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Performance and Emissions Characterstics of Diesel Engine Fueled With Tyre Pyrolysis Oil&Diesel Blends with Additives

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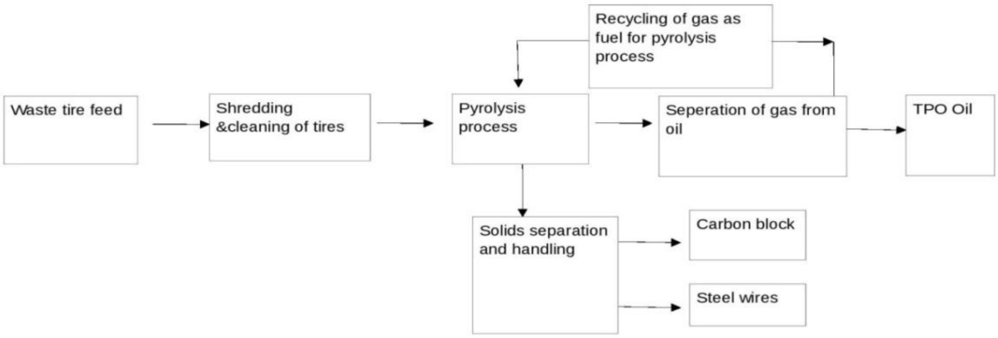
ABSTRACT: Due to the scarcity of conventional fuels and the crude oil, the price was going up day to day and there will be no more conventional fuels in future and also increasing the environmental pollution by the usage of crude oils, there is a need for the search of alternative fuel sources for the automobile applications. Therefore in the present investigation the oil taken is the tyre pyrolysis oil which was obtained by the pyrolysis of the waste automobile tyres.In the initial stage the test were conducted on four stroke single cylinder diesel engine by using diesel and base line data was generated. Further in the second stage experimental investigations were carried out on the same engine with same operating parameters by using the tyre pyrolysis oil blended with diesel in different proportions such as T10, T20 and T30 to find out the performance parameters and emissions. This work presents the experimental investigation carried on four stroke single cylinder diesel engine with Ethanol and Ethyl Hexyl Nitrate(EHN) as additives to the diesel-biodiesel blends.Ethanol was added as 5% and 10% by volume to the diesel-biodiesel blends and Ethyl Hexyl Nitrate(EHN) was added as 0.5% and 1% to the diesel-biodiesel blends.It was observed that the Brake Thermal Efficiency(BTE) increases in proportion to the blend percentage.The CO,HC and NOx emissions are decreased when compared to neat diesel.
Keywords: Tyre Pyrolysis oil,Ethanol,Ethyl Hexyl Nitrate(EHN),Emission characteristics.

I. INTRODUCTION

Biodiesel is an alternative fuel for diesel, every year in United State 280 millions tyres are being dumped in the landfills, which become an unacceptable solution hence the tyre pyrolysis oli is produed which can used in a useful way. Not only in United state all over the world there is an increase in waste tyres, so scrap tyres are used in the form of pyrolysis tyre oil which is used as a blend with diesel oil, which increases the-efficiency of the engine.The purpose of this work is to compare used tyre pyrolysis oil blends with conventional diesel fuel when fueled in a diesel engine. Before this there is need for survey on various alternate fuels used in diesel engines by various researchers. S.Murugan et al [1] carried out to evaluate the performance and emission characteristics of a single cylinder direct injection diesel engine fuelled by 10, 30 and 50 percent blends of Tyre pyrolysis oil (TPO) with diesel fuel (DF).Results showed that the brake thermal efficiency of the engine fuelled by TPO-DF blends increased with increase inblend concentration and higher than Diesel. NOx, HC, CO and Smoke emissions were found to be higher at higher loads due to high aromatic content and longerignition delay. M. Pugazhvadivu et al [2] used mahua oil as an alternative fixel for diesel engine. Roy et al.conducted experiments on the recycling of scrap tyres to oil and carbon black by vacuum pyrolysis.In this work a step-by-step approach has been used,from bench-scale system, to a process development unit and finally a pilot plant, to experiment and develop vacuum pyrolysis of used tyres.It was reported that the yield is 55% oil,25% carbon black,9% steel,5% fiber and 6% gas.The maximum recovery of oil is obtained at 415 deg.C below an absolute pressure of 2KPa.The specific gravity of this was 0.95 and its gross heating value was 43 MJ/Kg and total sulphar content about 0.8%.It was rich in benzyl and other petrochemical components..The engine performance improved and smoke, CO and HC emissions decreased while the engine was running with preheated mahua oil. A marginal increase in NOx emission was noted. M. Mani et al [10] conducted performance test on diesel engine by using waste plastic oil as alternate fiiel. The experimentalresults have showed stable performance with brake "thermal efficiency similar to that of diesel. Carbon dioxide and unburned hydrocarbons were marginally higher than that of the diesel baseline.The toxic gas CO emission of waste plastic oil was higher than diesel. Smoke reduced by about 40% to 50% using waste plastic oil at all loads.From the literature it is concluded that alternate fuels can be used as substitute for diesel by evaluating its properties and blending them with diesel in small proportions can improved performance parameters and reduce emissions without modifying the engine design.

