

Gasoline and Diesel Synthesis from Waste Lubricating Oil: A Kinetic Approach

¹N. B. Selukar, ²S. M. Wagh

¹Petrochemical Technology Department, U.D.C.T., Sant Gadge Baba Amravati University, Amravati, M.S. (India)

²Department of Chemical Technology, Laxminarayan Institute of Technology, R.T.M. Nagpur University, Nagpur, M.S. (India)

ABSTRACT: Waste lubricating oil arises wherever work is carried out with lubricating oil and where it is put to use for a particular purpose. Waste lubricating oil should be collected and reused in order to decrease detrimental effects on environment, and underground and surface waters, since it pollutes the atmospheric air as a result of burning and has adverse effects on living organisms. One litre of waste engine oil discharge to environment makes 8 lakh tons of water unusable, and more than 50 lakh tons of clean water undrinkable. Conversion of the waste lubricating oil into fuel and utilization of fuel product has positive effect on environment and atmospheric air, and also has economical balance.

A study of thermal treatment to waste lubricating oil has been carried out to obtain gasoline and diesel like fuel. The effect of temperature on quality and quantity of product fuel has been also studied.

Keywords: Fuel form of waste oil, Kinetics of pyrolysis, Lubricating oil, Pyrolysis of waste oil, Waste lubricating oil.

I. INTRODUCTION

^{1,2,3} Lubricating oils are prepared by blending different viscosity-based oils with suitable proportion of additives. Base oils are either derived from crude oil or synthetic material manufactured by chemical processes. Recycling of used lubricating oil is an intelligent option for any country, more so for India, as it would conserve our natural resources as well as foreign exchange. Mineral waste lubricating oil sources, particularly engine oils have attracted much attention as an alternative energy source. Conversion of the waste lubricating into fuel by using pyrolysis technique has positive effects on environment and atmospheric air, and also has economical value.

II. MATERIALS AND METHODS

^{4,5,6,7} The aim of this study is to obtain fuel from waste lubricating oils by pyrolysis technique. In this study waste lubricating oil were pretreated to remove contaminants. Then this waste oil samples were heated in the reactor at high temperature. This leads to convert waste oil into fuel. The product obtained was subjected to further fractionation to obtain gasoline i.e. petrol and diesel like fuel. After this process, typical characteristics of these fuels, such as specific gravity, viscosity, flash point, heating value, distillation characteristics were tested.

In order to carry out the work, following techniques were used:

1. Selection of feed, i.e. waste oil;
2. Filtration of waste oil;
3. Characterization of waste oil;
4. Water removals from waste oil, by dehydration of waste lube oil;
5. Characterization of dehydrated oil;
6. Selection of reactor for dissociation of waste oil or assembly used for dissociation;
7. Pyrolysis of waste oil;
8. Characterization of crack product;
9. Fractionation of crack product to petrol and diesel;
10. Characterization of these fractions.

The pyrolysis of waste oil has been carried out at three different temperatures 430°C, 445°C and 460°C, to study the effect of temperature on the product quality and quantity. The liquid product thus obtained was further subjected to fractionation to obtain gasoline and diesel like fractions.

III. RESULTS AND DISCUSSION

To study the effect of temperature on pyrolysis of waste oil, the various operating parameters used are as follows:

