Novel Non-Halogenated Flame Retardant Compounds

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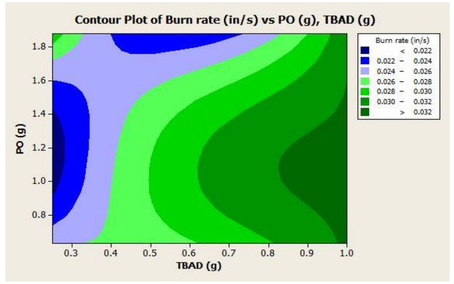
Introduction

- Halogenated flame retardants have been used in polymers for years but have environmental problems.
- Boric acid has also been used as a flame retardant but its acidity limits it applications.
- Decaborate is a non halogenated, non-acidic compound which may show promise in flame retardant applications.
- In this research work, we focused on the flame retardancy of combinations of triphenlyphosphine oxide and ammonium decaborate salts, bis(tetramethylammonium) decaborate (TMAD), and bis(tetrabutylammonium decaborate (TBAD).

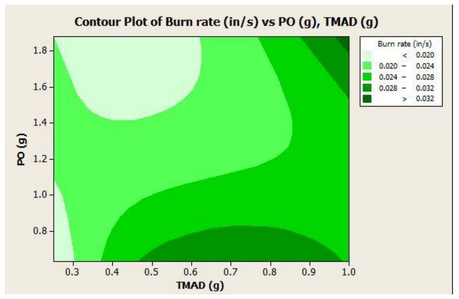
Experimental

- Bis(triethylammonium) decaborate was converted to the hydronium salt via an ion exchange column.
- The bis(hydronium) decaborate was then titrated with tetramethyl or tetrabutyl hydroxide until the solution was a pH of 7.0.
- The tetrabutyl derivative was then collected by vacuum filtration. For the tetramethyl derivative, the water was removed by distillation. The salts were then dried in a vacuum oven for 12 hours
- Varying levels of decaborate salts and phosphine oxide were combined in varying levels within a Design of Experiments and cast in polyurethane films
- Samples were then cut into strips and burned in a UL-94 Flame Chamber.
- Samples were also tested via TGA in Nitrogen to determine degradation temperature and char yields.

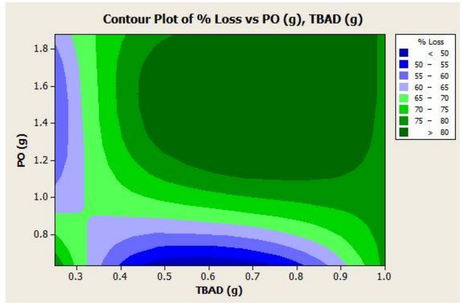
Burn Rate of TBAD Films



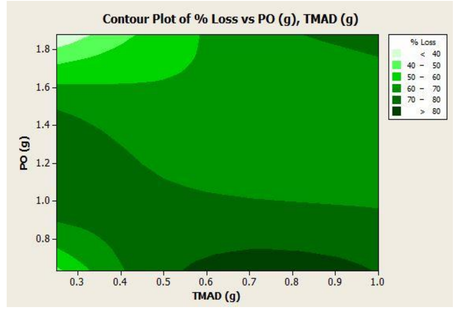
Burn Rate of TMAD Films



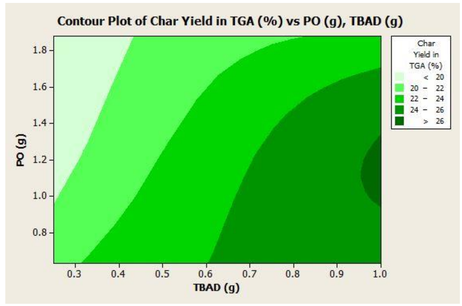
% Loss of TBAD Films



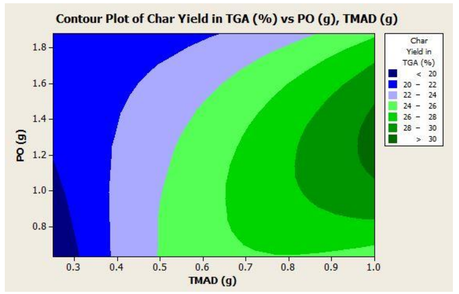
% Loss of TMAD Films



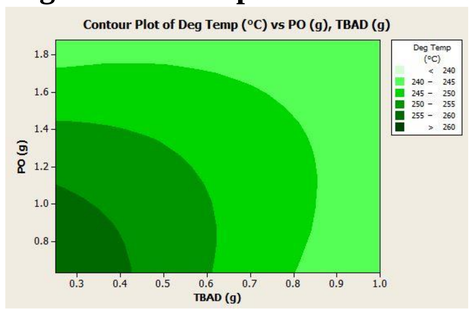
Char Yield in TGA of TBAD Films



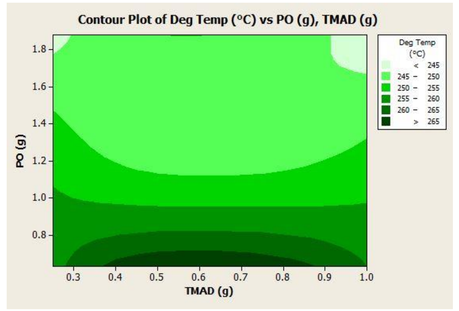
Char Yield in TGA of TMAD Films



Degradation Temp. of TBAD Films



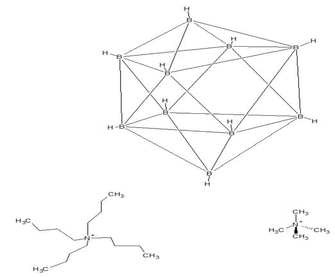
Degradation Temp. of TMAD Films



Design of Experiment Set-up

PO Level	Boron Level	PO (%)	Boron (%)
0	0	12.5	5
1	-1	18.75	2.5
0	-1	12.5	2.5
0	0	12.5	5
0	1	12.5	10
1	1	18.75	10
-1	0	6.25	5
0	0	12.5	5
-1	-1	6.25	2.5
0	0	12.5	5
0	0	12.5	5
-1	1	6.25	10
1	0	18.75	5

Decaborate Structure



Conclusion

- Various combinations of decaborate and phosphine oxide in polyurethane were cast and characterized.
- Decreases in burn rate were observed at high levels of TPO and medium levels of decaborates.
- Films loss during burn testing was minimized at low levels of TPO and medium levels of decaborate.
- Char yields increased with increasing amounts of decaborate.
- Continuing work with these materials will include characterization by cone calorimetry.

Acknowledgments

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