II. PREPARATION OF TYRE PYROLYSIS OIL



Initially an automobile tyre was cut into a number of pieces and the bead, steel wires and fabrics were removed. Thick rubber at the periphery of the tyre was alone made into small chips.The tyre chips were washed, dried and fed in to a mild steel pyrolysis reactor unit. The pyrolysis reactor used was a full insulated cylindrical chamber of inner diameter 110 mm and outer diameter 115 mm and height 300 mm. Vacuum was created in the pyrolysis reactor and then externally heated by means of 1.5 kW heaters. The process was carried out between 450°C and 650°C in the reactor for 2 hours and 30 minutes.

The products of pyrolysis in the form of vapour were sent to a water cooled condenser and the condensed liquid was collected as a fuel. The non condensable gases were let out to atmosphere. The TPO collected was crude in nature. For an output of 1 kg of TPO about 2.09 kg of waste tyres feedstock was required. The product yields from the process are Tyre Pyrolysis Oil (50 %), Pyro gas (40 %) and char (l0 %). The heat energy required to convert the waste tyres into the products was around 7.8 MJ/kg. The residence time of the pyrolysis process was 90 minutes. TPO was filtered by fabric filter and again filtered by micron filter to remove impurities, dust, low and high volatile fractions of hydrocarbons.

III. PROPERTIES OF THE TYRE PYROLYSIS OIL

The properties of TPO were found in the fuels laboratory, results obtained are shown in Table .

Heating value (kJ/kg)	**42500**	**42580**
Sulphur	**1.2%**	**0.06%**
Carbon residue (% by weight)	**<0.35**	**0.11**
Density (g/cc)	**0.840**	**0.843**
Kinematic Viscosity(cSt) at 40°C	**3.5**	**3.2**

IV. EXPERIMENTAL SETUP

The experimental setup shown in figure is a single cylinder four stroke naturally aspirated diesel engine.

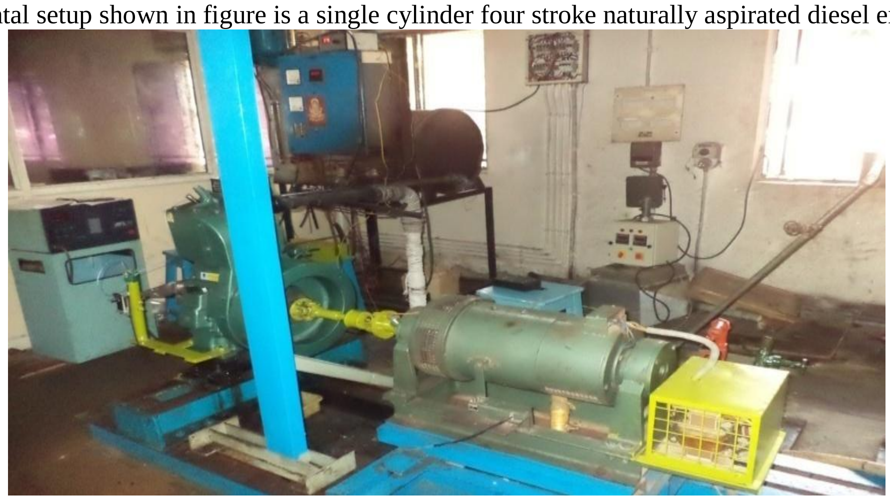


Figure 4.1: Engine Test Rig

The setup is provided with necessary instruments like Rope brake dynamometer, Smoke meter(Netel's-NPM-DSM),Gas analyzer(Netel's-NPM-MGA-2),etc.,for performance and emission analysis. The Specifications of the test engine is shown in given below.