1.	Type of reactor	=	quartz / quartz / quartz
2.	Capacity of reactor	=	1000 ml / 1000 ml / 1000 ml
3.	Feed used	=	Used oil
4.	Volume of feed used	=	500 ml / 500 ml / 500 ml
5.	To avoid bumping, material used	=	Silica pieces
6.	Heating device	=	Electrical heater, 2 KW
7.	Heating / Temperature controlling Device	=	Demmerstate
8.	Demmerstate reading	=	220 V / 210 V / 200 V
9.	Feed temperature used for Dissociation	=	460 ⁰ C / 445 ⁰ C / 430 ⁰ C ($\pm 2^0$ C)
10.	Maximum temperature of feed reach	=	462 ⁰ C / 447 ⁰ C / 432 ⁰ C
11.	Minimum temperature of feed	=	458 ⁰ C / 443 ⁰ C / 428 ⁰ C
12.	The temperature at which first drop of liquid product appeared	=	398 ⁰ C / 395 ⁰ C / 391 ⁰ C
13.	Time required to reach first drop of liquid product	=	12 min. / 15 min. / 19.11 min.
14.	Total time required to reach the 75% recovery (380 ml)	=	42 min. / 48 min. / 61 min.
15.	Quantity of liquid product obtained	=	440 ml / 424 ml / 416 ml
16.	Quantity of vapor product obtained	=	0.78 gm / 0.22 gm / 0.218 gm
17.	Quantity of residue obtained	=	53 ml / 70.8 ml / 79.6 ml
18.	Total losses (vapors collected + losses) ml	=	7.0 ml / 5.2 ml / 4.4 ml

^{6,7}The liquid product obtained by pyrolysis of waste lubricating oil at three different temperatures are subjected to characterization as per IP/ASTM norms. The results obtained are as follows:

Sr. No.	Properties	Feed	Liquid product (430 ⁰ C)	Liquid product (445 ⁰ C)	Liquid product (460 ⁰ C)
1	Colour	Black	Dark brown	Brown	Brown
2	Specific gravity, 20 ⁰ C	0.93	0.86	0.834	0.831
3	API gravity	20.65	27.48	38.16	40.85
4	Density, 20 ⁰ C	0.9326	0.861	0.839	0.833
5	Viscosity, cst (38 ⁰ C)	42.2	8.15	7.372	5.9215
6	Flash point, ⁰ C	186	44	43	40
7	Aniline point, ⁰ C	85	74	72	70
8	Diesel index	38.2	45.41	61.66	64.54
9	Smoke point, mm	---	22	21	19
10	CCR, wt%	0.9	0.78	0.66	0.6
11	Acid value, mg of KOH/gm	0.26928	0.1122	0.12566	0.17952
12	Saponification value, mg of KOH/gm	7.96	10.659	10.88	11.22
13	Calorific value, KJ/gm	38.93	40.319	40.823	40.83
14	Copper corrosion test, 3 hours at 100 ⁰ C / For	Not worse than no. 1	Not worse than no. 1	Not worse than no. 1	Not worse than no. 1

	product 50°C				
15	Pour point, °C	-6	Less than -20	Less than -20	Less than -20
16	Refractive index, 30°C	1.48345	1.4684	1.4672	1.4661
17	ASTM Distillation:				
	IBP, °C	---	87	64	60
	10%, °C	---	171	151	135
	20%, °C	---	219	211	200
	30%, °C	---	260	253	248
	40%, °C	---	295	290	285
	50%, °C	---	321	315	309
	60%, °C	---	345	343	338
	70%, °C	---	368	360	358
	80%, °C	---	---	---	386
	Total distillate%, (400°C)	---	73	75	88

^{8,9,10,11} Here in all three cases, it is observed that the product specific gravity is less than the feed, indicating that feed undergoes cracking to give product which is lighter in nature.

The lowest value of specific gravity is at temperature 460°C and higher value is at temperature 430°C. This is because the higher temperature gives more lighter product, again as cracking temperature increases, depth of cracking increases.

The order of increasing in viscosity and flash point is as 460°C < 445°C < 430°C indicating that the higher temperature cracking gives less viscosity and low flash point components. This is because as temperature increases the cracking increases which give more and more lighter product having low viscosity and low flash point.

The order of increasing in aniline point is as 460°C < 445°C < 430°C. As temperature increases, cracking increases which gives more aromatic HC. Because increases in cracking increases cyclisation and hydrogenation reaction. Hence increasing aromatic HC which have low aniline point. Again high molecular weight saturated HC having high aniline point, such high molecular weight HC are present in more quantity in low temperature i.e. 430°C product stream.

The order of increasing CCR value is 460°C < 445°C < 430°C. As lighter molecule gives low carbon residue than the heavier one. As high temperature cracking gives more lighter component than low temperature cracking but increase in CCR value is very less.

