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Use of Decahydrodecaborate as Flame Retardants in Coatings

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OUTLINE

- Introduction
- Current Flame Retardants
- Structures of TMAD and TBAD
- Sample Preparation
- Characterization
- Thermal Stability
- Cone Calorimetry
- Conclusions

INTRODUCTION

- Halogens have environmental impacts
  - Bioaccumulation
  - Toxic Gases and Smoke

- Many Non-Halogenated Replacements available
  - Phosphorous
  - Nitrogen
  - Boron

Morgan, A. B.; Wilkie, C. A. Non-Halogenated Flame Retardant Handbook; Scrivener Publishing: Beverly, MA, 2014.
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Rotblatt, K. Why Halogens are Dangerous to the Thyroid. http://www.lotussm.com/blog/why-halogens-are-dangerous-to-the-thyroid (accessed March 19,2017).
Yin, G.; Zhou, Y.; Strid, A.; Zheng, Z.; Bignert, A.; Ma, T.; Athanassiadis, I.; Qiu, Y.; Spatial distribution and bioaccumulation of polychlorinated biphenyls (PCBs) and polybrominated diphenyl etheres (PBDEs) in snails (Bellamya aeruginosa) and sediments from Taihu Lake area, China, Environmental Science and Pollution Research. [Online], 2017. https://link.springer.com/article/10.1007/s11356-017-8467-x (accessed March 19, 2017)

CURRENT FLAME RETARDANTS

- Polyurethanes
  - Melamine Cyanurate with aluminum phosphinate in films
  - Dimethyl propane phosphonate
- Boron
  - Boric Acid

Chen, M.; Shao, Z.; Wang X.; Chen L.; Wang Y.; Halogen-Free Flame-Retardant Flexibly Polyurethane Foam with a Novel Nitrogen-Phosphorous Flame Retardant, Industrial & Engineering Chemistry Research [Online] 2012, 51, 9769.

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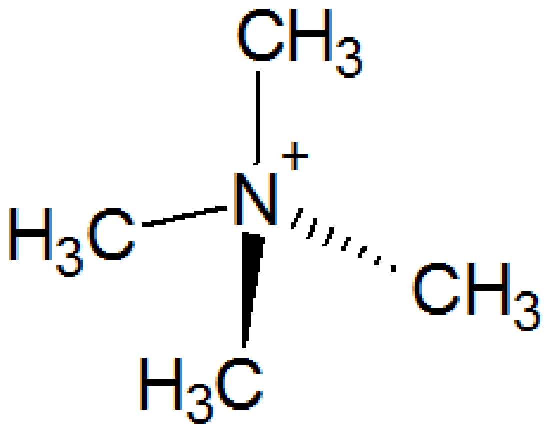
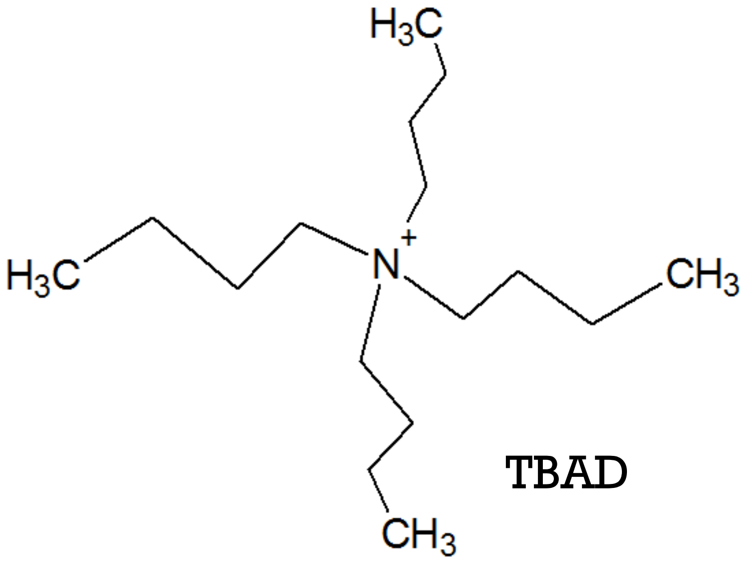
Ullah, S.; Ahmad, F.; Yusoff P.; Effect of Boric Acid and Melamine on the Intumescent Fire-Retardant Coating Composition for the Fire Protection of Structural Steel Substrates, J. Applied Polymer Science [Online], 2012, 128, 2983.

