China Petroleum Processing and Petrochemical Technology

Catalyst Research Volume 23, Issue 2, September 2023 Pp. 1172-1190

CONVERSION OF MEDICAL WASTE PLASTICS INTO LIQUID AND GASEOUS HYDROCARBON USING FLY ASH AS A CATALYST

D. Raja Kullayappa[1*], G. Karthikeyan[2], P. Premkumar[3], V. Elangkathir[4],

[1*]Research Scholar, [2,3] Associate Professor, [4] Research Fellow,

Department of Mechanical Engineering, FEAT, Annamalai University,

Annamalainagar-608002, Tamil Nadu

[1*] rajakullayappa326@gmail.com, [2] gkarthikeyanin@gmail.com, [3] ppklmeau@gmail.com,

[4] elangkathirvel1996@gmail.com.

Abstract

This research work implies that medical plastics waste can be transformed into liquid hydrocarbons by catalytic cracking process. The waste plastic used in this work are used syringes, saline bottle, facemask and plastic covers. Ash from power plant is used as catalyst. In this process the cat/pol ratio used is 0.1. Using IR spectra and elemental analysis the medical plastic wastes have been characterised based on the total weight percentage of carbon and hydrogen and the ratio of the weight percentage of carbon to that of hydrogen. Presence of C=C or C=O bond has been identified by the absorption in the region 1600 - 1700 cm-1 in the IR spectrum. During the degradation process, the temperature and time count of oil initiated and accomplished were tabulated. The weight of the product remaining in the reactor after degradation process was determined. During this process, the rate of production of liquid and gases were found. It was found that the conversion is 100% for mask and plastic covers, 85% for saline bottles and 65% for syringes. The yield of oil is more for mask and less for plastic covers. The evolution of gaseous hydrocarbon was also found. The hydrocarbon evolution was measured using the AVL gas analyser. From the result, it was found that the production rate of gaseous hydrocarbon is more for plastic cover and less for used plastic syringes The produced gas was burnt, and the temperature of the flame was recorded. The waste plastic Physical properties of the obtained oil were found and compared with sole fuel. The SEM & EDX spectrum was taken for the catalyst and the product remaining after degradation.

Keywords: Medical Plastic Cover, Syringe, Saline bottle, Mask, Catalytic Cracking Process, plastic oil.

INTRODUCTION:

Involvement of plastic product in medical field reduce its cost. The change from glass syringe and saline bottle to plastic reduce the cost of production. Due to this the weight of each material bringdown and waste due to breakage comes to an end. During covid-19 the mask saves many lives because of its affordable price. This is due to the production of mask from plastic material. Due to its affordably if the use of these produce got increased. Large in usage produce more accumulation. Annoying of proper disposable create environmental damage. Since all the plastic are from petroleum by product. A reverse mechanism can be used to convert the solid plastic into

Catalyst Research Volume 23, Issue 2, September 2023 Pp. 1172-1190

liquid petroleum compounds. The reverse mechanism is feasible by exploiting pyrolysis process. Many researchers are converting the waste plastic into liquid hydrocarbon. [1] have converted waste HDPE plastic into oil in two stage reactor using Y- zeolite with metals like Ni, Fe, Mo, Ga, Ru, and Co. They use 600 °C to pyrolysis the HDPE. They reported that by using two stage the yield of hydrocarbon compound increased in the liquid fuel. [2] Have converted the HDPE, LDPE & PP pellets into liquid fractions. They have produced 72% oil from LDPE at 390 °C. The oils produced from LDPE and HDPE had the physical properties nearest to diesel and the oil produced from PP had physical properties closer to gasoline.

[3] Have obtained liquid hydrocarbons from polymer mix containing PP, LDPE, & HDPE. They used MWW and MFI type zeolites as catalyst for cracking at 350 °C. They reported that oil produced using MWW catalyst, had properties closer to gasoline. [4] Have utilized the mixed medical waste plastic to produce oil in 40 min at a temperature of 773 °C. They reported that the yield of oil is 52% and high heating value of the oil is 41.32 MJ/ kg. [5] Have optimized the conditions for pyrolysis of PP and HDPE plastic using 7 and 3% natural zeolite. They reported that the yield of oil was 69.60 and 65.60 % for PP and HDPE plastics.

[6] Have reported that when the polymer catalyst ratio is 4:1 the yield of liquid hydrocarbon is more using Y- zeolite as catalyst. [7] Have converted the HDPE into liquid pyro oil at 330- 490 °C. they reported that time required for pyrolysis is 3 h. [8] Has used thermal cracking method to crack PP, LDPE, HDPE and its mixture into pyro oil. He used the temperature range of 400- 500 °C with 1:3 ratio of catalyst to polymer. He produced pyro oil with 88.5, 82, 82.5 & 81 % yield for PP, LDPE, HDPE and its mixture. [9] Have reviewed the mismanaged waste plastic of Africa into liquid hydrocarbon to run engine to produce electrical power. They reviewed the mismanaged waste plastic and produced 80% of oil yield with a calorific value of 44 MJ/kg and 6-7 % of gaseous products having a calorific value of 48 MJ/m^3. [10] Have converted the waste HDPE storage boxes into plastic crude. The physical proprieties of the plastic crude are similar to nature crude oil and gaseous product gets increased at low temperature using Y – Zeolite and $MgCO_3$ as catalysts. They report that the oil produced from HDPE plastics is having an ultra-low sulphur content.

[11] Have utilized the catalytic co- pyrolysis technique to convert the wastepaper and PVC into hydrogen rich syngas. They reported that PVC with 60% weight at 900 ^{0}C produce maximum hydrocarbon yield.

[12] Have done the co pyrolysis with medical waste from covid-19 and waste palm oil. They reported that using HLSM-5 catalysts the production of hydrocarbon is maximum.

[13] Have used the bench- scale reactor to transform the various kinds of plastics into liquid compounds. They utilize LDPE, LLDPE, HDPE, PP and polyolefin plastic. They reported that all the plastic gives 85% to 68 wt % of liquid outcome. [14] Have transformed the LDPE plastic into liquid hydrocarbon using silica-alumina catalysts which is derived from fly ash. [15] Transformed the HDPE plastic into liquid fuel by utilize the thermal cracking process. They reported that 69.335

of oil obtained at 500 °C during this process and find the calorific value as 41.5 MJ/kg. [16] Have transformed the LDPE in a pilot reactor into pyro oil. They use the temperature between of 550-650 °C for 2 h they used at charcoal as catalyst.

