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Effect of Flame-Retardants on the Properties of Vegetable Oil-based Polyurethane Foams

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Effect of Flame-Retardants on the Properties of Vegetable Oil-based Polyurethane Foams

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Introduction

- Polyurethanes can be produced using various starting materials and can be used in a variety of applications such as automobiles, furniture, construction, packaging, wood substitutes, coatings, and sealants.



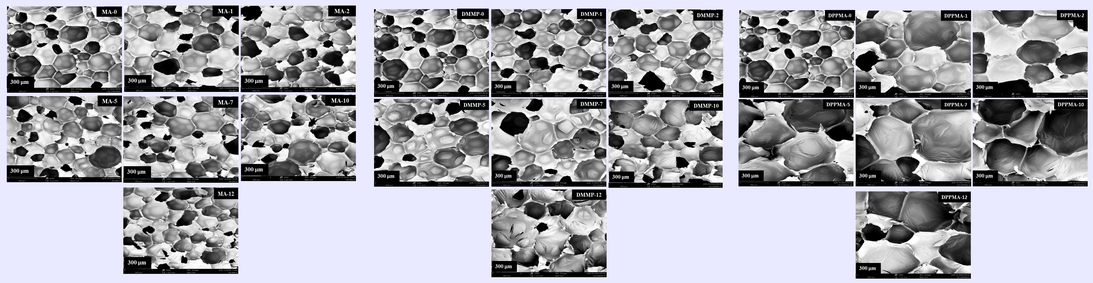
Major concerns


- Nowadays polyurethanes are moving towards bio-based resources as the petrochemical resources are hazardous to the human being and environment and less availablability.
- Polyurethane can catch fire easily due to its porous structure and high surface-to-volume ratio.

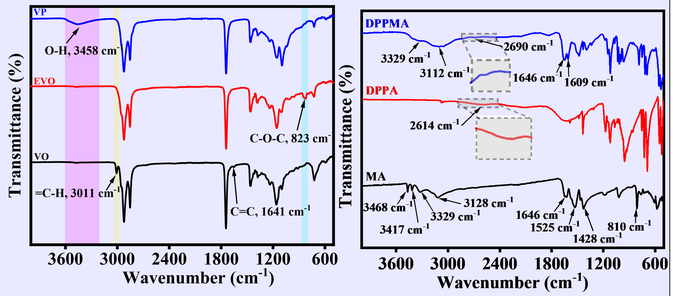
Solutions

- Vegetable oil was used as an alternative to bio-based compounds for the synthesis of rigid polyurethane foam to reduce the use of petroleum-based products due to its low cost and easy availability.
- Three various types of bio-based flame retardants such as melamine, dimethyl methyl phosphate, and DPPMA (melamine salt) were also incorporated in PU foams to decrease the flammability of PU foams.
- All foams containing different FR showed industrial-grade properties.

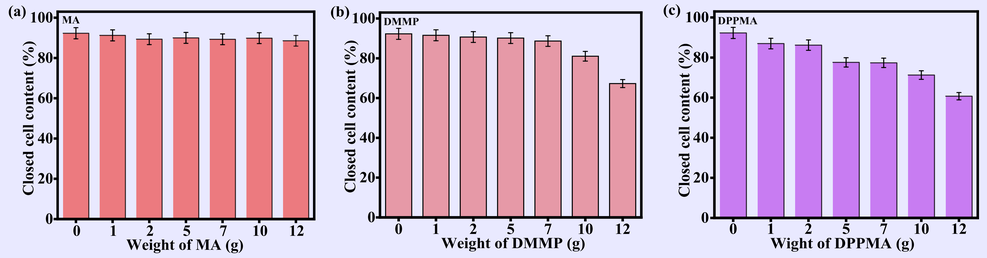
Results and Discussions



SEM image of foams having different amounts of melamine, DMMP, and DPPMA flame retardant