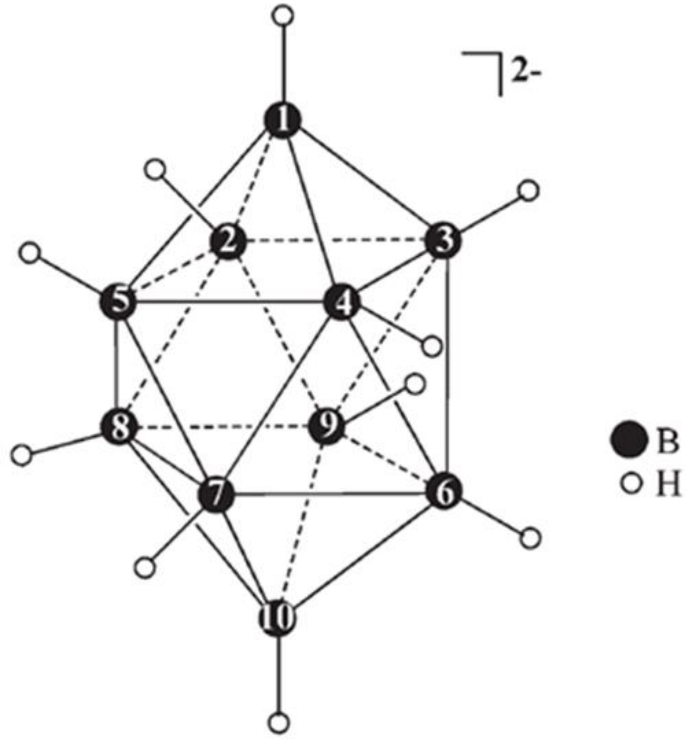
STRUCTURES OF TMAD AND TBAD



TMAD



TBAD

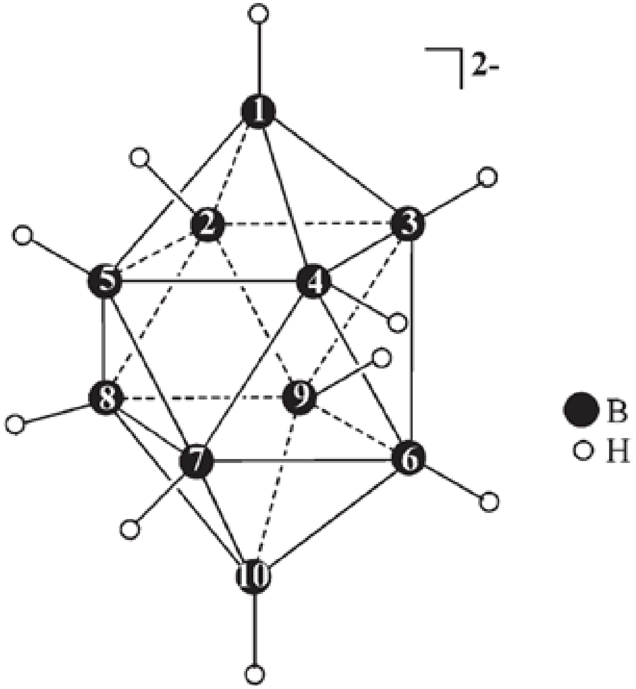


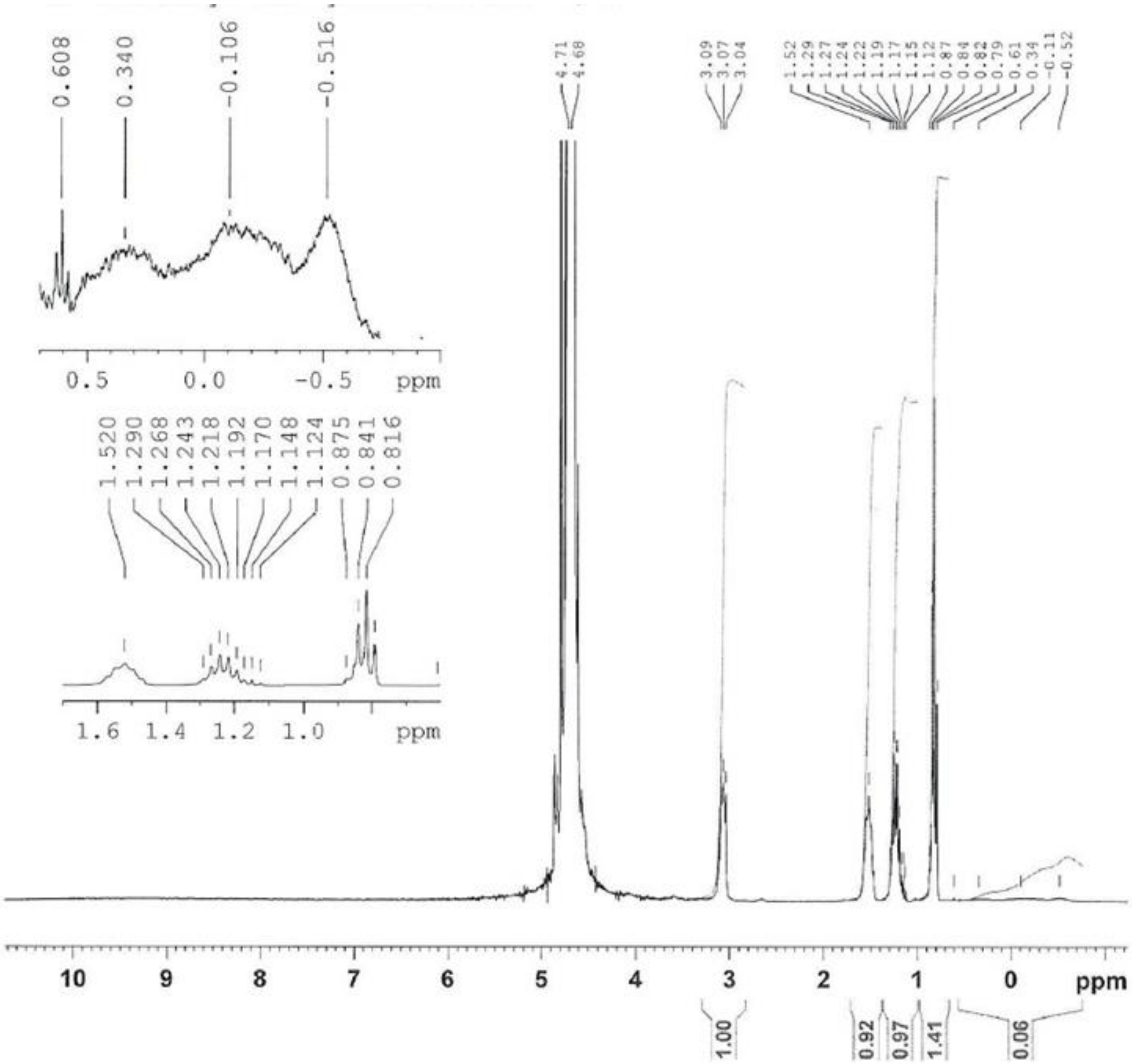
Ghaida, F.; Laila, Z.; Ibrahim, G.; Naoufal, D.; Mehdi, A.; New triethoxysilylated 10-vertex closo decaborate clusters. Synthesis and controlled immobilization into mesoporous silica. Dalton Transactions [Online], 2014, 43, 13087.

SAMPLE PREPARATION

- Polyurethane was obtained from Etco Specialty Products
- Base Samples of 10 wt% and 20 wt% were used for TBAD, TMAD, and Boric Acid
- Design of Experiment used as well
  - Varying Weight % Levels of 5%, 8.75%, and 12.5%
  - Triphenyl phosphine oxide and either TMAD or TBAD

