Characterization of biomedical plastic waste sample of Glucose bottle and syringe

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Abstract

In this research paper sample of Glucose bottle and syringe waste collected from the recycling center were sampled and characterized according to type of polymer, presence of impurities and Qualitative requirement. The received data was applied for overall estimation of recycling capacity.Referance samples with known plastic ratio taken and tested for like FTIR for Quantification of plastic contents .X-ray Spectroscopy for the elemental Analysis.

Keywords

FTIR, Elemental Analysis, X-ray Spectroscopy

INTRODUCTION

Biomedical waste (BMW) is a largest pollutant generated in the medical sector as a result of operations such as medical diagnosis, treatment, and vaccination of humans and animals, as well as biological research and development. Several studies have been published on this topic [4]. One cannot imagine life without plastic with broad usage in the sector like Grocery, Packing, Food and Beverage etc. In 2021 per capital plastic consumption in India reached 15 kilogram per person in 2021.Medical waste is one of the booming plastic wastes after COVID 19 .This waste include of various syringe, Glucose bottle , Plastic wrapper etc many of which may be recycled. Better medical waste management improved recycling rate, save energy and save power and add new economic activities. In medical waste collection center. AIIMS Delhi produced 23500 kg of plastic waste per month in 2018 [1].Plastics represents a very large group of individual polymers with different chemical and technical characteristics (Hansenet al., 2013)[2].Most applicable plastic waste polymer in use are polypropylene , polystyrene ,High density Polyethylene , Low density Polyethylene, PVC etc.[3].

Figure 1. (a)Raw material from Clinical Lab waste as a Glucose bottle (b) Shredded sample of the Glucose bottle after process

According to the World Health Organization (WHO,2018), the composition of bio-medical waste is as follows- non-hazardous waste (85%) and hazardous waste (15 %), with infectious waste accounting for 10 percent and radioactive or chemical waste accounting for 5 percent, every year, it is estimated that more than 5.2 million people, including 4 million children, die as a result of diseases caused by medical waste throughout the world [5]. It has been determined that the severe acute respiratory syndrome, commonly known as Coronavirus disease (COVID-19) was responsible for the sudden increase in healthcare waste generation. Public health and the environment have been put to grave dangers as a result of this increased BMW. Moreover, given the technical, practical, and budgetary restrictions, India is already rassling with poor BMW.

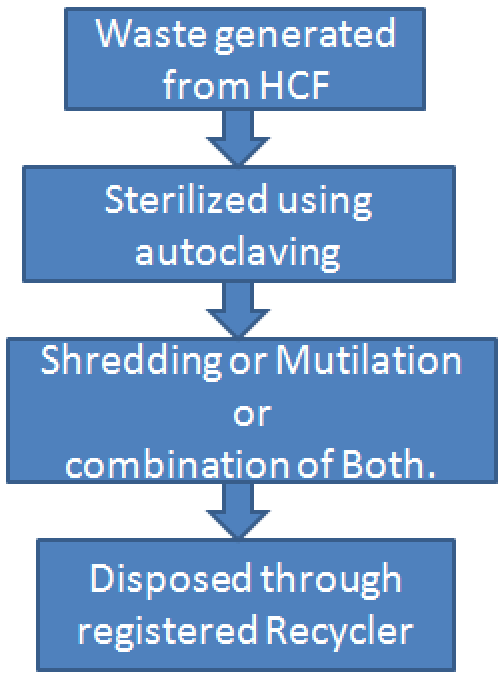

Figure 2: Treatment and Disposal facility of Red color waste

All recyclable plastic waste gathered from the HCF must sterilized using Autoclaving /microwaving / hydro-calving followed by shredding or mutilation or combination of sterilization and shredding. Recyclable waste must never be disposed of along with general waste in dry stream and same is required to be disposed of only through registered or authorized recyclers or to waste to energy plants or plastics to diesel or fuel oil or for road making, whichever is possible.

MATERIALS AND METHODS

Polymer blend of Glucose bottle low density polyethylene–$(CH_2\text{-}CH_2)_n$– which is a soft, flexible, light weight plastic material based on plastic medical waste were collected from the supplier of medical plastic waste. This includes syringe, gloves, bags, drapers etc.We consider Glucose bottle and Syringe sample as a characterization sample. The different parts of the syringe, i.e., body, plunger and elastomeric piston seal are made of medical grade polyethylene $[(C_2H_4)_n]$, polypropylene $[(C_3H_6)_n]$ and polydimethylsiloxane $[((CH_3)_2SiO)_n$; silicone rubber], respectively. The collected material was sorted in the laboratory.