IV.1. Specifications Of The Engine:

Type of Engine	Four stroke single cylinder vertical air cooled diesel engine
Rated power	4.4kw
Rated speed	1500 rpm
Bore dia	87.5 mm
Stroke length	100 mm
Compression ratio	17.5

V. RESULTS AND DISCUSSION

The performance and emission characteristics of a high speed diesel engine at various loads from no load to full load fueled with tyre pyrolysis oil and its diesel blends with additives like ethanol and ethyl hexyl nitrate are discussed below as per the results obtained.

V.1. Specific Fuel Consumption (SFC):

The variation of brake specific fuel consumption with brake power is shown in fig.1.the plot it is reveals that as the the load increases the fuel consumption decreases. At full load condition the BSFC obtained are 0.36kg/kw-hr, 0.32 kg/kw-hr,0. 34kg/kw-hr ,0.32kg/kw-hr ,034kg/kw-hr,0.2966kg/kw -hr and 0.32kg/kw-hr for fuels of diesel,TP10,TP20,TP30 ,TPE 10,TPE 20 &TPE30 respectively. The BSFC of tyre oil blend TPE20 decreased when compared to the diesel at full load condition.

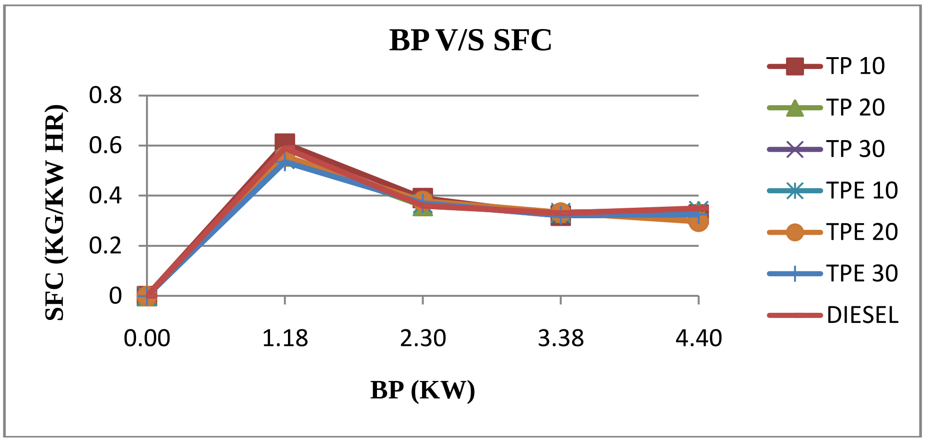


Fig:5.1. Variation of specific Fuel Consumption with brake power

V.2. Brake Thermal Efficiency(BTE):

The variation of brake thermal efficiency with brake power is shown in fig. 2.from the the plot it is observed that as the the load increases the brake thermal efficiency increases. At full load condition the brake thermal efficiency obtained are 23%, 26.07%,24.88%,26.06%,24.88%,27.56% and 26.06% for fuels of diesel,TP10,TP20,TP30 ,TPE 10,TPE 20 &TPE30 respectively. The brake thermal efficiency of tyre oil blend TPE20 increased when compared to the diesel at full load condition.

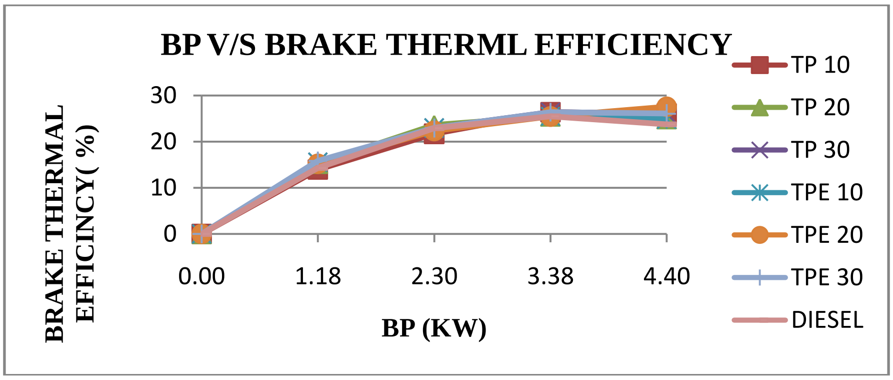


Fig:5.2. Variation of Brake Thermal Efficiency with brake power

V.3. Indicated Power(IP):