[17] Have converted the polypropylene waste into pyro oil in a batch reactor using sulfonated carbon as catalyst produce from sugarcane bagasse. They used different ratio of catalyst to polymer. They found that 1.5 ratio gives the highest liquid yield of 86.14% using a temperature of 420 °C.

[18] Used 200 grams of $MgCO_3$ as catalyst to degrade the 5 kg HDPE plastic and produced 92% liquid. [19] They used synthesized catalyst and obtained 75.6% of oil by degrading the HDPE plastic. [20] Have used HDPE plastic and converted it into liquid using $TiCl_3$ catalyst at a temperature of 400-430 °C. [21] Have converted the LDPE plastic into liquid hydrocarbon with can yield of by 80.2% using SA-l catalyst at 430 °C. [22] Have used LDPE plastic and obtained 83% oil using clay, saponite as catalyst.

[23] Have converted the waste mask used during covid-19 in a closed reactor into liquid oil using a reactor temperature of 400 °C for 1hr. they produce 75% of liquid fuel with waxy substance.

[24] Have utilized microwave heating to convert the various types of plastic into liquid. They use microwave absorber as carbon.

[25] Have converted the waste plastics into liquid hydrocarbon and utilized it to test the emission in Kirloskar AV -1 engine using biogas from cow dung as a source of heat to crack the waste plastic.[26] Have converted the packing covers into liquid hydrocarbon of 53.7% and produce biogas from food waste and utilizes it as a heating source in reactor.

[27] Have utilized fly ash to convert the single time used plastic into hydrocarbons.[28] Have done a comparative study on the reaction rate of red mud and fly ash in the degradation process of single time used plastic. They reported that fly ash produces oil yield of 51% when cat/poy is 0.05.

In this work the used plastic items from hospitals like syringe, saline bottle, mask and its plastic covers are converted into liquid hydrocarbon by using fly ash as catalyst. In this work biogas is used as a heating agent.

MATERIAL COLLECTIONS

The medical waste plastics were collected as per the Indian government norms. During the collection the collector was wearing mask, gloves and apron. Every half an hour, the collectors washed his hands with sanitizer.

Collection of covers

The covers were collected from the dustbin by wearing hand gloves. The collected covers were kept in sunlight for one day.

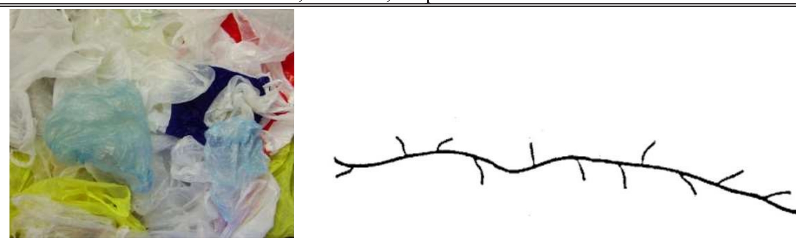


Figure of Plastic covers made up of LLDPE and its Chemical structure

Collection of mask

The used masks were collected from the hospital in a plastic drum. After the collection, the masks were kept in sunlight to remove the wetness present in the mask for one day. Then the masks were kept under UV light for one hour to defuse the microorganisms. Then the masks were cut into small pieces, using a hand scissor.

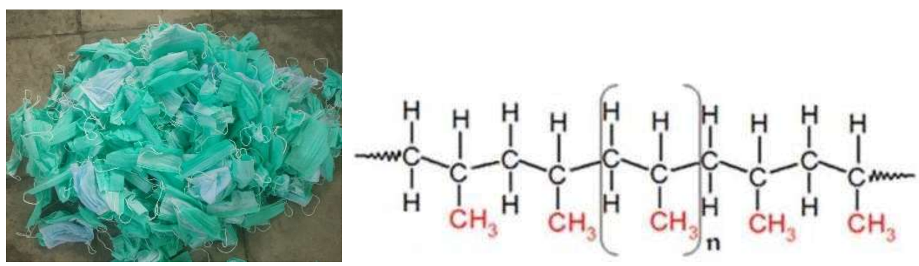


Figure of Mask made up of PP and its Chemical structure

Collection of saline bottles

During the collection of saline bottles, the needles and the tubes were removed and put in the medical hazardous waste dustbin. After that the top of the bottle was cut and the remaining liquid present in the bottle was poured in the medical hazardous waste, bin. Then this bottle is kept in sunlight for two days. Then sanitiser is sprayed on the Celine bottle and kept dry for one day. After that the bottles were cut into small pieces in a cutting machine of approximate size 1 cm^2, of area.

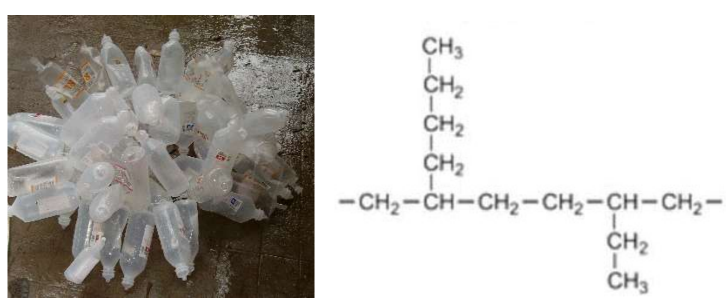


Figure of Saline bottle made up of LDPE and its Chemical structure

Collection of syringes

During the collection of syringes, the needles were removed carefully by wearing hard gloves. The needle with cover was thrown in the medical hazardous waste collecting bin. After that the syringes are made to suck the solution prepared by adding 300 ML of sanitiser with 1 L of water. The sucked water is pumped outside. This is used to clean the inner surface of the syringe. Then the syringes are kept in sunlight for one day to remove the moisture present inside the syringes. Then the syringes were cut in the cutter.

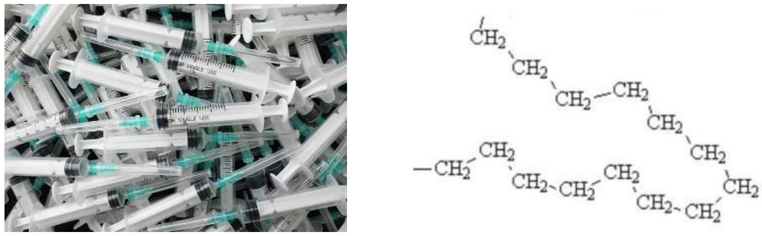


Figure of Syringe made up of HDPE and its Chemical structure

CHARACTERIZATION OF PLASTIC:

The characterization of medical plastic waste was done by FTIR, spectra and elemental analysis

Plastics are made up of organic polymers. Organic polymers are made by different methods. Polymerisation of alkenes like ethylene and propene will give polymers containing only carbon and hydrogen. When these polymers are degraded only simple aliphatic hydrocarbons will be obtained. Some alcohols may be formed due to aerial oxidation.