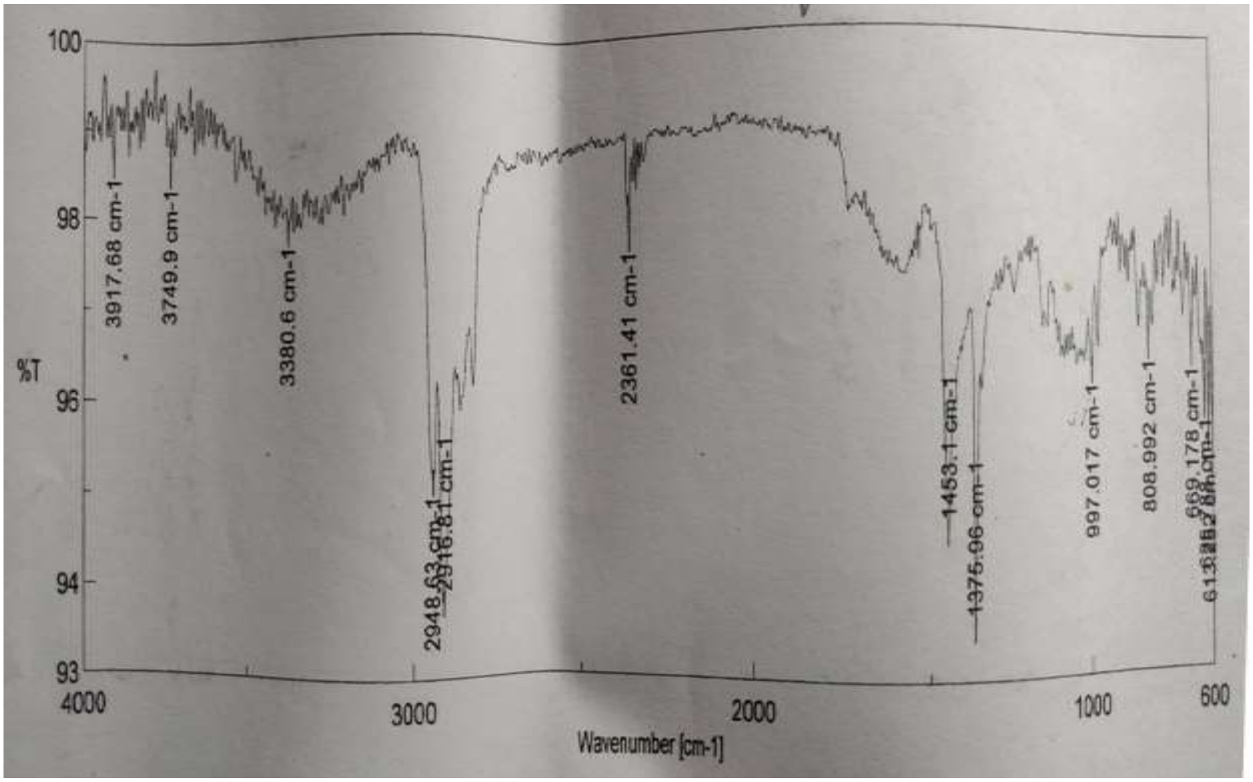

Figure 2. FTIR spectrum of Syringe sample: PP- polypropylene

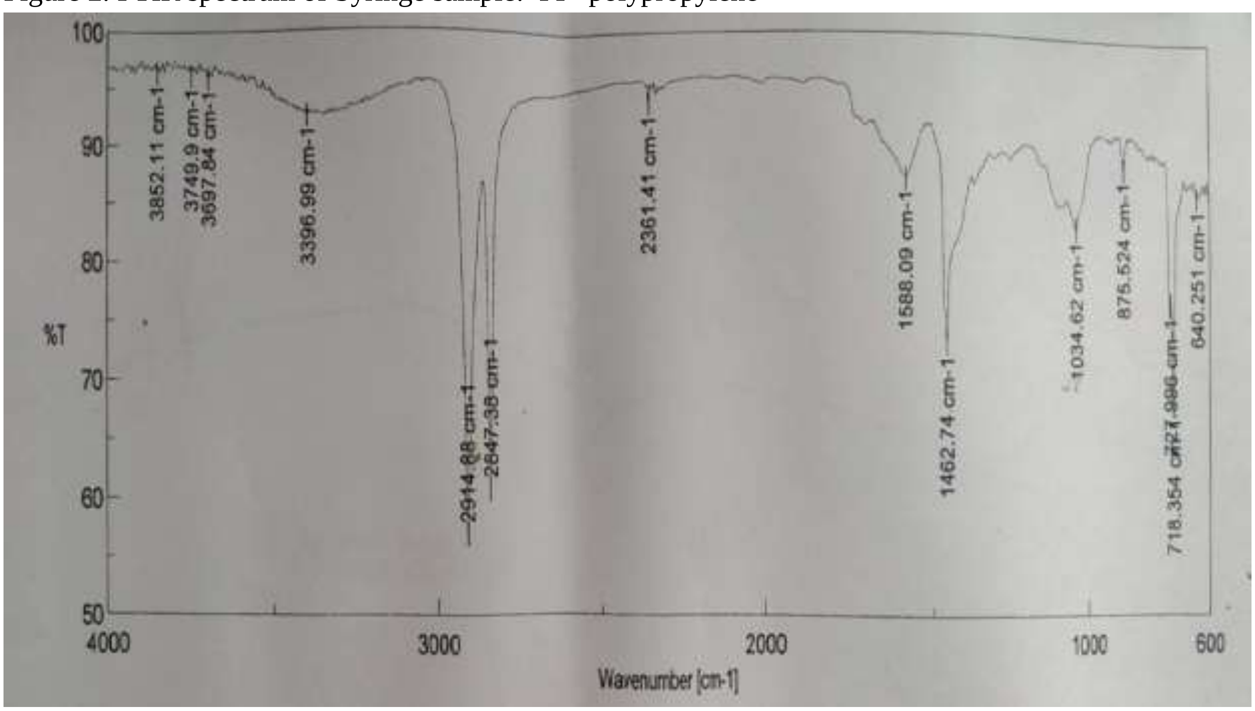

