Asian Journal of Information Technology 7 (5): 215-217, 2008
ISSN: 1682-3915

Foam Production Using Soya Bean Oil as Surfactant

O.A. Olu-Arotiowa, L.A. Jimoda, D.O. Araromi and R.O. Yusuf
Department of Chemical Engineering, Ladoke Akintola University of Technology,
P.M.B 4000, Ogbomoso, Nigeria

Abstract: Production of polyurethane foam has been made more cost effective by introducing soya-oil as a surfactant. Consequently, profit maximization has brought about the need to introduce less expensive stabilizing agent. This led to the use of soya-oil in substituting for the commonly used silicone oil. This was carried out in varying concentrations of silicon and soya-oil. It was however proven that soya-oil cannot act as surfactant in polyurethane foam but a combination of 75 silicon oil and 25% vegetable oil gives polyurethane foam with desired physical and mechanical properties. The costing of the price per block of foam produced shows that foam production using vegetable oil as surfactant is cost effective and characterized by foams of better quality.

Key words: Silicone oil, soya-oil polyurethane, toluene diisocyanate

INTRODUCTION

Polyurethane foam industries have in recent times replaced foams produced from natural and synthetic latex technology. This is not only as a result of the fact that polyurethane structure gives a tough molecule able to make high loadings, but also because it can be prepared to a much lower density than latex foams of the same load bearing capacity. However, the need for maximizing profit and environmental issues caused by fossil fuel exploration has necessitated the replacement one of the most expensive chemicals in flexible foam synthesis.

Over the years, seed has generally been regarded as a waste, except for a minute fraction that is used in Agriculture for planting. The natural existence of oil in seed and in varying proportion together with the application of the knowledge of seed oil extraction techniques suggests that vegetable oil could possibly be extracted and be used for industrial purposes. One of the major industrial uses of oil is in the production of polyurethane foam (Olu-Arotiowa *et al*., 2007).

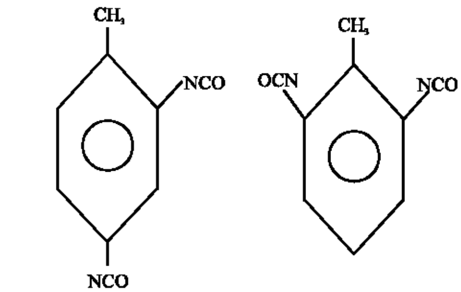
The production of polyurethane foam requires the presence of additives such as foaming or blowing agent, surfactants and stabilizers (Abiagor *et al*., 2004). However, silicone oil which is usually silicone-polyalkylene oxide block copolymer (Ajayi, 1999) emulsifies by bringing together incompatible ingredients, homogenizes the chemical mix and lowers the bulk surface tension (Jimoda, 2002). It is the most expensive of all the foam ingredients, presently, it is sold for #1, 1000:00 per kilogram in Nigeria. Hence, raw material substitution which is the basis of this study is highly justified.

Vegetable oil contains mainly esters of the type 12 hydroxyl 9 octadecanoic acid (Tsagli and Oldham, 1991). The presence of these hydroxyl groups makes the oil suitable for use in urethane type reactions, such as reactions between diissocyanates and hydroxyl-terminated compounds. Also, the hydrogen bonding of these hydroxyl groups confers a high degree of viscosity on the oil (Oguniyi and Fakoyejo, 1998). Although, this seed oil is not edible, it consists of 14 stearic acid, 20 oleic acid, 55 linoleic acid and 8% linolenic acid (Makanyjuola, 1999), the last three being unsaturated acids. Other seed oils such as soya oil and castor oil have been used in isocyanate reactions to make polyurethane elastomers, millables, castables, adhesives and coatings (Aigbodia *et al*., 1999). Also, the epoxidation of rubber seed oil at 200°C under reduced pressure has been used to obtain heptaldehyde and undecalonic acid, while various treatments of the vegetable oil can be used to obtain sebacic acid and ω-amino undecanoic acid (Olu-Arotiowa *et al*., 2007). This research work investigated the price per block and suitability of using soya-oil as substitute for silicone oil as stabilizer in foam synthesis.

