International Journal of Basic and Applied Sciences

(A peer reviewed International Journal)

Performance Analysis of Castor Oil Based Polyurethane Foam

International Journal of Basic and Applied Sciences, Vol. 1 No. 3. pp. 255-257 2277-1921. 2012

ISSN *2277 – 1921*

Article type *Full Length Research Article*

Submission date *22 June 2012*

Acceptance date *10 July 2012*

Publication date *15 July 2012*

Article URL *http://www.crdeep.com/category/ijbas*

Authors *M.D Ayo[1,*], I.C.Madufor[2], L.O.Ekebafe[1], M.N.Chukwu[1], O.G. Tenebe[2], K.O. Eguare[1]*

Center for Rural Development Ecology and Environment Protection

CRDEEP Head Office: 315/10, Kaulagarh Road, Rajendranagar, Indervihar, Dehradun, 248001, Uttrakhand, India.

International Journal of Basic and Applied Sciences Vol.1 No.3. 2012. Pp. 255-257

Full Length Research Paper

Performance Analysis of Castor Oil Based Polyurethane Foam

M.D Ayo[1,*], I.C.Madufor[2], L.O.Ekebafe[1], M.N.Chukwu[1], O.G. Tenebe[2], K.O. Eguare[1]

[1]*Department of Polymer Technology, Auchi Polytechnic, P.M.B. 13, Auchi, Nigeria*

[2]*Departnment of Polymer/Textile Engineering, Federal University of Technology, Owerri, Nigeria*

****Corresponding Author: M.D Ayo***

Abstract

The performance analysis of castor oil-based polyurethane foam in comparison with the conventional polyol based foam was investigated. Castor oil was extracted from the seeds using a hydraulic press and characterized in terms of moisture content, volatile content, acid value, free fatty acid and saponification value. The results are within the range reported in literature. It was made to react with toluene, di-isocyanate and other materials to obtain the polyurethane foam; also, the polyether polyol was used with other materials to obtain the conventional foam. In-situ polymerization was used in the production of polyurethane foam using the extracted oil as polyol. It was observed that good quality foam can be obtained from correct formulation and proper mixing of the ingredients. The analysis shows that castor oil based foam is best for high density semi-rigid foam while polyether polyol is suitable for low density flexible foam. Results of foam characterization in terms of compression set and density conform to standard foams

Keywords: *Polyol, castor oil, polyester polyol, polyurethane*

Introduction

The use of agricultural by-products (maize cob groundnut husk, cassava peel, cocoa pod husk, plantain peel, rubber seed shell, castor seed etc) to produce materials that are competitive with synthetic ones is gaining attention over the last decade, because of availability of materials, and low cost [1,2].

The development of commodities derived from petrochemical polymers has brought many benefits to mankind. However, it is becoming more evident that the ecosystem is considerably disturbed and damaged as a result of pollution occasioned by discharge of heavy metals and the non- degradable materials used in disposable items. Therefore, the interest in polymers from renewable resources has recently gained exponential momentum and the use of biodegradable and renewable materials to replace conventional petroleum materials for disposable and other industrial applications is becoming popular and necessary[3,4].

Castor plant (Ricinus communis), readily available in Nigeria, is a natural resource which is a viable source of oil that can be used for many industrial applications. It contains about 85% ricinoleic acid, Cis-1,2-hydroxyoctadec-9-enoic acid[5]. There have been many studies on the synthesis and characterization of a wide variety of polymers based on vegetable oils.[6,7] Although they possess double bonds, which are used as reactive sites in coatings, they cannot be converted easily to high-molecular-weight products without the introduction of more reactive functional groups, such as hydroxyl, epoxy, or carboxyl groups. Various chemical pathways for the functionalization of triglycerides and fatty acids have been studied.[8]

This present study examined the performance of the oil in the production of polyurethane foam.

Materials and Methods

Materials

Castor seeds were obtained from Ososo, in Akoko-Edo local government area of Edo State, Nigeria. The chemicals used; Acetone, Phenolphthalein, sodium hydroxide, ethanol, diethyl ether, hydrochloric acid, potassium hydroxide, N,N-cyclohexylamine, N,N-dimethylethanolamine, silicon surfactant, methylene chloride, di-isocyanate-diphenyl methane(MDI), and Feron II, were of analytical grade and supplied by BDH, England.

Extraction of Castor Oil

The castor seeds were first peeled and separated from the shell and then grinded to a very small size-particles called “meal”. The meal was filled into a filter bag of about 2 micros, and the hydraulic press used to extract the oil.

Characterization of the seed oil

Samples of the seed oil extracted were characterized in terms of moisture content, volatile content, acid value, saponification value and free fatty acid value according to standard methods AOAC[9] and loss on ignition, ASTM 7348 [10].

Foaming process

The formulation below was used for both the conventional polyol and the castor oil

All the ingredients were weighed according to the formulation and mixed thoroughly to form a colloidal dispersion and methylene chloride was bubbled into the mixture before toluene di-isocyanate was added with continuous stirring. The mixture was poured into a mould and allowed to stay for about 24 hr.

Table 1. Formulation for the production of the polyurethane foam

Materials	Polyol (pphr)	Castor oil (pphr)
Polyol	100	-
Castor oil	-	100
Water	4.2	4.2
Dimethylamine-ethanol	4.2	4.2
Stannous octate	0.25	0.25
Silicone oil	1.02	1.02
Methylene Chloride	3.67	3.67
Toluene di-isocyanate	65.0	65.0

Testing of the polyurethane foam

Samples of the foam formed were tested in terms of compression set according to ASTM 385 [11], Hardness test was determined by adopting the standard dead load method, tensile strength, elongation at break according to ASTM D 813 [12] and density using standard method AOAC [13].

