Synthesis of Novel Phosphorus, Sulfur-Containing Fire Retardants

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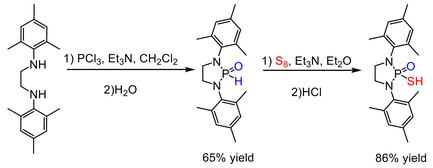
Introduction

Fire retardants (FR) play an essential role in NASA's HARPP objective — to supply non-halon fire protection for manned missions. Phosphorus based FRs have been found to be a more environmentally friendly solution. However, these FRs face the threat of leaching due to inadequate molecular weight. The synthesis of a green novel phosphorus-sulfur based FR will aid in this goal. The addition of sulfur will increase the molecular weight, provide greater thermal stability, and gain corrosion resistance. Therefore, our research aimed to i) synthesize a novel phosphorothioic acid-based FR to be used in manned missions.



Hypothesis

Hypothesis 1: Prevention of leaching can be achieved by using a phosphorus-sulfur based flame retardant for increasing molecular weight.

Hypothesis 2: Bulky derivatives of phosphorothioic acid flame retardants can accomplish increased stabilization of the compound or stabilized radical intermediates.

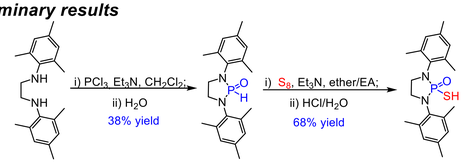
Research background

-With the promising result of our preliminary data, we will explore synthesis of chiral phosphorothioic acids as flame retardants.

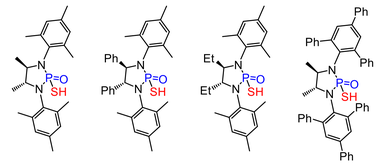
-Along with this, we will explore synthesis of novel chiral phosphorothioates as flame retardants.

The Goal

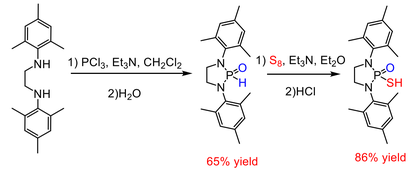
Preliminary results



Proposed: synthesis of novel chiral phosphorothioic as fire retardant



Results

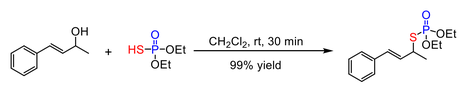


-Testing Hypothesis 1: synthesizing a novel phosphorothioic acid.

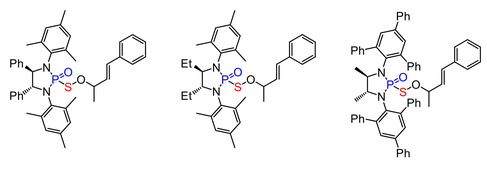
-Test with achiral compounds first to see if possible, then use chiral.

The Goal

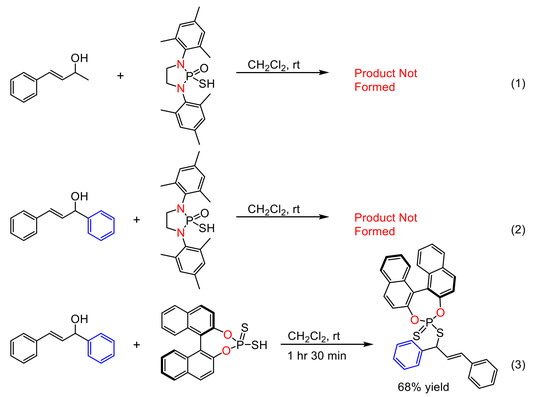
Preliminary results



Proposed: synthesis of novel chiral allyl phosphorothioates as fire retardant



Challenges Faced



-Product not formed (eq. 1)

-Bulkier allylic alcohol used to stabilize, product not formed (eq. 2)

-Phosphorothioic acid with Oxygen groups instead of Nitrogen groups worked (eq. 3)

Challenges Faced

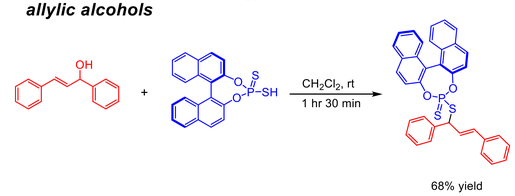
-Test our hypothesis based on literature methods

-Investigate what role electronics play for synthesis

-Optimize the flame retardant reaction (eq. 3)

Research Findings

New Synthetic Methodology of thiophosphorylation of allylic alcohols

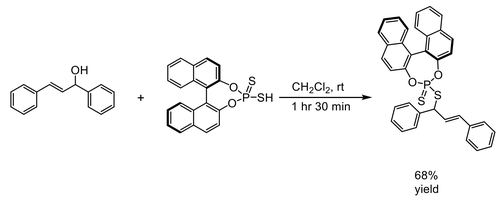


-Novel synthesis of phosphorothioic acid FR achieved (86%)

-Novel synthesis of allyl phosphorothioate FR achieved (68%)

-Nitrogen electronics not favored for allyl phosphorothioate FR synthesis

Results



Acknowledgements

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