Development of process for the Catalytic Degradation of synthetic polymers.

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By

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CERTIFICATE

This is to certify that the thesis entitled "Development of process for the Degradation of Synthetic polymers ", being submitted by Ashish Sachan for the award of Master of Science degree is a record of bonafide research carried out by him at the Chemistry Department, National Institute of Technology, Rourkela, under my guidance and supervision. The work documented in this thesis has not been submitted to any other University or Institute for the award of any other degree or diploma.

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Ashish Sachan
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CONTENTS

INTRODUCTION:

The rapid rise in the production and use of synthetic polymers has resulted in significant increase in non biodegradable waste, which in turn create severe environmental problem. All synthetic polymers are non biodegradable because of containing non polar bonds in the chain. There is no standard method for the disposal of this type of waste. The only method that is being used is the incineration process which is very expensive and often produces unacceptable emission because of the process which has both endothermic and exothermic reactions.

Disposal of waste by landfill is also undesirable as it would result in high coast and poor biodegradability. Even the cities of having low economic growth generate large amount of plastic waste due to plastic packaging, plastic shopping bags, PET bottles and other goods/appliances which uses plastic as the major component. As we know that all polymers contains a long chain of carbon & hence it is regarded as a cheap source of energy when the polymers are burnt at the temperature above 1100 degree Celsius the main product formed is carbon dioxide.

Literature review

Synthetic polymer

Synthetic polymers are human-made polymers. From the utility point of view they can be classified into four main categories: thermoplastics, thermosets, elastomers and synthetic fibers. They are found commonly in a variety of consumer products such as money, super glue, etc. ...

Synthetic polymers first emerged in 1909 with the creation of Bakelite, which was produced initially for use in the casing of electrical components and went on to be used in jewelry and furniture. (See Reference 1). More commonly known today as plastics, or manufactured plastics, synthetic polymers can be found in an extensive array of items, ranging from product packaging to life-saving medical equipment. As the use of this material continues to climb and impact the municipal solid waste (MSW) stream, existing methods of recycling are being refined, and alternative methods are being explored.

Some properties of synthetic polymers are given as below:

1. Synthetic polymers are the polymers made in industry by chemical substances.

2. Many of the raw materials for synthetic polymer are obtained from petroleum after the refining and cracking process.

3. The types of synthetic polymer include:

   A. plastics
   B. fibre
   C. Elastomer

According to the U.S. Environmental Protection Agency, synthetic polymers now constitute more than 12 percent of the MSW. Although various types of plastics represent varying degrees of success, the recycling rate for synthetic polymers as a whole is only 8 percent: In 2010, of the 31 million tons of plastic waste, only 2.4 million were recycled.

Aim & Objective

Keeping the above facts in the mind this project has been undertaking with the following aim and objective:-

1. Synthesis of a suitable catalyst for the degradation of selective polymers.

2. Optimization of the catalytic activity by changing catalysis.

3. Design of fixed bed reactor.

4. Selective degradation or cracking of polymer in appropriate reaction Condition.

5. Stabilization or utilization of product.

The contact between catalyst and the waste is very important because if poor contact exists then the large amount of residue would be generated. For this purpose the, a laboratory fluidized bed reactor has been successfully designed to study the chemical cracking of polymers as it would primarily limit the contact between volatile product and catalyst/mixture.

Therefore, the objective of my work is to developed modern laboratory fluidized bed reactor to study the product formed by the reaction between the various catalyst and synthetic polymers. Additionally, after investigating the result we would try to provide some basis for the optimization that would be cost effective, selectivity of the product and purity would be increased.

Materials and Methods

After going through the literature it is decided to use the following catalyst for the degradation of synthetic polymers.

1. Activated kaolin.

2. Montemorilite.

3. MCM-41.

4. MCM-41-Al.

Attempts are made to synthesize a number of other catalysts which would be cost effective and efficient.
MCM-41 and MCM -41-Al catalyst are being conventionally synthesised and activated as per the following procedure in reference1. However the rapid way to synthesise the highly ordered MCM-41is given below For the synthesis of MCM dissolved in a mixture of water/ethanol and then the ammonia solution and sodium acetate were added to this solution. After about 10 min stirring at 200 rpm a clear solution was obtained. Then the TEOS was added at one time to this solution. The final molar composition of the resulting gel was TEOS:1; CTAB: 0.22; Sodium acetate: 0.034; NH Ethanol: 1; Water: 155. After 2.5 hours stirring at room temprature the obtained gel was transformed to a Teflon-lined stainless-steel vessel and aged at 343 K for 5 hours. Finally the white precipitate was filtered and washed with desire amount of water and then calcined in air at heating rate of 1 K/min up to 823 K and held at this temperature for 5 hours.

The Reactor

A detailed description of the experimental system is shown schematically in figure 1. The catalyst is being small enough to effectively fluidize.