Results and Discussion

Characterization of the seed oil

Table 2 shows the results of the characterization and percentage oil yield from castor seeds. From the table, the castor seeds yielded 54.79% oil suggesting that little quantity of castor seeds yields high quantity of oil which is profitable economically.

From the characterization, the percent moisture and volatile content, acid and free fatty acid (FFA) values ranges between 0.1 – 0.2 as shown in Table 3

The saponification value is as low as 181.4, indicating that the oil can be used in numerous industrial applications as in the in-situ polymerization for the polyurethane foam, Devine & Williams [14]. The saponification value of the oil was 181.4; similar to that of typical seed oils such as sunflower, corn, and safflower oils [15] whose average saponification value range from 175 to 250

Results of foam characterization

From the results in Table 3, polyether polyol based foam has a density which is within the density specification with a tolerance of ±0.5kg/m^3. The result could be attributed to the water content of the castor oil, which is lower than that of the polyether polyol and as such will yield denser foam at the blowing index used. Since the foam density has an inverse relation with the blowing index. As already mentioned, the density of foam is an essential feature, because it allows obtaining more low-weight material, especially if it is to be used as a packing material.

Also, the hardness at 35%, elongation at break, tensile strength and compression set meet the required specification for the suitability of the foam for usage. The low percentage elongation for the castor oil based foam can be attributed to the brittleness and the hardness of the foam which might be due to the higher number of crosslink density per molecule of the polyurethane foam. The tensile strength is less than the specification because of poor resilience of the castor oil based foam. Previous studies,[16] discussing, for example, the synthesis of polyurethane foam debris from the pineapple shell, indicated that the lignocellulosic materials incorporated as a reinforcement provide a polyurethane matrix, a greater ability to withstand compression tests and increase the modulus.

Compression analysis, involving the exertion of a certain force on a sample, is aimed at observing its deformation under test conditions: it reveals the compressive stress
(σ), *i.e.* the load per unit area, and the compression modulus (E), which involves splitting between compressive strength and deformation. The modulus provides information on the material's ability to withstand an applied load, before reaching the breaking point.

Conclusion

From the study, it was observed that good quality foam can be obtained from correct formulation and proper mixing of the ingredients. The analysis shows that castor oil based foam is best for high density semi-rigid foam while polyether polyol is suitable for low density flexible foam.

Table 2. Result of castor seed oil characterization

Seed Oil	Wt. of Oil(g)	Acid value	% FFA	Saponification value	Loss on Ignition	% Moisture/ (%)Volatile	oil yield
Castor oil at ambient	10	2.18	1.09	181.4	0.20	0.18	60.8

Table 3. Result of the foam testing

Parameter	Polyol based foam	Castor oil based foam	Specification	Remarks(Vitafoam)[17]
Density	0.019g/cm^3 or 19.0kg/m^3	0.0329g/cm^3 or 32.91kg/m^3	18.5 – 19.5 kg/m^3	Castor oil based foam exceeded specification
Hardness at 35%	265N	295N	240-300N	Both met the specification
Elongation at break	250%	115%	204-267%	Castor oil based foam did not meet specification
Tensile strength	110KN/m^2	84 KN/m^2	99KN/m^2	Castor oil based foam did not meet specification
Compression set	6.0%	7.0%	4.0-8.0%	Both met specification

References

[1] Gassan,J Chate, A. Bledzki A.K: Calculation of elastic properties of natural .bers. J Mater Sci;36(15):3715–20, (2001)

[2] Ruys, D Crosky A, Evans W.J: Natural bast fibre structure. Int J Mater Product 2002.

[3] Van Wyk, J.P.H. (2001) Biotechnology and the utilization of biowaste as a resource for bioproduct development. Trends BioTechnol. 19, 5, 172–177

[4] Mohanty, A.K. et al. (2000) Biofibres, biodegradable polymers and biocomposites: An overview. Macromol. Mater. Eng. 276/277, 1–24

[5] McGraw (1987): Encyclopedia of Science and Technology, McGraw Hill Book Company, London

[6] Li, F.; Larock, R. C. J Appl Polym Sci 2002, 1533,84.

[7] Eren, T.; Kusefoglu, S. H. J Appl Polym Sci 2004,91, 2700

[8] Khot, S. N.; LaScala, J. J.; Can, E.; Morye, S. S.; Williams, G. I.; Palmese, G. R.; Kuseeoglu, S. H.; Wool, R. P. J Appl Polym Sci 2001, 82, 703

[9] AOAC, 1990. Official Methods of Analysis, 1990. 15th edition, AOAC Inc, Arlington, VA, USA.

[10] ASTM 7348, Standard method of testing heat loss, 1983

[11] ASTM 365 Standard method of testing Compression set (1983)

[12] ASTMD 813: Standard method for testing for tensile strength (1983)

[13] Firestone D (1998): Official methods and recommended practices of the American oil Chemists Society, 5th Ed, AOCS, chapaign, Illinois

[14] Devine J. and William P.N. The chemistry and technology of edible oils and and fats, pergamon press inc, int'l, inc. Pam , new York, 1982 p22

[15] O'Brien R.D. 2004: Fats and Oils: Formulating and processing for applications 2nd edition CRC Publishing Washington, DC

[16] Vega-Baudrit, J.M. Moya, M. Sobaja and M. Durán, *Química e Industria*, **49**, 531, (2002).

[17] Vitafoam manufacturing specification manual, 1997.