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Desulfurization of Pyrolysis Oil Obtained from Plastic Waste by Using Adsorption Method

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Abstract - *Aim of this study is desulfurization of product obtained from the pyrolysis of plastic waste. Oil obtained from the pyrolysis of plastic waste has same chemical properties as that of diesel but with high sulfur content. This work focuses on the desulfurization of pyrolytic oil obtained from plastic waste with the help of adsorption by using activated carbon as an adsorbent. Characterization of sulfur compound present in oil is done with the help of FTIR, GC-MS tests. Removal of sulfur is analyzed with the help of XRF. For the removal of sulfur optimization of adsorbent dose and bed height batch and column experimentation was carried in this study.*

Key Words: Activated carbon, Adsorption, Desulfurization, Mercaptan, Plastic waste oil, Thiol.

1.INTRODUCTION

Rapid industrialization and urbanization increases the demand of plastic which produced huge amount of plastic waste. The management and disposal of plastic waste have become major problem, non degradable nature of plastic make its disposal more difficult. The idea of waste to energy recovery is one of the promising techniques used for managing plastic waste. There are many methods available for energy recovery from plastic waste out of which pyrolysis process most promising method. Main drawback of this pyrolysis oil obtained from plastic to use as a fuel is its high viscosity and sulphur contain. This present study focuses on the desulfurization of pyrolysis oil obtained from the comingled plastic waste. In this study adsorptive desulfurization is used for removal of sulfur compound from the pyrolytic oil which can be reduced its sulfur content.

Now a days the energy crises and environmental degradation is the main problem. Around the globe, people are trying to replace gasoline and diesel fuel due to the impact of energy crises and hike in oil price. Plastic waste is the third largest contributor to municipal solid waste (MSW) after food and paper. High consumption of plastic leads to large mass disposal as plastic waste represents around 20–30% by volume and 10–12% by weight in MSW. The search for effective fuels from waste materials has experienced a great push. Increase in energy demand and depletion of conventional sources of energy like fossil fuel reservoirs, forces us to find and alternative fuel which is effective, cheaper and sustainable to decreases consumption of fossil fuel and degradation of environment.

Among the different fuels available, oil produced from pyrolysis of plastic waste has become the centre of attention because of its dual benefit, that of recovering energy from waste materials and reducing the environmental problems caused by waste plastic . However, the amount of sulphur compounds in the fuels obtained from pyrolysis of these waste materials is even higher than in the fuels distilled from crude oil. Moreover, the facilities for hydro-desulfurization are not usually present in companies who carry out pyrolysis processes.

There are desulfurization technologies that do not use hydrogen for catalytic decomposition of organo-sulphur compounds, and they are effective for removing high level of sulfur removal. These desulfurization technologies are studied for different types of fuel but not on fuel obtained from plastic waste. Using hydro-desulfurization technique for refining oil obtained from plastic waste make it less economical. For economical and efficient removal of sulfur from plastic's pryolytic oil alternative method has to study. This study is mainly focus on the adsorptive desulfurization method for removal or organo-sulfur compound from pyrolysis oil using activated carbon.

2. EXPERIMENTAL WORK

2.1 Materials

Commercially available activated carbon is used as an adsorbent and oil obtained from pyrolysis of plastic waste is used as an adsorbate for the adsorptive desulfurization. Oil used for the experimental work is collected from 'Part Pert Technologies' having following properties:

TABLE 1. PROPERTIES of PYROLYTIC OIL

Sr. No.	Property	Method Adopted for testing	Result
1.	Ash content	ASTM D482	Nil

2.	Carbon residue	ASTM D534	0.38% bt wt
3.	Flash point	ASTM D93	< 40^0c
4.	Kinematic viscosity	ASTM D445	2.235 cSt
5.	Cetane index	ASTM D4737	60
6.	Water content	Karl-fisher method	110 ppm
7.	Density	ASTM D1298	0.8015
8.	Sulfur content	ASTM D4294	0 m

2.2 Experimental method

The analytical method used to follow the decrease in sulfur content has been x- ray fluorescence spectroscopy (XRF) for the total sulfur content of the samples. To know the molecular structure of the sulfur compounds that gives total sulfur amount gas chromatography-mass spectroscopy and Fourier transform infrared spectroscopy (FTIR) were used. Presence of thiols, sulphones, sulfurous acid is detected from GC-MS, FTIR analysis which is shown in fig 1 and 2.

