Highly efficient thermal stability of bio-based rigid polyurethane foam via melamine and its derivatives as additive flame retardant

M.S. Polymer Chemistry
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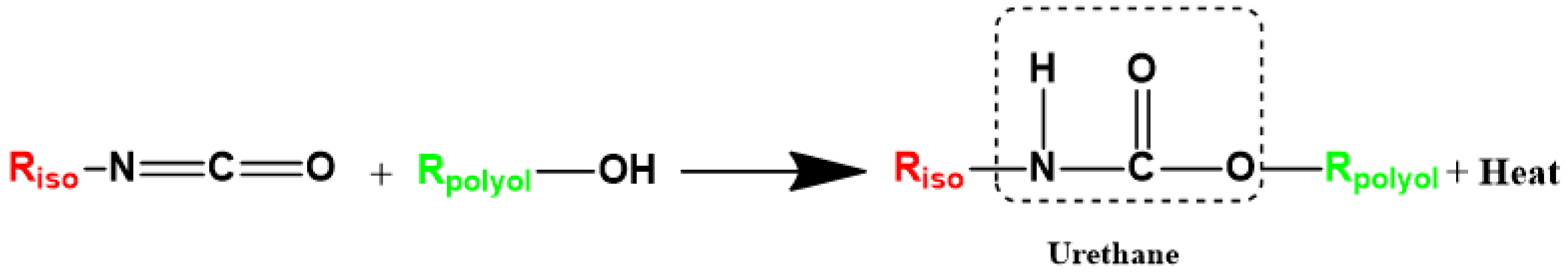
Introduction

1. Polyurethanes are considered as one of the most versatile class of polymers in world.
2. About 32% of the total polyurethane production is used for rigid polyurethane foams.
3. Rigid foams have shown remarkable performance in decreasing energy costs in residential and commercial applications.
4. PU foams are synthesized by a polyaddition reaction between polyols and isocyanates.



5. In recent decades, development of bio-based materials are increasing attention due to high price of energy, concern about global warming and depletion of petrochemical resources.
6. β-myrcene is a natural alkene found in several flowers, fruits and plants.
7. The purpose of this study is to the synthesis of myrcene-based polyol that use for the preparation of foams as well as improve the fire-resistant properties of bio-based rigid polyurethane foams.

PU Applications

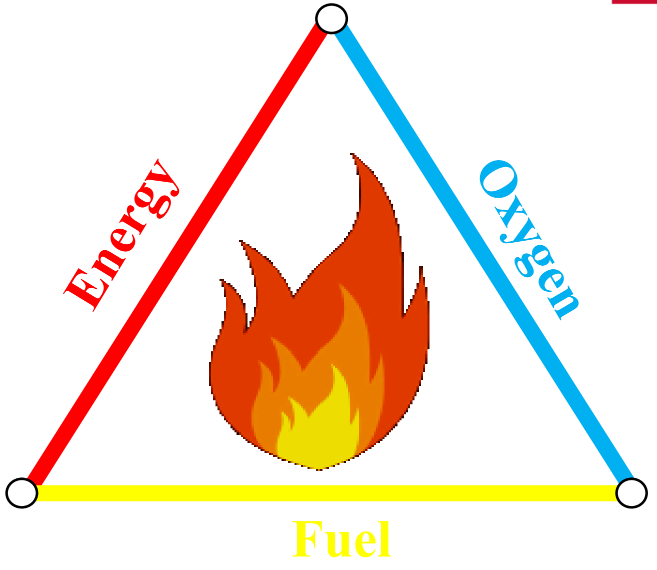
Categories	Application	Production
Flexible foams	Vehicle, seating, matrasses, …	36%
Rigid foams	Household applications, insulation board, packaging, …	32%
Elastomers	Medical applications, glues, …	8%
Adhesives and sealant	Casting, sealant	6%
Coating	Vehicle (bumpers, side panels)	14%
Binder	Assembling of wood broads, rubber, or elastomer flooring surfaces	4%