The order of increasing smoke point is as 460°C < 445°C < 430°C. This is indicating that the high temperature cracking gives more aromatic HC than the low temperature.

Acid value shows the trend of increase acid value and saponification value as cracking temperature increases. Here the acid value is less than 0.2 mg of KOH/gm of sample. But saponification value having very high value i.e. more than 10 mg of KOH/gm of sample.

IV. MATERIAL BALANCE

S. N.	Temperature → Sample ↓	430°C	445°C	460°C
		Quantity in ml		
1	Feed	500	500	500
2	Crack product	416	424	440
3	Residue	79.6	70.8	53.0
4	Gases in gm	0.218	0.22	0.78

5	Diesel	302 (72.6%)	306 (72.17%)	316 (71.82%)
6	Petrol	114 (27.40%)	118 (27.83%)	124 (28.18%)

V. CONCLUSION

From all these observations, it is confirm that when used oil is subjected to high temperature, i.e. more than 400⁰C, it undergoes cracking. Again depth of cracking increases as temperature increases. At high temperature cracking gives more and lighter product. Similarly high temperature gives products with more aromatic hydrocarbon.

Again high temperature pyrolysis gives comparatively less percent of diesel yield and high percentage of gasoline yield. At high temperature yield of residue is also less. This also indicates that pyrolysis temperature increases, the depth of cracking increase to yield more lighter hydrocarbons.

VI. ACKNOWLEDGEMENT

Authors are thankful to U.D.C.T., S.G.B. Amravati University, Amravati, M.S. (India) and Laxminarayan Institute of Technology (L.I.T.), R.T.M. Nagpur University, Nagpur, M.S. (India) for providing help to carry out this research work.

REFERENCES

1. OrhanArpa, RecepYumrutas, ZekiArgunhan, "Experimental investigation of the effects of diesel-like fuel obtained from waste lubrication oil on engine performance and exhaust emission", *Fuel Processing Technology*, vol. 91, page no. 1241 – 1249 (2010).
2. Su Shiung Lam, Alan D. Russell, ChernLeing Lee, Howard A. Chase, "Microwave-heated pyrolysis of waste automotive engine oil: Influence of operation parameters on the yield, composition, and fuel properties of pyrolysis oil" *Fuel*, vol. 92, page no. 327 – 339 (2012).
3. N. B. Selukar, "1-Butanol Solvent Treatment to Waste Lube Oil for Recycling", *Ultrachemistry*, vol. 7(3), 385 – 390 (2011).
4. OrhanArpa, RecepYumrutas, AyhanDemirbad, "Production of diesel-like fuel from waste engine oil by pyrolytic distillation", *Applied Energy*, vol. 87, page no. 122 – 127 (2010).
5. ThalladaBhaskara, MdAzharUddinb, AkinoriMutoa, YusakuSakataa, YojiOmurac, Kenji Kimurad, Yasuhisa Kawakamid, "Recycling of waste lubricant oil into chemical feedstock or fuel oil over supported iron oxide catalysts", *Fuel*, vol. 83, page no. 9 – 15 (2004).
6. "Standard method for analysis and testing of petroleum and related products", vol. I, published by 'The Institute of petroleum', London by John Wiley and Sons (1993).
7. "Standard method for analysis and testing of petroleum and related products", vol. II, published by 'The Institute of petroleum', London by John Wiley and Sons (1993).
8. V. P. Sukhanov, "Petroleum Processing", published by Mir Publisher, Moscow (1982).
9. B. K. Bhaskar Rao, "Modern Petroleum Refining Processes", Fourth edition, published by Oxford – IBH Publications (2002).
10. Dr. Ramprasad Yadav, "Petroleum Refining Technology", published by Khanna Publications, New Delhi, page no. 137 – 141 (2007).
11. C. V. Philip, J. A. Bullin, R. G. Anthiny, "GPC characterization for Assessing Compatibility Problems with Heavy fuel Oils", *Fuel Processing Technology*, page no. 11 to 14 (2006).