (ethanol viscosity is about half of the viscosity of butanol), however increases risk of self-ignition of the blend due to low flash point. Butanol is much safer solution with this respect. It has also higher heating value and energy density, it is better miscible and more stable with blends of pyrolysis oil and diesel, and it is less corrosive. All these factors promote butanol as a solvent for further pyrolysis oil-diesel mixtures.

This work in-progress presents results of pyrolysis oil-diesel blends with ethanol and butanol. Coming study will extend list of solvents to iso-butanol and pentanol.

Work cited:

Weerachanchai P., Tangsathitkulchai C. and Tangsathitkulchai M. Phase behaviours and fuel properties of bio-oil-diesel-alcohol blends [Journal] // World Academy of Science, Engineering and Technology. - 2009. - Vol. 56. - pp. 387-393.