The variation of indicated power with brake power is shown in fig.3.the plot it is reveals that as the the load increases the indicated power decreases. At full load condition the indicated power obtained are

7.1kw,6.18 kw,6.36 klw,6.14 kw 5.96 kw,5.78 kw, and 5.97 kw for fuels of diesel,TP10,TP20,TP30 ,TPE 10,TPE 20 &TPE30 respectively. The indicated power of tyre oil blend TPE20 decreased when compared to the diesel at full load condition.

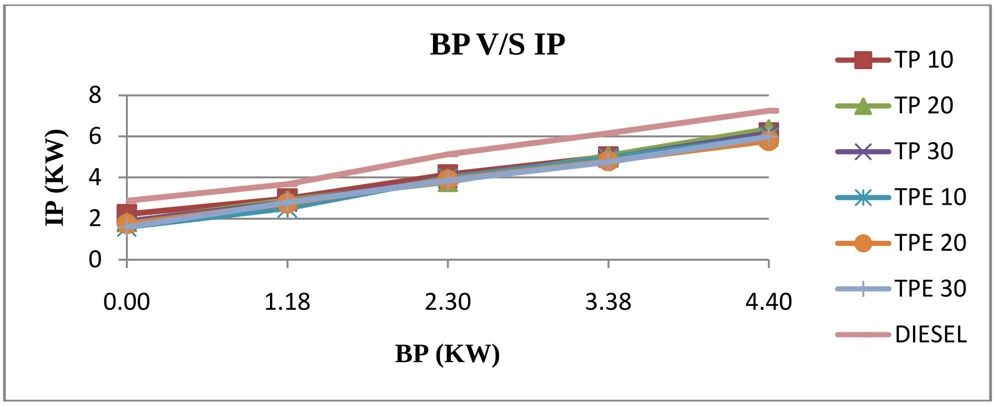


Fig:5.3. Variation of Indicated Power with brake power

5.4. Mechanical Efficiency:

The variation of mechanical efficiency with brake power is shown in fig.4.the plot it is reveals that as the the load increases the mechanical efficiency increases. At full load condition the mechanical efficiency obtained are 60.8%,71.08%,69.14%,71.53%,73.75%,74.01%and 73.55%.for fuels of diesel,TP10,TP20,TP30 ,TPE 10,TPE 20 &TPE30 respectively. The mechanical efficiency of tyre oil blend TPE20 increased when compared to the diesel at full load condition.

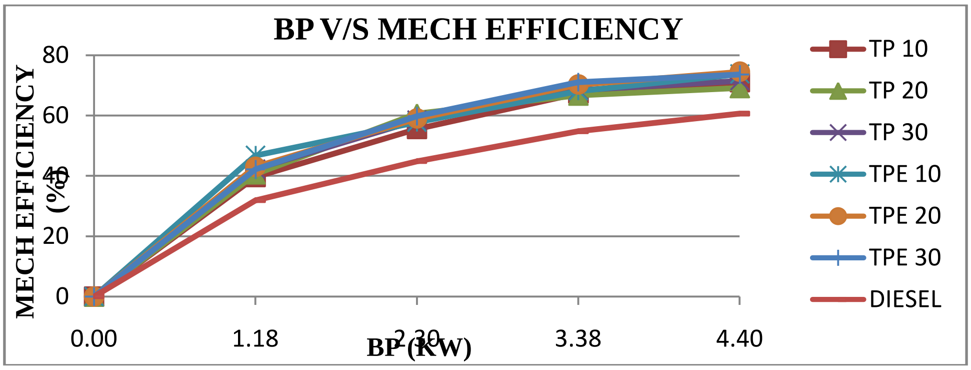


Fig:5.4. Variation of Mechanical Efficiency with brake power

5.5. Carbon Monoxide (CO):

The variation of CO emission with brake power is shown in fig.5.the plot it is reveals that as the the load increases the CO emission decreases. At full load condition the Co emissions obtained are 0.05%,0.038%,0.039%,0.051%,0.049%,0.03% and 0.048% for fuels of dieselTP10,TP20,TP30 ,TPE 10,TPE 20 &TPE30 respectively. The Co emission of tyre oil blend TPE20 decreased when compared to the other diesel at full load condition.