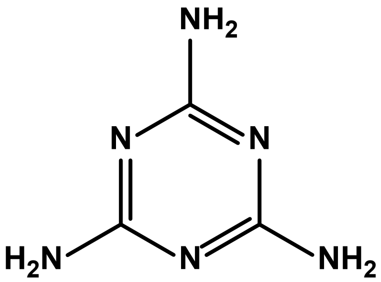


Disadvantage of PU

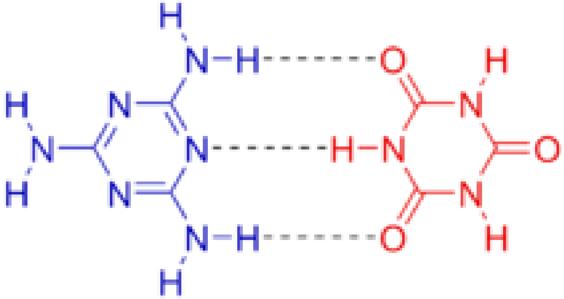
1. Unfortunately, rigid polyurethane foams are highly flammable that catch fire in a short amount of time as well as spread the flame quickly.
2. The porous structure of polyurethane foams is the reason for their rapid ignition.
3. When polyurethane foam is exposed to a source of heat, ignition occurs and various bonds are broken at different temperature ranges.
4. Decomposition of polyurethane is an exothermic reaction, which produces, a large amount of hazardous and toxic gases, including N_2, CO, HCN, CO_2, H_2O, and NO_x



