

Aluminum Hypophosphite as an Effective Flame-Retardant in Bio-Based Rigid Polyurethane Foams

Felipe M. de Souza, J. Choi, Ram K. Gupta

Pittsburg State University



Background

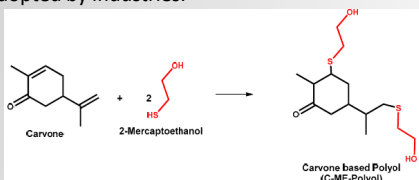
- ❖ Necessity of including bio renewable materials into the industry is a requirement to make processing more economical and sustainable
- ❖ Polyurethane market size was about 37 billion dollars which includes constructions, car seats, dampers for shoes, coatings, insulating walls, adhesives and many others.
- ❖ The synthesis is a facile reaction between a polyol (-OH) and isocyanate (-NCO) along with surfactants, catalysts and blowing agents.
- ❖ Carvone (Essential oil from bay leaf) was the biobased starting material used to make polyurethane foam along with aluminum trihydroxide (ATH) (Commercial) and aluminum hypophosphite (AHP) used as a blended flame retardant.

Overcome the Status-quo

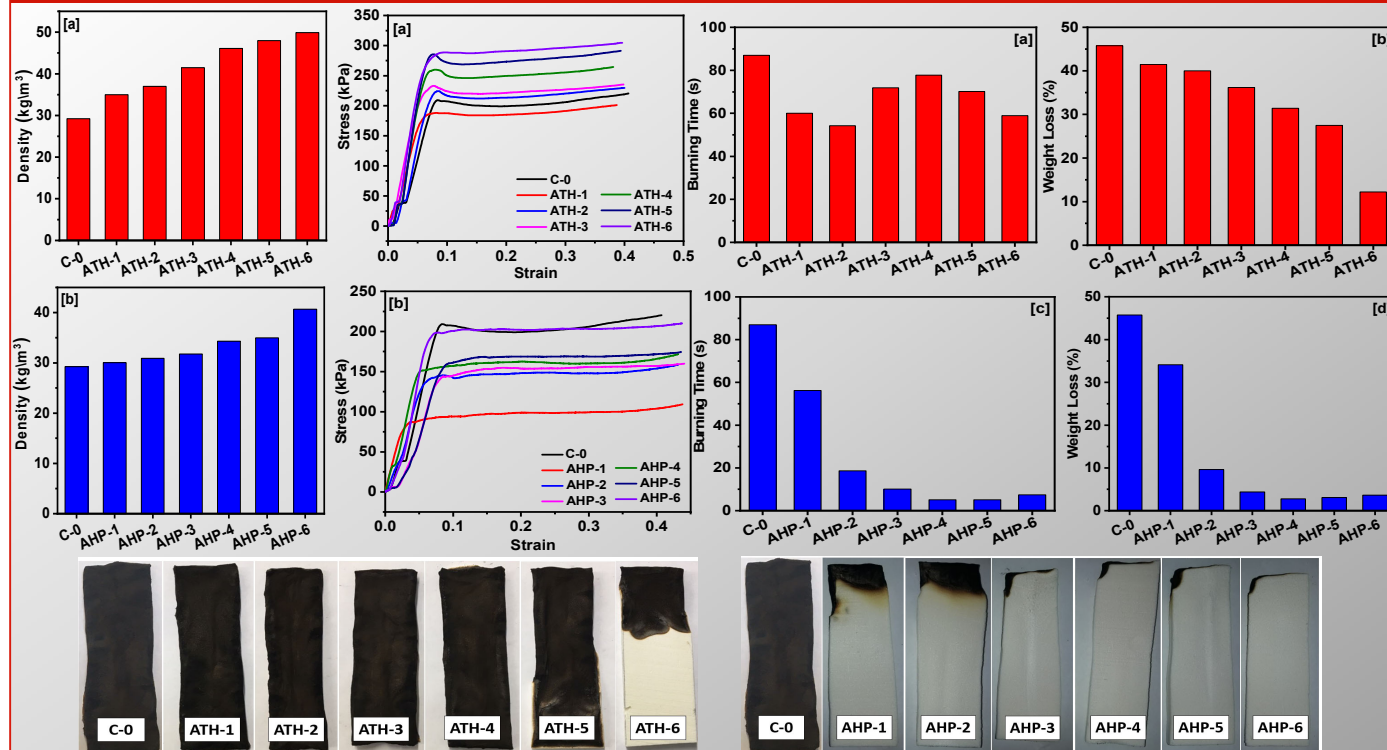
- ❖ The low-weight and high mechanical strength are attractive properties of polyurethanes. However, its susceptibility to fire is an issue.
- ❖ Add flame retardancy without compromise much of mechanical properties and total cost of processing.
- ❖ Decrease the release of toxic smokes as these can impose life-threatening situations.
- ❖ Addition of flame-retardants which are eco-friendly and allow ease synthesis and processing.
- ❖ Use low-cost materials to develop high performance polyurethane foams.

Solution through the research

- ❖ High flame retardancy was obtained after introduction of low amounts of AHP in comparison to ATH.
- ❖ Facile procedure through blending that can be reproduced in large scale.
- ❖ Extremely quick self-quenching response, no dripping and high weight conservation.
- ❖ Despite the decreased the compressive strength after addition of AHP the polyurethane foams were still within the applicable range adopted by industries.



Results and discussion



- ❖ Facile synthesis of polyol performed under UV-light.
- ❖ Burning time dropped from 98 s to 58 s (ATH-6 – 15.4 wt.%) and 5.2 s (AHP-6 – 8.9 wt.%).
- ❖ Weight loss percentage dropped from 45 to 15% (ATH-6) and 3.6% (AHP-3)
- ❖ The compressive strengths were in average 240 kPa (ATH) and 130 kPa (AHP), which are satisfactory values for most of industrial applications.
- ❖ Average Closed cell content for the foams was around 95%.
- ❖ Density of the foams had an average of 42 kg/m³ (ATH) and 33 kg/m³ (AHP).

Summary

- Carvone based polyol was synthesized using thiol-ene reaction also known as click-chemistry and later used to make polyurethane foams
- Low-cost, green synthesis, facile processing and high-performance polyurethane in regard of density, compressive strength and flammability reduction.
- AHP was used as a flame retardant is a low-cost and eco-friendly alternative that can be obtained through facile wet synthesis and blended into the polyurethane pre mixture and introduce effective flame retardant properties without causing much deterioration into the compressive strength.

Future work & Acknowledgement

- Use other sources of bio renewable materials to make polyurethane foams
- Synthesize flame-retardants through facile methods that are eco-friendly and can be scaled up.
- Sincere acknowledgment for the Polymer Chemistry Program and Kansas Polymer Research Center, Pittsburg State University for providing financial and research support for the accomplishment of this work.