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DEPOLYMERIZATION OF PET WASTE USING GREEN METHODS

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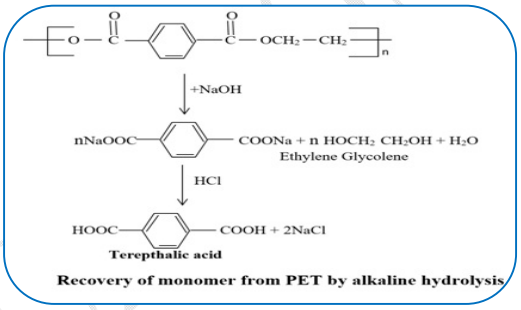
ABSTRACT :

Invention of more environment friendly products and processes are main object of green chemistry. Use of phase Transfer in Depolymerization of PET is an example. Catalyst in recovery of monomer terephthalic acid by Poly(ethylene terephthalate) waste using sodium or potassium hydroxide is a method in which more than 95% product TPA is possible at lower temperature in less time is observed. Experimentally, when 10 gm PET waste refluxed with 10gm NaOH in 100ml distilled water, in presence of Tetrabutyl ammonium bromide 0.2% weight of PET waste in fine powder form 95% recovery within 90 minutes of 100°C was found. Recovery of catalyst is also very easy after recovery of monomer. Due to all these advantages over conventional method use of PTC is product step to promote greener way of depolymerization of all types of plastic or polymers.



Recovery of monomer from PET by alkaline hydrolysis

KEYWORDS : *Green chemistry, Depolymerization, PET Phase transfer catalyst, Alkaline hydrolysis.*

INTRODUCTION:

Industrial development,Increasing urbanization Modern life style are main cause of pollution. Scientific community is continuously watching the changes in environment due to all these activities, changes in climate is becoming a part of life, since few years. Green chemistry principle can save the environment.Eco-friendly methods and energy saving techniques are part of studies under Green chemistry.

Use of plastic throughout the world is increasing, usage of plastic or polymer, poly(ethylene terephthalate) in packaging industry, synthetic fibre, films is increasing by almost 10% in Asian countries and by 7% in the world. The consumption of PET is increasing because, it has many qualities.It is strong yet light weight, transparent. PET is a thermoplastic polymer has high strength, odourless non-toxic, non-permeability to CO_2 gas and relativity of low cost. Due to all these qualities PET is used as synthetic fiber, for drinking water and soft drinks bottles, in photographic films and packaging of other food material. Since, last few years its use in also increasing in, Engineering building, construction material and automotive industry.

Increases in abnormal population in India and nearby countries, use of PET is increasing continuously. As the use of PET is increasing, waste management of this polymer is becoming a great problem.Because most of PET waste goes to landsfill and water sources like river and ultimately to sea water. Although PET is non-toxic but it does not decompose naturally, Partially degradation is possible by thermoxidative oxidation; ultraviolet light initiate the in coporation of oxygen, this causes PET to become brittle, breaking into small pieces. The process continuous until polymer breaks to lower molecular. This entire process is very slow and generally takes 60 to 500 years.

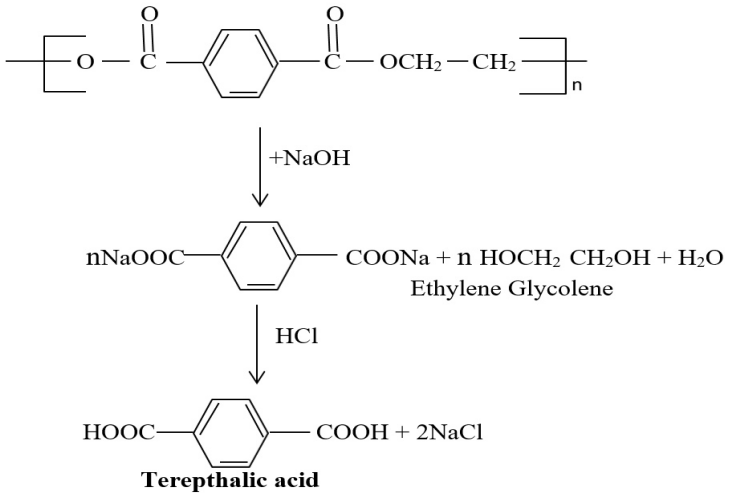
Environmentalist are very much concerned due to huge deposits of waste in soil and water sources therefore more and more processes invented.Green chemistry principles are also important with cost cutting in the processes, industry should take advantage of novel changes. Chemical recycling of PET waste is important route to control environment by producing terephthalic acid (TPA) Monomer, which can be used again. Many methods of recycling are known Hydrolysis by water, alkali and acids, Aminolysis, Ammonolysismethanolysis, Glycolysis etc. Out of all these, alkali hydrolysis in different conditions were studied.