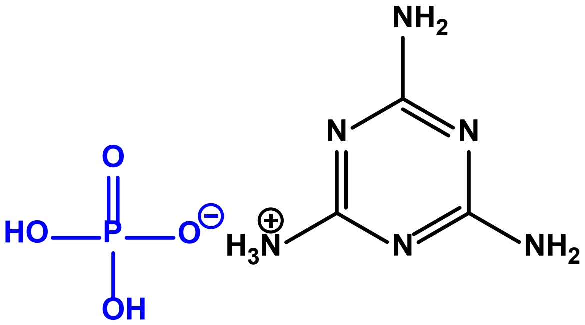
Flame retardants



Melamine

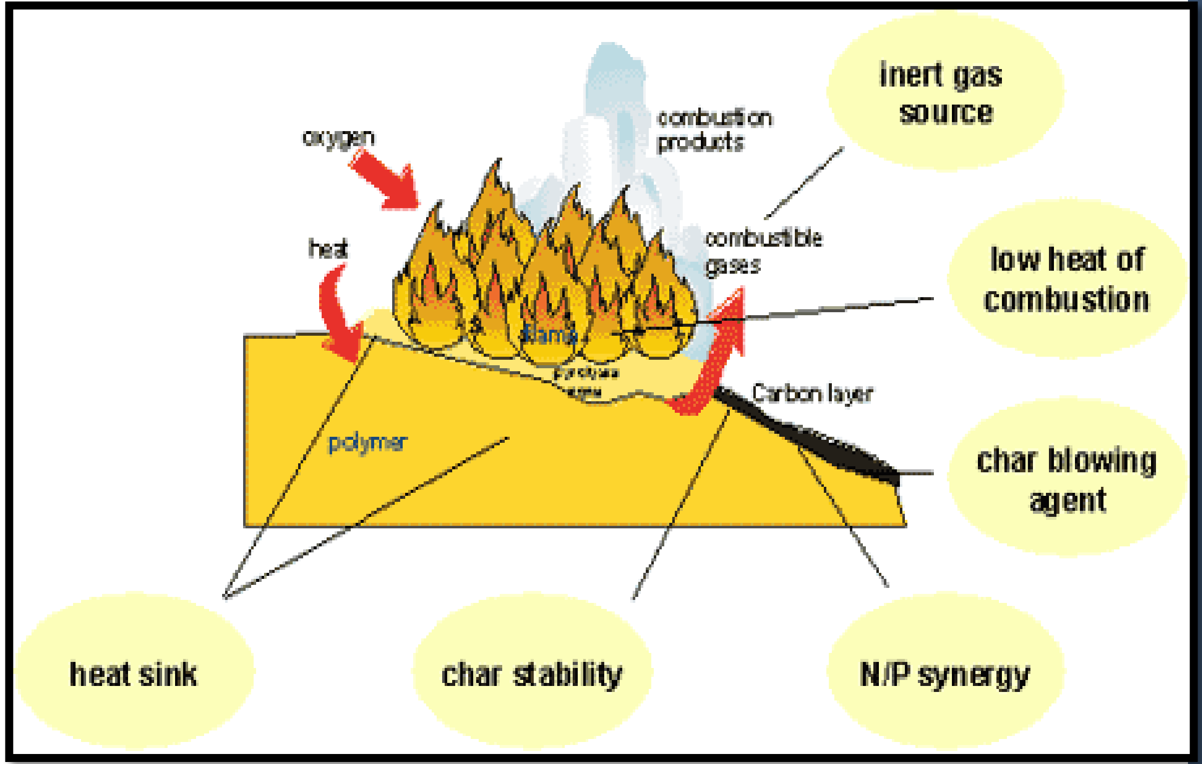


Melamine Cyanurate



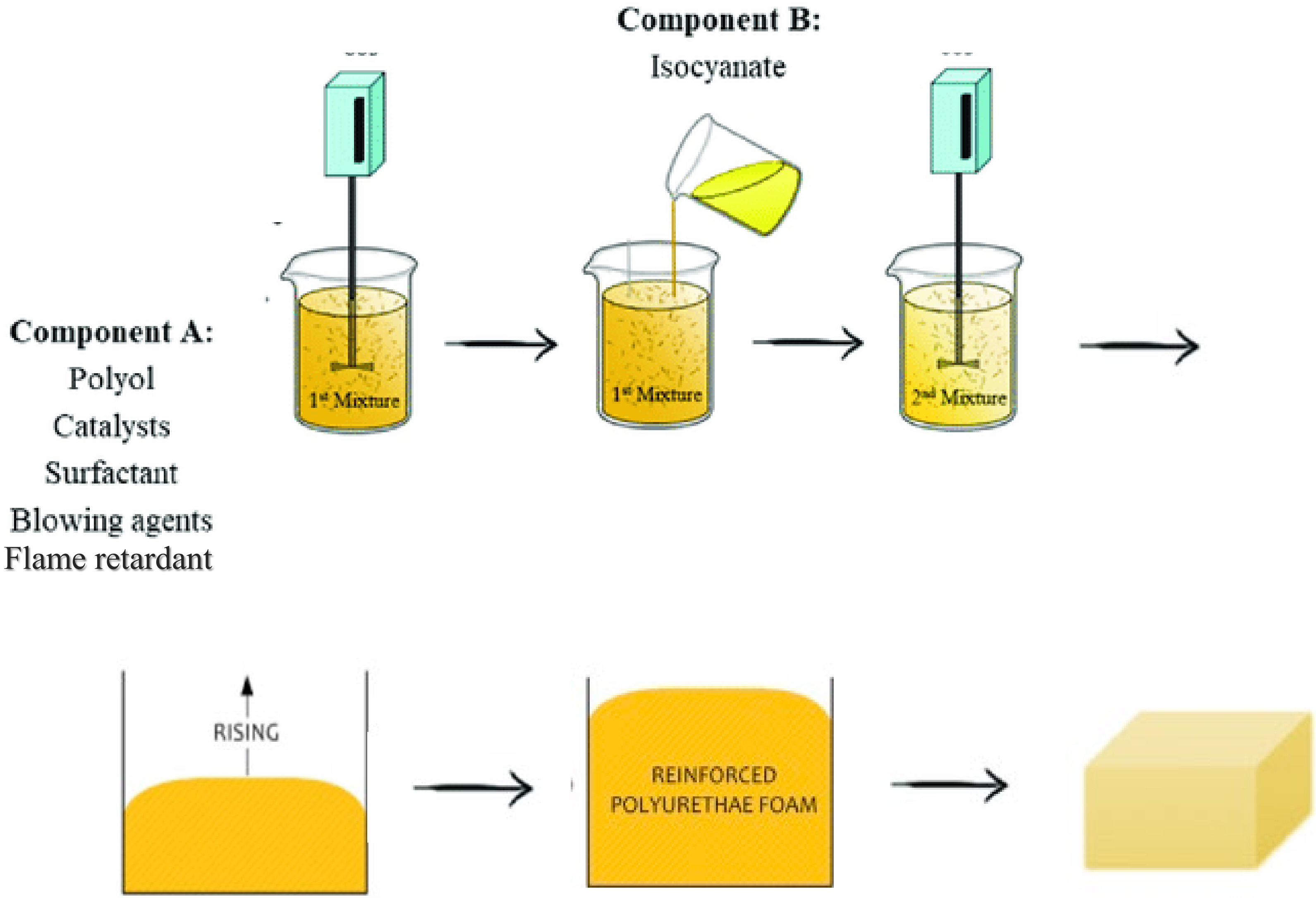
Melamine Phosphate

http://fr.polymerinsights.com/fr-types/nitrogen-based/melamine



https://polymer-additives.specialchem.com/selection-guide/flame-retardants-for-fire-proof-plastics

