Feasibility Study on Chemical Recovery of Polymeric Waste Products and its Impacts on the Environment

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***Abstract*:- Polymeric products are those which are inevitable from our day to day life. They are now becoming unavoidable in applications ranging from production to consumer use and packaging. They are also environmentally inert until they become waste in dump. Their major advantage is having the property of reuse, recovery options. Without giving other substitute option for these compounds, no complete ban would be possible. Even though there are some methodologies available for re-processing the polymeric waste, they are not in commercial practice due to the precautionary practice of hazardous exhausts. This review article is trying to show various methods in reprocessing the polymeric compounds, application of recovered materials in the practical field through experimentation with their scope in future. From the study, spectroscopy method is used to characterize the polymeric compounds. The HAZOP analysis procedure is used to find the risk in commercialization of the selected process and the product application risk.**

Keywords: Polymeric compounds, spectroscopy, HAZOP, risk, hazardous, reuse.

1. INTRODUCTION

Plastics are characterized by their chemical structure of the polymers involved and branches of the chain after polymerization. There are two types of plastics: thermoplastics and thermosetting polymers. Main difference between them is that, Thermoplastics can be melted back to form liquid but the thermoset will be in permanent solid shape. The experimentation is using the thermoplastics to make them reusable in various fields.

Mostly household Polymeric waste are from the below seven categories only viz., Polyethylene Terephthalate (PETE or PET), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low-Density Polyethylene (LDPE), Polypropylene (PP), Polystyrene or Styrofoam (PS), Miscellaneous plastics (includes: polycarbonate, polylactide, acrylic, acrylonitrile butadiene, styrene, fiberglass, and nylon) (Ali Karaduman et al 2017). But sometimes household polymeric waste is made of composite form with aluminium and tin for packaging of food products.

While one person is neglecting the waste generated from his home, it is been sent to dump sites. Instead if he segregates at source then it could be used for reprocessing. Our waste management departments are stammering in this segregation part only. But there are available techniques to segregate also. (Wajeeha Saleem et al and S.M. Al-Salem et al in 2016)

2. MATERIALS AND METHODOLOGY

Some methods which are reviewed for chemical recovery process has been explained. This also includes various chemicals and materials need for in the process

2.1 Various methods for chemical recovery

The methods which are reviewed are (i) dissolution method, (ii) thermal degradation. And the best suitable method is selected for the lab scale experimentation.

2.1.1 Dissolution method

The traditional method of dissolution can be done to reduce a polymeric compound into a powdered or grain in form. This is a simple mechanical recycling process and can also be called as Re-precipitation. As shown in the figure 1. For this method the standard procedure of mixing polymers and solvents has to be done.

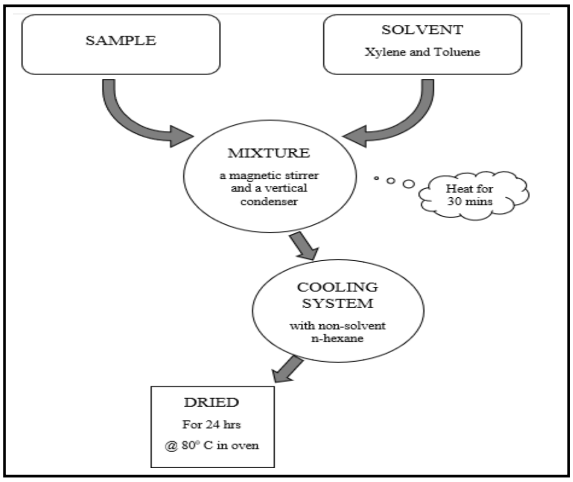

Fig 1: Dissolution method

As per the theoretical selections, HDPE or LDPE or PP are taken as polymer sample and solvent here would be xylene and toluene. Sometimes deionized water is also used for reprecipitation, whereby an aqueous solution will be obtained and is called as hydrogel as suggested by Herman
S. Mansur et al in the year 2004.

2.1.2 *Thermal cracking*

Thermal cracking of polymeric compounds involves, using heat as a component to degrade polymers in the absence of atmospheric oxygen. Nitrogen can be used in the closed system of thermal cracking as to get good result from the liquid and gaseous effluent. This process can either be called as pyrolysis as shown in fig 2.

In the first stage of the process the collected samples are sorted out and then categorized as per the plastic waste management rules 2016. Then the sample is placed in the reactor. Reactor would be placed in the heating mantle and the desired temperature is fixed according to the category of the compound used as sample. After the interior temperature of the reactor reaches its desired temperature, the evolving gas is allowed to passthrough the condenser.