Some polymers are made from derivatives of alkenes such as vinyl chloride and methyl methacrylate. Such polymers will not give simple hydrocarbons on pyrolysis. Also, polystyrene, a polymer made up of styrene molecules, will give aromatic hydrocarbons on pyrolysis.

Some polymers are obtained by using two different monomers. For example. Polyamides are made by combining dicaboxylic acids and diamines. Polyesters are made by combining dicarboxylic acids and diols.

Plastics are made by using a single polymer or a mixture of two or more polymers. A plastic will give simple aliphatic hydrocarbons on pyrolysis only if it contains polyalkenes to a significant extent.

Therefore, any plastic should be characterised for its suitability for pyrolysis. This can be done by elemental analysis and IR spectra. The elemental analysis of medical waste plastics is recorded and tabulated in Table 1. The IR spectra are shown in Plate 1.

Table 1. Elemental analysis of medical waste plastics

Sl. No.	Weight [mg]	Name	N [%]	C [%]	H [%]	S [%]
1	10.3900	Plastic cover	0.21	70.41	10.28	0.130
2	5.0200	Mask	0.00	77.87	13.06	0.000
3	10.2300	Saline bottle	0.00	85.11	14.24	0.019
4	20.7600	Syringe	0.01	85.20	14.20	0.000

If a polymer is made up of simple alkenes the total weight percentage of carbon and hydrogen will be 100. In simple polyalkenes there will be two hydrogen atoms for each carbon atom and the ratio of weight percentage of carbon to that of hydrogen will be 6. Polystyrene is made up of styrene molecules. In this polymer there will be only one hydrogen atom for each carbon and the ratio of the weight percentage of carbon to that of hydrogen will be 12. However, the total weight percentage of carbon and hydrogen will be 100.

In polyethers some CH_2 units are replaced by oxygen atoms. In such polymers the total weight percentage of carbon and hydrogen will be significantly less than 100. However, these polymers contain two hydrogen atoms for each carbon and the ratio of weight percentage of carbon to that of hydrogen will be only 6.

Poly methyl methacrylate is made up of methyl methacrylate molecules. In methyl methacrylate there are five carbons and eight hydrogen atoms. Hence, the ratio of the weight percentage of carbon to that of hydrogen will be 7.5.

For the plastic covers used in this study the total weight percentage of carbon and hydrogen is only 80.69. The ratio of the weight percentage of carbon to that of hydrogen is found to be 6.85. These observations suggest that the plastic covers used in this study are mixtures of polyalkenes and poly methyl methacrylate. For masks used in the study the total weight percentage of carbon and hydrogen comes as 90.93 whereas the ratio of the weight percentage of carbon to that of hydrogen comes as 5.96. These observations suggest that the masks used in this study have been made by mixing polyalkenes and polyethers.

For syringe plastic and saline plastic used in this study the total weight percentage of carbon and hydrogen is close to 100. Also, the ratio of the weight percentage of carbon to that of hydrogen is close to 6 for both these plastics. These observations suggest that saline and syringe plastics are largely made up of polyalkenes.

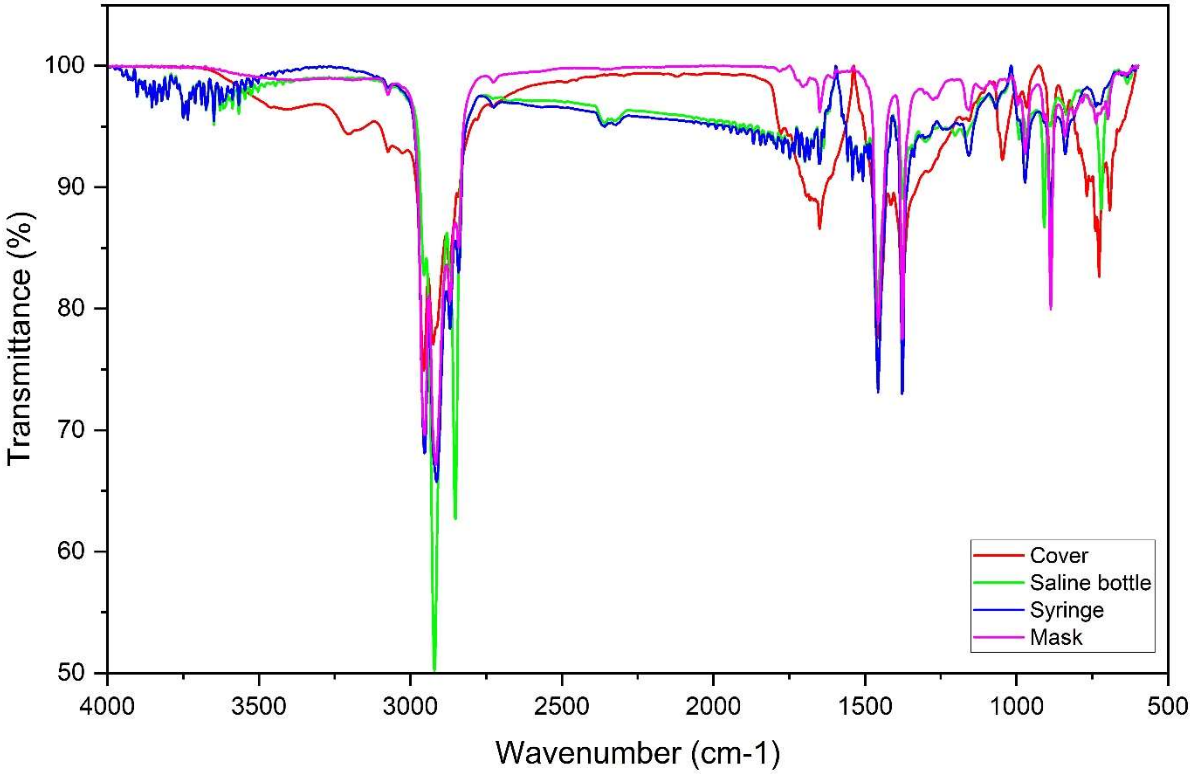


Plate .1 IR spectrum of medical waste plastics

In the IR spectrum of plastic covers there is a broad absorption band around 1650 cm-1. This is due to C=O stretching vibration. By elemental analysis it has been found that the plastic covers used in this study contain significant amounts of poly methyl methacrylate. This contains COOMe groups. The C=O group in the COOMe group is responsible for the absorption around 1650 cm-1. However, the other polymers used in this study do not show absorption in this region because they do not contain C=C or C=O bond.