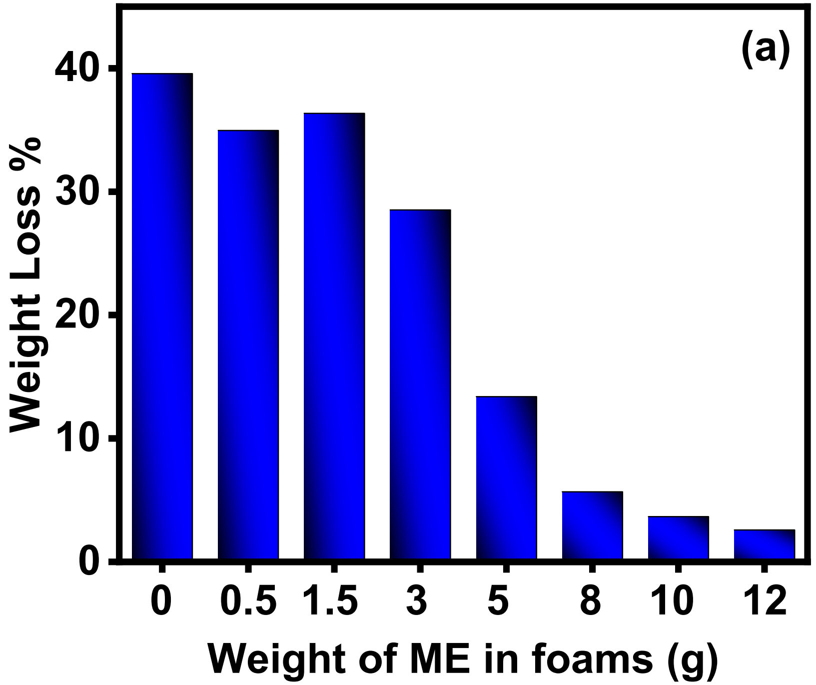
Synthesis of rigid polyurethane foams

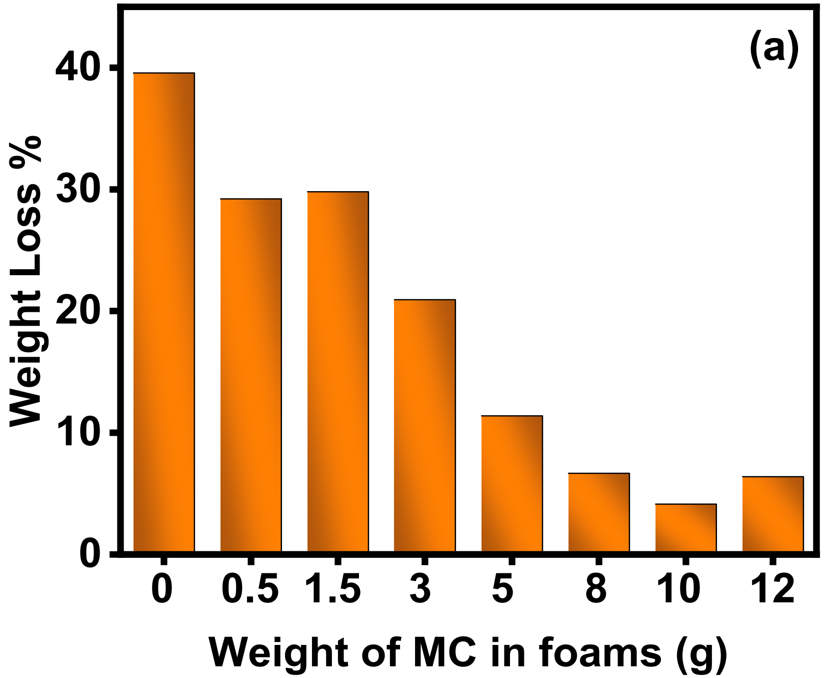


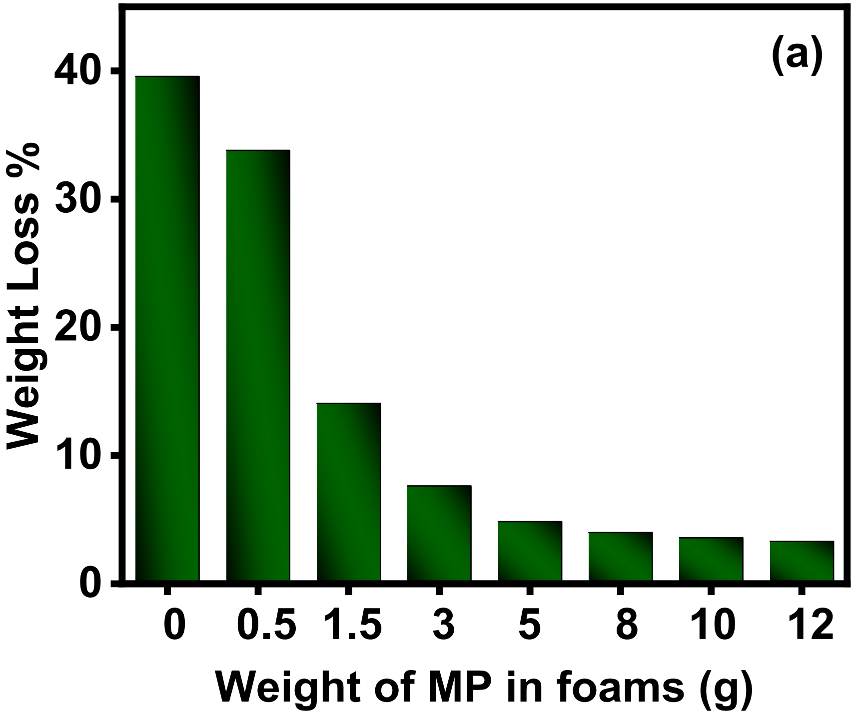
Kim, Jong-Min, Jeong-Hyeon Kim, Jae-Hyeok Ahn, Jeong-Dae Kim, Sungkyun Park, Kang Hyun Park, and Jae-Myung Lee. "Synthesis of nanoparticle-enhanced polyurethane foams and evaluation of mechanical characteristics." *Composites Part B: Engineering* 136 (2018): 28-38.

Członka, Sylwia, Anna Strąkowska, Piotr Pospiech, and Krzysztof Strzelec. "Effects of chemically treated eucalyptus fibers on mechanical, thermal and insulating properties of polyurethane composite foams." *Materials* 13, no. 7 (2020): 1781.

