

Thermal treatment of the High ash Coal with Electronic Waste plastics and characterization of the co-liquefied oil

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1. Introduction

In modern scenario, crude oil price hike and its declining resources have raised the concern for alternative fuels in the energy sector. Coal is considered as one of the most effective alternative source of petroleum oil as the amount of coal deposits is ten times larger than that for the other carbonaceous resources worldwide (Vasireddy *et al* (2011)). On the other hand, the rate of electronic waste (EW) generation is climbing every year and with the plastics (around 30.0%) being a major constituent, EW becomes a global threat to the environment. Thermochemical recycling methods are subjected to organic waste valorisation and waste plastics with high hydrogen (H) and carbon (C) content, higher heating value (about 40.00 MJ/kg) become potential feedstock for liquid fuel production (Wang *et al* (2004)). Co-liquefaction is a thermochemical treatment that brings an opportunity to convert a mixed feed of coal and EW plastics into high calorific transportable liquid product (Kanno *et al* (2000); Wang *et al* (2004)). However, literature survey is indicative towards lesser number of research work on the co-liquefaction of high ash coal (HAC) with EW plastic. To the best of our knowledge, co-liquefaction study of HAC with printer cartridge plastics (PCP) under nitrogen atmosphere in absence of commercial solvent and catalyst is rare. This paper reports the experimental study of co-liquefaction of a mixed feed of HAC and DPCP at a temperature 400°C, 2MPa initial N₂ pressure in different reaction times. Efforts have been made to find the optimum condition for achieving maximum oil yields. Further, co-liquefied oil was characterized using different analytical methods (FT-IR, GC-MS etc.) and physical properties were determined and compared with available market fuels to investigate possible blending and/or to use as an alternate fuel for boilers, furnaces etc.

2. Materials and Experimental procedure

HAC was collected from Jharkhand (India) and EW plastics were gathered from discarded printer cartridge. Hexane and tetrahydrofuran were used in co liquefied product fractionation and are commercially available reagents with a high grade. After size reduction, powdered coal and waste plastics samples were stored in the airtight container for experimental purpose. Proximate analysis and calorific values are shown in Table 1. Co-liquefaction experiments were performed using 6 g of the mixed feedstock of HAC and EW plastics (50:50 mixing ratio) in a high pressure reactor system at 400°C by pressurizing the reactor up to 2MPa using N₂ (Figure 1). After completion of the experiments, the reactor was allowed to cool to room temperature and then gas was collected from the gas outlet and remaining product fractions were separated by filtration and extraction methods using hexane and tetrahydrofuran solvents in sequence. Finally, co-liquefied oil was separated from hexane and tetrahydrofuran was separated from asphaltene and pre-asphaltene (PAA) using rotary evaporator.

Table 1. Proximate and calorific value analysis of the feeds

Analysis	DPCP	HAC
Moisture (wt. %)	0.83	2.10
Volatile matter (wt. %)	94.32	20.80
Ash (wt. %)	1.13	30.40
Fixed carbon (wt. %)	3.72	46.40
Calorific value (MJ/kg)	37.86	22.30



Figure 1. High pressure reactor system

3. Results and Discussions

TGA analysis showed that the weight loss of EW plastics is significantly higher than HAC in the temperature range 350-400°C. Overlapping thermal degradation temperature interval between HAC and EW plastics becomes favourable for hydrogen transfer from EWP to HAC during co-liquefaction. From the experimental results, it was found that there exists a synergistic effect of mixing EW plastics with HAC to convert the feed mixture into desired oil. Maximum oil yield of 39.25 wt.% was achieved at 400°C and 30 min. of reaction time. FT-IR analysis showed presence of different functional groups in the oil and comparable to that of the diesel (Figure 2). The ultimate analysis of co-liquefied oil obtained at 400°C and 30 min. is reported in Table 2. The co-liquefied oil has a significant H/C ratio (1.27), which enhances the possibilities to use the oil as fuel alternative with less greenhouse gas emission (Pathak *et al* (2022)).

Table 2. Ultimate analysis of oil

Analysis	Co-liquefied Oil
Carbon (wt. %)	87.02
Hydrogen (wt. %)	9.33
Oxygen (wt. %)	2.40
Nitrogen (wt. %)	1.25
Sulfur (wt. %)	-

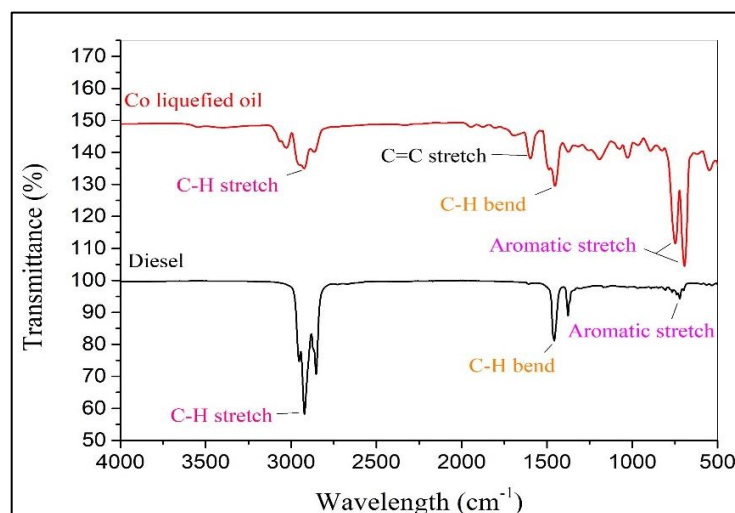


Figure 2. FT-IR analysis of co-liquefied oil and diesel

4. Conclusions

Co-liquefaction of HAC and EW plastics brings an effective way to convert solid materials into transportable liquid oil. EW plastics can be a potential hydrogen donor during thermal treatment of HAC that enhances the overall feed conversion and oil yield. FT-IR study showed comparability of co-liquefied oil with that of diesel fuel and confirms absence of water molecule or polymeric -OH functional group. The H/C ratio of the co-liquefied oil (1.27) is also comparable to that of available market fuel. With quality upgradation via different secondary refining processes, HAC and EW plastics co-liquefied oil can be a suitable option to blend with market fuel and use as an alternate fuel in boilers, combustors and modified heat engines. Co-liquefaction of HAC and EW plastics becomes a cheaper way of getting valuable oil from coal without using costly hydrogen, solvents and catalyst and brings a sustainable way for EW management.

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