Production of Alkylbenzenes from Pure Polythene Wastes.

Abdulghaniyy Olawale Ilias[1] and Abdulkabir Oladele Oladimeji*[2]

[1]Department of Water Resources and Engineering Services, Ministry of Water, Kwara State, Nigeria.
[2]Department of Chemical Sciences, Ondo State University of Science and Technology, Okitipupa, Nigeria.

E-mail: oladimeji.abdulkabir@gmail.com[*]

ABSTRACT

Following different inventions to provide an environmentally friendly process for recycling polythene waste materials, we have carried out the production and characterization of alkyl benzenes. The alkyl benzenes were prepared by a process which involved simultaneous introduction of benzene (30 mL), polythene (discarded water packaging sachet) 0.5 g, and aluminum chloride (0.1 g) into a reactor at 130 °C and 760 mmHg. The production was carried out by varying the reaction time (five minutes intervals). For each time, the melting point and the solubility of the products were determined. UV and FT-IR spectroscopic analyses were used in the characterization of the products obtained. A colorless and waxy solid of alkyl benzene obtained each time showed UV absorptions in the range of 241 and 260 nm. The IR absorptions (umax, cm-1) 1633, 1470 and 729 for aromatic benzene were also detected. The percentage yield of the product increased with reaction time. The products also agree favorably well with data obtained from commercial grade alkyl benzenes.

(Keywords: recycling, polythene, polythene wastes, alkylbenzenes)

INTRODUCTION

Polyethylene (PE) or polythene (IUPAC name polyethene or poly(methylene)) is the polymer of ethene, a simple gaseous hydrocarbon molecule usually obtained from petrochemical sources or by dehydrogenation of ethane [1]. It is a large molecule that consists of chains of methylene (-CH_2^-). The most important polyethylene grades are high density polyethylene (HDPE), linear low density polyethylene (LLDPE) and low density polyethylene (LDPE) [1]. All the grades are primarily used in packaging (plastic bags, plastic films, plastic bottles, and containers). Polythene wastes are therefore generated after primary use.

The wastes include, but are not limited to, used bottles, sandwich bags, and water sachets. Across the world, solid waste management systems face a challenging issue of safe disposal of non-recyclable polythene bags [2]. Careless polythene disposal has constituted nuisance and health hazard to our environment. The effects of this are environmental pollution and space problem because polythene wastes are not easily biodegradable [3]. Over the years, the quantity and generation rate of solid wastes in Nigeria have increased drastically. In Ilorin, the Kwara state capital, solid wastes generation was projected to be 0.43 Kg/person/day by the year 2020 [4].

Recycling of waste plastic materials is an important research area, driven by commercial and environmental influences. Waste polythene materials are being recycled into new products and chemical substances. Rasul, et al. carried out the recycling of waste high density polythene using barium carbonate catalyst at a temperature of 450°C and 2-hour reaction time. The hydrocarbon fractions obtained from the recycling resembled gasoline, kerosene, and diesel oil in almost all of the characteristic properties [5].

The alkylbenzenes are derivatives of benzenes in which one or more hydrogen atoms are replaced by alkyl groups of different sizes [6]. The simplest member is toluene, in which a hydrogen atom of the benzene was replaced by a methyl group. Alkylbenzene is usually made by alkylation of benzene with alkene in the presence of aluminum chloride or zeolite catalyst [7]. Various research projects have shown different approaches in alkylbenzene production.

The Friedel-Crafts alkylation is one of the oldest commercial routes to linear alkylbenzene production. The process involves chlorination of n-paraffin to mono-chloroparaffins followed by alkylation of benzene using aluminum chloride catalyst [8].

Fred et al. investigated a new invention, in which ethyl benzene is produced by a process which involves simultaneously and continuously introducing ethylene, benzene, and aluminum chloride catalyst into a reactor at temperature between 130 – 200 $^{\circ}$C and pressure high enough to maintain the reactants substantially in the liquid phase [9].

Shenglin and Fucun produced ethylbenzene through alkylation of dilute ethylene with benzene at a temperature of 140- 185 $^{\circ}$C and a pressure of 1.6-2.1 Mpa. The ethene conversion was above 95% while the ethylbenzene selectivity was above 83% [10]. This prospective study was designed to investigate the usefulness of discarded pure water sachet (LDPE) in preparation of alkylbenzene. To the best of our knowledge, no study has employed this approach in the production of alkylbenzenes.