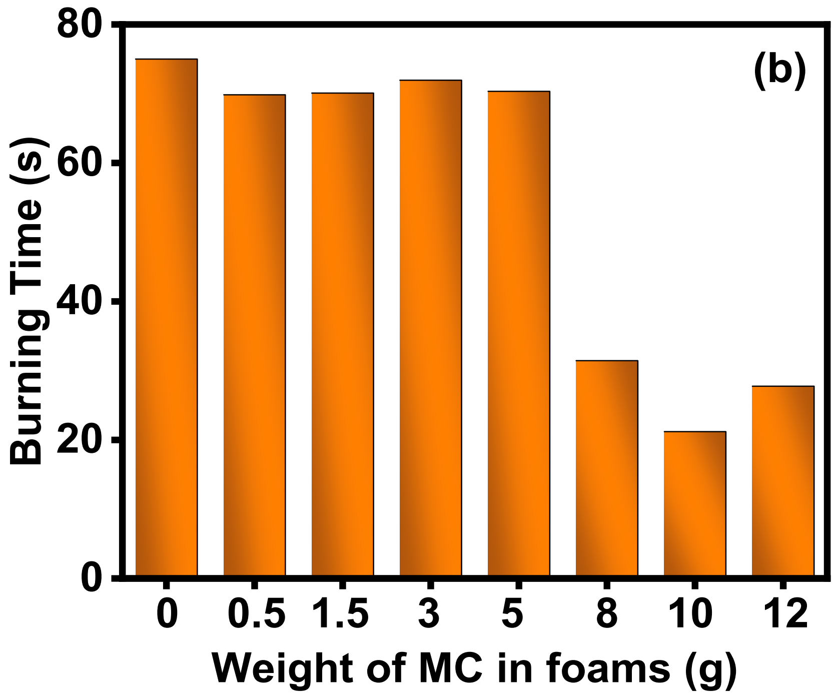
Horizontal flame tests

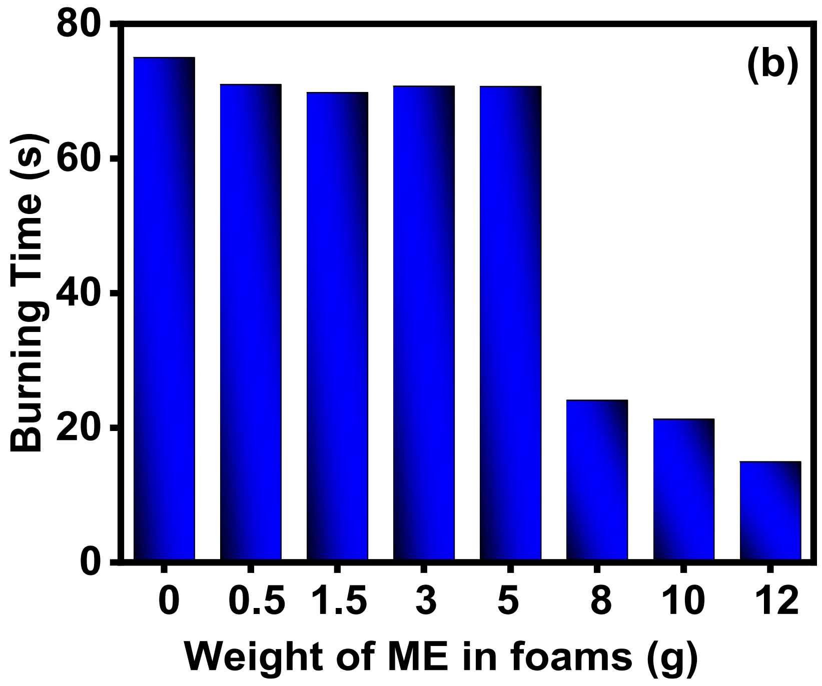


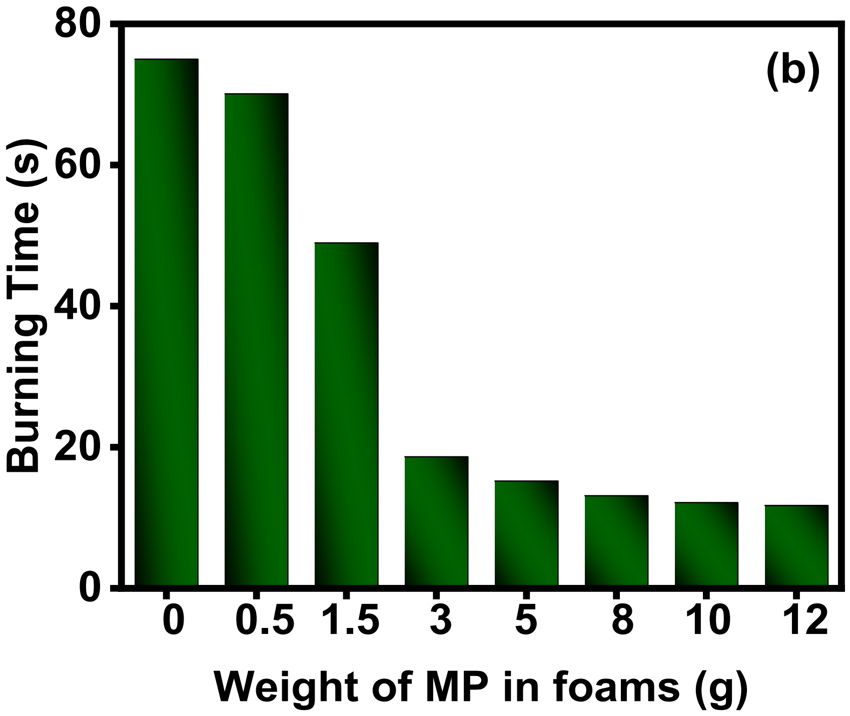




Horizontal flame tests







Conclusion

- ✓ Bio-based polyurethane foams were formed by utilizing myrcene, an unsaturated essential oil.
- ✓ Melamine and its derivates cause a large improvement in thermostability and decline the flammability issues of RPUF.
- ✓ As a result, using eco-friendly materials such as myrcene and nitrogen-based flame retardants offered an effective option to enhance the physicomechanical and thermal stability of rigid polyurethane foams

FR wt.%	Density	CCC%	Compressive Strength (kPa)	Burning Time (s)	Weight Loss %
17.3 wt.% (12 ME)	60-70 Kg/m^3	93-95%	200 kPa	14 s	2.5%
14.8 wt.% (10 MC)	60-70 Kg/m^3	93-95%	267 kPa	21 s	4.1%
12.2% (8 MP)	60-70 Kg/m^3	93-95%	195 kPa	11 s	3.3%