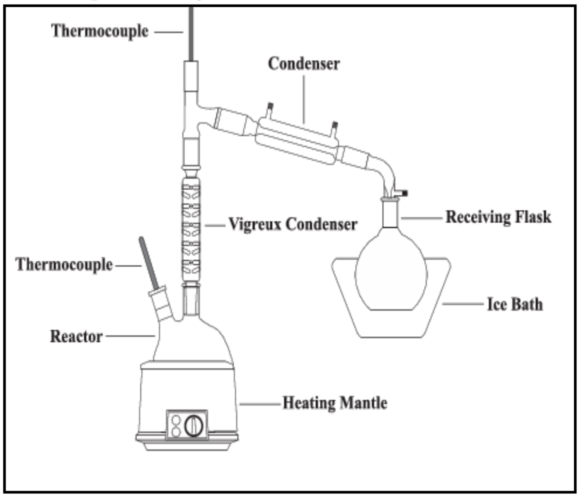

Fig 2: Thermal cracking – Pyrolysis setup

Now the condenser helps us to modify the phase of the gas to liquid. The liquid is collected in a receiving flask which is placed inside the ice bath. Here, Thermocouple is used for measuring the temperature. (C. Albano et al in 1999.)

2.1.3 *Hydrogen Recovery*

The process is a budding technology experimenting by Dr. Moritz Kuehnel et al in 2017 and it uses light absorbing material, for instance quantum dots can be added to the sample before it is placed in an alkaline solution and then exposed to sunlight which creates hydrogen. Which can be absorbed by seeing bubbles evolving. The process is unique and cheap as it does not need precleaning of samples for grease and oil, at the initial stage. The study was conducted only by using the Polyethylene terephthalate (PET). One part of the PET material is separated as hydrogen, carbon dioxide and the other part remains as solution and is intact and used for making recycled plastic products.

3.3 *Liquid effluent phase*

The final substance collected in the receiving flask should be a liquid effluent. But, even in the room temperature of 30^0 C the liquid gets converted into solid material. Hence, the experimentation needs to be done in a closed environment to get the best result.

3.4 *Mixed waste and unmixed waste as sample*

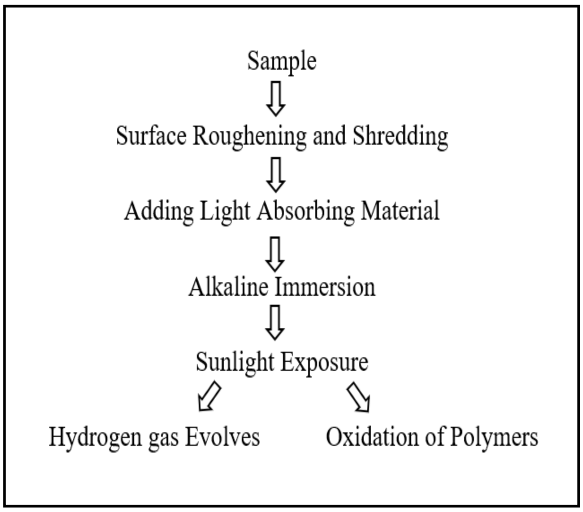

Fig 3: Hydrogen recovery from polymeric compounds – process

3. RESULT AND DISCUSSION

The selected best method is experimented in lab scale and then the following results were obtained.

3.1 *Temperature*

The original thermal cracking process have to be done at the temperature of 350^0 C to 900^0 C but the lab scale experimentation only accepts average temperature of 60^0 C and thus the rate of gas production will be very small and the smelted polymer will return to the solid state and cannot be made as oil substance (Edy Hartulistiyosoa et al in 2015).

3.2 *Gas pressure*

The evolving gas need to be flow through the condenser by gravity flow, but in this experiment the gas production rate and up flow velocity is comparably less to flow through the condenser and sometimes the condensation occurs in the reactor itself creating an aqueous solution inside the reactor. Which is considered as the final substance.

If the sample taken is monolithic. Which means the single category of waste then the quality of liquid produced is not good and so they are getting turned into solid easily. But if the sample used is a mixed sample, then the liquid effluent will be stood for some more time as liquid the application can be easy.

Table 1: suitable method for processing the polymeric compounds

Type of polymeric compound	*Suitable method for processing*
Polyethylene Terephthalate	Dissolution method Hydrogen recovery Thermal cracking
High-Density Polyethylene	Dissolution method Thermal cracking
Polyvinyl Chloride	Shredding and making into pellets
Low-Density Polyethylene	Dissolution method Thermal cracking
Polypropylene	Thermal cracking after pretreatment
Polystyrene or Styrofoam	Compression Baling
Miscellaneous (like polycarbonate, polylactide, acrylic, acrylonitrile butadiene, fiberglass, and nylon).	Integrated recycling based on kind and its volume

4. CONCLUSION

After the completion of the study from the selected study area, the liquid effluent needs to be upgraded to use (Lopez et al 2015). Various methods like dissolution method, thermal cracking, hydrogen recovery was studied and from them thermal cracking was selected for lab scale experimentation purpose.

The procedure of thermal cracking was executed in the lab and issues like gas production rate, solidification of derived compound, temperature was stated. Characterisation of the derived chemical would be done by spectroscopic method and HAZOP analysis procedure will be used to assess the possible risk associated with the process and product.

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