Figure 3. FTIR spectrum of Glucose bottle sample: LDPE –Low Density Polyethylene

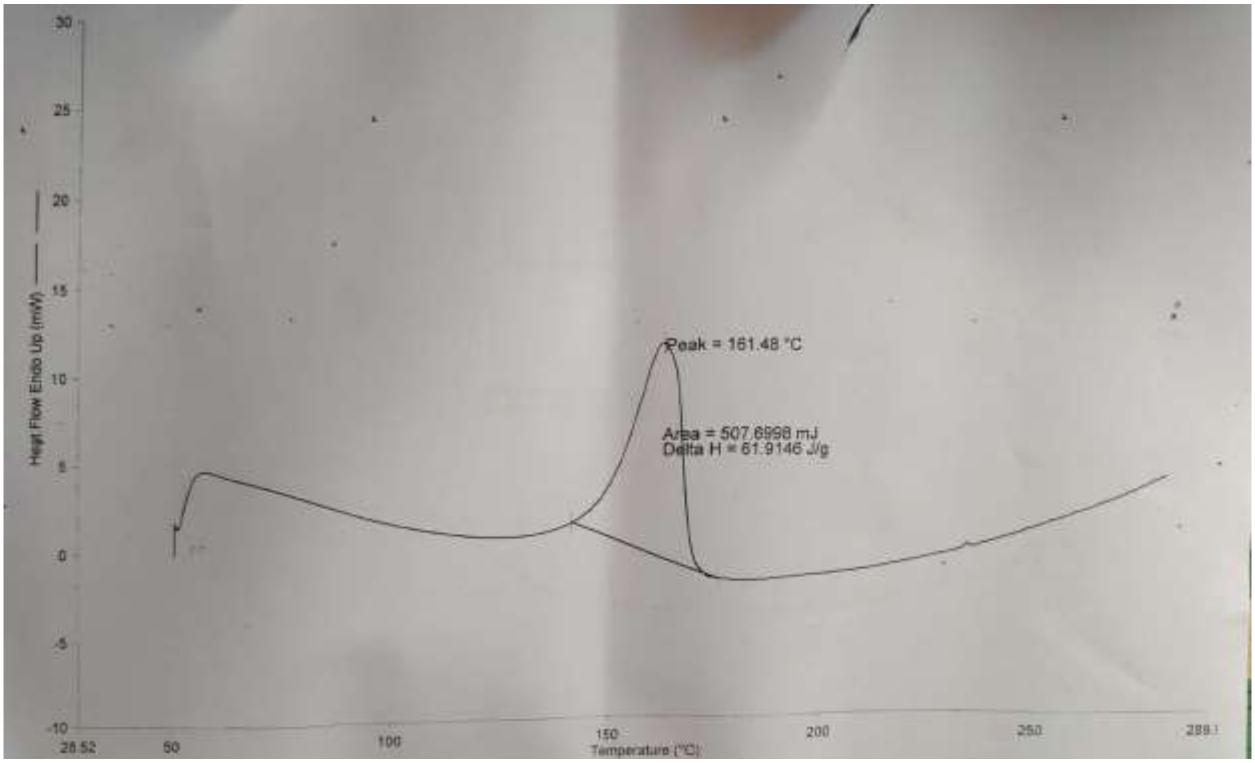

Figure 4. Differential Scanning