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ANALYZING THE SUITABILITY OF USING DIESEL LIKE FUEL EXTRACTED FROM WASTE ENGINE OIL

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A B S T R A C T

Alternate fuel is one of the major issue for the replacement of the conventional fossil fuel. Alternate fuel from the waste resources is the dominant field in the research work. Extraction of of diesel like fuel from waste engine oil (WEO) is the aim of the present study. For utilizing the WEO as the alternate fuel, the WEO should be converted to diesel like fuel by way of cracking the WEO by using the catalysts red mud (WEORM) and fly ash (WEOFA). The converted diesel like fuel should be analyzed for its properties before utilizing it in the diesel engine. As per ASTM standards, some of the important properties are analyzed and found that which is almost closer to the properties of the diesel fuel. Similarly diesel like fuel is analyzed with FTIR and GC to know the chemical compositions and the result confirmed that diesel like fuel contains hydrocarbons are alkanes, GC analysis confirmed that diesel like fuel mainly composed of praffins, napthanes and aromatics.

INTRODUCTION

Diminishing of fossil fuel sources, steep rise in fuel price, growing of demand and environmental hazards as a result of continuous search for researcher's to investigate the possible alternative fuels for internal combustion engines. Waste to useful energy is the new trend for the researcher's to identify the suitable alternate fuel from the waste resources [1]. Therefore scientist and researchers all over the world working hard to utilize the new technologies that allowed the re-cyclic or reuse of the waste material as a source of energy [2]. The production of waste automotive engine oil is estimated as 24 million tons each year throughout the world. Treatment and disposal of waste automotive engine oil is the major problem for modern society, since it contains a mixture of aliphatic and aromatic hydrocarbons [3-6].

Used oil dumped on the ground, sewers or sent to landfills is capable of seeping into ground and surface water. Just one litre of used oil can render one million litres of water undrinkable [7, 8]. It was also a serious threat to plant and animal life. The Ministry of Petroleum and Natural Gas, Government of India, in 2012-2013 statistics stated that crude oil production is about 37.882 MMT, in that lubrication oil production is about 896 TMT. Around 60% of the production becomes waste. Less than 45% of available waste oil was collected for recycling and the remaining 55% was either misused or discarded by the end user in the environment [9].

Red mud, an aluminum industry waste, contains a mixture of many metal oxides, 30-60% of which constitutes Fe_2O_3; [10-13] in addition, other constituents like TiO_2, Al_2O_3, SiO_2 and traces of V_2O_5 are also present [14-16]. Coal fly ash is a particulate material produced from the combustion of coal in thermoelectric power plants.

Ash contamination poses a serious threat to environment. The confirmed presence of heavy metals in fly ash their bioactivity and biotoxicology, first of all, their mobility can cause significant environmental problems [17]. Contamination during disposal of fly ash, as well as interaction of fly ash and heavy metals in the environment is very limited. A lot of investigations have revealed that leachable coal ash contaminants, particularly arsenate, chromium, selenium, boron, strontium, and barium, have different effects on the quality of impacted environments [18, 19].

This study investigates the characterization of the catalyst used to convert the WEO into diesel like fuel. The important properties of the diesel like fuel such as density, viscosity, flash point and fire point, calorific value, etc were tested. Effects of catalyst and their characteristics were discussed.

MATERIALS AND METHODS

A catalytic fuel reformer was designed and fabricated to convert the WEO into diesel like fuel. Schematic representation of the system was shown in fig. 1. The

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system was consisted of several components such as fuel tank, control panel, reactor, thermocouple, stirrer, condenser, fuel storage tank. The fuel tank is used to supply the WEO into the reactor.

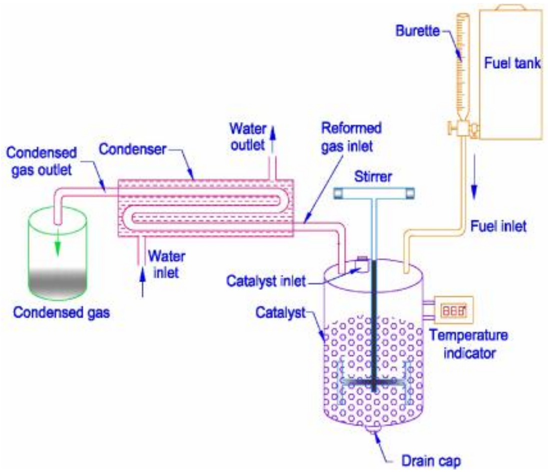

Figure 1 Schematic diagram of the catalytic fuel reformer

The reactor of the system has a cylindrical shape with inner diameter of 15 cm and the length of 45 cm. The reactor was designed and fabricated to heat the WEO along with the catalyst. It includes an electrical heating unit which can be used to heat the WEO with catalyst upto 800^{o}C. The electrical heater has resistance heater and a voltage control which is used to adjust the heating rate. The heating control is performed by control panel. The stirrer is used to mixing the WEO with catalyst uniformly and also to distribute the temperature uniformly. The thermocouple is used to measure the temperature in the reactor. The condenser unit is used to condense the reformed WEO gas from the reactor. A water cooled condenser was used to condense the reformed WEO gas.