EXPERIMENTAL:

PET waste, in powder form is refluxed in three necked round bottom flask, attached with magnetic stirror and thermometer on third mouth condenser is fixed. The whole assembly is placed in thermostate. First set of experiment were performed with 10gram PET waste 100 um particle size with 2 to 12gram NaOH in 100ml distilled water at 100°C for 90 minutes. At the end of each set the content were cooled and treated with conc. HCl until the solution became acidic white precipitate is filtered washed with distilled water many times, vaccum dried at 90°C and weight was measured (Table No. 1)

In second set of experiment 10gram PET waste 100um and 10% NaOH in 100ml distilled water is refluxed at different temp. for 100 minutes, every time same process for precipitation, drying weighting was performed (table No. 2)

In third set experiment 10 gram PET waste was refluxed with 10% NaOH in 100ml distilled presence of phase transfer catalyst (PTC) tetra butyl ammonium bromide 0.2% weight PET weight was refluxed for many temperatures ranging from 60 to 120°C similar process for precipitation filtration were refluxed (Table No. 3)



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ROLE OF PHASE TRANSFER CATALYST:

Poly (ethylene terephthalate) is present in powder form (solid phase) and NaOH is present in liquid phase, so that phase transfer catalyst works with interfacial mechanism. PTC (Tetrabutyl ammonium bromide) catalyst have covalent bond in between Nitrogen and butyl group, therefore catalyst have organic character, Catalytic role of PTC to transport ^{-}OH reactive anion from NaOH (Miscible part to external) Surface of PET powder (solid phase), in this way, the ester linkage in PET molecule became easier to attack by hydroxyl ion and the depolymerization is increase terephthalate ion return to aqueous phase. Tetrabutyl

ammonium bromide has enough character to lipophilic, while small enough in order to avoid steric hindrance.

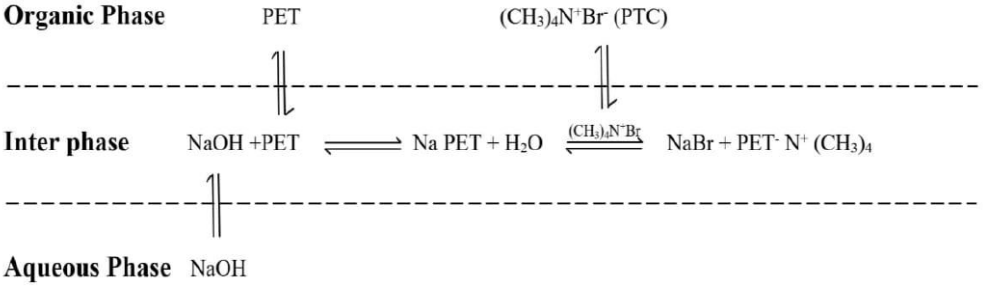

Table 1: Conversion of PET waste powder to TPA with variation of amount of NaOH temp 108°C time 100 minutes

Sr. No.	% of NaOH in distilled water	% of conversion
1	2	22
2	4	36
3	6	58
4	8	74
5	10	80
6	12	80