Calorimetry (DSC) (Syringe Sample)

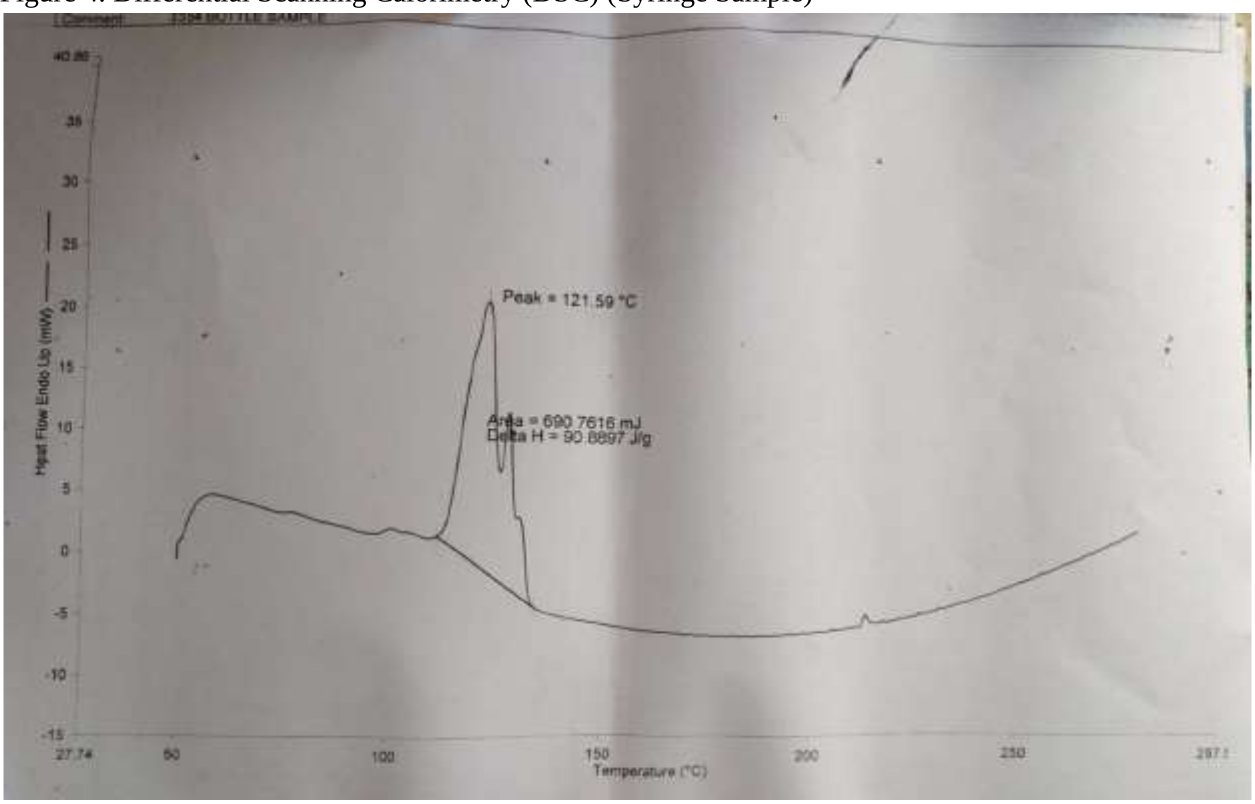

Figure 5. Differential Scanning Calorimetry (DSC) (bottle Sample)

