Lignin polyol in production of oil based polyurethane elastomers and rigid foams

Tomaš Vlček[1], Aiga Paberza[2], Mikelis Kirpluks[3], Ugis Cabulis[4]

[1] *Research scientist at SYNPO, akciová společnost,S. K. Neumanna 1316, 532 07 Pardubice, Czech Republic, tomas.vlcek@synpo.cz*
[2] *Assistant of Polymer laboratory of Latvian State Institute of Wood Chemistry, Dzerbenes 27, Riga, Latvia, LV-1006, aiga.paberza@gmail.com*
[3] *Assistant of Polymer laboratory of Latvian State Institute of Wood Chemistry, Dzerbenes 27, Riga, Latvia, LV-1006, mkirpluks@edi.lv*
[4] *Head of Polymer laboratory of Latvian State Institute of Wood Chemistry, Dzerbenes 27, Riga, Latvia, LV-1006, cabulis@edi.lv*

Introduction

Rigid polyurethane (PU) foams and PU elastomers belong to a group of products that are widely used in construction, automotive, thermal insulation etc.

Nowadays, due to economical and environmental concerns, it is very actual and perspective to replace petrochemical polyols by renewable biomass as example castor oil, tall oil, rapeseed, sunflower, soya oil, of which is possible to obtain polyol component that are suitable for production of various PU materials. Another possibility to increase renewable material content in PU foam and elastomer production is to apply lignin as co-polyol or/and filler.

Lignin (from Latin lignum which means wood) isolated from the waste biomass is a natural polyol of a polyphenolic structure available in the form of a dark brown powder that is partially soluble in organic solvents. From chemical point of view, lignin is composed of carbon, hydrogen and oxygen in different proportions; lignin contains hydroxyl, mehoxyl, carbonyl and carboxyl functional groups in various amounts depending on its botanic origin. Hydroxyl groups and free positions in the aromatic ring determine reactivity of lignin and make it applicable in macromolecular chemistry [1].

The aim of this study was to varify applicability of lignin as a co-polyol in a solvent free production of castor oil based PU elastomers and tall oil amide based rigid PU foams. Tensile strength, toughness and surface hardness of PU elastomers and correlation between lignin content and closed cell content, density and compressive strengths for rigid PU foams were investigated

Experimental

In this work we studied the potential applicability of lignin (OH# = 120 mg KOH/g, A.V. = 74.2 mg KOH/g) (CIMV, France) as a co-polyol in a solvent free production of castor oil (OH# = 150 mg KOH/g, A.V. = 1.7 mg KOH/g) based PU elastomers and tall oil amide ((OH+NH)# = 286 mg KOH/g; A.V. = 4.4 mg KOH/g; H_2O = 0.14 wt. %) based rigid PU foams. Prior to the synthesis we first prepared fine dispersion of powdery Kraft lignin in castor oil and tall oil amide. Then we diluted the prepared up to 50 % dispersions in excessive amount of corresponding oil polyol and amide and in case of the foam preparation we added surfactants, catalysts and blowing agents. For foam production we made mixtures with different lignin content (0-50 wt. % in tall oil polyol) and reacted with polymeric 4,4'-

diphenylmethane diisocyanate (pMDI). We performed mechanical testing of PU rigid foams on testing machine Zwick/Roell Z100. We measured closed cell content and density according to the standards ISO 4590 and DIN 53420, respectively.

For PU elastomers we reacted the polyol and amide phases with 4,4'-diphenylmethane diisocyanate (MDI, Suprasec 2642).

Results and discussion

Rigid PU foams with densities of 30-36 kg/m^3 and with closed cell content of 81-98 % were obtained. Closed cell content and density (Fig.1) increases with lignin content in foams. Fig.1 also shows that maximum compressive strength (0.16 MPa) corresponds to 25 wt. % lignin content in tall oil polyol and this compressive strength is 1.8 times higher than for foams without lignin.

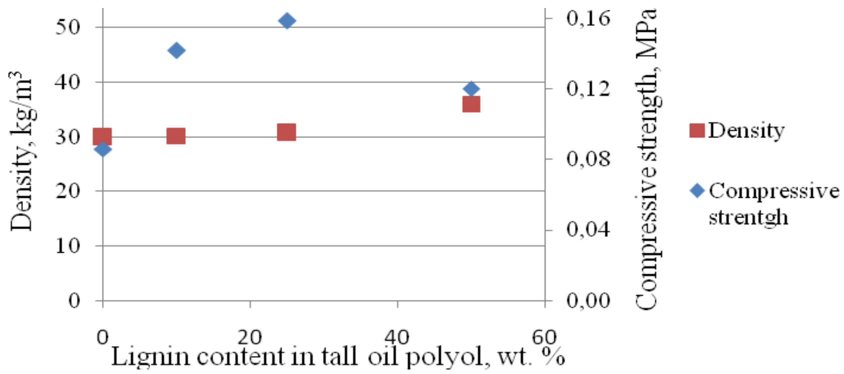

Fig.1 *Density and compressive strength versus lignin content in tall oil polyol*

We found that lignin is a suitable modifier of elastomeric polyurethanes if used up to 15 wt. %. Lignin applied to castor oil based elastomers increased about 2.5 x tensile strength and even 3.5 x toughness of the studied system. Surface hardness increased about 50 % up. Lignin addition further reflected in increase of glass transition temperature from -3 to 19 °C. The most interesting finding was dramatic improvement of electrical internal resistance that increased from 1x10^9 to 8x10^{12} Ohm.

Conclusions

It was possible to obtain good quality PU foams with lignin content up to 13 wt. %. Getting PU rigid foams with higher lignin content was troublesome by reason of increasing viscosity of polyol component. PU rigid foams with lignin have higher content of closed cells than foams without lignin, it is important characteristic for thermal insulation materials.

Lignin used as modifier of PU cast resins up to concentrations of about 15 wt. % improves mechanical properties, surface hardness and electrical resistance, increases glass transition temperature. Elastomers modified with lignin can be potentially used in production of flexible floorings or electrical appliances such as condensers.

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References

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