A NOTE ON SEMIRIGID POLYURETHANE FOAMS BASED ON CASTOR OIL

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Many of the modern commercial rigid and semirigid foams in the market are more than a mere modification of the conventional polyester as originally used by Bayer[1]. The modifications in raw materials range from the introduction of blowing agents to the use of fatty acid modified polyols and to a greater extent even the wide use of polyethers as raw mateirals[2,3]. In spite of the unique and outstanding physical properties of rigid foam, its wide scale acceptance has been retarded due to its high cost. Recent trends in industrial research has been in the direction of developing less expensive raw materials. Castor oil is one of the obvious choices as a substitute mainly because of its chemical composition which provides necessary functional groups. Compositions based on castor oil usually employ some polyethers like polyethylene glycols and these are foamed up by the semi-prepolymer or prepolymer methods using a suitable catalyst. The noteworthy feature of the work presented in this communication is the elimination of external catalyst and of any intermediate step like prepolymer or semiprepolymer. These factors are likely to contribute considerably in reducing the cost of castor oil based polyurethane foams.

METHODS AND MATERIALS

As a part of our detailed investigations on polyurethane foams[4] based on partly indigenous raw materials, several compositions using castor oil and castor oil fatty acids have now been examined for foaming with diphenyl diisocyanato methane*. The judicious use of di and triethanolamines coupled with the proper choice of hydroxyl and carboxyl values made it easy to prepare semirigid foams by one shot method without the use of external catalyst. Castor oil compositions reported in Table 1 were prepared by stirring a mixture of amine and castor oil or castor oil fatty acids at various temperatures ranging from 35 to 160°C in nitrogen atmosphere. The time taken for preparing suitable resin varied from 60 to 150 minutes. The carboxyl and hydroxyl values were determined by the ASTM methods[5] and varied from 1—150 and 100—450 respectively.

Initial experiments, using Lissapol *N* as the cell stabiliser, yielded foam of coarse structure and hence silicone oil has been used in these compositions (Table 1). It has been observed that Ferric acetyl acetonate in these compositions, accelerates the cure of the foam without affecting the foam initiation time. A study of the formulations incorporating different amounts of water revealed that the maximum amount of water that these formulations can take is only 4 parts for every 100 parts of resin. The foaming mixture was prepared by combining castor oil modified ester, diisocyanate and silicone cell stabiliser along with a curing agent and water. These were blended together with a high speed stirrer and the free rise of the foam observed.

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*Suprasec D or DA of I.C.I.

TABLE I†

Serial No.	Composition (In molar proportions as under)		Hydroxyl + Carboxyl numbers	Foam initiation time (Sec)	Rise time (Sec)	Tack free curing time (min)	Density lbs./ft.^{3}	Structure of Foam
1	2		3	4	5	6	7	8
	Castor oil	Triethanolamine						
1	0·18	0·16	424·02	7—8	60	5	5·13	Fine textured foam
2	0·56	0·50	429·30	10	40	7	..	Coarse textured, unsatisfactory
	Castor Oil fatty acids	Triethanolamine						
3	0·15	0·13 (Lissapol. N)	495·6	5	20	6	1·96	Fairly uniform textured foam
4	0·16	0·16	372·9	6	30—35	5	3·69	Fine textured foam
5	0·22	0·20 (Lissapol. N)	450·2	5	15	5-6	1·87	Coarse textured foam
6 (a)	0·22	0·20	441·1	2	20	2	4·04	Fine textured foam, Shrinkage on standing
(b)	0·22	0·20 (Lissapol. N & silicone Oil)	441·1	2	18	2–3	5·18	Fine textured foam
7	0·37	0·25	408·3	2	4	5	2·23	Coarse textured foam
8	0·37	0·33	373·2	3	5	1	2·17	Fairly uniform textured foam
9	0·50	0·56	415·6	5	40	1·5	2·05	Fine textured foam, appreciable shrinkage on standing

TABLE 1†—(*contd*).

1	2	3	4	5	6	7	8
10	Castor Oil fatty acids (Lissapol. N)	333·25	20	120	12	2·01	Very fragile and powdery foam
	Castor Oil fatty acids Diethanolamine						
11	0·2 0·1	471·7	6	50	2·5	3·24	Fragile and powdery foam
12	0·2 0·2	537·9	2—3	25—30	2—2·5	3·01	Fine textured powdery foam
13	0·28 0·25	436·56	4	41	2·5	3·12	Fine and uniform textured foam
14	Castor Oil fatty acids and Daltolac 41*	258·53	7	60	7	3·3	Fine textured foam noticeable shrinkage
15	Castor oil fatty acids (0·2), Sebacic acid (0·1), Glycerol (0·05) and Triethanolamine (0·15)	319·69	14	36	9	2·87	Moderately fine textured foam

†Compositions 1, 4, 9, 13 and 15 were prepared at 160°C and the rest at 35°C.

*I.C.I. Polyether Resin.

TYPICAL RECIPE

Resin	100 parts
Diisocyanate	100—200 parts (depending upon hydroxyl and carboxyl values of the resin).
Water	4 parts
Silicone oil F. 110/40 (ICI)	1 part
5% Ferric Acetyl acetonate in acetone solution	0·25 part

RESULTS AND DISCUSSIONS

Molecular weight between the cross links[6] as calculated for these formulations range from 1,000 to 2,200 gms which is characteristic of semirigid foams. In general, compositions prepared at lower temperature showed practically no shrinkage than the ones prepared at higher temperature. However, the foams based on the lower temperature range tended to be fragile while those derived from the latter, ranged from semirigid to rigid. With compositions based on higher temperature, foam initiation time was comparatively less than that for lower temperature. Some of the compositions showed appreciable shrinkage and it was partly eliminated by the use of excess of silicone oil or even adjusting the speed of the stirrer. In particular, the reaction between the resins and the diisocyanate was so fast that it was difficult to achieve complete mixing in some cases.

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REFERENCES

1. Bayer, O., *Angew. Chem.*, **A 59** (1947), 275.
2. Saunders, J. H. & Frisch, K.C. "Polyurethanes Chemistry and Technology" (Interscience Publishers), 1962.
3. LeBrass, *S.P.E.J.*, **16** (1960), 421.
4. Venkataramani, B., *Def. Sci. J.*, **13A** (1963), 27.
5. A.S.T.M. D 1638-60 T.
6. Saunders, J. H. & Frisch, K.C., "Polyurethanes Chemistry and Technology" (Interscience Publishers) (1962), p. 266.

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