EXPERIMENTAL SETUP

Reactor is a metallic closed container in cylindrical shape, provided with two opening at the top. A valve is fit in the first opening, the valve will open and close during the feeding of medical waste plastic into the reactor. Another opening is fit with a water cooled, condenser. The bottom of the reactor is fit with a biogas burner, where the biogas is supplied from a biogas plant. The side of the reactor is fitted with a hand hole to draw the remaining material after degradation. In the water-cooled condenser the cracked vapour is converted into liquid form. The uncondensed gas is analysed with AVL Di Gas analyser to analyse the evaluation of gaseous hydrocarbon release during the cracking process. The evolved gas is lighted and the flame temperature is recorded.

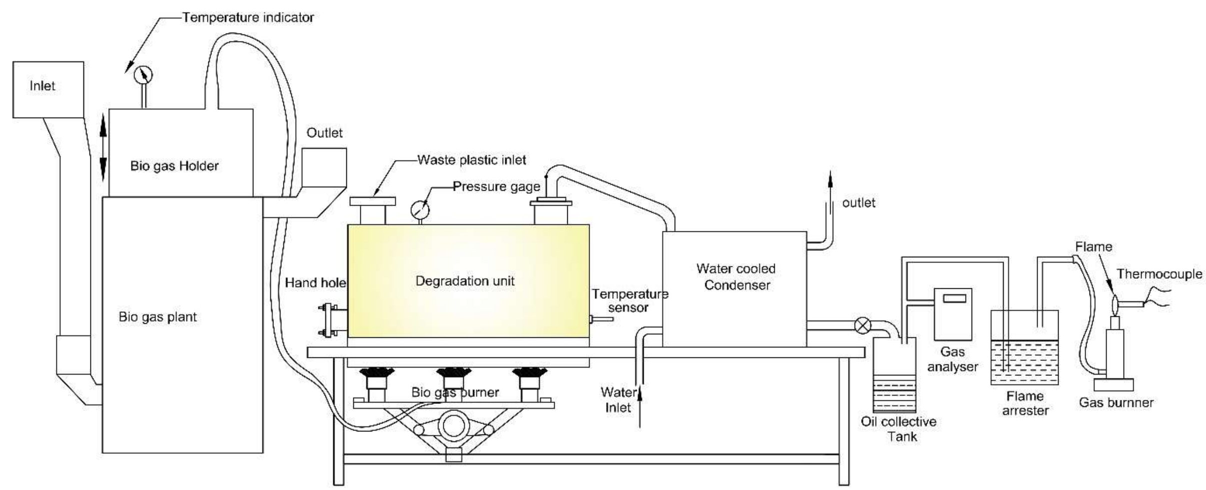


Fig. 1 Schematic diagram of bio gas fired waste plastic oil extraction plant

RESULTS AND DISCUSSION

Characterisation of plastics used in this study

Degradation of plastic cover

During the degradation process 1kg of plastic cover and 100 g catalyst were used. The variables are recorded by using this procedure. The mixture of catalyst polymer temperature was raised gradually. The oil was collected continuously. The mixture temperature inside the reactor was recorded for every 10 min. The volume of the liquid collected was noted with a time gap of 10 min. Also, after each 10 min interval, the rate of release of gaseous hydrocarbons was noted. The observed results for the degradation of plastic covers with cat/pol = 0.1 are shown in Table 2

Table 2. Results of monitoring the degradation of plastic cover using cat/pol = 0.10

Time mins	Temperature inside the reactor Mix (°C)	Amount of oil collected (ml)	Rate of release of Gaseous hydrocarbon (ppm)
0	34	-	-
10	54	-	-
20	98	-	910
30	118	-	1650
40	131	19	2030
50	156	24	3800
60	177	30	2350
70	196	38	1988
80	218	47	1220

90	231	52	906
100	242	66	710
110	259	82	498
120	267	91	320
130	295	55	202
140	310	33	154
150	344	-	102

From Table 2 it observed that no formation of liquid upto 30 min. After 40 min the oil collected was only 19 mL which is quite small. When the cat/pol mixture temperature is 131 °C the initiation of gas evolved gets started after 40 min. However, significant amount of gases are evolved after 20 min when the temperature is 98 °C. Up to150 min the formation of oil is nil and no gas evolution. Therefore, the degradation is complete at 310 °C. All experiments were conducted in a similar manner. The temperature at which the oil initiated commenced is denoted as T_i. Temperature at which the oil formation accomplished is denoted asT_f.

After the degradation the product remaining in the reactor was collected and weight of the product was found. The weight of the product remaining in the reactor is equal to the weight of the catalyst. This shows that all the medical plastic covers are converted into hydrocarbon.

Solid, liquid and gases products occurs during polymer degradation. The solid particles remains in the reactor may be in form of unconverted plastics transformed into coke are carbonaceous product after it gets cooled.

Yield calculation:

The product produced during degradation are in the form of solid, liquid and gaseous products are indicated as Y_S, Y_L andY_g, respectively. W_P indicates the weight of the plastics material. W_c Indicates the weight of the catalyst. W_s indicates the weight of unchanged polymer.

Then, $W_S = W_P - W_c$

W_L indicates the weight of the liquid product produced during degradation product.

All the weights are in grams

The yields of solid, liquid and gaseous product can be found by using below equation

$$Y_S = \frac{W_s}{1000} \times 100 \qquad (\%)$$

$$Y_L = \frac{W_L}{1000} \times 100 \qquad (\%)$$

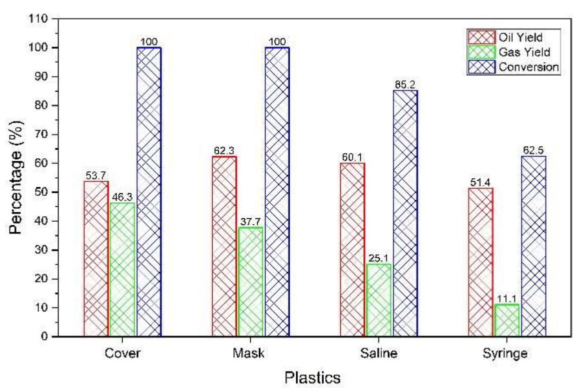
$$Y_g = (100 - Y_s - Y_L) \qquad (\%)$$

For one run the values of Y_S , Y_L and Y_g were determined for each case.