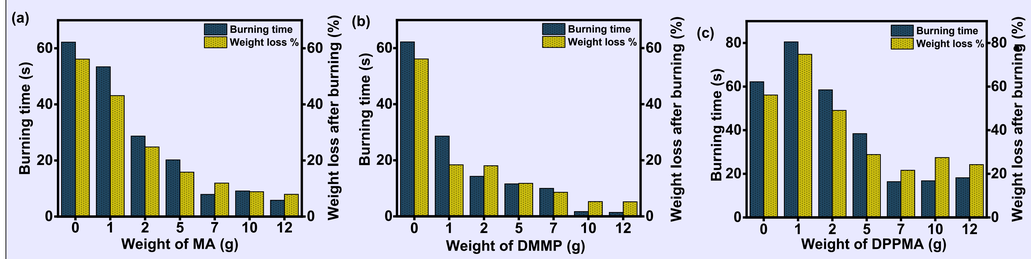
FT-IR and GPC of vegetable oil polyol and flame retardant DPPMA.



Closed cell content containing different FR in various amounts.

- The successful modification of vegetable oil-based polyol and DPPMA flame-retardant was done through FTIR spectroscopy flame retardant

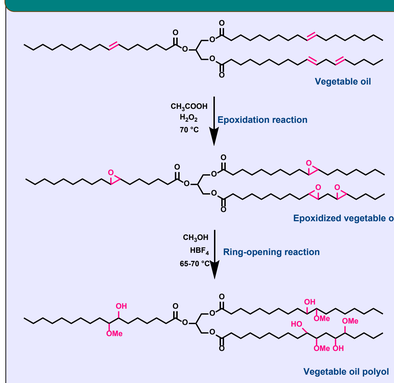
- The above figure shows that increasing wt.% of melamine does not affect the closed cell content of all the samples as they have shown more than 90%. In short, all the samples have good thermal resistance. While using the DMMP closed content values are higher from 0 to 7 wt.%, whereas it decreased after the higher content of DMMP. Apart from this, DPPMA has shown a decreasing trend in closed-cell content. Overall, melamine and DMMP have shown good thermal resistance in all the synthesized samples.



Burning time and weight loss percentage of foam containing various FR

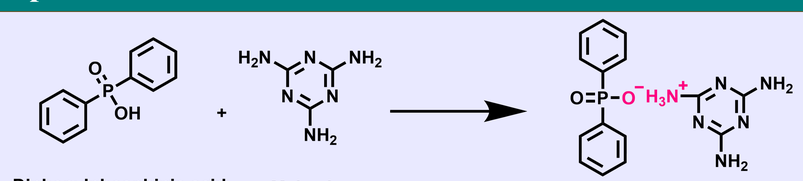
The above figures indicate the burning time of all the samples using different flame retardants, DMMP shows the lowest burning time of 1 sec at 12 wt% which is the best of all the samples. However, melamine shows at 5 s and DPPMA shows at almost 20 s at 12 wt.%. At 0 wt.% all the samples show at almost 60 s of burning time. In all the samples, DPPMA shows first increasing then decreasing trend after increasing the wt.% of DPPMA. Hence, the results indicate that the foam containing DMMP flame retardant showed the lowest burning time and weight loss as compare to other flame retardants,.

Experiments

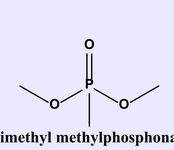


The chemical reaction for the synthesis of vegetable oil polyol.

- The vegetable oil was converted into epoxidized vegetable oil through an epoxidation reaction and then the epoxide oil was converted into the vegetable oil polyol through a ring-opening reaction



The chemical reaction for the synthesis of flame retardant DPPMA.



Herein three various flame retardants were incorporated in the Pu foam in different quantities to analyze the effect of flame retardant on the vegetable oil-based PU foam.

Conclusion

- All PU foam showed good closed-cell content above 60 % for DPPMA and DMMP and 89% for MA flame retardant.
- The horizontal burning test showed an effective decrement in weight loss and burning time after adding different amounts of FR but the best result was observed in DMMP FR foam of 1s burning time and 5.1 % .
- Due to the easy availability, low cost and bio-based content, which makes them favorable for PU foam.

Acknowledgment

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