Batch study is done with 0.5 to 5 gm weight of commercially available activated carbon in 50 ml of pyrolytic oil for 6 hrs on mechanical stirrer. Also by varying pH, contact time batch wise adsorption study was carried out. After experimentation of adsorption samples are filtered for testing.
Column study was carried out by by varying bed height.

3. RESULT AND DISCUSSION

Among the desulfurization methods found in literature adsorptive desulfurization is easy and cost effective method. This method was chosen for this study as it gave good result for tire pyrolytic oil and diesel with similar sulfur content [4][8].

FTIR analysis before adsorption fig.1 shows sulfone stretch is shown at wave number 3449.26. Strong, medium C-H stretch is shown at 2924.80 and 2854.61 stretch. C=H, C triple bond is shown at 722 to 1639 stretch. FTIR analysis after adsorption fig. 2 shows O-H stretch at 2956 and strong medium C-H, C=H stretch at 2924 to 721wave number.

Fig-1 FTIR graph before adsorption.

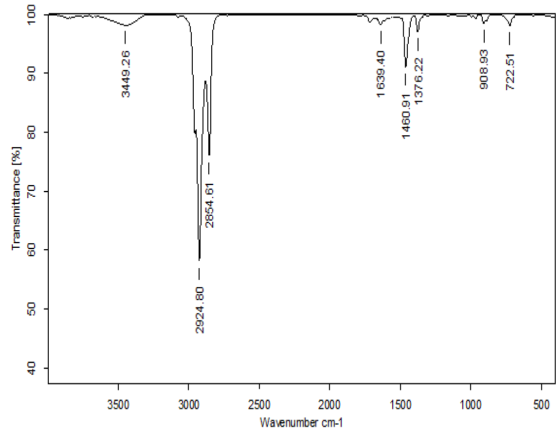
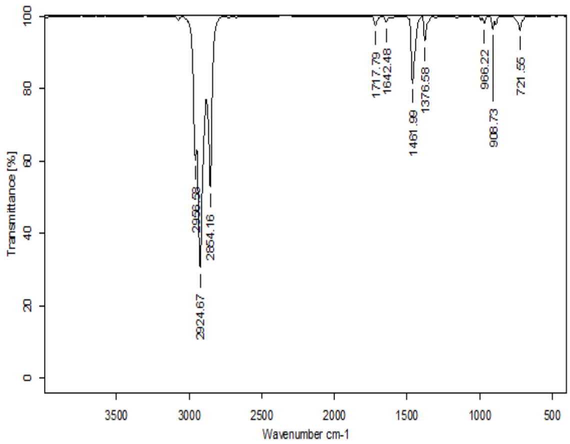


Fig-2 FTIR graph after adsorption



GC-MS analysis before adsorption gives the idea about molecular structure of sulfur present in pyrolytic oil. At retention time 16.22 presence of **thiol** group in the sample is detected. The library of GC-MS at this retention time presence of tert-hexadecanethiol is shown. Major peaks found in GC-MS are of long chain hydrocarbons, aldehyde, ketones.

GC-MS analysis after adsorption fig. 4 shows the presence of alcohol majorly along with the presence of long chain hydrocarbons. It indicates that oxidation of sulfur compound is takes place while adsorption process which helps for removal of sulfur compounds froms the sample.