Preparation of catalysts

Red mud catalyst

The red mud samples were collected from aluminum plants located in different sites from India. The red mud was allowed to the shaker. The shaker had three different sizes of sieves. It removed the core particles present in the red mud and the powder form of red mud was collected. The NaOH was added as the bonding material into the sieved red mud. Then the red mud was prepared in the form of pellets. The size of pellets was approximately 20 to 30 mm diameter. The pellets are subjected into the oven and heated the pellets about 80 ^{o}C for the period of one hour. Then the dried pellets are allowed to cool in the room temperature.

Fly ash catalyst

The fly ash samples were collected from Neyveli Lignite Corporation of Tamil Nadu. Similar to red mud samples the fly ash also subjected into the shaker and the powder form of fly ash samples were collected. The NaOH was added as the bonding material into the sieved fly ash. Then the fly ash was prepared in the form of pellets of 20 to 30 mm diameter. The pellets are subjected into the oven and heated the pellets about 80 ^{o}C for the period of one hour. Then the dried pellets are allowed to cool in the room temperature.

RESULTS AND DISCUSSION

Fuel Characterization

Some of the important properties of the diesel fuel, fresh engine oil (FEO), WEO, waste engine oil with red mud (WEORM) and waste engine oil with fly ash (WEOFA) were discussed. Fuel properties are analyzed based on its ASTM standards viz., the density was measured according to ASTM D1298 method, kinematic viscosity was measured according to ASTM D445 method, flash point and fire point were measured as per ASTM D93, calorific value was measured as per ASTM D5865 method, specific gravity was measured as per ASTM D1298 method and calorific value was measured as per ASTM D240. Some of the important properties of diesel fuel, FEO, WEO, WEORM and WEOFA were shown in table 1.

Table 1 Properties of Diesel, FEO, WEO, WEORM and WEOFA

Property	Measurement Standards	Diesel	FEO	WEO	WEORM	WEOFA
Specific gravity @ 27°C	ASTM D1298	0.8298	0.881	0.879	0.8312	0.8361
Kinematic viscosity @40°C in CSt	ASTM D445	2.57	85	52	1.65	1.54
Flash Point in°C	ASTM D93	50	215	197	35	33
Fire Point in °C	ASTM D93	56	-	-	37	36
Gross calorific value in MJ/kg	ASTM D240	44.67	43.6	45.4	42.68	41.22
Density@15°C in gm/cc	ASTM D1298	0.8072	0.879	0.858	0.8121	0.8221

The heavier hydrocarbon in FEO is converted into light hydrocarbon in WEO and reflects lower density but higher calorific value than that of the FEO. And also because of the cracking of the WEO the densities and viscosities of the WEORM and WEOFA lower to that of WEO and closer to that of the diesel fuel. The lower calorific value of the FEO was likely due to the presence of carbon and long-chain carbon compounds of lower calorific value in the oil matrix. The flash points of the WEORM and WEOFA were found to be lower than that of diesel. The flash points and kinematic viscosities are lower for WEORM and WEOFA when compared to that of the diesel fuel.

GC analysis

To know the chemical composition of WEO, WEORM and WEOFA, the samples were analyzed using GC-MS. The results of GC-MS analysis were shown in figures 2 and 3. GC-MS results showed that the WEO containing C_8-C_{24} hydrocarbons was thermally cracked with red mud as catalyst containing mainly of C_{10}-C_{30} hydrocarbons with the presence of aliphatic hydrocarbons and aromatics. This showed that the occurrence of cracking of compounds to produce some aromatic structures possibly derived from cyclisation and aromatization reaction that occurred during thermally cracked. Similarly the WEO was thermally cracked with fly ash catalyst comprising mainly of C_{13} hydrocarbons.

