# Use of Red Phosphorus in Polypropylene Based Sealant to Increase Flame Retardancy in Electric Vehicles

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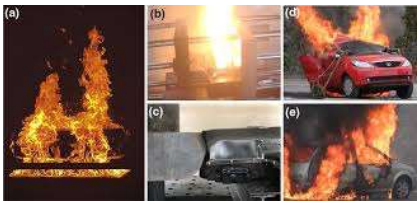
Phosphorus is the future of flame retardancy for polyolefins. Red phosphorus is a very common flame retardant used by firefighters to help put out forest fires. Polypropylene is the one of the most commonly used plastics in the automotive industry, as well as being extremely modifiable with additives. While EV's are less prone to fires than regular ICE's, their public perception is almost the exact opposite of the truth ("While EV fires are not as common as gas-powered vehicle fires, they are more difficult to extinguish, due to how the batteries are protected from the elements."(*Data Shows EVs Are Less of a Fire Risk than Conventional Cars | Office of Environmental and Energy Coordination*, 2024), and without public perception there are no sales. Therefore, in order to increase the public consensus of EV's while also making EVs safer, introducing phosphorus as an additive for polypropylene is the next logical step for the EV industry.

## THE PROBLEM

- The fire safety perception of EV's is terrible and steps must be taken to improve it.
- EV batteries are much harder to extinguish than traditional ICE's due to the increased resistance to the elements.
- EV's must be changed to keep up with the times, while also being consistently improved.




## THE SOLUTION

Red phosphorus is a common flame retardant that is used in forest fires to help prevent the spread of fire. It is also a common additive used in plastic to help improve flame retardancy. By using red phosphorus-based sealant, the overall flame retardancy of EV's will be increased, and public perception will follow along.


## RESEARCH PLAN

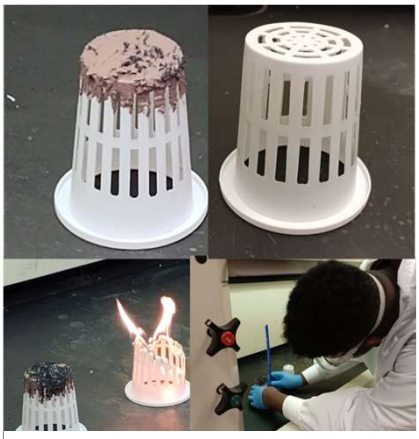
- Acquire the necessary knowledge on red phosphorus and its chemical reactivity in order to better prepare for experimentation.
- Understand battery technology for electric vehicles.
- Learn how polypropylene is used as a fire retardant
- Investigate fire suppression processes

## EXPERIMENTAL SECTION

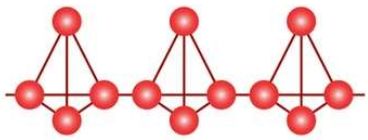
My experiment design involved setting up a controlled burn experiment using a fire-retardant sealant made from polyproline that contained a red phosphorous compound.

Step 1: I took the phosphorus-based flame retardant and applied it to the cup to represent the model of a EV battery tray.

Step 2: I used the vertical burning test in order to test the overall mass to loss ratio and see the heat spread of the given material.



Allotropes of Phosphorus

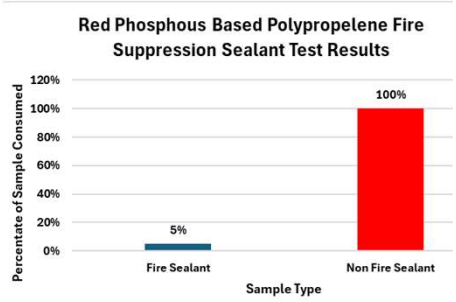


Red Phosphorus

## RESULTS

In the end, the sealant did function as planned due to the red phosphorus inside of it. When the red phosphorus sealant was exposed to heat, it began to swell, with the intent being to break off the source of heat.

The sealant grew up to 3 times it's original height and maintained a somewhat solid state without melting. This experiment was conducted 10 times inside of a fume hood in order to minimize the effects of the outside environmental conditions. The plastic cup that did not have the sealant on it almost completely melted down to liquid and showcased an almost night and day difference between the red phosphorus based sealant, and the non - modified cup.




## FUTURE WORK

In the future, I plan to further expand upon this project by using a thermochar base substance and microencapsulated red phosphorus powder, to serve as a mixture for a improved version of the paste I used in this experiment. Other than improving on the current formula, mixing the red phosphorus as a filler directly into propylene should serve as another amazing tool to use in the use of additives for flame retardancy.

**Conclusion:** At the beginning of this project, the vision I had was almost completely different than what was applied. Originally it was crucial that polypropylene and red phosphorus were combined during the solid phase of polymerization. However, after further research on both Ev's and phosphorus, I decided a paste solution would work the best in tandem with the current cooling system. At the end of this project, I had learned an abundance of information about Ev's and phosphorus that I did not know before.

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