MATERIALS AND METHODS

Instrumentation

IR spectra were recorded on a Nicolet Impact 330 FT-IR spectrometer (Thermo Optec, USA). UV spectra were recorded on a Hitachi U-3200 spectrophotometer; λ_{max} in nm. Melting points were determined using a Gallenkamp apparatus and are uncorrected. All reagents and chemicals used were purchased from Merck, Germany. The solvents were of analytical grade.

Sample Collection

The materials used were discarded "pure water" polythene sachets (LDPE) obtained from different dumpsites in Ilorin metropolis of Kwara State, Nigeria.

Preparation of Alkyl Benzene

The sachets were washed with detergents and water. They were then air dried and cut into smaller pieces of 0.5 g. The pieces of the sachets were soaked in 30 mL of toluene in a beaker and covered for 30 minutes. The beaker was later heated at 100°C in a water bath for 15 minutes until the pieces of sachet dissolved completely. The liquid content was filtered to obtain a colorless filtrate and a waxy residue. The weight of the air dried residue and filtrate volume were recorded accordingly.

The 0.5 g residue was re-dissolved in 30 mL of benzene in the presence of 0.1 g aluminum chloride catalyst. The Alkylation was maintained at 130°C and normal atmospheric pressure for 15 minutes under reflux according to a standard procedure described by Fred et al. [8]. The experiment was repeated four times using a time incremental interval of five minutes.

Physical Tests

The solubility test was performed using benzene, xylene, and toluene as solvents. The melting point was determined using a thin capillary tube (melting point tube).

Spectroscopic Analysis

Infrared (IR) spectrum was recorded for each of the alkylbenzenes prepared each time using a Nicolet Impact 330 FT-IR. Each spectrum was run on a KBr disc for 35s. The UV analyses were also performed using Hitachi U-3200 UV Visible Spectrophotometer.

RESULTS AND DISCUSSION

Products obtained at reaction times of 15, 20, 25, 30 and 35 seconds were tagged AB1, AB2, AB3, AB4, and AB5, respectively. Each product was a colorless waxy solid which is insoluble in water but soluble in benzene, xylene, and toluene at temperatures of 85, 90, and 100°C, respectively. The melting points of the products ranged from 75.6 to 77.8 °C (Table 1) against the 115°C melting point of the LDPE precursor used for the preparation. All the compounds showed absorbance between 241 and 260 nm.

Each product showed IR absorption peaks at around 1470 to 1473 cm^{-1} , 1633 to 1637 cm^{-1} and 716 to 729 cm^{-1} to affirm the presence of -CH=CH- stretch of benzene, -C-H- stretch of

benzene and out of plane -CH- bending vibration of mono substituted benzene, respectively.

Table 1: Products Yield and Melting Point.

S/N	Product	Mass (g)	% yield	Melting point (^{o}C)
1	AB1	0.67	34	75.6
2	AB2	0.67	34	76.4
3	AB3	0.70	40	76.8
4	AB4	0.70	40	77.4
5	AB5	0.80	60	77.8

Key; AB= alkylbenzene

Table 2: Comparison of the IR Spectroscopic Data of the Products with Commercial Grade Ethylbenzene, Benzene, and Polythene Sachet.

S/N	Product	-CH=CH- stretch of aromatic. Frequency (cm^{-1})	-C-H- stretch of benzene. Frequency (cm^{-1})	Out of plane -C-H- bending vibration of substituted benzene (cm^{-1})
1	AB1	1472.14	1635.67	729.21
2	AB2	1473.93	1637.11	719.13
3	AB3	1471.47	1634.81	716.96
4	AB4	1470.96	1633.56	718.94
5	AB5	1473.36	1637.60	729.40
6	Ethylbenzene	1455.81	1604.24	728.24
7	Benzene	1455.53	1634.55	absent
8	Polythene sachet	absent	absent	absent

DISCUSSION

The solubility of the products and the melting point values agreed with other solid alkylbenzenes like eicosylbenzene [11].

The UV absorptions in the range of 241 to 260nm affirmed the presence of a benzene ring in the prepared alkylbenzenes. Methylbenzene has similar absorbance at 253 to 268 nm [12]. The slightly low absorbance value of 241 and 242nm in the prepared alkylbenzene might be due to the interference from the large size of the alkyl group on the benzene ring as the reaction time increased.

The IR absorption peaks obtained around 1470 to 1473 cm^{-1} , 1633 to 1637 cm^{-1}, and 716 to 729 cm^{-1} affirmed the presence of -CH=CH- stretch of benzene, - C-H- stretch of benzene, and out of plane -CH- bending vibration of mono substituted

benzene, respectively. The intensity of the peaks increased with reaction time. The peaks were compared with the peaks in the spectra (which were run under the same condition) of commercial benzene, ethyl benzene and the polythene sachet used in the preparation of the alkyl benzenes as shown in Table 2.