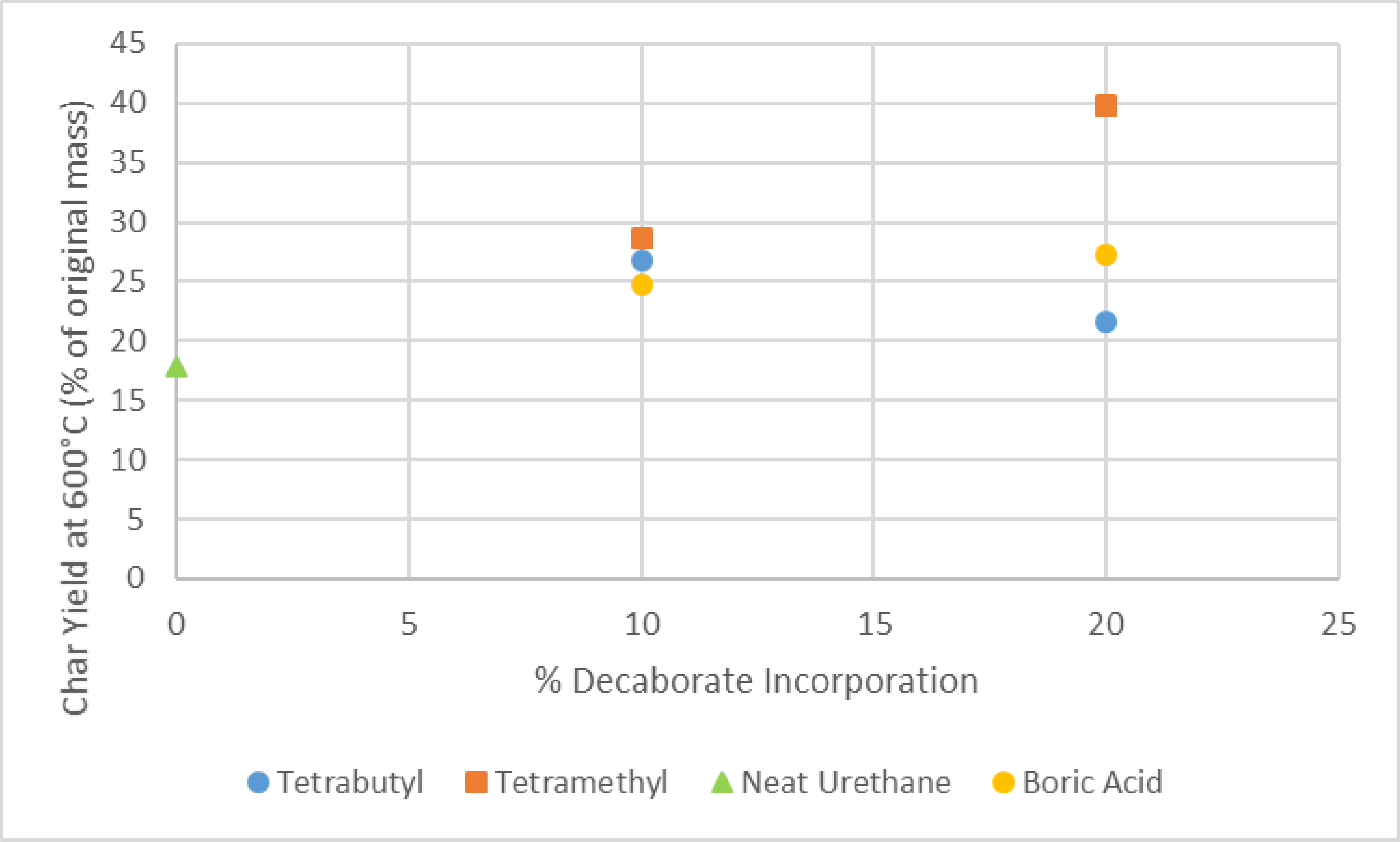
$^1H - NMR$ OF TBAD





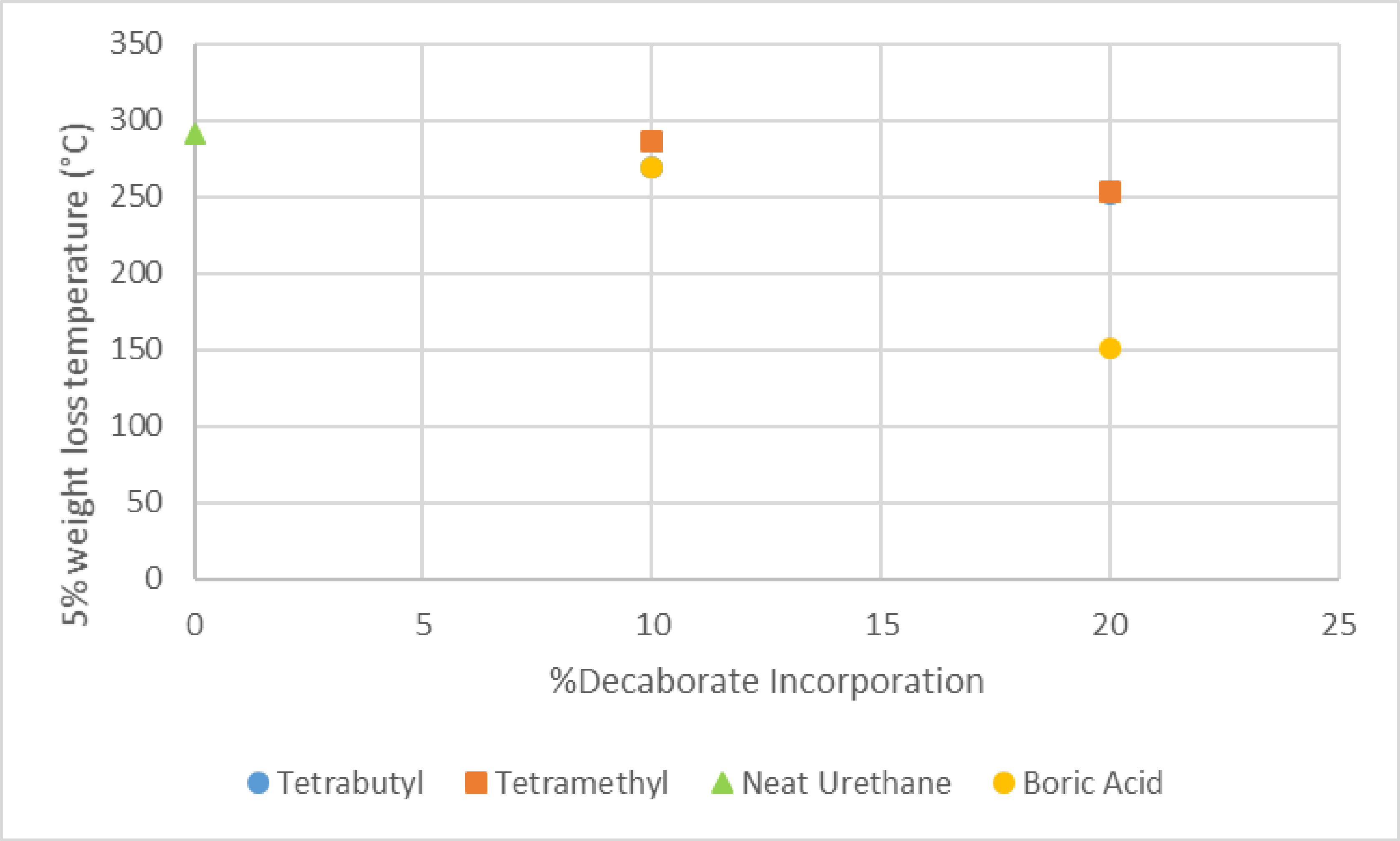
THERMAL STABILITY

- Char Yield