XRF analysis before adsorption gives the sulfur content 540 ppm. After the experimentation of batch study with 5gm of activated carbon with stirring speed 200-250 rpm and contact time 6 hrs XRF test gives sulfur content 255 ppm. The effect of dosage on percentage removal of sulfur from plastic pyrolytic oil sample is as shown in following graph no

1. It is observed that with the increase in adsorbent dosage percent removal of sulfur also increases.

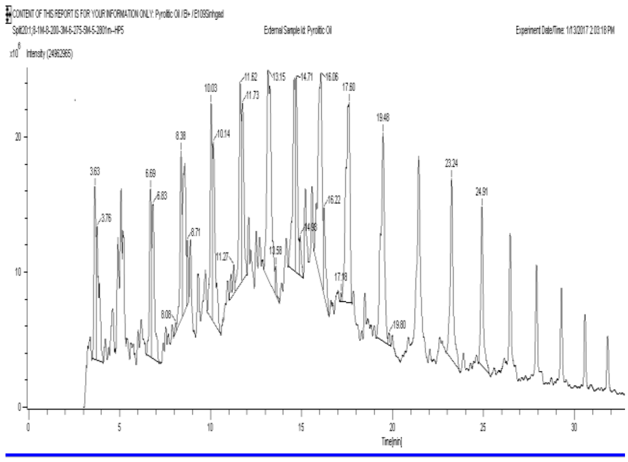


Fig-3. GC-MS graph before adsorption

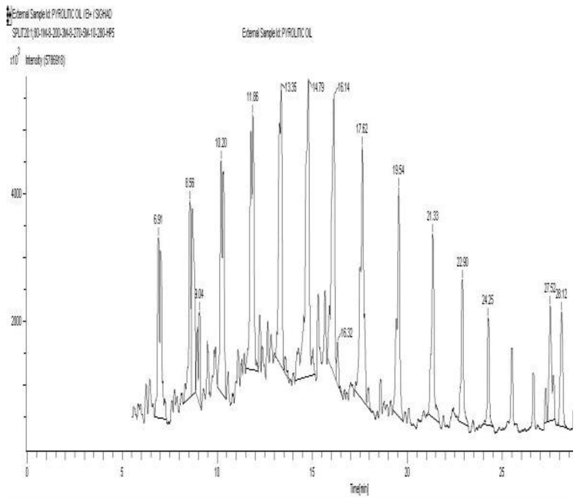
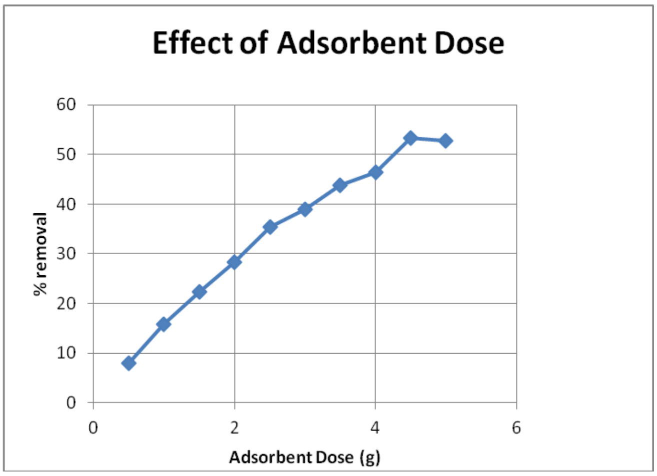
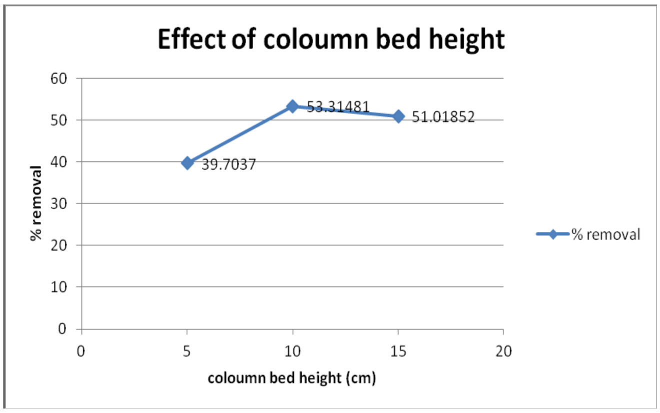


Fig- 4. GC-MS graph after adsorption.