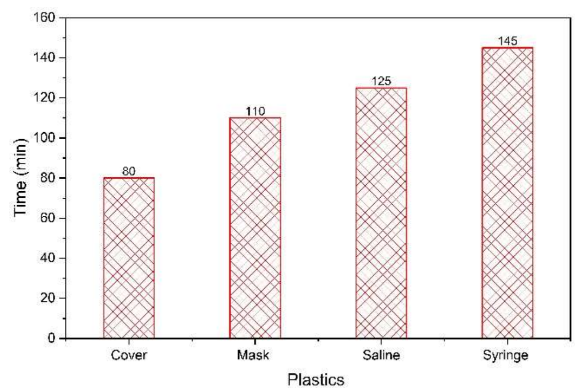
Table. 3 The values of T_i, T_f, Ys, Y_L, Y_g

Si no	Plastics	Ti ^{0}C	Tf ^{0}C	YS %	YL %	Yg %
1.	Cover	180	342	0	53.7	46.3
2.	Mask	188	402	0	62.3	37.7
3.	Saline	227	420	14.8	60.1	25.1
4.	Syringe	250	455	37.5	51.4	11.1

The solid will contain unchanged plastic, solid hydrocarbons and other carbonaceous matter



Oil, gas yield and rate of conversion



Degradation time for various medical plastics

Fig. 2 oil, gas yield and rate of conversion & Degradation time for various medical plastics

Degradation of waste cover

Most of the covers for covering medical items are made up of low linear density polyethylene and LDPE.

From the Fig. 2 it is seen that for the during the degradation process the temperature of oil and initiated and accomplish was found to be 180 & 342 °C. The time for complete degradation took 120 mins. During this process, the oil produced, and gas evaluation is 53.7 & 46.3 %. After the degradation process, it was found that complete conversion of plastic occurs into liquid and gaseous hydrocarbon. During the study, it was found that more amount of gases hydrocarbon was formed. This is because of the low molecular weight of the plastic nature and catalyst to polymer ratio is more.

Degradation of mask

During the degradation of mask, the yields of oil and gaseous production were found to be 62.3 and 37.7% respectively. The time for degradation is 140 mins. The rate of converted from mask

Catalyst Research Volume 23, Issue 2, September 2023 Pp. 1172-1190

to oil and gaseous is 100%. The production of liquid hydrocarbon was high for mask when match up with other plastics because of its molecular weight and correct composition of catalyst used.

Degradation of saline bottle

The production of oil occur and accomplished at 227 – 420 °C. The yield of gaseous and oil products were found to be 60.1 & 25.1%. The production of oil yield is more when compared to the gas. Even though the oil production is more the total yield of oil and gas is only 85.2%. This is due to be higher molecular mass of the input product. This shows that the cat/pol ratio is not sufficient. The conversion may be 100% if the cat/pol ratio gets increased.

Degradation of syringe

During the degradation of syringe, the oil and gas obtained is very low of 51.4 and 11.1 %. The temperature of degradation occurs at a range between 250 to 455 °C. The rate of conversion very low when compare to other plastic. This is due to the high molecular mass of plastic, which is made up of HDPE. Due to this, the plastic may not be able to crack at this temperature range and cat/pol ratio. More oil and gas can be obtained by increasing cat/pol ratio.

Study of gaseous product from medical waste plastic

The uncondensed gaseous product evolved during cracking process was evaluated using AVL Di-gas analyser. The gas produced was burnt and the temperature of the flame was measured.

Table 4: Gas evaluation and flame temperature observed during the high evaluation period

Plastics	Maximum rate of evaluation (ppm)	Maximum Temperature (°C)
Cover	3800	798
Mask	2750	690
saline bottle	1850	580
Syringe	1280	542

From the Fig. 3 it is observed that at a particular time the rate at which gaseous product evolved higher. The flame temperature is recorded and tabulated in Table 3 during the high evolution rate of gaseous hydrocarbons.

China Petroleum Processing and Petrochemical Technology
Catalyst Research Volume 23, Issue 2, September 2023 Pp. 1172-1190

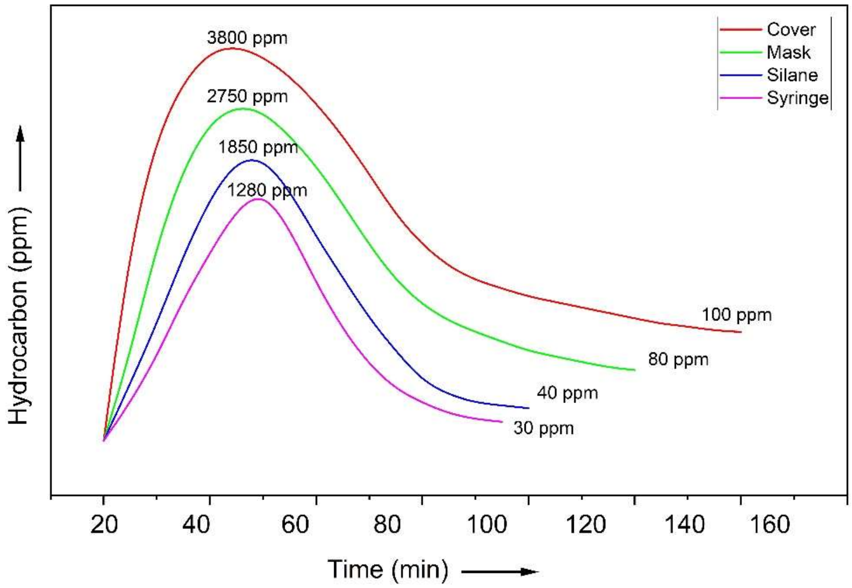


Fig 3. Evolution of gaseous product

Gaseous products should contain C_1–C_4 hydrocarbons such as methane, ethane, ethylene, propane, propene etc., which can be formed by the degradation at the terminal end of the polymer. The breaking of the terminal CH_2–CH_3 bond will give methane. The breaking of the next bond CH_2–CH_2CH_3 will give ethylene or ethane. Thus it seems that the terminal C–C bonds can be easily broken than the C–C bonds in the interior part of the polymer molecules.

(4a) Plastic cover (4b)Mask (4c)Saline (4d)Syringe

Fig . 4 a, b, c & d. Photographic view of uncondensed gas burnt during high rate of gas evaluation

From the Fig. 4, it is seen that the uncondensed gas produced during the degradation of plastic cover is more. So, the intensity of flame is higher with blue and yellow colours. It evolves 3800 ppm hydrocarbon when it is burnt it produces 798 °C. Since most of the plastic covers are made up of LLDPE. The molecular mass is very less. So, during cracking the long chain of hydrocarbon breaks into very short chain of hydrocarbon which may not be able to condense in the condenser. This produces more gas yield in turn produce high intensity flame.

