Fall Student Research Symposium 2022 Fall Student Research Symposium

12-5-2022

Investigating the Color-Changing Properties of Poly-Phenyl Sulfide

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INTRODUCTION

PPS is a highly insulating polymer used in spacecraft applications. While punching out samples of PPS to test for charging effects, a profound color change was found around the cut edge. Initial testing revealed that PPS changes from its original tan color to a bright blue-green when under immense amounts of stress. After some time, the material slowly returns to its original color. This kind of material that undergoes a chemical reaction due to mechanical energy input is referred to as a mechanophore.

This anomalous color change led to an inquiry into whether PPS reacts only with mechanical energy, or if other forms of energy would initiate the color change, or even accelerate the recovery time.

MOLECULAR INFORMATION

The Fortron™ brand of Polyphenylene Sulfide is a linear linked unfilled polymer, so the molecular structure is fairly simple. The material is made up of continuous chains of a benzene ring attached to a sulfur atom, repeated.

Research into other mechanophore reactions suggest that sufficient mechanical energy introduced to the system causes the compound to undergo a ring-opening mechanism somewhere within the phenyl group [1].

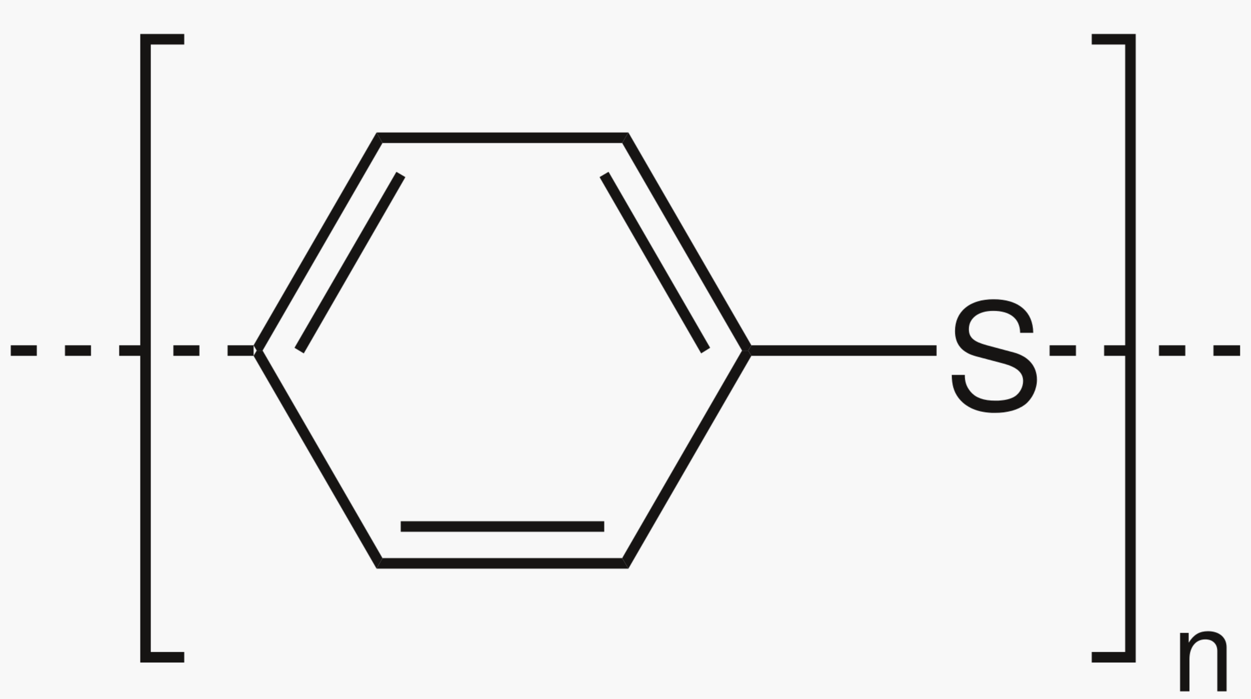


Figure 1: PPS skeletal structure

UV IRRADIATION

Four samples were punched out then given sufficient time for the cut edge to fully revert to the original color. After this, pressure was applied to two samples using a simple arbor press at similar magnitudes until a significant amount of blue-green color showed. Next, one pressed sample and one unpressed sample were exposed to an average intensity of ~1850 μW/cm^2 for one hour. The other pressed and unpressed samples were covered to reduce UV exposure.