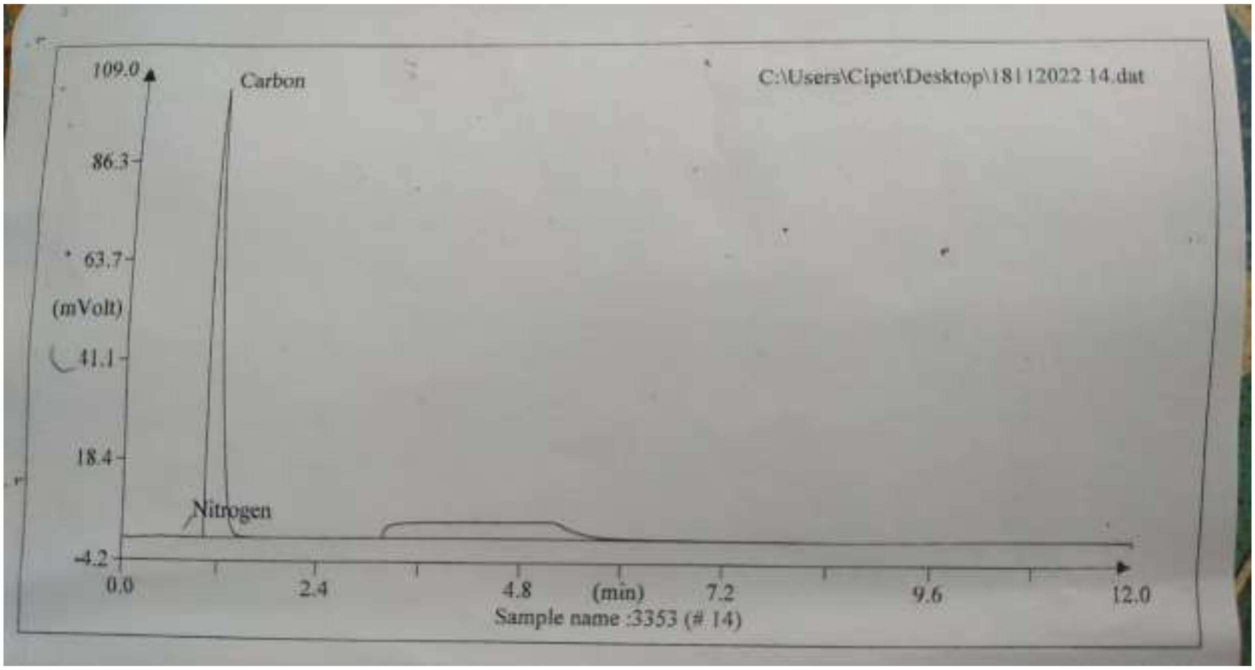

Figure 6. Elemental Analysis (Syringe Sample)