From the Fig. 2, the mask produces the maximum yield of oil when compared to all the plastics on the yield of gas is low than plastic cover. The rate of evaluation of gas, 2750 ppm and the temperature of the burnt to gas is 690 °C.

The degradation of saline bottles produces less gas and less oil. Saline bottles are made up of LDPE. The molecular mass is less when compared to syringe and high when compared to plastic cover and mask. The evolution of gas produced during the degradation of saline bottle is 1850 ppm and the temperature produced by burning the gas is 580 °C.

From the Fig. 4, it is seen that the flame intensity of syringe is much lower than all the plastics. This is due to the higher molecular mass of the plastic material which is made up of HDPE. Due to this the amount of catalyst is not sufficient to crack the plastic. So, it produces low gas and oil yield. The evaluation of hydrocarbon is 1280 ppm and the flame temperature is only 542 °C. This implies that the conversion of syringe into gases and liquid hydrocarbon is less.

Hence, it is concluded that the gaseous product produced during degradation of medical waste plastics can effectively burnt and it can be used as a heating source to carack the plastic.

1. Physical properties obtained oil:

The Table 5 shows the physical properties of the various liquid hydrocarbon obtained from medical waste plastics.

Table 5. Physical properties obtained oil from medical plastics waste

Property	Methods	Plastic oil from				Petrol	Diesel
		Cover	mask	Saline	Syringe		
Density 15 °C kg/m^3	IS-1448-P16	757	766	771	773	730-770	820
Kinematic viscosity at 40°C [cst]	IS-1448-P25	1.77	1.86	2.35	2.35	1.81	2.5
Flash point °C	IP-36	57	54	64	67	-43	62
Fire point °C	IP-16	52	53	54	54	25	43
Pour point °C	IP-16	-	-	-	-	Below -4	-
Gross calorific value MJ/kg	IS-1448	43.7	44.3	42.5	43.2	45	42.3

From the property Table 5 it is seen that the value of density, kinematic viscosity, flash point and fire point are not equal to the sole fuels. All these property values are lower than that of petrol and diesel. From the property Table 4 it is seen that the obtained oils contain low and high boiling liquid hydrocarbon. So, the obtained oil should be fractioned into low and high boiling liquid hydrocarbon. Then these oils can be utilized to run the engine at lower emission.

2. Involvement of catalyst during cracking process

Cracking of a polymer involves the break of C-C bond and formation of new C-H bonds. Also, one C-C bond is converted to C=C bond

$$-CH_2CH_2-CH_2-CH_2- \rightarrow -CH=CH_2+CH_3CH_2-$$

Any chemical reaction should go through a transition state which has very high energy. The excess energy of the transition state over that of the reactant is called energy of activation. At a given temperature the rate of a chemical reaction depends on the energy of activation. Since the energy of activation is too high for cracking of polymer, the reaction proceeds at a reasonable rate only at considerably higher temperatures.

However, the use of a catalyst makes the reaction to proceed in a different path which involves the catalyst. The catalyst is regenerated finally. The different path has a deferent transition state which has a lower energy than the transition state for uncatalyzed reaction. Hence, the catalysed reaction can take place at a higher rate than the uncatalyzed reaction at any given temperature.

SEM image of catalyst before and after degradation of medical waste plastics

The active participation of fly ash during the degradation was evident by the SEM image from the same image. It is seen that the fly ash contains cluster of regular and irregular snow coloured sphere.