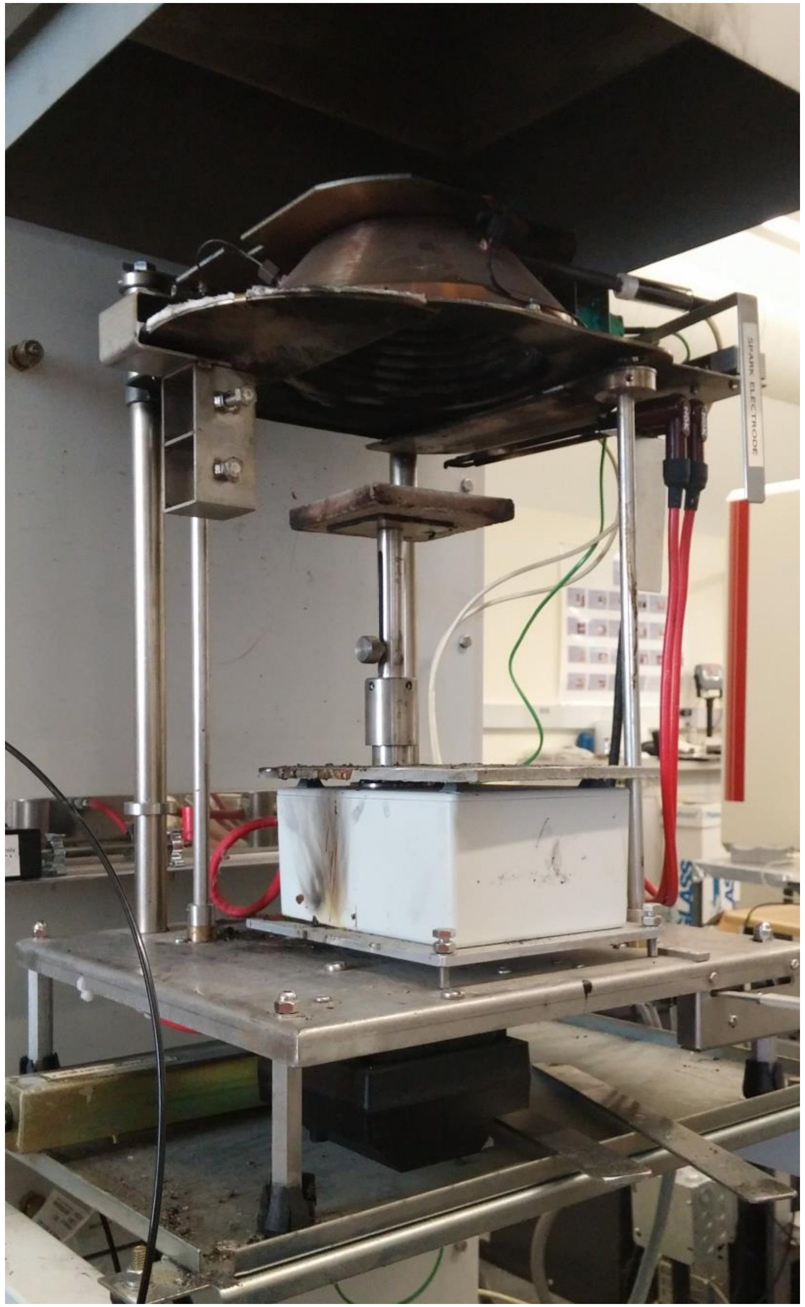


THERMAL STABILITY

5% Degradation



CONE CALORIMETRY



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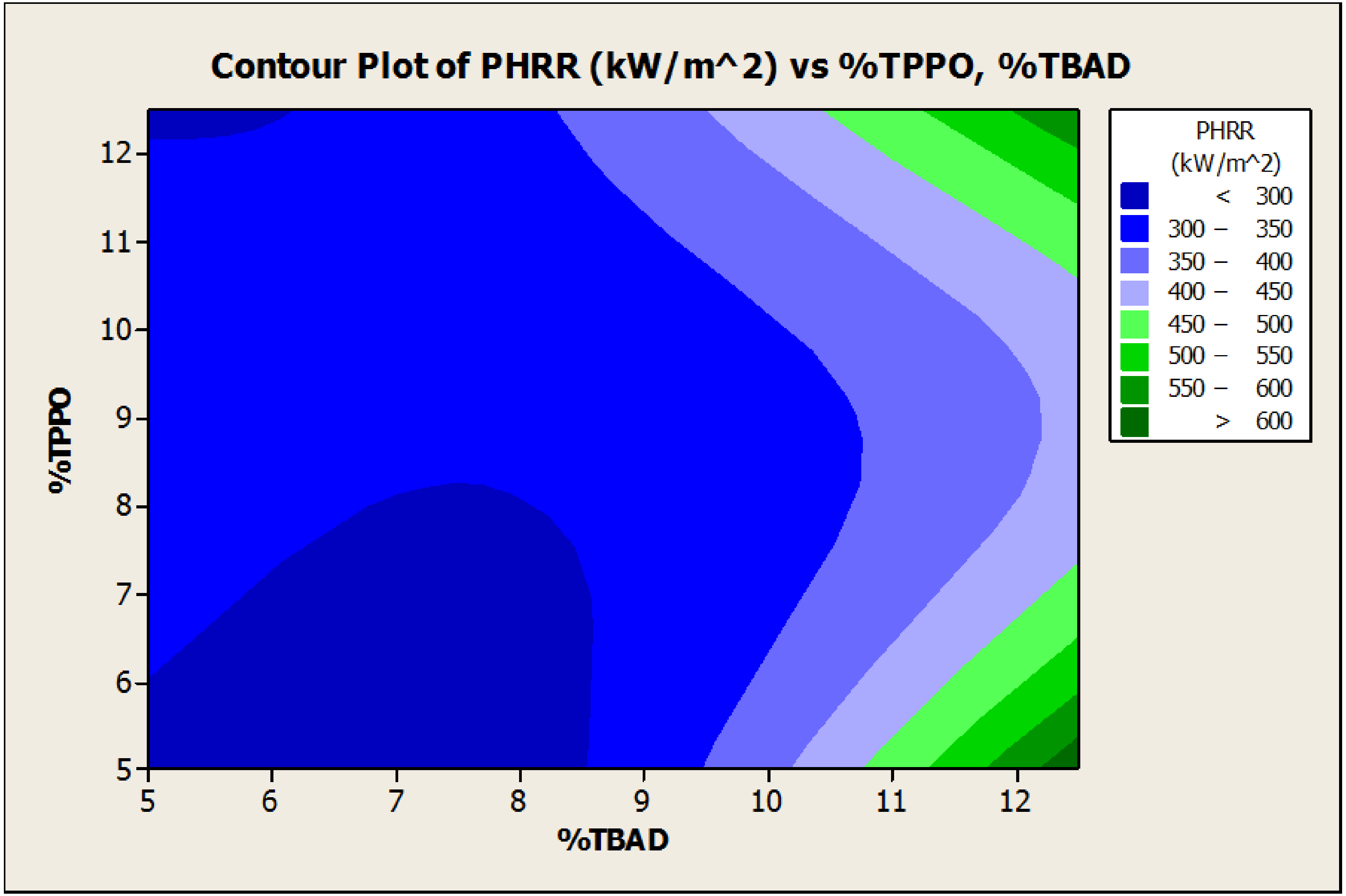