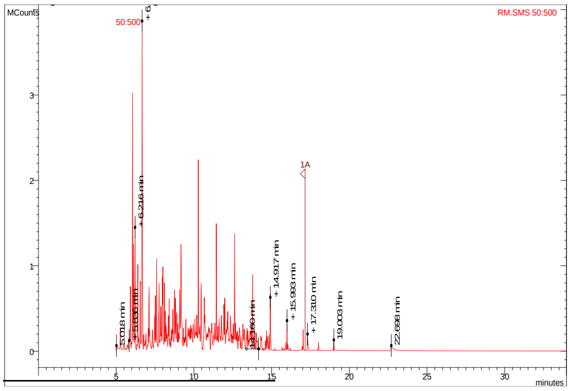

Figure 2 GC-MS chromatograms of WEORM

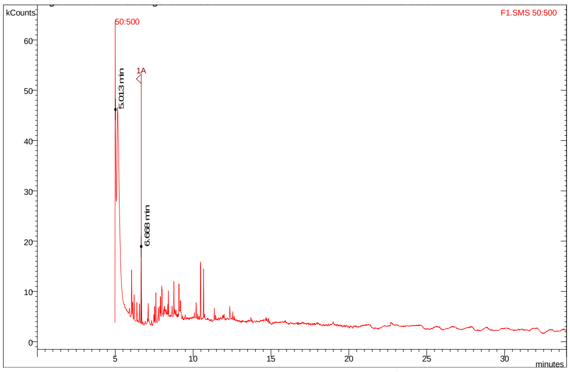

Figure 3 GC-MS chromatograms of WEOFA

Hence similar to fossil diesel fuel, they mainly contain praffins, napthenese and aromatics. Aliphatic hydrocarbons are most abundant component in both the oil WEORM and WEOFA. This indicates the cracking of waste oil to small hydrocarbon components and heterogeneous reactions that occurred during thermally cracked.

FT-IR analysis

To identify the functional groups present in WEO and it can offer information regarding the chemical change of the functional groups which may play an important role in investigating the influence of catalyst with WEO by using FT-IR spectroscopy. The representative FT-IR spectra of the diesel fuel, WEORM and WEOFA in the 4000-400 cm^{-1} wave number region are presented in Figure 4.

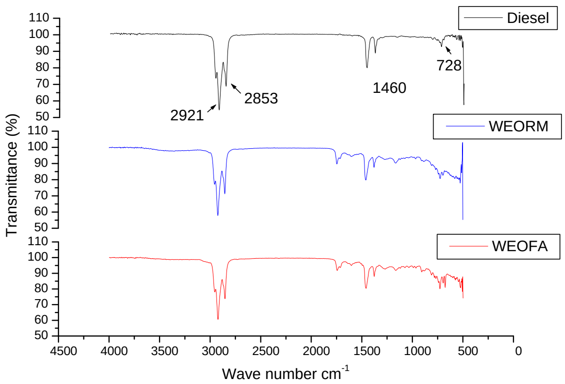

Figure 4 FTIR of Diesel, WEORM and WEOFA

The FT-IR spectrum reveals the presence of different functional groups. The two strong peaks observed at ~2921 cm^{-1} and ~2853 cm^{-1} in the diesel fuel correspond to the asymmetric and symmetric stretching mode of C-H groups. These two strong bands indicate the presence of alkanes in the diesel fuel. The intense infrared bands observed at ~1460 cm^{-1} and ~728 cm^{-1} arise mainly from the C-H asymmetric bending and C-H out of plane bending respectively, indicating the presence of alkanes. Further, the FT-IR spectra of WEORM and WEOFA showed the presence of bands similar to functional groups present in the diesel fuel. Hence, the FT-IR results confirmed that most of the hydrocarbons found in the WEORM and WEOFA were alkanes and thus a potential to be used as alternate fuel in diesel engine.

CONCLUSION

Diminishing of fossil fuels, increasing price and awareness of the increased environmental consequences of emissions from diesel engines makes the researchers to identify the new and renewable alternate fuel. In the present study, the possibility of using WEO as diesel like fuel was investigated. The collected WEO was allowed in to the catalytic fuel reformer. Two different catalysts red mud and fly ash were used in this investigation. The reformed gas from the catalytic fuel reformer was condensed using condenser and the sample was analyzed. Characteristics of the diesel like fuel, such as density, flash point, fire point, viscosity, calorific value were tested and found to be close to that of the diesel fuel. Red mud and fly ash were used as catalysts. Based on their individual properties both the catalysts were efficiently utilized to convert the WEO into diesel like fuel. The GC-MS results revealed that the heavier hydrocarbon presents in the WEO was cracked into light hydrocarbon because of the catalysts WEORM, WEOFA and which is similar to that of diesel fuel. FT-IR results confirmed that most of the hydrocarbons found in the WEORM and WEOFA were alkanes and thus a potential to be used as alternate fuel in diesel engine anyway further experimental investigation has to be carried out in the engine to performance, emission and combustion characteristics of the engine.

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