Flammability and Thermal Properties of Rigid Polyurethane Foams Containing Wheat Straw Lignin

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Concept

The study was done in three main steps: 1) oxypropylation of wheat straw lignin, 2) producing rigid PU foams in two ways: using lignin as filler and using synthesized lignopolyol, 3) testing flammability and thermal stability. 0-100% of commercial polyetherpolyol Lupranol 3300 was substituted by the synthesized lignopolyols to produce rigid PU foams. Also rigid PU foams filled with the lignin (0-15%) were obtained. Flammability properties were measured with FTT Dual Cone Calorimeter and by small scale flammability method. Total heat release (THR) and total smoke release (TSR) were determined. Thermogravimetric analyses were done to examine thermal stability.

Motivations and Objectives

The manufacture of PU on lignin basis provides an opportunity for utilizing renewable resources for materials which are normally produced from fossil carbon sources. Various lignins (for example, Kraft, Soda and Organosolv) have previously been shown to use in production of polyurethanes [1]. Thermal stability of the PU foams can be improved by addition of liquified lignin [2] and also using lignin as a reactive reinforcing filler [3].

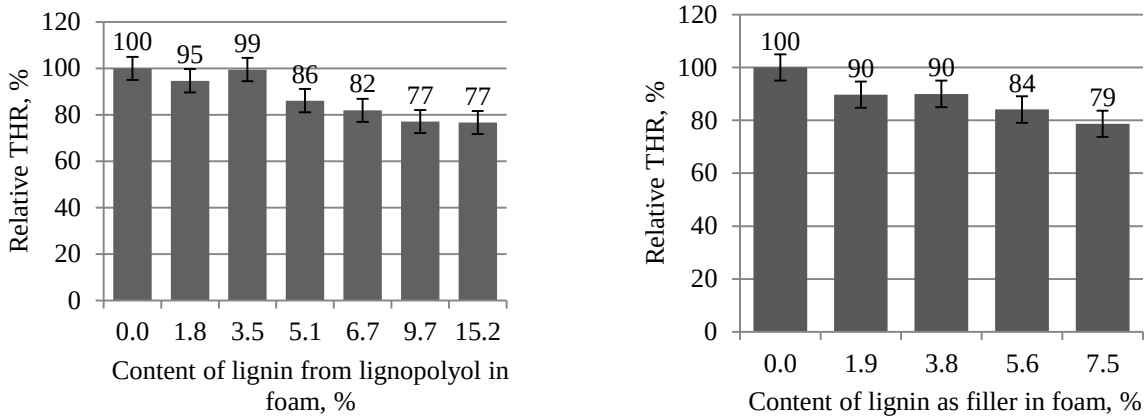
Properties of lignin containing PU depend on the lignin type used. Due to development of new generation of biomass processing, the examination of novel lignin products for creation of lignin-containing PU remains actual up to now. A French company CIMV *(Compagnie Industrielle de la Matière végétale)* have patented technology of the initial extraction of the biomass components – cellulose, hemicellulose and lignin.

For preparation of lignin containing PU in this study a novel BIOLIGNIN^{TM} was used. BIOLIGNIN^{TM} is extracted from wheat straw in organic acid media using biomass refinery technology. The influence of chemically non-modified BIOLIGNIN^{TM} and oxypropylated BIOLIGNIN^{TM} on flammability and thermal properties in rigid PU foams was studied.

Results and Discussion

Liquid lignopolyols were synthesized by oxypropylation method of air dried BIOLIGNIN^{TM} in high pressure laboratory scale reactor. Different ratio of BIOLIGNIN^{TM} and propylene oxide was used. In rigid PU compositions Lupranol 3300, Lupranol 3422, catalyst, surfactant, physical blowing agent (Solkane 365/227) and polymeric diphenylmethane diisocyanate were used. Flammability properties were measured with FTT Dual Cone Calorimeter (Fire Testing Technology Ltd., UK). Tests were done according to ISO 5660-1 standard. PUR foam was exposed to 35kW/m^2 heat flux for 300 s. Also the flammability of rigid PU foams was tested by small scale test according to EN ISO 11925-2 standard. Thermogravimetric analyses with Mettler Toledo TGA/SDTA were done to examine thermal stability properties.

THR results are shown in Figure 1. THR results are calculated in relative units –THR for sample without lignin is 100%.



a b

Figure 1 Relative total heat release: a) for foams obtained from lignopolyol; b) for foams filled with chemically non-modified lignin.

Figure 1 shows that THR decreases with increasing lignin content. THR decreases by ~20% adding 7.5% lignin as filler (Figure 1 a). THR decreases by ~25% if lignin from lignopolyol in foam is 10-15% (Figure 1 b). The same trend is observed for influence of lignin on TSR.

Conclusions

Improvement of flame resistance and thermal stability is observed if chemically non-modified lignin as well as oxypropylated lignin is used. BIOLIGNIN^{TM} is prospective raw material to improve thermal characteristics of rigid PU foams. The optimum thermal and flammability characteristics for rigid PU foams is obtained when content of lignin from lignopolyol in foam is ~10-15% and ~8% when lignin as filler is used.

Acknowledgement

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References

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