Similar peaks were seen at 1473.36 and 1455.53 cm^{-1} to indicate -CH=CH- stretch of aromatic in commercial grade benzene and ethyl benzene respectively. No such peak appeared in the spectrum of the polythene sachet. Only the commercial grade ethyl benzene showed similar absorption at 728.24 cm^{-1} to indicate out of plane -CH- bending vibration of mono substituted benzene. Such absorption was absent in both the commercial grade benzene and the polythene sachet. John et al., in their determination of toluene and ethyl benzene, also concluded that both showed absorption peaks at 724-732 cm^{-1} and 694-702 cm^{-1}, respectively for aryl C-H out of plane bending [13].

CONCLUSION

The alkylation of benzene in the presence of aluminum chloride was done successfully because the alkylbenzenes prepared showed similar properties when compared with commercial grade benzene and ethyl benzene. The spectra and physical property data of the prepared alkylbenzenes also differed from that of the polythene sachet material to affirm that the conversion was done successfully. It is our belief that if the idea in this research work is replicated on industrial scale, the dream of creation of wealth from waste would be achieved in alkylbenzene production. This will not only increase the volume of alkylbenzene produced worldwide but will also create a new employment opportunity and rid our environment off polythene wastes pollution.

ACKNOWLEDGEMENTS

REFERENCES

1. Piringer, O.G. and A.L. Baner. 2008. *Plastic Packaging: Interactions with Food and Pharmaceuticals (2nd ed.)*. Wiley-VCH: Berlin, Germany. ISBN 978-3-527-31455-3.

2. Williams, E.A. and P.T. Williams. 1997. "Analysis of Products Derived from the Fast Pyrolysis of Plastic Waste". *Journal of Analytical and Applied Pyrolysis*. 40-41:347-363. doi:10.1016/S0165-2370(97)00048-X

3. Ukpong, E.C. and C.M. Peter. 2011. "Material Recoveries from Polythene Recycle as an Environmental Pollutant in Nigeria". *Continental Journal of Water, Air and Soil Pollution*. 2(1):31-41.

4. Babayemi, J.O. and K.T. Dauda. 2009. "Evaluation of Solid Waste Generation, Categories and Disposal Options in Developing Countries: A Case Study of Nigeria". *Journal of Appl. Sci. Environ. Manage*. 13(3):83-88.

5. Rasul, J., S. Jasmine, and G. Hussain. 2010. "Catalytic Degradation of Waste High Density Polythene into Fuel Production using Barium Carbonate as a Catalyst". *Journal of Fuel Processing Tech*. 91(11):142.

6. Wikipedia. 2015. "Alkylbenzene". Available from: En.wikipedia.org/wiki/alkylbenzene

7. Gerzeliev, I.M., S.N. Khadzhiev, and I.E. Sakharova. 2011. "Ethylbenzene Synthesis and Benzene Trans Alkylation with Diethybenzenes on Zeolite Catalyst". *Journal of Petroleum Chemistry*. 51(1):39-48.

8. Wikipedia. 2015. "Linear-Alkylbenzene". Available from: En.wikipedia.org/wiki/linear-alkylbenzene

9. Fred, A, E. Loisuie, I. Junior, C.M. Alishar, and D. Jliques. 1973. *Alkylation Process*. 1-5.

10. Shenglin, L. and F. Chen. 2009. "Highly Selective Ethyl Benzene Production through Alkylation of Dilute Ethylene with Gas Phase-Liquid Phase Benzene and Transalkylation Feed". *Journal of Natural Gas Chemistry*. 18(1):21-24.

11. Chemical Product. 2015. *Chemicalbook*. Available from: http://www.chemicalbook.com/chemicalproduct

12. Wikipedia. 2015. "Toluene". Available from: En.wikipedia.org/wiki/toluene

13. Diehl, J.W., J.W. Finkbeiner, and F.P. DiSanzo. 1993. "Determination of Benzene, Toluene, Ethybenzene and Xylene in Gasoline by Gas Chromatography/Deuterium Isotope Dilution Fourier Transform Infrared Spectrometer". *Anal. Chem*. 65(18):2493-2496.

SUGGESTED CITATION

Ilias, A.O. and A.O. Oladimeji. 2016. "Production of Alkyl Benzenes from Pure Polythene Wastes". *Pacific Journal of Science and Technology*. 17(1): 219-222.

Pacific Journal of Science and Technology