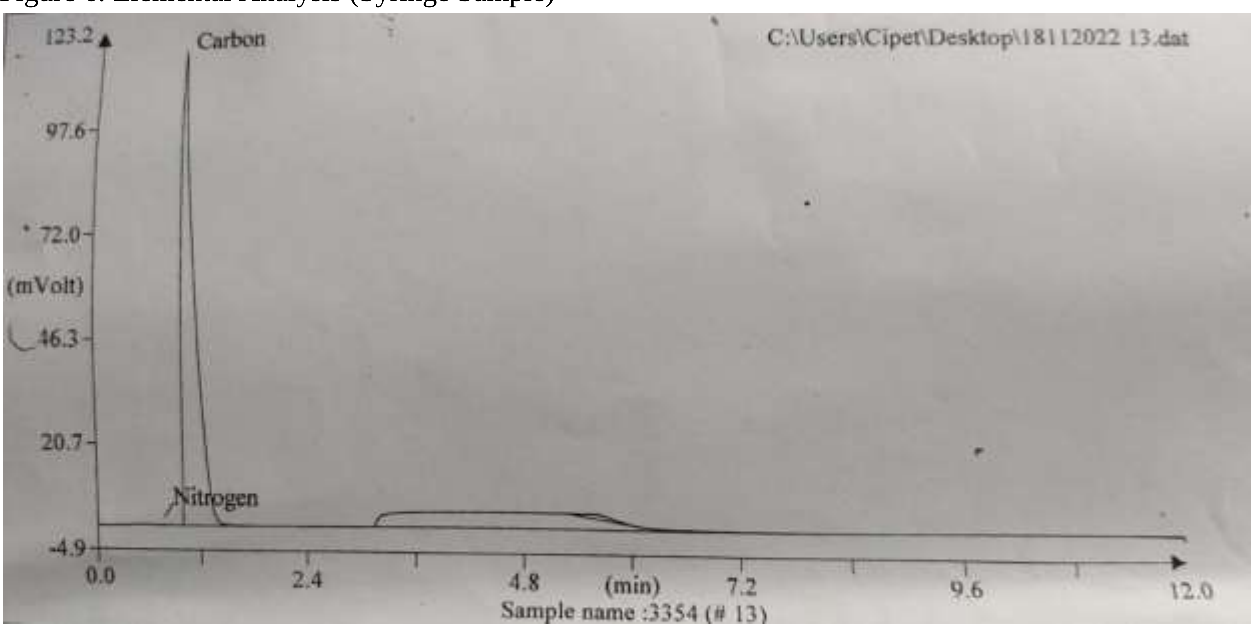

Figure 7. Elemental Analysis (bottle Sample)

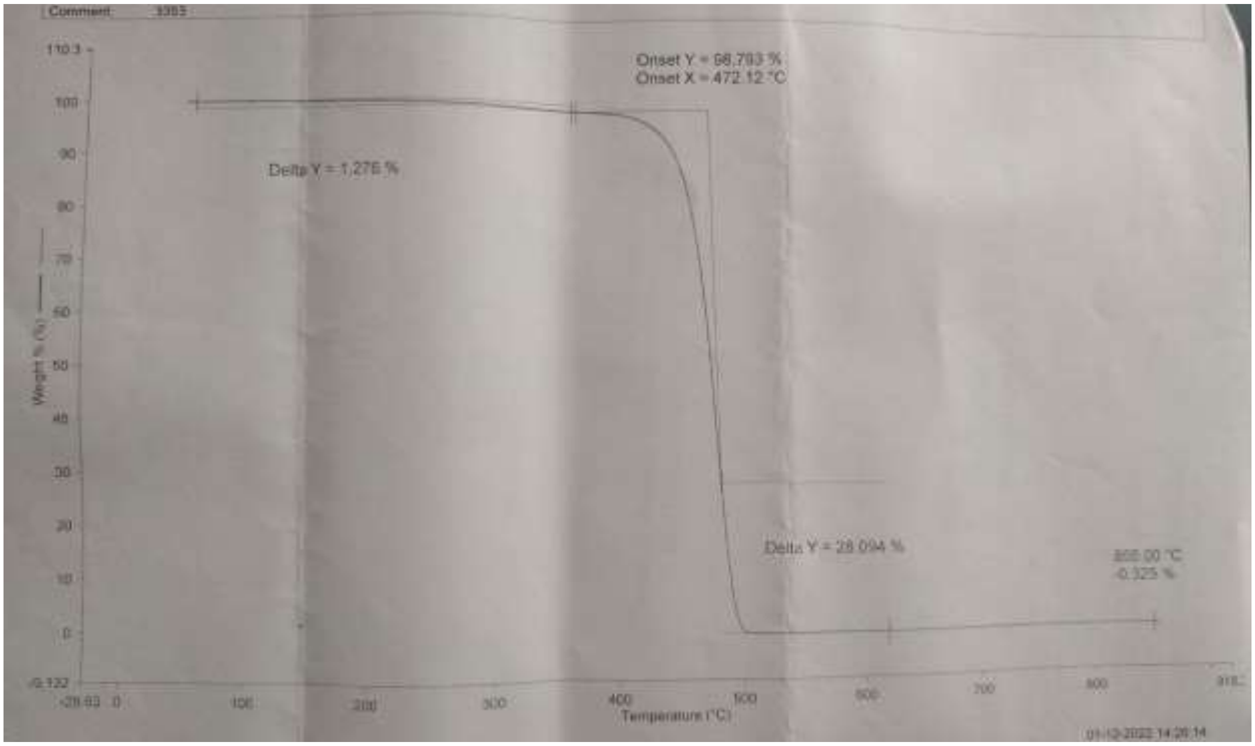

Figure 8. TGA test (Syringe Sample)