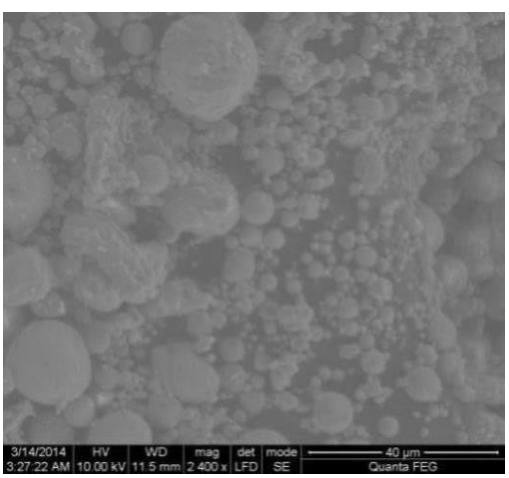


fig 5a Fly ash

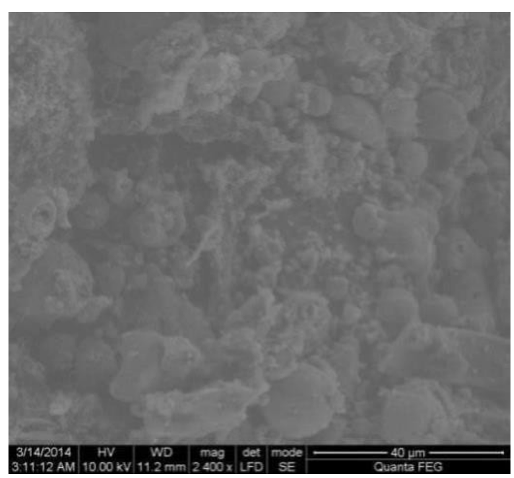


fig 5b. Fly ash after degradation of plastic cover

Catalyst Research Volume 23, Issue 2, September 2023 Pp. 1172-1190

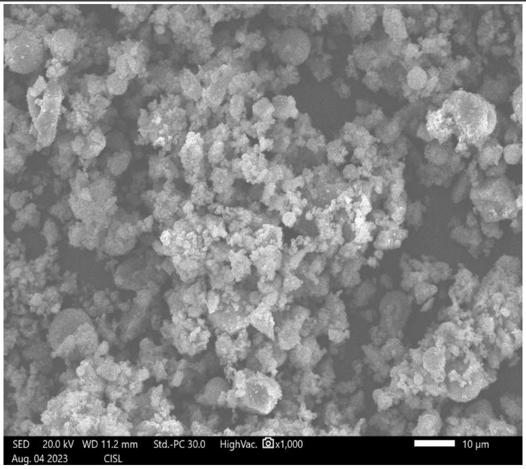


Fig 5c. fly ash after degradation of mask

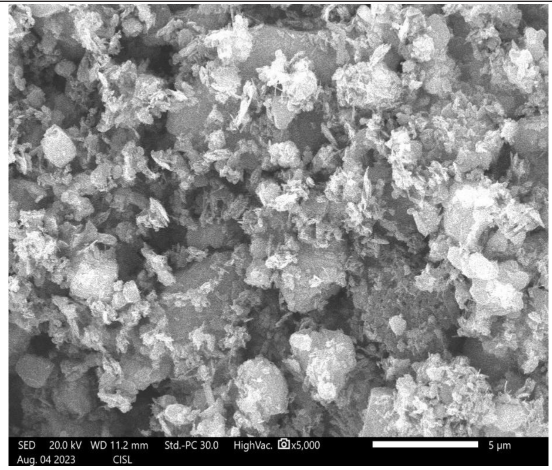


Fig 5d. Fly ash after degradation of saline

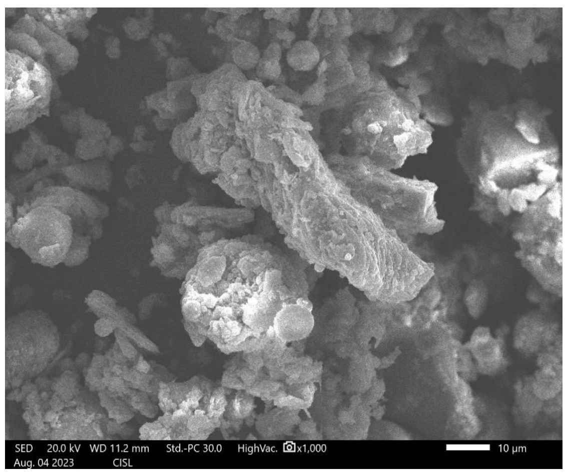


Fig .5e Fly **ash after degradation of syringe**

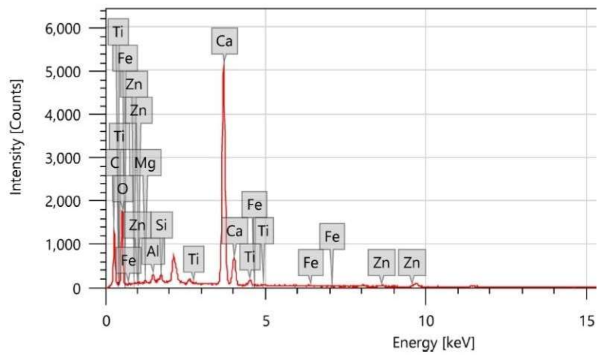
The SEM image fly ash after degradation of cover and mask shows that the sphere shape in the fly ash is converted like broken ice pieces. This shows that physical change occurs during the degradation, process of plastic cover and mask. There is no presence of any foreign material in the catalyst after degradation.

After the degradation of saline bottle and syringes, the fly ash seems to have some foreign materials. This implies that the degradation is not complete and some plastic material remain in it.

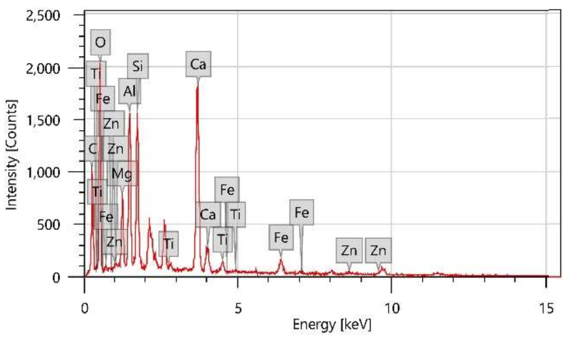
EDX:

The EDX spectra fly ash and fly ash after degradation of plastic cover is shown in plate 2. From EDX spectra it's seen that the fly ash contains many compounds but the presence of silica is higher. The presence of silica in fly ash plays a vital role during degradation process. After degradation of medical waste plastics the fly ash does not goes under any physical change. This implies that the fly ash plays a role during the degradation process.

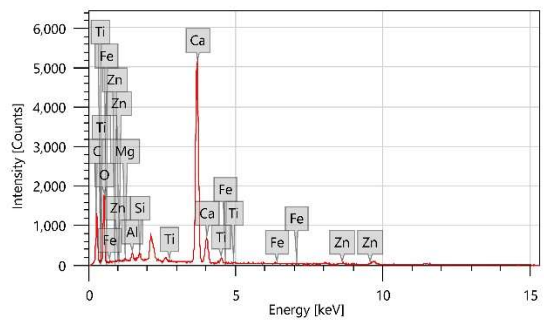
Catalyst Research Volume 23, Issue 2, September 2023 Pp. 1172-1190



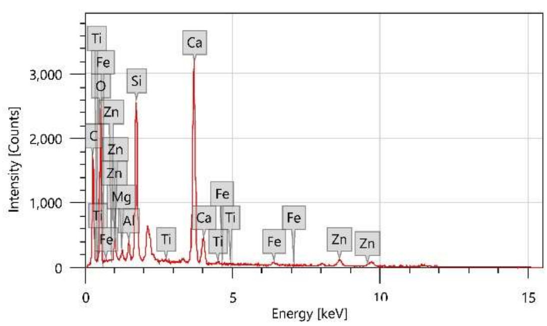
saline



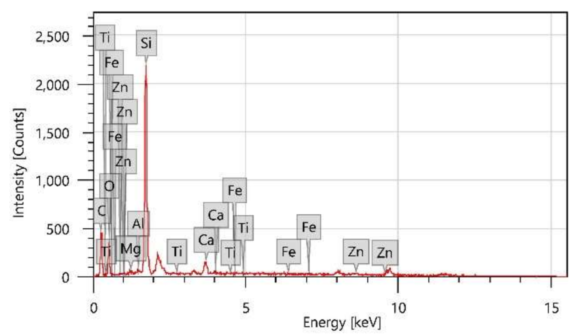
Fly ash



Mask



Plastic cover



Syringe

CONCLUSION:

1. The medical waste plastics can be converted into useful liquid and gaseous hydrocarbon.
2. 100 % conversion for plastic cover and mask was successfully made.
3. The properties of medical waste plastic oil found is having the property between gasoline and diesel. So if it is subjected to fractional distillation then they will be a change in physical property.
4. The yield of oil is more for mask and less for syringes.
5. The yield of gaseous product is more during the degradation of plastic cover.

ACKNOWLEDGEMENT:

This work was done under a project sponsored by TANSCHE (Tamil Nadu State Council for Higher Education). The authors and principal investigator Dr. P. Premkumar are thankful to TANSCHE for sanctioning this project in the Department of Mechanical Engineering, Annamalai University. The authors are thankful to Mining Research Laboratory and Centralized Instrumentation and Service Laboratory, Annamalai University.