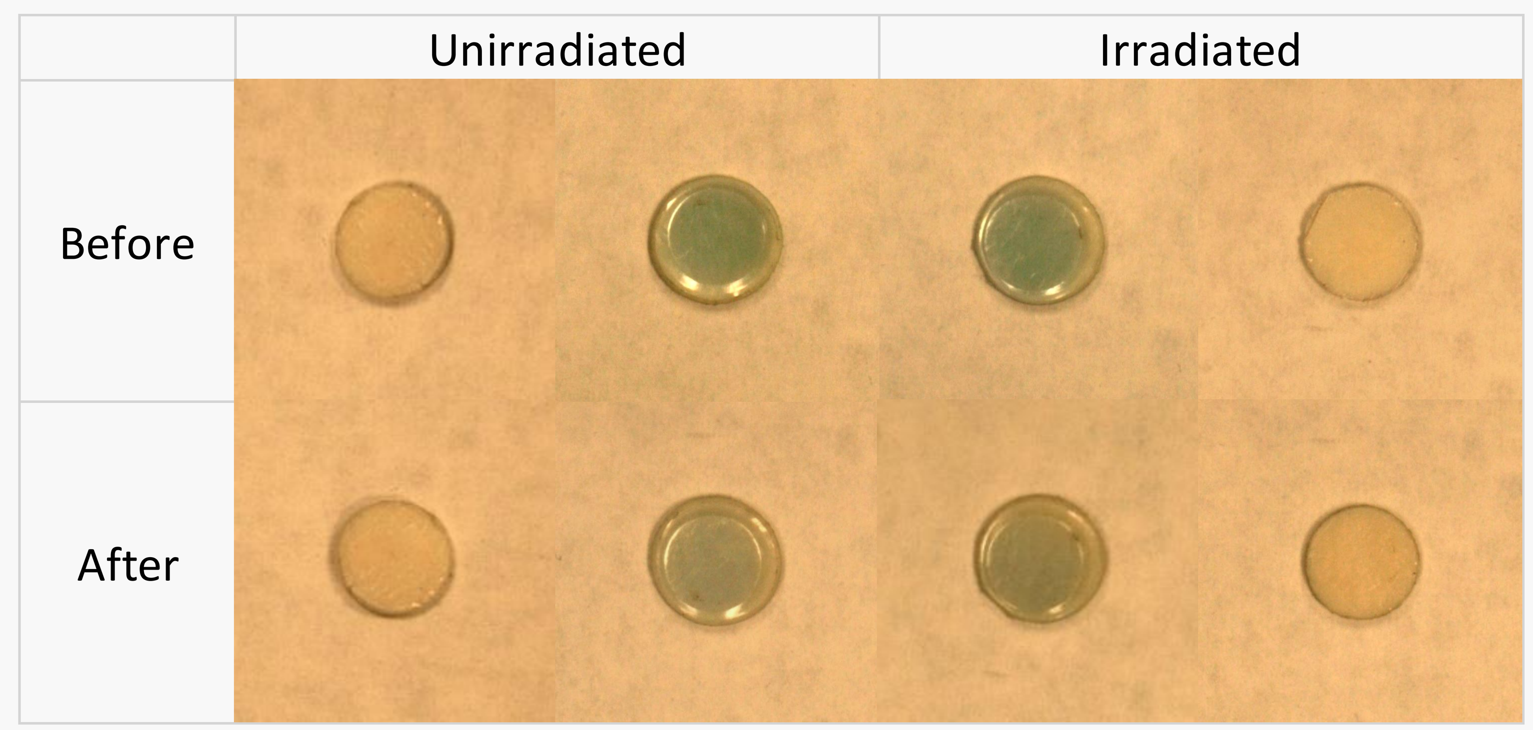


Figure 2: Comparison of UV irradiated samples

HEAT

Again, four samples were punched out and given sufficient time to recover. Two samples were pressed with similar amounts of pressure to initiate blue effect. One pressed and one unpressed sample were heated in an oven at ~155ºC for 20 minutes. The other two samples were left to ambient temperature.