MATERIALS AND METHODS

Toluene diisocyanate, TDI (80: 20 of 2, 4 and 2, 6 isomers, respectively):

Corresponding Author: O.A. Olu-Arotiowa, Department of Chemical Engineering, Ladoke Akintola University of Technology, P.M.B 4000, Ogbomoso, Nigeria



2,4- Toluene di-isocyanate 2,6- Toluene di-isocyanate

polyol, stannous octoate, dimethyl amino ethanol, water, methyl chloride and silicone oil were supplied by Bode foam Nigeria limited Ibadan. Manufacturers do vary the ratio of the isomer blend but the most commonly used is the 80: 20 (2,4-TD1: 2,6-TD1) blend. For higher load bearing foams however, the blend ratio of 65: 35 is often used. TD1 is a very toxic chemical and for this reason, it must be handled with care.

Preparation of soya-oil: Soya bean was sun dried and the crushed nut oil was extracted with the use of hexane at a temperature of 60-80°C in a Soxhlet extractor. The oil so obtained was then tested for colour, refractive index, specific iodine value, acid value, hydroxyl value, saponification value and water content as described previously (Olu-Arotiowa *et al*., 2005; Ulrich and Reagan, 1978).

Foam preparation: Polyol, 280 mL of water (as foaming agent), silicone oil/soya-oil (as stabilizer) stannous octoate, dimethyl amino ethanol were mixed together. After which TDI was stirred in with an electric stirrer to ensure good dispersion of reagents and foam of good cell structure. The whole mixture was then poured into a mould. The foam samples produced were left to stand for 24 h before they were tested to ensure complete curing. The formulations used for preparing the foam.

Mechanical properties Polyurethane foam samples were tested for tensile strength and elongation at break using a J.J tensiometer manufactured by New Brunswick Scientific Co., USA, at 30°C following the procedure of ASTMD 3489. A known volume of each sample was obtained and weighed to obtain its mass. Density was then calculated as mass per unit volume. The colour of each sample was observed by visual examination while naked flame was also applied to each sample to observe burning characteristic. Compression set measurement was obtained according to procedures of ASTMD 3574.

RESULTS AND DISCUSSION

The properties of vegetable oil are shown in Table 1. The various polyurethane foam formulation and their respective properties are shown in Table 2. Formulation 1, a conventional polyurethane foam formulation made up of 100% silicon oil was used as the control. Formulation 5 contained 100% soya-oil as a substitute for silicon while formulation 2-4 contained 25, 50 and 75% soya-oil, respectively. It was observed that in all the products obtained, the intensity of the yellow colour increased with increase in the quantity of vegetable oil used. However, in a separate experiment, where bleached vegetable oil was used, the foam produced was colourless.

The results as presented in Table 2 showed a reduction in cost price per block of foam produced with increase in quantity of vegetable oil used in foam formulation. In all the vegetable oil containing formulations with the exception of formulation 2, the tensile strength was greater when compared with the 100% silicon oil formulation.

The introduction of soya-oil in formulations 2-5 led to a rapid increase in compression set. The increase in compression set observed in soya-oil formulated foam may be due to the cleavage of the rigid cross links formed between vegetable oil and Toluene Diisocyanate (TDI), which prevented substantial elastic recovery. This implies that foam formulations containing vegetable oil may not be suitable for cushioning purposes as recovery from elastic deformation will generally be poor. Among the five formulations, formulation 2 had density that approached that of the control standard (i.e. 25 kg m^{-3}). This shows that not more than 25% of soya-oil may be used as substitute for silicon oil in foam meant for cushioning. The results showed a gradual decrease of the elongation-at-break with increase in quantity of vegetable oil used. This result may likewise be due to the rigid cross links produced between toluene diisocyanate and vegetable oil.

It is to be noted, that the properties of foam in formulation 5 where soya-oil is 100%, compare reasonably

Table 1: Properties of vegetable oil used

Properties	Experimental value	Literature data (cold pressed)	Literature data (extracted)
Specific gravity (30°) (Kg m^{-3})	0.86	0.96	0.96
Appearance	Clear	Clear	Clear
Refractive index (30°)	1.48	1.47	1.47
Colour	Yellow	Yellow	Yellow
Acid value	3.0	3.0	3.0
Hydroxyl value	164.0	164.0	164.0
Iodine value	85.6	85.0	84.2
Water content (%)	0.56	0.48	0.47
Saponification value	180.0	182.0	177.0