References

1. Akubo, K., Nahil, M. A., & Williams, P. T. (2019). Aromatic fuel oils produced from the pyrolysis-catalysis of polyethylene plastic with metal-impregnated zeolite catalysts. Journal of the energy institute, 92(1), 195-202.
2. Rodriguez Lamar, Y., Noboa, J., Torres Miranda, A. S., & Almeida Streitwieser, D. (2021). Conversion of PP, HDPE and LDPE plastics into liquid fuels and chemical precursors by thermal cracking. Journal of Polymers and the Environment, 29(12), 3842-3853.
3. Dwivedi, U., Pant, K. K., & Naik, S. N. (2021). Controlling liquid hydrocarbon composition in valorization of plastic waste via tuning zeolite framework and SiO_2/Al_2O_3 ratio. Journal of Environmental Management, 297, 113288.
4. Rasul, S. B., Som, U., Hossain, M. S., & Rahman, M. W. (2021). Liquid fuel oil produced from plastic based medical wastes by thermal cracking. Scientific Reports, 11(1), 17048.
5. Erawati, E., Hamid, H., & Ilma, A. A. (2018). Pyrolysis Process of Mixed Polypropylene (PP) and High-Density Polyethylene (HDPE) Waste with Natural Zeolite as Catalyst. Molekul, 13(2), 106-113.
6. Tiwari, D. C., Ahmad, E., & Singh, K. K. (2009). Catalytic degradation of waste plastic into fuel range hydrocarbons. International Journal of Chemical Research, 1(2), 31-36.
7. Kumar, S. L., Radjarejesri, S., & Jawahar, R. R. (2020). Characterization of waste plastic oil as biodiesel in IC engines. Materials Today: Proceedings, 33, 833-838.
8. Panda, A. K. (2018). Thermo-catalytic degradation of different plastics to drop in liquid fuel using calcium bentonite catalyst. International Journal of Industrial Chemistry, 9(2), 167-176.
9. Bassey, U., Sarquah, K., Hartmann, M., Tom, A. O., Beck, G., Antwi, E., & Nelles, M. (2023). Thermal treatment options for single-use, multilayered and composite waste plastics in Africa. Energy, 270, 126872.
10. Kunwar, B., Moser, B. R., Chandrasekaran, S. R., Rajagopalan, N., & Sharma, B. K. (2016). Catalytic and thermal depolymerization of low value post-consumer high density polyethylene plastic. Energy, 111, 884-892.

11. Wang, C., Jiang, Z., Song, Q., Liao, M., Weng, J., Gao, R., ... & Chen, G. (2021). Investigation on hydrogen-rich syngas production from catalytic co-pyrolysis of polyvinyl chloride (PVC) and waste paper blends. Energy, 232, 121005.

12. Su, G., Zulkifli, N. W. M., Ong, H. C., Ibrahim, S., Cheah, M. Y., Zhu, R., & Bu, Q. (2023). Co-pyrolysis of medical protective clothing and oil palm wastes for biofuel: Experimental, techno-economic, and environmental analyses. Energy, 273, 127221.

13. Nishino, J., Itoh, M., Ishinomori, T., Kubota, N., & Uemichi, Y. (2003). Development of a catalytic cracking process for converting waste plastics to petrochemicals. Journal of material cycles and waste management, 5, 89-93.

14. Na, J. G., Jeong, B. H., Chung, S. H., & Kim, S. S. (2006). Pyrolysis of low-density polyethylene using synthetic catalysts produced from fly ash. Journal of Material Cycles and Waste Management, 8, 126-132.

15. Dutta, N., Mondal, P., & Gupta, A. (2022). Optimization of process parameters using response surface methodology for maximum liquid yield during thermal pyrolysis of blend of virgin and waste high-density polyethylene. Journal of Material Cycles and Waste Management, 24(3), 1182-1193.

16. Soliman, A., Farag, H. A., Nassef, E., Amer, A., & El Taweel, Y. (2020). Pyrolysis of low-density polyethylene waste plastics using mixtures of catalysts. Journal of Material Cycles and Waste Management, 22, 1399-1406.

17. Premalatha, N., Prathiba, R., Miranda, M. A., & Miranda, L. R. (2021). Pyrolysis of polypropylene waste using sulfonated carbon catalyst synthesized from sugarcane bagasse. Journal of Material Cycles and Waste Management, 23, 1002-1014.

18. Jan, M. R., Shah, J., & Gulab, H. (2010). Degradation of waste high-density polyethylene into fuel oil using basic catalyst. *Fuel*, *89*(2), 474-480.

19. Uddin, M. A., Koizumi, K., Murata, K., & Sakata, Y. (1997). Thermal and catalytic degradation of structurally different types of polyethylene into fuel oil. Polymer degradation and stability, 56(1), 37-44.

20. Ding, W., Liang, J., & Anderson, L. L. (1997). Thermal and catalytic degradation of high-density polyethylene and commingled post-consumer plastic waste. Fuel Processing Technology, 51(1-2), 47-62.

21. Uddin, M. A., Koizumi, K., Murata, K., & Sakata, Y. (1997). Thermal and catalytic degradation of structurally different types of polyethylene into fuel oil. Polymer degradation and stability, 56(1), 37-44.

22. Manos, G., Garforth, A., & Dwyer, J. (2000). Catalytic degradation of high-density polyethylene on an ultra-stable-Y zeolite. Nature of initial polymer reactions, pattern of

formation of gas and liquid products, and temperature effects. Industrial & engineering chemistry research, 39(5), 1203-1208.

23. Aragaw, T. A. (2020). Surgical face masks as a potential source for microplastic pollution in the COVID-19 scenario. Marine Pollution Bulletin, 159, 111517.
24. Aishwarya, K. N., & Sindhu, N. (2016). Microwave assisted pyrolysis of plastic waste. Procedia technology, 25, 990-997.
25. **D. Raja Kullayappa1, G. Karthikeyan2 P. Premkumar2, C. G. Saravanan2 (2023).** Conversion of medical plastic covers made up of LDPE hydrocarbons using biogas as a source of heat. European Chemical Bulletin,12(10), 1401-1422.
26. **J.** Nishanth Jude Roy, P. Premkumar, S Mohamed Iqbal, A Balaji. Experimental investigation strategies to augment the diesel engine performance and reduction of emission characteristics by the effect of waste plastic oil. ASEAN Engineering Journal, 13:3 (2023) 47-53.
27. Nalluri, P., Premkumar, P., & Sastry, M. C. (2023). Experimental study on a computerized VCR diesel engine running on oil made by pyrolyzing waste plastic using Red mud as a catalyst. Green Analytical Chemistry, 5, 100054.
28. Nalluri, P., Kumar, P. P., & Sastry, M. C. (2021). Experimental study on catalytic pyrolysis of plastic waste using low cost catalyst. Materials Today: Proceedings, 45, 7216-7221.