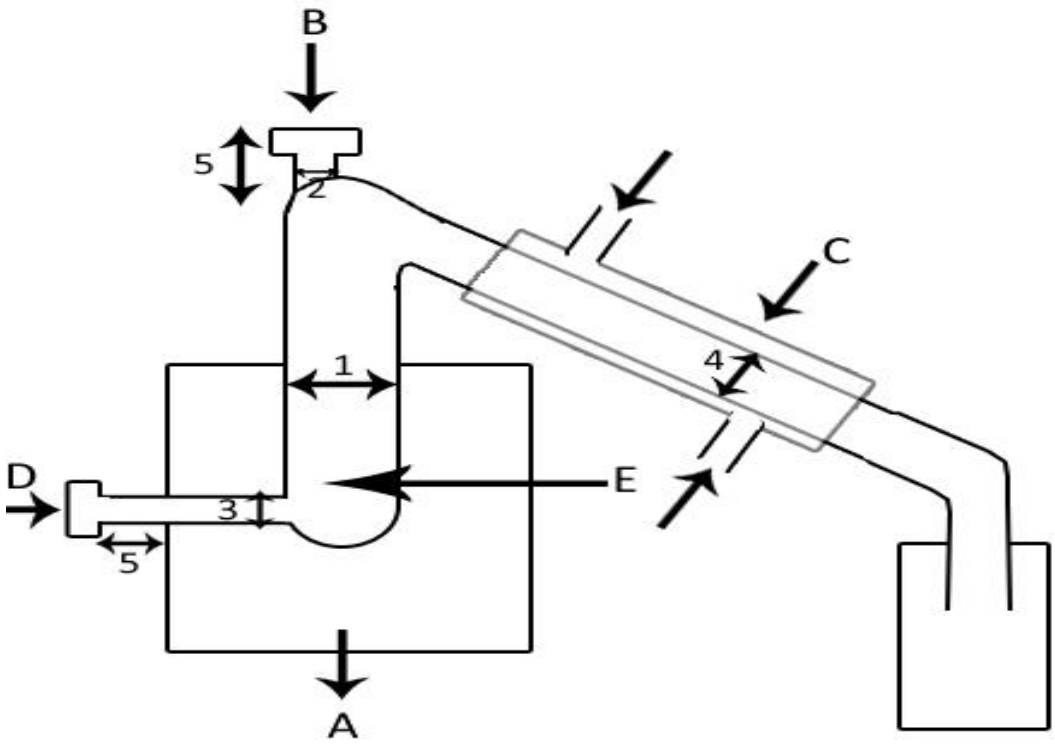

Figure 1. schematic diagram of catalytic fluidized bed reactor system.

Keys:

A- Electrically Heated Furnace.

B- Small opening Inlet for Reactants.

C- Condenser.

D- Small outlet for Removal of residue.

E- Stainless Steel Reactor

Discussion

As it is application oriented project it required sufficient information regarding a catalyst, fixed bed reactor & product obtained is still in the process. Therefore further work is required.

Result

The basic objective of this work is to crack the polymer selectively so, that the fragmented products contains similar number of carbon atoms in chain as in the kerosene petrol & diesel.

References

1. synthesis and characterization of AIMCM_ 41 molecular sieves
Yu Sun, Yinghong Yue, Zi Gao 1997

2. D.S. Scott, S.R. Czernik, J.piskorz, D.radlein, Energy & Fuels, 4,407(1990).

3.. Y. Ishihara, H. Nambu, T. Ikemura, T. Takesue, ***J. Appl.*** *folym.* Sci., ***38,***

4. Lee, M. *Chem. Br.* **1995**, *31*, 515-516.

5. Uemichi, Y.; Kashiwaya, Y.; Tsukidate, M.; Ayame, A.; Kanoh, H. *Bull. Chem. Soc. Jpn.* **1983**, *56*, 2768-2773.

6. Catalytic degradation of high density polyethylene over mesoporous and microporous catalysts in a fluidised-bed reactor Y.-H. Lina,), M.-H. Yanga, T.-F. Yehb, M.-D. Gerb 2004

7. Demirbas A. Pyrolysis of municipal plastic waste for recovery of gasoline-range hydrocarbons. J. Anal. Appl. Pyrolysis, 2004; 72: 97-102.

8. Seo YH, Lee KH, Shin DH. Investigation of catalytic degradation of high-density polyethylene by hydrocarbon group type analysis. J Anal Appl Pyrol, 2003; 70(2): 383-398

9. Lin YH, Yang MH. Catalytic reactions of post-consumer polymer waste over fluidised cracking catalysts for producing hydrocarbons. J Mol Catal A-Chem, 2005;231(1-2): 113-122.

10. Lee KH, Thermal and Catalytic Degradation of Waste HDPE (5th chapter),Feedstock Recycling and Pyrolysis of Waste Plastics, John Wiley & Sons, Ltd, 2006