Use of Fast Pyrolysis Bio-Oils in Synthesis of Polyurethane Foams

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Abstract
Fast pyrolysis of biomass under various conditions produce bio-oils with varying contents of sugars (e.g. Levoglucosan). We present a method to synthesize polyurethane foams (PUF’s) using fast pyrolysis bio-oils.

Background
Fast pyrolysis of biomass results in three main products: • Syngas (a mixture of Carbon monoxide and Hydrogen) • Bio-oil (a liquid phase rich in organics – sugars and aromatics) • Bio-char (a charcoal encapsulate containing various salts)

These products can be upgraded or processed to generate more consumer friendly products like gasoline (from bio-oil), fertilizer pellets (from bio-char).

The bio-oil obtained from fast pyrolysis contains various organic molecules ranging from long chain alkanes to polycyclic aromatics and sugars, some of which are shown in Figure 1. The concentration of these products vary depending on the pyrolysis conditions.

Materials & Methods
Polyurethane foams are synthesized by reacting organic units carrying hydroxyl groups with isocyanates to produce carbamate linked chains (Figure 3). The reaction also involves several other components like blowing agents and chain extenders that effect the quality of the foam synthesized. We seek to identify the effects of the quantity of blowing agent and surfactant used on the compressibility of the foams produced. To this effect we have carried out experiments varying the quantity of these agents to qualitatively identify the effect on the polyurethane foam produced using fast pyrolysis bio-oils.

The reaction mixture consists of several components which affect the quality of the foam produced.

Polyol: Bio-oil (1.0 eq)
Isocyanate: Toluene diisocyanate (TDI) (1.6 eq)
Extender: Polyethylene glycol 400 (PEG 400) (0.6 eq)
Surfactant: Polyether modified polysiloxanes
Blowing Agent: Water
Catalyst: Stannous 2-ethyl hexanoate (0.005 eq)

Results

Role of polysiloxanes as surfactant: The surfactant stabilizes the windows formed during the foaming process. This helps in reducing the density of the foam. Increasing amounts of surfactant did not significantly affect the density of the foams, Figure 5, but consistently produced brittle/hard foams with low compressibility.

Role of water as the blowing agent: The density of the foam decreases as amount of water increases, as shown in Figure 6. Increasing amount of water also increases compressibility of the foam.

Conclusions
• Bio-oils with high sugar content can be used to synthesize polyurethane foams.
• The compressibility of the foam produced depends on the quantity of surfactant and blowing agent present in the reaction mixture.
• High levels of surfactants result in brittle but low density foams.
• High levels of blowing agent result in low density soft foams.
• High concentrations of both surfactant and blowing agent result in foams with higher compressibility.

References

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Figures:
Figure 1. Some of the molecules identified in fast pyrolysis bio-oils.
Figure 2. Polyurethane foams are manufactured in various shapes with varying levels of compressibility and density.
Figure 3. Schematic representation of reaction between polyol and diisocyanate.
Figure 4. Polyurethane foams are manufactured in various shapes depending on the pyrolysis conditions.
Figure 5. Increasing amounts of surfactant do not affect the quality of foam, but consistently produce brittle foams.
Figure 6. Foams produced using bio-oil with constant quantity of surfactant and increasing amounts of water, from left to right.
Figure 7. Foams produced using 1.3 eq of blowing agent and 0.7 eq of surfactants result in foams with low density and higher compressibility.