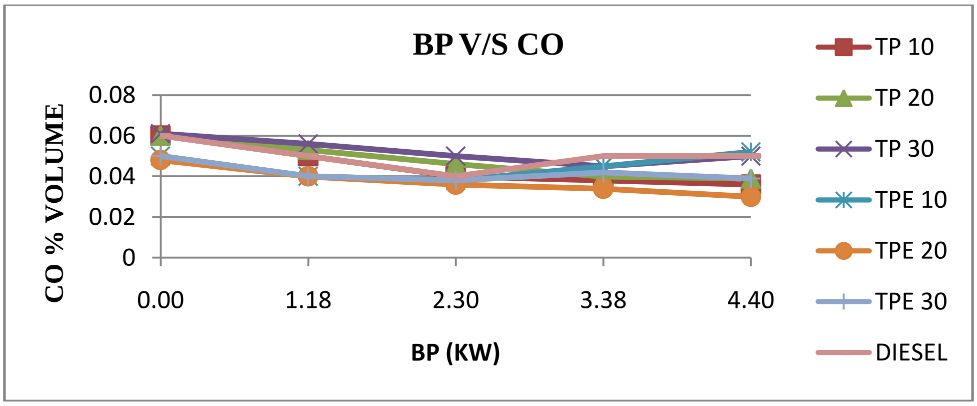


Fig:5.5. Variation of Carbon Monoxide with brake power

5.6. Unburned Hydrocarbon (HC):

The variation of HC emission with brake power is shown in fig.6.the plot it is reveals that as the the load increases the HC emission decreases. At full load condition the HC emissions obtained are 47ppm, 43ppm,38ppm, 36ppm,35ppm, 22ppm and 31ppm, for fuels of diesel,TP10,TP20,TP30 ,TPE 10,TPE 20 &TPE30 respectively. The HC emission of tyre oil blend TPE20 decreased when compared to the diesel at full load condition.

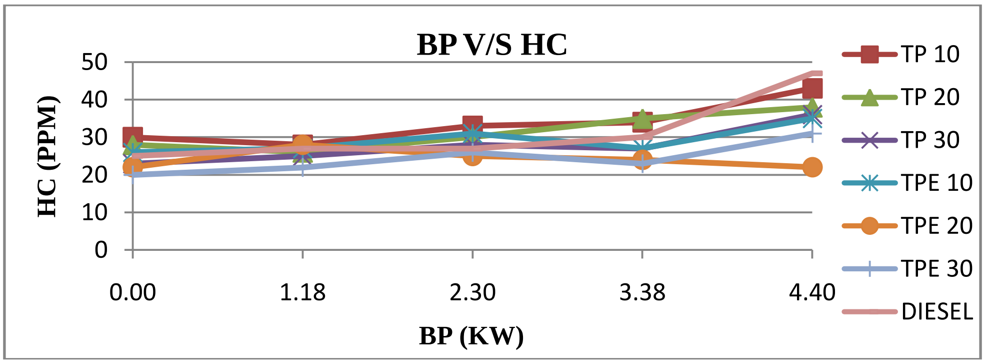


Fig:5.6. Variation of Unburned Hydrocarbon with brake power

5.7. Co2 Emission(CO2):

The variation of CO2 emission with brake power is shown in fig.6.the plot it is reveals that as the the load increases the CO2 emission decreases. At full load condition the CO2 emissions obtained are: 7.8%,8.2%,7.9%,8%,7.8%,7.5%,and 7.7%, for fuels of diesel,TP10,TP20,TP30 ,TPE 10,TPE 20 &TPE30 respectively. The CO2 emission of tyre oil blend TPE20 decreased when compared to the diesel at full load condition