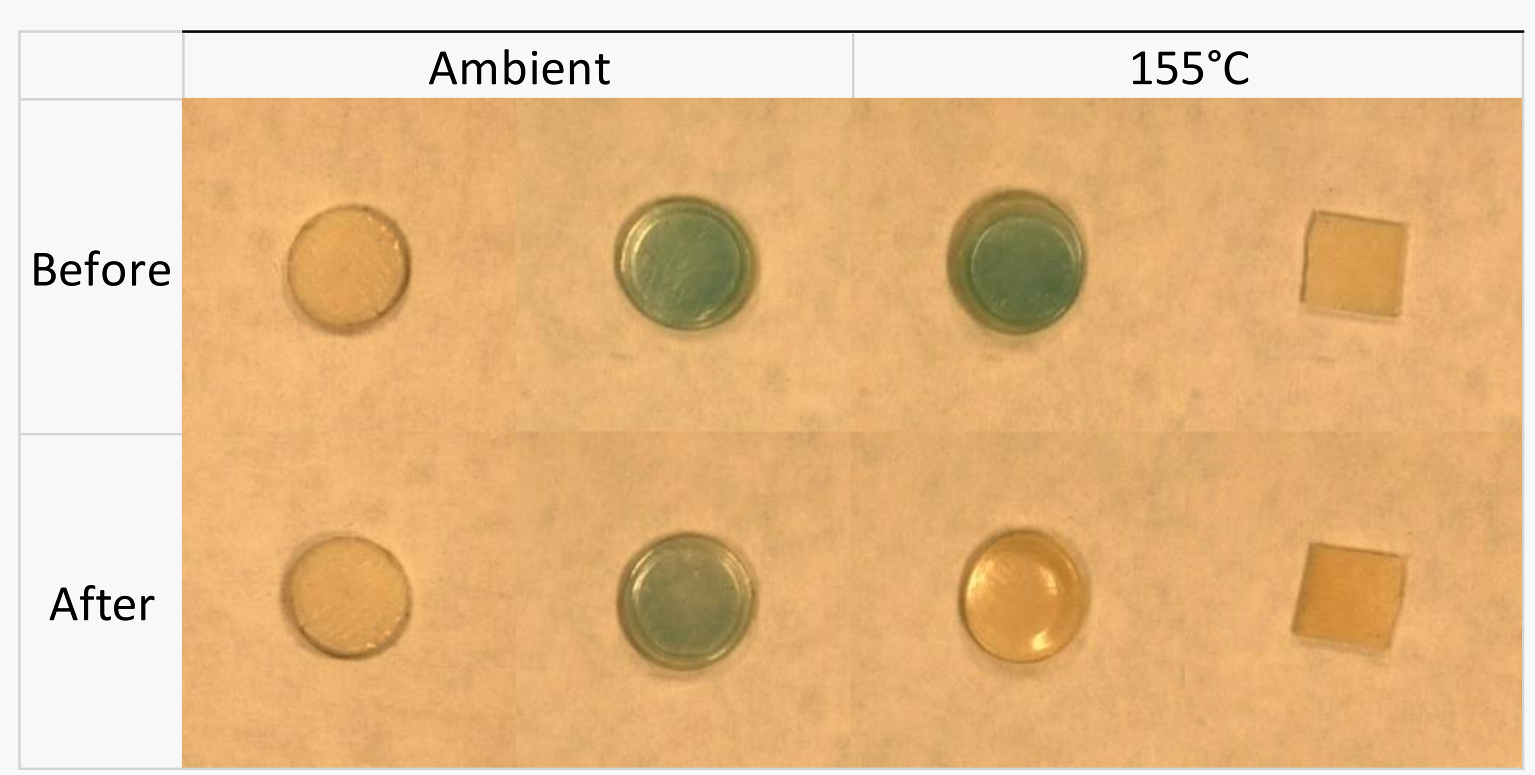


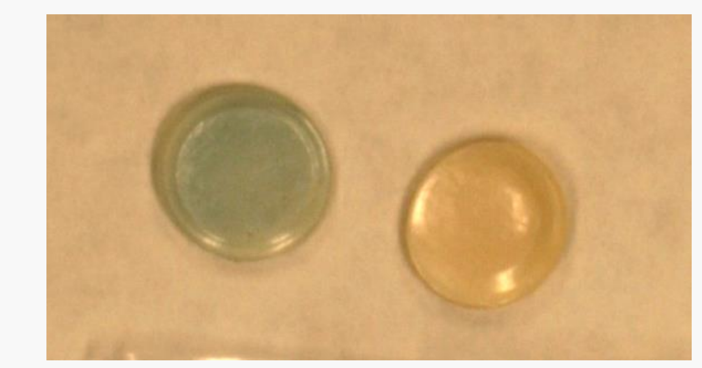
Figure 3: Comparison of heated samples

RESULTS

Comparing the UV irradiated samples to the unirradiated samples, the irradiation seems to have a slight darkening effect, yet this is not a significant enough result to conclude that UV radiation initiates color change or affects recovery time.

When comparing the heated samples however, the sample that was pressed then heated completely recovered its original color after 20 minutes, while the pressed ambient sample retained much of the blue coloring.

Figure 4: Heated and ambient samples side-by-side after 20 minutes



FUTURE WORK

While this experiment conclusively showed that heat greatly accelerates color recovery, the UV testing wasn't definitive. Using a UV source with greater intensity may aid in acquiring more conclusive results.

Samples may also be tested in the future to obtain quantitative results, such as the factor at which heat affects the color recovery rate, and at what pressure color change is initiated.

Since this material is used for its insulating properties, it may also be applicable to test the electrical properties of the material while in its color-activated state.

REFERENCES

[1] Regulating Color Activation Energy of Mechanophore-Linked Multinetwork Elastomers
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