Source: Abiagor *et al*. (2004) Properties of vegetable oil

Table 2: Categories of formulation used for polyurethane foam synthesis

Chemicals	F 1(g)	Cost (#)	F 2	Cost (#)	F 3	Cost (#)	F 4	Cost (#)	F 5	Cost (#)
Polyol	100.00	31.75	100.00	31.75	100.00	31.75	100.00	31.75	100.00	31.75
TDI	46.20	29.08	50.60	31.85	56.40	35.51	61.00	38.40	66.00	41.55
Water	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70
Amine	0.25	5.00	0.25	5.00	0.25	5.00	0.25	5.00	0.25	5.00
Silicone	100.00	110.00	75.00	82.50	50.00	55.00	25.00	27.50	0.00	0.00
Soya-oil	0.00	0.00	25.00	4.00	50.00	8.00	75.00	12.00	100.00	16.00
Stanous octoate	0.25	0.33	0.25	0.33	0.25	0.33	0.25	0.33	0.25	0.33
Methyl chloride	0.50	0.08	0.50	0.08	0.50	0.08	0.50	0.08	0.50	0.08
Price		179.94		159.20		139.37		118.76		139.00

with properties of semi-rigid foams (Ulrich and Reagan, 1978), which are types of foam used in thermal insulation, refrigeration, packaging and transportation. All the foam samples continued to burn when exposed to naked flame and they can be classified as flammable. However, a mono-hydroxyl compound can be used in place of silicon oil for further research.

CONCLUSION

This investigation showed that foams synthesized from 100% silicone oil compare favourably with foams produced from mixtures of 75% silicone oil and soya-oil as stabilizers, especially in terms of density. However, foams synthesized from 100% soya-oil compare favourably well with semi-rigid foams synthesized using silicon oil. Price comparison with quality is the objective function of being in business. Result from Table 2 shows that it is wise to use a mixture of soya-oil and silicone oil as substitute for silicon in polyurethane foam synthesis. The price variance shows that the more the percentage of soya-oil in foam formulation, the less the price, but because of product quality not more than 25% soya-oil must be used.

REFERENCES

Abiagor, R.D, P.O. Uadia, T.A. Foglia, M.J. Hass, K.C. Jones, E. Okpefa, J.U. Obibuzor and M.E. Bafor, 2004. Lipids-catalysed production of biodiesel fuel from some Nigerian lauric oils. Biochem. Soc. Tran., 28 (6): 979-981.

Aigbodia A.I., F.E. Okiemeni and I.O. Bakare, 1999. *In situ* epoxidation of Rubber seed oil by per acetic Acid. Nig. J. App. Sci., 17: 38-41.

Ajayi, J., 1999. Lecture delivered on chemistry of polyurethane at training program organised by manufacturers association of Nigeria in conjuction with TEMM Consulting Ltd. Ikeja, pp: 1-11.

Jimoda, L.A., 2002. Emission measurement in batch and continuous polyurethane foam production. In: Process. M.Sc Thesis, Department of Chemical Engineering, Obafemi Awolowo University, Ile-Ife, Nigeria.

Makanyjuola, D., 1999. Handbook of Flexible Foam Manufacture. 1st Edn. Longman, Nigeria.

Oguniyi, D.S. and W.R. Fakoyejo, 1998. Industrial utilization of castor oil 1. Poyurethane foam synthesis and properties. J. Nig. Soc. Chem. Eng. INSCHE., 17: 40-43.

Oluarotiowa, O.A., D.O. Araromi and T.J. Afolabi, 2005. Conversion of sweet orange seed oil to biodiesel. Sci. Focus, 10 (2): 35-40.

Olu-Arotiowa, O.A, F.I.Adelowo and O.K. Afolabi, 2007. Foam production using epoxidised orange seed oil. J. Eng. Applied Sci., 2 (12): 1774-1776.

Tsagli, K.J. and J.H. Oldham, 1991. Bio-conversion Energy, Rural Energy surveys and the use of vegetable oil as potential fuel in Ghana. In: Proc. Biennial ISES Solar World Congress Denner Colonado, USA. Pergamon Press, USA: 1(II): 849-854.

Ulrich, H.F. and S.L. Reagan, 1978. Recycling of polyurethane and isocyanine foam in advance urethane science and technology, London. Mclauren and Sons, 15: 52-75.