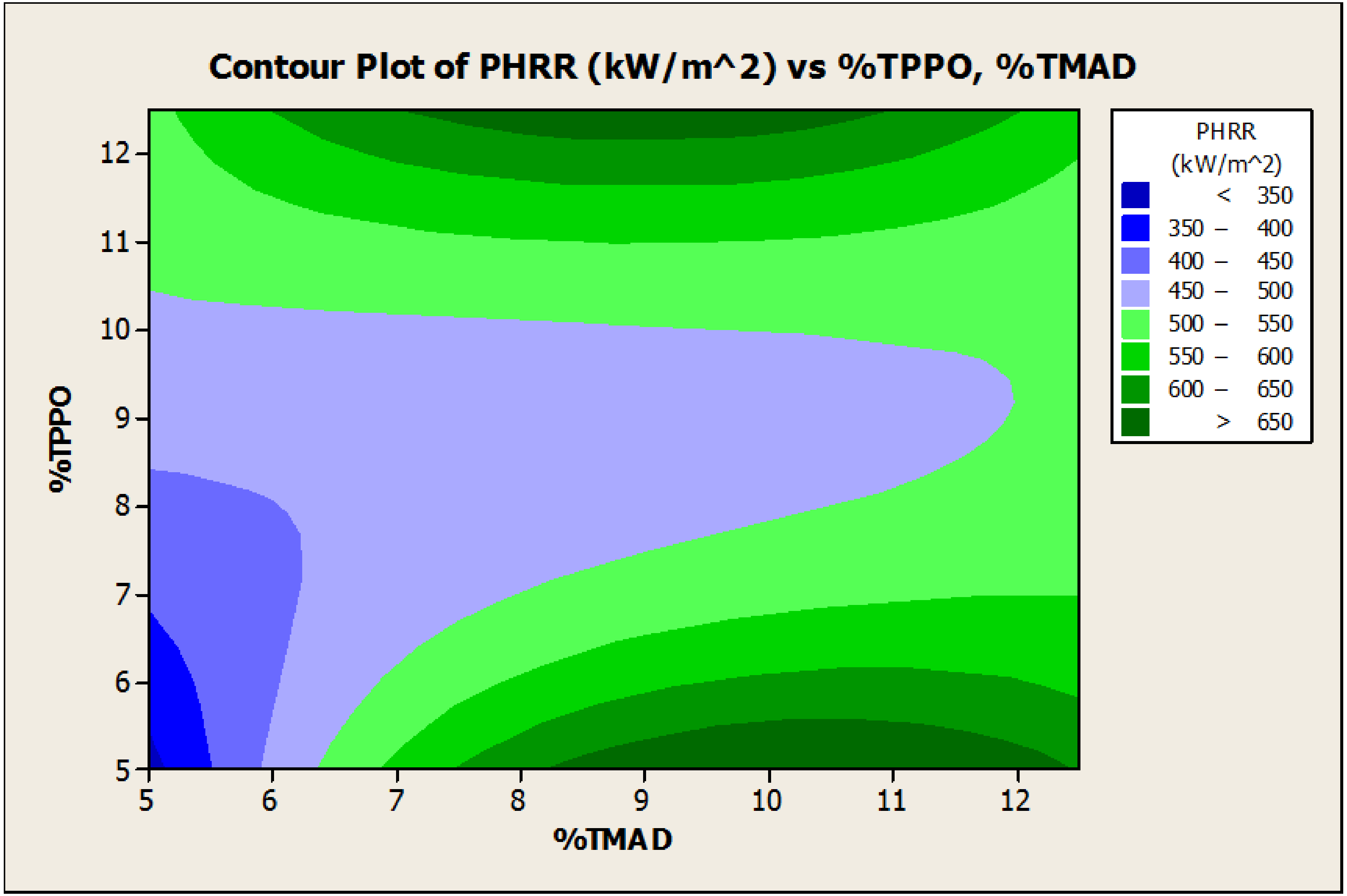
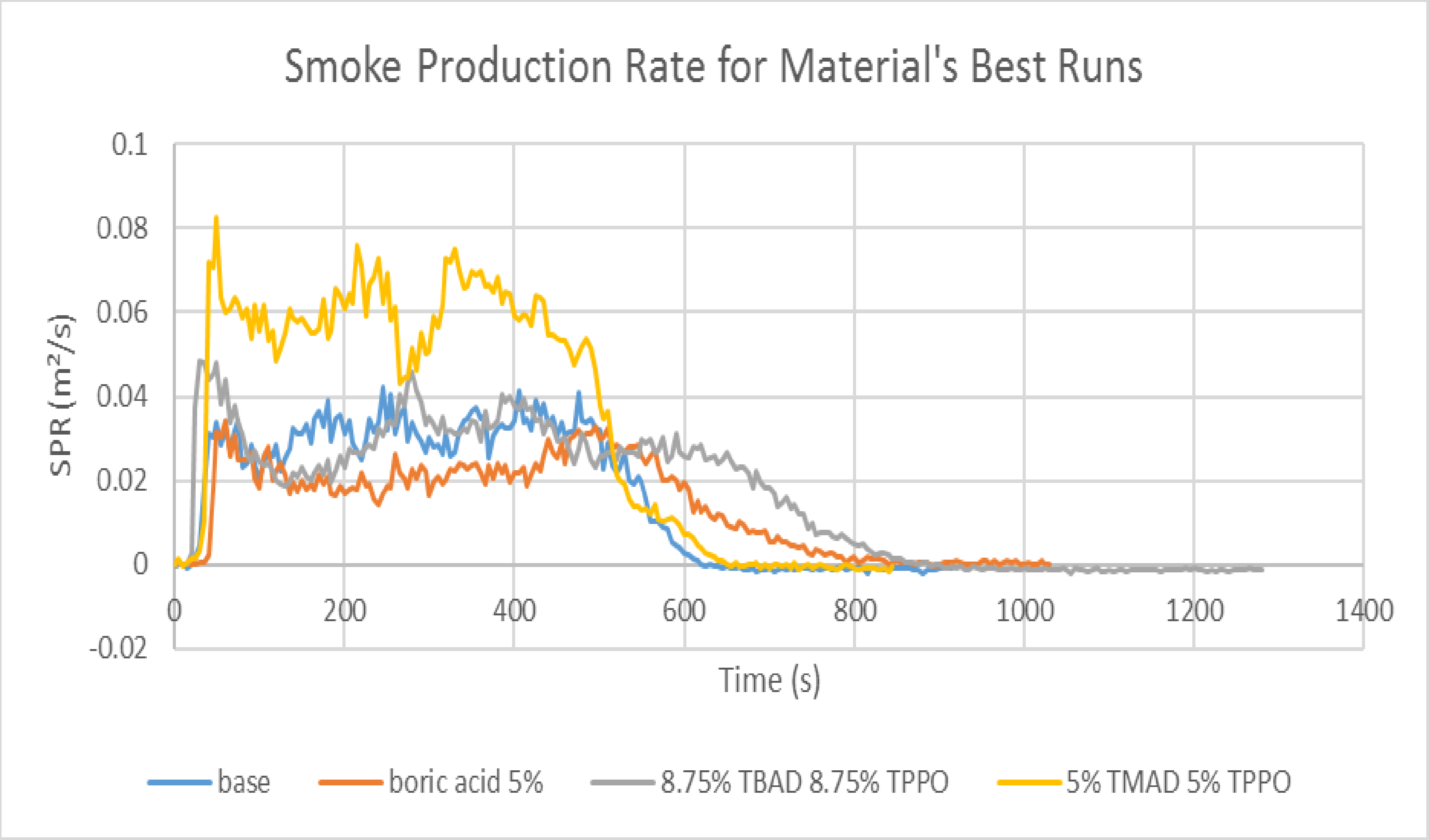
PEAK HEAT RELEASE RATE OF TBAD DOE



PEAK HEAT RELEASE RATE FOR TMAD DOE



SMOKE PRODUCTION RATE



CONCLUSIONS

- New non-halogenated materials were synthesized in TMAD and TBAD
- 5% Decaborate and 5% TPPO Weight blend is best for TMAD and TBAD
- Heat release rate and peak heat release rate were reduced
- Significant Charring was observed
- Future work

THANK YOU
ANY QUESTIONS