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Recycling of Polystyrene using Hydrotalcite as Degradation Catalyst

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Abstract—*The degradation of Polystyrene has been successfully achieved using hydrotalcite as catalyst. The reaction was carried out at 250°C and degradation is completed in 1 hr. Thus we can conclude that the best result obtained by using Hydrocalcite as catalyst and without the use of any catalyst.*

Keywords:—*Polystyrene; Catalysts; Hydrotalcite.*

1. INTRODUCTION

Polystyrene is one of the extensively used polymeric materials. It is an aromatic polymer made from the aromatic monomer styrene, a liquid hydrocarbon that is commercially manufactured from petroleum by the chemical industry. It is use in manly packaging applications, especially in the beverage industry.[1] Polystyrene are most often used in electrical, vibrational, and thermal insulator applications. Additionally, polystyrene are used in applications related to packaging, refrigerator doors, air conditioner cases, containers and molded household wares, boats water coolers and a variety of other uses. As can be seen, use of polystyrene is prevalent. Despite the prevalence of polystyrene, there are disadvantage associated with its use. Polystyrene does not readily degrade and typically cannot reused. Expanded polystyrene is widely used as food trays, packaging materials, or adiabators because of its excellent shock observing property. Low thermal conductivity and light weight.

15 million metric tons of polystyrene are produced annually worldwide, most of which ends up in landfill. Hence, the conversion of waste polystyrene (a dead end product) into a useful commodity is desirable. As a result of its widespread use and poor rate of recycling, polystyrene is viewed as a major post-consumer waste product. As an alternative to polymer recycling, polystyrene can be burned to generate heat and energy or converted back to its monomer components for use as a liquid fuel. A number of techniques for converting plastic back to its monomer components have been developed, one of which, pyrolysis, involves thermal decomposition in the absence of air to produce pyrolysis oils or gases. In addition to their use as fuels, pyrolysis oils may also have a biotechnological use, i.e., as a starting material for the bacterial synthesis of value added products. Due to the biotechnological conversion of polystyrene to PHA, post consumer polystyrene is, potentially, a starting material for the synthesis of biodegradable plastic. Indeed this work creates a substantive link between petrochemical and biological polymers and potentially opens up a new area of exploration for the petrochemical industry.

There are several methods used for degrading the polymer like, thermal, mechanical, radioactive, chemical biological etc. The effect of several catalysts and oxidizing agents on the polymer degradation has been extensively studied. Degradation of waste plastic in to fuel oil is one of the treatment methods that has been proposed for recycling of waste plastics as an energy sources. Most of the studies on the degradation of plastic to fuel deal mainly with single component plastics such as polystyrene, poly propylene.

Poly (alkylacrylates), poly (alkyl methacrylates), and their copolymers are used in several industries for points, textiles, automobiles, fibers, lubricants, microelectronics.[2]Because of their mechanical and electrical properties, of optical clarity, and high chemical and thermal stability.[3-4]

The effect of alkyl group on the thermal, ultrasonic, and enzymatic degradation of poly (alkyl acrylates) have been studied.[5-14] Although many attempts have been made to convert polystyrene into styrene monomer or fuel oil by thermal as catalytic degradation techniques. Those techniques are very energy intensive since the reaction temperature is generally higher than book it is there for worthwhile to pay attention to the dissolution/ precipitation techniques as concerned with energy consumed for reuse of waste poly styrene. The advantage of this technique in Clute a massive reduction of the bulk volume, removal of some insoluble contaminants and the quality of the precipitated polymer comparable with the vergin polymer. Hydrotalcite enhance rate of reaction due to large surface area, week Lewis acid, high adsorption capacity while other commonly used catalyst like (sodium hydroxide, metal acetate (lead, zinc, cobalt, and manganese)[22] shows low surface area. Hydrotalcite has been used in various other applications such as stabilizer for resins and rubber e.g. polyethylene, polypropylene, and chlorine containing resins as well as paints, agricultural, films, inks, and deodorants.[23,24] Hydrotalcite can be easily recycled and reused and easily separated from the product while various kinds of other catalysts, such as titanium–phosphate[25], metal acetate (lead, zinc, cobalt, and manganese) [22] and solid superacids[26] are difficult to separate from the products, as illustrated in the literature.[23]

