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Influence of recycled polyurethane polyol on the properties of flexible polyurethane foams

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Abstract

Flexible PU foam was synthesized by using recycled PU foam polyol (Infrigreen) which contain 4 functionality obtained from glycolysis wasted PU foam, as a polyol. PU foam is prepared by incorporation of recycled PU foam polyol 2, 4, 6, 8 and 10wt% in petrochemical polyol (CARADOL.SA34-05) which contain 2 functionality. Triethlylenediamine (TEGOAMIN 33) was used as the gelling catalyst. Polyether modified polysiloxane (TPGAOSTAB B8715 LF2) was the surfactant. Distilled water was used as a blowing agent to generate foam. Polymeric methylenediphenyl diisocyanate (pMDI) which contain 2.7 isocyanate groups/molecule was used for generate urethane linkage and carbon dioxide. The parameters investigated are characteristic time, i.e. cream time, gel time, rise time and tack free time, cell structure and cell morphology, tensile properties, compressive properties and compression set were compared with petrochemical based PU foam. It was found from the research that, cream time, gel time, rise time and tack free time, decrease with the recycled PU foam polyol content. It was also found that the incorporation of recycled PU foam polyol led to the increase in smaller cell size and large distribution of cell size. Tensile properties and compressive properties of PU foam increase with polyol functionality, including crosslink density and urea formation in PU foam. Decreasing of shape recover properties of PU foam obtained at high recycled PU foam polyol contents. This was caused by the deformation of hydrogen bonding between hard segments of PU chains. These results indicate that tensile properties and compressive properties of PU foam enhance by incorporation of recycled PU foam polyol.

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*Keywords:*Flexible polyurethane foam; characteristic time; cell size distribution; recycled PU foam polyol; compressive properties

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1. Introduction

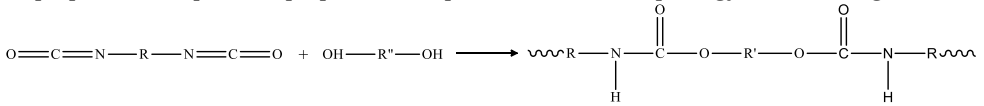
Polyurethane is polymeric materials that have urethane linkages and can be prepared by addition polymerization between isocyanates and polyols [1]. The properties of PU foam depend on chemical of polyol, functionality of polyol, crosslink density, foam density, urea content and cell structure.

Polyol structure and functionality play the important role on the properties of final foam product [1, 2]. The short chain polyol with trifunctional alcohols are used to produce more rigid foam while longer chain length polyols with trifunctional alcohols are used to generate more flexible foam[2, 3]. Other components such as: water is added as blowing agent for foam foaming. Triethlylenediamine and polyether-modified polysiloxane were used for catalyst and surfactant are function as promoting nucleation as well as stabilizing the foam formation during foam development stage.

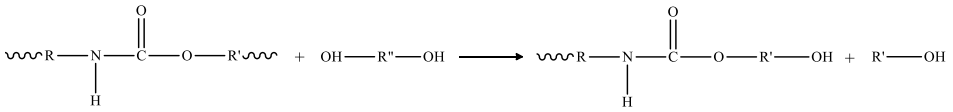
In general, toluene isocyanate (TDI) and methylenediphenyl diisocyanate (MDI) are often use for isocyanate to produced urethane linkage from reaction between isocyanate and polyol was showed in Scheme 1. TDI has difunctionality are most use for prepare rigid foam and semi-rigid foam. TDI is not suitable to prepare polyisocyanurate foam. In general MDI is consisting of methylenediphenyl diisocyanate (MDI) and polymeric methylenediphenyl diisocyanate (pMDI). The pMDI is widely used for rigid foam, semi-rigid foam and polyisocyanurate foam. The pMDI has average functionality in range 2.3 to 3.0[1, 2, 4, 5]

Flexible PU foam is widely used for furniture, bedding, cushioning, packaging, transportation, and etc. Therefore PU foam produce a lot of waste after using. The major waste manage of the PU are incinerated. Nowadays PU foam recycling is an urgent task to produce high quality polyols reducing postconsumer PU. In term of chemical recycling, the urethane bonds can be broken down resulting the polyols. In the literature, the recycling processes have been described based on hydrolysis and hydroglycolysis [4]or methanolysis which can convert the polyurethane into polyol. In the glycolysis processes, the polyurethane chain is degraded by successive transesterification reactions of the urethane bond with low molecular weight glycols in the presence of catalyst. The reaction was showed in Scheme 2. The glycolysis processes described above show recovered polyols in liquid mixture. The products obtained contain active hydroxyl groups that possess high reactivity for PU foam synthesis [5].

In this study, flexible PU foams was prepared by using recycled PU foam polyol which contain 4 functionality and equivalent weight was 1650.29. Polyether polyols, petrochemical based polyol, was used for the main polyol component which contains 3 functionality and equivalent weight 315.23. The pMDI was used as diisocynate which contain 2.7 functionality. In this study, chain extender was not used for PU foam formation. The structural, apparent density, tensile properties, compression properties, compression set and morphology were investigate.



Scheme 1. Reaction of isocyanate with polyol



Scheme 2. Glycolysis reaction of PU foam

2. Experimental

2.1. Materials

The Polyol and other chemicals used in this study are listed in Table 1. The controlled polyol used is petrochemical based polyol which is commercially available (C.SA34-05). It was kindly supplied by PTT Global Chemical, Thailand.

Recycled PU foam polyol was also tried to be used to replace petrochemical based polyol. The commercial one is Infrigreen 100. This polyol was also kindly supplied by PTT Global chemical, Thailand.