Table 2: Conversion of PET waste to TPA with variation of temperature in ^{o}C for 100 minutes

Sr. No.	Temperature	Percentage conversion
1	60	26
2	80	56
3	100	68
4	120	80
5	140	86
6	160	84

Table 3: Conversion of PET waste to TPA with variation of temperature in for 100 minutes in presence of PTC

Sr. No.	Temperature	Percentage conversion
1	60	48
2	80	74
3	100	95
4	120	93

CONCLUSION:

Recovery of monomer TPA in presence of 10 gram PET waste and 10% NaOH (10gram) was found maximum. For second set of experiment it was found that when temp was increased upto 140°C recovery of monomer TPA increased continuously then peak was formed. At 140°C in 100 minutes refluxed time recovery of TPA was 86%, however in presence of catalyst tetra butyl ammonium bromide at lower temp 100°C in 100 minutes refluxed time recovery of TPA monomer was reached upto 95%. Thus, use of PTC catalysts are the best way to control environment pollution and principle of green chemistry can be achieved.Chemical recycling of PET waste is according to the principles of sustainable development because

by this method recovery of the same monomer TPA is formed from which PET is originally made. The use of different catalyst to improve rate of reaction at lower temp was reported. Use of zinc, lead, manganese acetate are also effective, but metal pollution is also cause of concern. Phase transfer catalysts are more environment friendly. We found Tetra butyl ammonium bromide as catalyst is one of the most suitable catalyst to the principles of green chemistry.

REFERENCE: -

1) Fujita, A; Sato M and Marakami M process for Depolymerization of polyster scrap. Japan patent 4,284,646 (1985)

2) Fujita A, Sato M and Marakami M Process for Depolymerization of polyster scrap. US patent 4,609,680 (1986)

3) Karayannidis G. P. and Achilias D. S. (2004) Chemical recycling of Poly (ethylene terephthalate) as an indicator of sustainable development

4) Karayannidis G. P. and AchiliasD. S. Chemical recycling of PET macromolecular Material and Engineering 292 (2) 2007 PP 128-146

5) Alter H. Disposal and reuse of polymers Encyclopaedia of polymer science and Engg. Wiley interscience New York 5 (103) 1986

6) J. Scheirs Chapter 4 Recycling of PETpolymer recycling, Wiley series in polymer science J. Wiley & sons 1998

7) MieczyMakosza Phase transfer catalyst. A green methodology in organic synthesis. Pure Appl. chemVol 72 No. 7 pp 1399-1403 (2000)

8) Mishra S, Goje V. S. and Zope V. S. Plastic waste Management and Environment New Delhi March 2001, 15,163.

9) J. Das, A.B. Halgeri, V. Sahu and P.A. Parikh; Alkaline Hydrolysis of PET in presence of a phase transfer catalyst, Indian Journal of Chemical Technology Vol. 14 March 2007, pp. 173-177

10) R. Lopez-Fonseca, M. P. Gonzalez-Marcos, J. R. Gonzalez-Velasco & J. I. Gutierrez-Ortiz; Chemical Recycling of PET by alkaline hydrolysis in presence of quarternaryphosphonium and ammonium salts as phase transfer catalyst. WIT Transactions of Ecology and the Environment, Vol 109, 2008 WIT Press

11) D. Spaseka, M. Civkaroska; Alkaline Hydrolysis of PET recycled from the postconsumer soft drink bottles, Journal of University of Chemical Technology and Metallurgy,45, 4, 2010, 379-384

12) Hussain I. Khalaf, Omar A. Hasan; Effect of quaternary ammonium salt as a phase transfer catalyst for the microwave depolymerization of polyethylene terephthalate waste bottles, Chemical Engineering Journal 192(2012) 45-48

13) YevaTorosyan, AndranikAvetisyan, GagikTorosyan; Phase transfer catalyst for green catalyst, Journal of Faculty of Food Engineering, Stefan cel Mare University of Suceava, Romania, Volume XII, Issue 1-2013, pag. 12-17