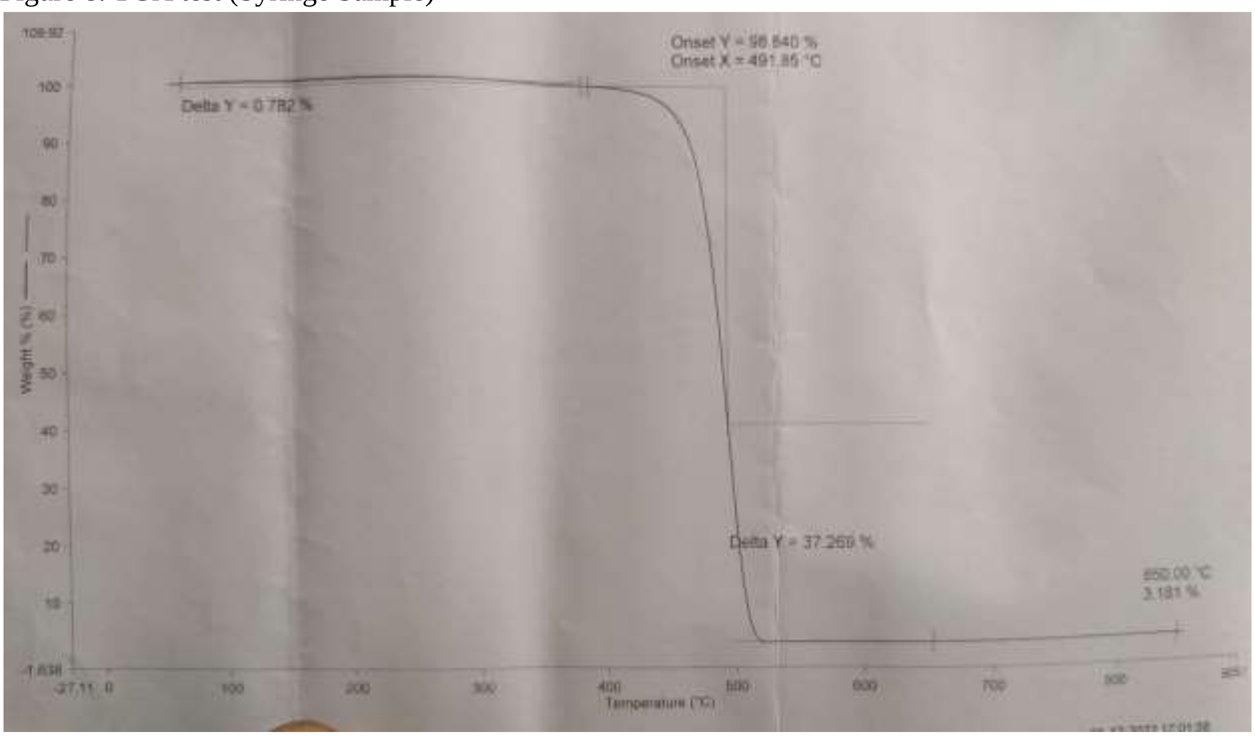

Figure 9. TGA test (bottle Sample)

RESULTS AND DISCUSSION

The Spectra obtained by the Infrared Spectra reveled that Majority of the plastic material analysed were composed of LDPE and PP.

FTIR Analysis

The pure polymer samples were analysed with the FTIR technique. With a model FT/IR -4700 type A with serial Number D046761788 with Accessory ATR PRO ONE and Accessory S/N CA c 13826180 with incident angle 45 deg selected in Accordance to ASTM E1252 standard FTIR performed. Light source condition is standard and with detector TGS with accumulation 12 spectrum of 100 FTIR spectrometer equipped with an attenuated total reflection device with zinc selenide crystal used. We considered zero filling with cosine Apodization with 16 gain aperture 7.1 mm with a scanning speed of 2mm /sec and filter 30000Hz.The spectra were collected by co-adding 16 scans at a resolution of 4 cm $^{-1}$ in the range from 4000 to 600 cm^{-1}. For quantitative analysis of the recycled material, a calibration curve was obtained. In Figure 2. Of the syringe FTIR X- axis represent Infrared spectrum.

Figure 2 shows the spectrum of sample Syringe. It is possible to define this polymer as polypropylene. The FTIR spectrum of polypropylene presents a shoulder at 2948 cm^{-1} , and the asymmetric and symmetric in-plane C–H (–CH3) at 1453 and a shoulder at 1375 cm-1 confirms that it is a polypropylene. The peak at 1376 cm-1 is assigned to –CH3 group.

Figure 3 shows the spectrum of sample Glucose Bottle. The main stretching vibrations for polyethylene appear at 2847 and 2914.The main bending mode of the –CH2 is located at 1462.As In case of LDPE these bans are located at 1462.

