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Research paper

Polyurethane foams produced from pyrolysis oil – Production and possible application

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ABSTRACT

Rigid polyurethane (PU) foams are widely used for instance in building insulation. Two component systems comprising of a polyol as component A and a diisocyanate as component B are generally applied. Both components are produced from fossil oil resources. The liquid products from fast pyrolysis of biomass contain a large variety of organic compounds with −OH functional groups. This gives rise to the idea to substitute the polyol component in PU foams with such biomass based intermediates. Pyrolysis condensates derived from woody and herbaceous biomass were dried and samples of PU foams were produced with varying amounts of condensate substituting the polyol component. Especially the foams made from condensates produced from straw showed good insulation properties, which were expressed as low thermal conductivity. Here, with a substitution degree of 80% a thermal conductivity of 0.0283 $Wm^{-1}K^{-1}$ was achieved, which was 8% lower than for the foams produced from commercial components (0.0308 $Wm^{-1}K^{-1}$). Preliminary results for the measurement of compressive strength indicated that the required value of 150 kPa can easily be achieved, especially with a high degree of substitution. These results show a high potential for the application of bio-based intermediates in the building sector. Further research on other properties is necessary, but the main requirements for thermal conductivity are already met without optimization of the catalyst/stabilizer system.

1. Introduction

Polyurethanes (PU) are one of the most widely used polymeric materials in the world. One of the most important commercial polyurethane product is polyurethane foam (PU foam), which is commonly classified as flexible, semi-rigid or rigid, depending on its mechanical performance and core density [1]. Rigid polyurethane foam is one of the most important insulating materials used in the construction industry today, because of its excellent combination of low thermal conductivity and proper mechanical properties [2]. PU foams are polymers formed by a condensation reaction between isocyanates having more than one reactive isocyanate group per molecule and alcohols having two or more reactive hydroxyl groups per molecule (see section 2). Similar to other polymeric materials, also polyurethane industry strongly relies on fossil resources, as the main feedstocks used in polyurethane products synthesis (isocyanates and polyols) are obtained mainly from petroleum. Due to environmental concerns great efforts are made to find renewable substitutes for these raw materials. One of the promising substitutive resources is biomass as the only renewable carbon source. Many researchers have shown that the polyols derived from biomass-based materials, such as palm [3], soybean [4], wheat straw [5], corn stover [6] and sugarcane bagasse [2] have suitable characteristics (e.g. hydroxyl numbers, viscosities, molecular weight) for making polyurethane foams with comparable properties to conventional polyurethane foams. One of the promising methods to make use of residues from forestry and agriculture and to produce biomass-based oil is pyrolysis [7]. During pyrolysis, 3 products are formed: a solid residue called bio-char, a liquid fraction called pyrolysis

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