2. EXPERIMENTAL

Synthesis of Hydrotalcite catalyst

For hydrotalcite synthesis $Mg(OH)_2$ (2.33g) and Al_2O_3 (0.52g) were suspended in distilled water (100ml) separately and mixed in a R.B. flask. Sodium bicarbonate ($NaHCO_3$) solution (0.1N) was then added drop wise with stirring until the pH reached 9-10, then the solution was refluxed at 80^0C for 3 hours. The resulting white product was filtered and repeatedly washed with distilled water. It was dried in oven at 100^0C for 9-10 hours.[27]

Prepration of Fuel oil from Thermocole

Initially 5 gm thermocole were taken in a 500 ml beaker. Now 0.050 gm Zinc Oxide/ Magnesium Oxide/ Copper Black/ Calcium Oxide/ Hydrocalcite were mixed in it (As catalyst).15 ml of Toluene is added to this mixture, with continuous stirring.Just after addition of Toluene, the thermocole is completely dissolved. The resulting solution is transparent. The solution is converted in the form of thin layer film. When the layer is completely dried, convert it in the small pieces. Now set the distillation assembly, maintaining temperature 250^0C.The layer is converted in the forms of fumes, which was condensed as oil. The oil were taken out and measured in the measuring cylinder.

Table 1. Use Chemical

S.No.	Poly-styrene	Toluene (Solvent)	Zinc Oxide/ Magnesium Oxide/ Copper Black/ Calcium Oxide/ Hydrocalcite
1	5 gm	15 ml	-
2	5 gm	15 ml	0.050 mg
3	5 gm	-	0.050 mg

3. RESULT AND DISCUSSION:

After distillation of fuel oil from thermocole we found that no change in colour of fuel oil occurs at room temperature. The weight of fuel oil obtained is 2.1 gm, and density is 0.5865 gm/cm3. Also the viscosity calculated is 0.001865 poise. The flash point and fire points of fuel oil are 68 C and 74 C respectively. The fuel oil obtained using Hydrocalcite as catalyst and without using Hydrocalcite are 4.8 ml and 4.9 ml respectively.

After distillation of fuel oil from thermocole we found that no change in colour of fuel oil occurs at room temperature. The weight of fuel oil obtained is 6.76 gm, and density is 0.8481gm/cm3. Also the viscosity calculated is 0.007105 poise. The flash point and fire points of fuel oil are 72 C and 79C respectively. The fuel oil obtained using Magnesium Oxide as catalyst with solvent and without Solvent using Magnesium Oxide are 3.9 ml and 4.0 ml respectively.

Thus we can conclude that the best result obtained by using Hydrocalcite as catalyst and without the use of any catalyst.

Table 2. Effect on yield of use of different type of catalysts:

S.No.	Polystyrene	Solvent	Catalyst	Temp.	Time (hr)	Yield (ml)	Density (gm/cm3)	Viscosity (poise)
1.	5 gm	15 ml	ZnO	250 ^{0}C	1:30	3.1	0.9291	0.6397
2.	5 gm	15 ml	MgO	250 ^{0}C	1:15	3.9	0.6732	0.0091
3.	5 gm	-	MgO	250 ^{0}C	1:05	4.0	0.8481	0.0071
4.	5 gm	15 ml	Cu black	250 ^{0}C	1:30	3.3	0.9720	0.0700
5.	5 gm	15 ml	CaO	250 ^{0}C	1:10	3.5	0.9699	0.0721
6.	5 gm	15 ml	Hydrocalcite	250 ^{0}C	1:25	4.8	0.4942	0.0076
7.	5 gm	-	Hydrocalcite	250 ^{0}C	1:15	4.9	0.5865	0.0081
8.	5 gm	15 ml	-	250 ^{0}C	1:30	2.5	0.4673	0.0063

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