Bond	Functional Group	Frequency in cm^{-1}	Graph no
C-H	Alkane	2916-2948	Figure_02 (3353 syringe)
C-H	Alkane	2847-2914	Figure_03 (3354 Bottle)

Table 1: FTIR sample functional group

DSC TEST

In a lab, testing was performed with a Differential scanning calorimetry on the samples in order to obtain the melting points of the different polymers that compose the plastic waste, a technique that is also widely used to complement the previous ones. The analysis was performed on Perkin-Elmer Thermo balance model STA 6000, in accordance with the standard ISO ASTM D 3418 used. In the case of the Syringe sample, DSC uses new technology which combines ultra fast responsiveness with high stability. After the test piece is melted, cooled and reheated, only a single melting peak is obtained at 161.48 ˚C for Figure 4. The heating of melting is 90.5 J/g, which yields a percent crystallinity of 43.7%.

In order to determine the type of polyamide the melting temperature was determined. From figure 4. Maximum peak found at a melting temperature of 161.48 °C with e Area of 507.69 mj and delta H value 61.9146 J/g from figure 5. Maximum peak found at a melting temperature of 121.59 °C with Area of 690 .76 mj and Delta H value 90.8897 J/g. Area under the curve indicate the latent heat of Melting and Delta H with positive value describes that Endothermic process.

ELEMENTAL ANALYSIS

A CHNS test carried out by IS 17088/ASTM D 5338 standard. Based on carbon % value the highest % found 0.86 % more in the syringe sample.Refering both the sample Carbon weigh % content synthesized is found higher in both the samples in below table.

For syringe Sample:

Retention time(min)	Area(.1*uV*sec)	Element%	Component Name
0.792	2419	0.000	Nitrogen
0.058	9230701	86.867	Carbon
0.03	5003705	0.000	
	14236830	86.867	

Table 2: Relative proportions (in %) of elements on the blend surfaces in Syringe sample

For bottle Sample:

Retention time(min)	Area(.1*uV*sec)	Element%	Component Name
0.792	3120	0.000	Nitrogen
0.033	11329610	86.037	Carbon
0.03	5899096	0.000	
0.467	219465	0.000	
	17451290	86.037	

Table 3: Relative proportions (in %) of elements on the blend surfaces in bottle sample

TGA TEST

Test performed TGA analysis as per ASTM 1131 for the sample of Glucose bottle and Syringe sample also. Thermo gravimetric (TGA) analysis provides determination of endotherms, exotherms, and weight loss on heating, cooling, and more. Materials analyzed by TGA include Polymer samples. For figure.9 test sample weight 6.793 mg with heating from 50 °C to 850 °C at 20 °C/min. For figure.8 test sample weight 8.292 mg with heating from 50 °C to 850 °C at 20 °C/min.

Thermo gravimetric analysis uses heat to force reactions and physical changes in materials. TGA provides quantitative measurement of mass change in materials associated with transition and thermal degradation. TGA records change in mass from dehydration, decomposition, and oxidation of a sample with time and temperature. Characteristic thermo gravimetric curves are given for specific materials and chemical compounds due to unique sequence from physicochemical reactions occurring over specific temperature ranges and heating rates. These unique characteristics are related to the molecular structure of the sample. Set the inert (usually N2) and oxidative (O2) gas flow rates to provide the appropriate environments for the test. Place the test material in the specimen holder and raise the furnace. Set the initial weight reading to 100%, and then initiate the heating program. The gas environment is preselected for either a thermal decomposition (inert - nitrogen gas), an oxidative decomposition (air or oxygen), or a thermal-oxidative combination.

CONCLUSIONS

The study carried out in this work initially related to the pretreatment of Bio medical waste as per severity of the element involves in the Medical Waste. Identification of Polymeric material with functional group figure 2 and 3.found from FTIR The characterization of the raw material carried out with various methods like Infrared Spectroscopy and the melting points of the different polymers that compose the plastic waste, DSC techniques showed that the plastic fraction of the MSW from was composed mainly of LDPE and PP. figure 4. Maximum peak found at a melting temperature of 161.48 °C with e Area of 507.69 mj and delta H value 61.9146 J/g from figure 5. Maximum peak found at a melting temperature of 121.59 °C with Area of 690.76 mj and Delta H value 90.8897 J/g. Elemental Analysis traces highest weight percent of carbon element with 86% in both the samples. TGA curve shows the weight loss (%) w.r.t the temperature increase as temperature is increased the weight percentage decreases due to different reactions take place with increasing the temperature.

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