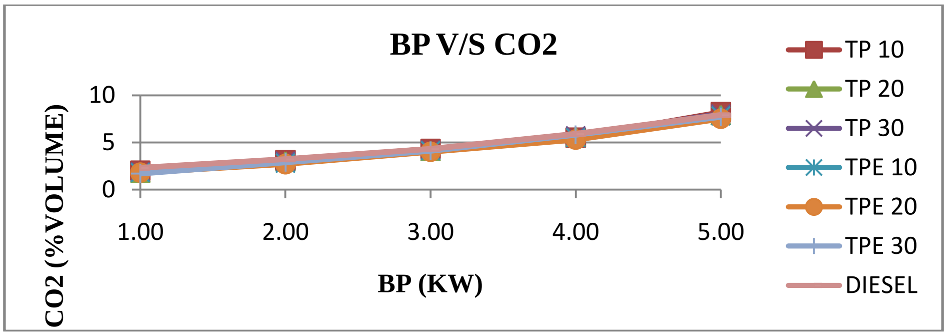


Fig:5.7. Variation of carbon dioxide with brake power

5.8. OXIDES OF NITROGEN (NOx):

The variation of NOx emission with brake power is shown in fig.6.the plot it is reveals that as the the load increases the NOx emission decreases. At full load condition the NOx emissions obtained are : 680ppm,782ppm,743ppm,732ppm,725ppm,678ppm,692ppm, for fuels of diesel,TP10,TP20,TP30 ,TPE 10,TPE 20 &TPE30 respectively. The NOx emission of tyre oil blend TPE20 decreased when compared to the other blends at full load condition

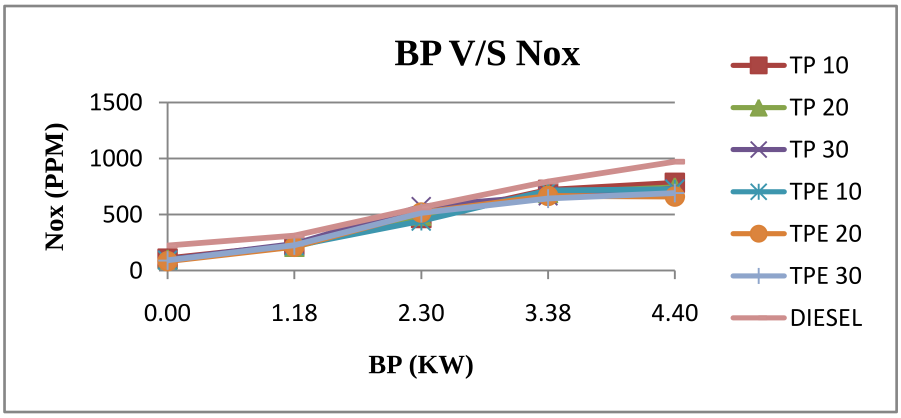


Fig: 5.8.Variation of oxides of nitrogen with brake power

VI. CONCLUSIONS

The conclusions derived from present experimental investigations to evaluate performance and emission characteristics on four stroke single cylinder diesel engine fueled with diesel TPOblends with Ethanol and EHN as additives are summarized as follows.

1. Brake thermal efficiency increased with all blends when compared to the conventional diesel fuel.
2. The Brake specific fuel consumption is decreased with the blends when compared to diesel.
3. CO,CO2 and HC emissions are decreased significantly with the blends when compared with diesel.
4. From the above analysis the blend TPE 20 shows the better performance compared to other blends(TP 10,TP 20,TP 30,TPE 10&TPE 30) and diesel.

NOMENCLATURE

B.P	Brake Power
BSFC	Brake Specific Fuel Consumption
BTH	Brake Thermal Efficiency
CO	Carbon Monoxide
HC	Unburned Hydro Carbons
NOx	Oxides Of Nitrogen
ppm	parts per million
TP 10	TYRE PYROLYSIS OIL 10%,ETHANOL 5%,EHN 0.5%,DIESEL 84.5%
TP 20	TYRE PYROLYSIS OIL 20%,ETHANOL 5%,EHN 0.5%,DIESEL 74.5%
TP 30	TYRE PYROLYSIS OIL 30%,ETHANOL 5%,EHN 0.5%,DIESEL 64.5%
TPE 10	TYRE PYROLYSIS OIL 10%,ETHANOL 10%,EHN 1%,DIESEL 79%
TPE 20	TYRE PYROLYSIS OIL 20%,ETHANOL 10%,EHN 1%,DIESEL 69%
TPE 30	TYRE PYROLYSIS OIL 30%,ETHANOL 10%,EHN 1%,DIESEL 59%
EHN	Ethyl Hexyl Nitrate.

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