Environmently Friendly Glass Fiber and Nanoclay Reinforced Polyurethane Foam

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Introduction

Rigid polyurethane foams(PUFs) are widely used in most areas of insulations such as storage tank and pipe line for transporting liquefied gas[1]. Thermal insulation and compressive strength of rigid PUFs are prime importance in LNG carrying cargo. Furthermore, dimensional stabilities under severe working temperature(room temperature ~ -150℃) is also critical property[2, 3].

In this study, glass fiber and nanoclay are used for improvement in mechanical property, thermal insulation, and dimensional stability of rigid PUF for LNG cargo. Thermal insulation was also enhanced by controlling cell structure and using superior blowing agent(HFC-365mfc) which has no environmental problem like CFC-141b.

Experimental

Rigid PUFs were prepared from sorbitol based polyol with a functionality of 5.5 and glycerin based polyol with a functionality of 3.0 and ester type polyol and chain extender, silicone surfactant, catalysts, environmently friendly blowing agent, glass fiber and nanoclay.

Table 1. Formulation of Rigid PUFs

Materials		pphp
Polyols	Glycerine base	0~100
	Sorbitol base	0~100
Surfactant		1~2
Catalysts	Geling	0.05
	Blowing	0.05
Blowing agent		10~15
Glass fiber		0~ 20
Nanoclay		0~ 5
DMBA		1~10

PUFs were foamed with one shot method. All materials were mixed at 3000rpm and mixtures were poured into an open mold where glass fiber matt was placed at the bottom.

Reactivity was monitored by cream time, rising time, and gelation time during foaming. After 2 days postcure, compressive modulus and strength were measured at room temperature and -170°C with UTM. Thermal insulation efficiency was determined with thermal conductivity. Scanning electron microscopy(SEM) and transmission electron microscopy(TEM) were used to see cell structure and distribution of glass fiber and nanoclay.

Results and discussion

The thermal conductivity of rigid PUFs is characterized by its ability to transport heat from one side of the sample to the other. Fourier's equation is used to determine heat transfer by conduction through a material. One dimensional form of the equation is:

$$q/A = -k*dT/dx$$

where, q is heat loss, A is area, k is thermal conductivity of the material, dT is the change in T(K) across material, and dx is the thickness of material. The cell structure has a strong effect on k. We obtained fine cell structured PUFs with high closed cell content(over 90%) by designing PU chain structure and formulation of PUFs resulting in remarkably reduced k. Nanoclay was well intercalated and interfoliated by PU chains with the aid of DMBA having ionic interaction between carboxylic acid and Na^+ within each plate of clay resulting in increase of interplates space. Well dispersed clay in nanoscale significantly enhanced compression and tensile strength of PUFs. Stress might be transfered from PU matrix to inorganic clay. In addition, we could find that cell structure of PUFs was not affected by inorganic calys because their size(in nanoscale) is too small to reduce interfacial tension between PU and gas in cells and destroy the walls of cells.

Figure 1 is the schematic distribution of glass fiber matt during foaming reaction. Glass fiber matt was uniformly distributed vertical to rising direction resulted from blowing and viscosity build-up during foaming. The balance of blowing and gelation is critical to get uniformity, which could be controlled with foam rising profile. Glass fiber was also incorporated to improve not only mechanical properties but also dimensional stability of PUFs nanocomposites. Glass fiber and nanoclay reinforced PUFs showed excellent dimensional stability in variation of temperature from -150°C to 120°C. All of PUFs nanocomposites were foamed with environmently friendly blowing agent(HFC-365mfc) instead of HCFC-141b which has brought environmental problem.

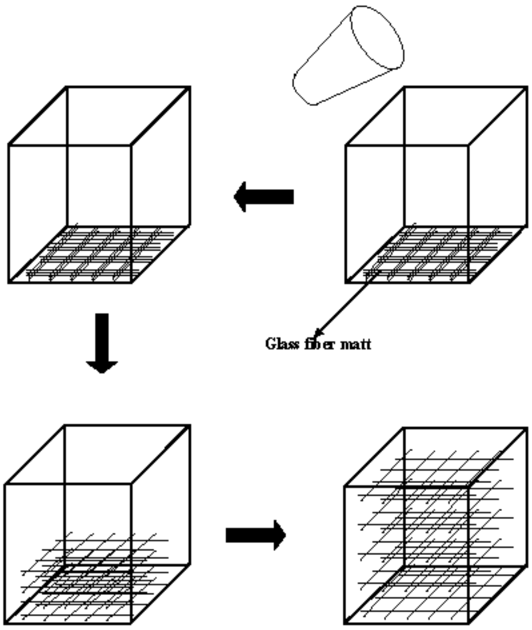

Figure 1 schematic Representation of the Distribution of Glass Fiber Matt during Foaming.

Conclusions

Rigid polyurethane foams reinforced with glass fiber and nanoclay were prepared and characterized in terms of mechanical incorporating properties, thermal conductivity, and dimensional stability. Thermal insulation was enhanced by controlling cell structure, incorporating nanoclay, and designing PU structure. With the incorporation of caly and glass fiber, mechanical properties and dimensional stability were remarkably improved.

References

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