Graph no 1. Relation between Adsorbent dose and percentage removal of sulfur

The effect of fixed column bed height viz 5cm, 10cm, 15cm, on percentage removal of sulfur from the plastic pyrolytic oil is as shown in graph no 2. It is observed that at 10 cm bed height percentage removal of sulfur is more.



Graph no 2. Relation between bed height and percentage removal of sulfur

4. CONCLUSION

From FTIR and GC-MS analysis presence of thiol and sulfone group of sulfur is confirmed in oil obtained from the pyrolysis of plastic waste. From the test result of after adsorption, adsorption of sulfur compound on activated carbon is confirmed. XRF results shows change in concentration of sulfur before and after adsorption hence from all the results it is concluded that adsorptive desulfurization is possible for pyrolysis oil which is obtained from plastic waste by using activated carbon as an adsorbent. The experimental data on batch study and column study shows that more than 50 % adsorption is possible with the help of commercially available activated carbon. To use plastic waste oil as a fuel we need to enhance the procedure by using various alteration and changes in concentration of adsorbent and nature of adsorbent

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REFERENCES

1) Moinuddin Sarker, Mohammad Mamunor Rashid "First Simple and Easy Process of Thermal Degrading Municipal Waste Plastics into Fuel Resource" *IOSR Journal of Engineering (IOSRJEN) , p-ISSN: 2278-8719,,* PP 38-49 ,September 2012

2) Bidhya Kunwar, H.N.Cheng, Sriram R Chandrashekaran, Brajendra K Sharma "Plastics to fuel: a review" *renewable and sutainable energy reviews,* 54,421–428 (2016)
3) Viswanath K. Kaimal , P. Vijayabalan " A study on synthesis of energy fuel from waste plastic and assessment" *waste management*(2016)(article is in press)
4) Isam A. H. Al Zubaidy, et,al. "Adsorption Process of Sulfur Removal from Diesel Oil Using Sorbent Materials" *Journal of Clean Energy Technologies, Vol. 1, No. 1, January 2013*
5) Pratibha Gawande, Dr. Jayant Kaware "Review of low cost adsorbents for desulfurization of liquid fuel".*IJSRSET vol. 2 issue 1.* Print ISSN : 2395-1990 (2016)
6) Muhammad Ishaq, et,al., "Adsorptive desulfurization of model oil using untreated, acid activated and magnetite nanoparticle loaded bentonite as adsorbent", *journal of Saudi chemical society*2015(article in press)
7) Adeyi, Abel Adekanmi et,al., " Comparative Analysis of Adsorptive Desulphurization of Crude Oil by Manganese Dioxide and Zinc Oxide" *Research Journal of Chemical Sciences* ISSN 2231-606X Vol. 2(8), 14-20, August (2012)
8) Ana-María Al-Lal, et.al., " Desulfurization of pyrolysis fuels obtained from waste: Lube oils, tires and plastics" *Fuel* 150 208–216(2015)
9) A.S.M Rezaun Nabi, "Purification of tire pyrolytic oil and its use in disel engine", IOSRJournal of engineering (ISORJEN), p:2278-8719, vol.4 , issue3 , march (2014)
10) Sandip V. Patil , et al., " Investigating role of sulphur specific carbon adsorbents in deep desulphurization" *Journal of Environmental Chemical Engineering* 2 1495–1505(2014)
11) Rashad Javadli ,Arno de Klerk " Desulfurization of heavy oil"*Appl Petrochem Res*earch *journal* 1:3–19(2012)
12) Prof.Gaurav.B.Daware et, al., "desulphurization of diesel by using low cost adsorbent" *International Journal of Innovative and Emerging Research in Engineering* Volume 2, Issue 6, 2015
13) M.S. Patil, et al., "Desulfurization of hydrocarbon liquid fuels by adsorption" *Journal of engineering research and studies* E-ISSN 0976-7916, vol. 2 ,81-98 march (2011)