



***The Compatibility of Conformal Coating
with Vapor Hydrogen Peroxide
Sterilization: Protecting the Icy Jovian
Moon Europa from You!***

July 19, 2017

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JOHNS HOPKINS
APPLIED PHYSICS LABORATORY

Purpose

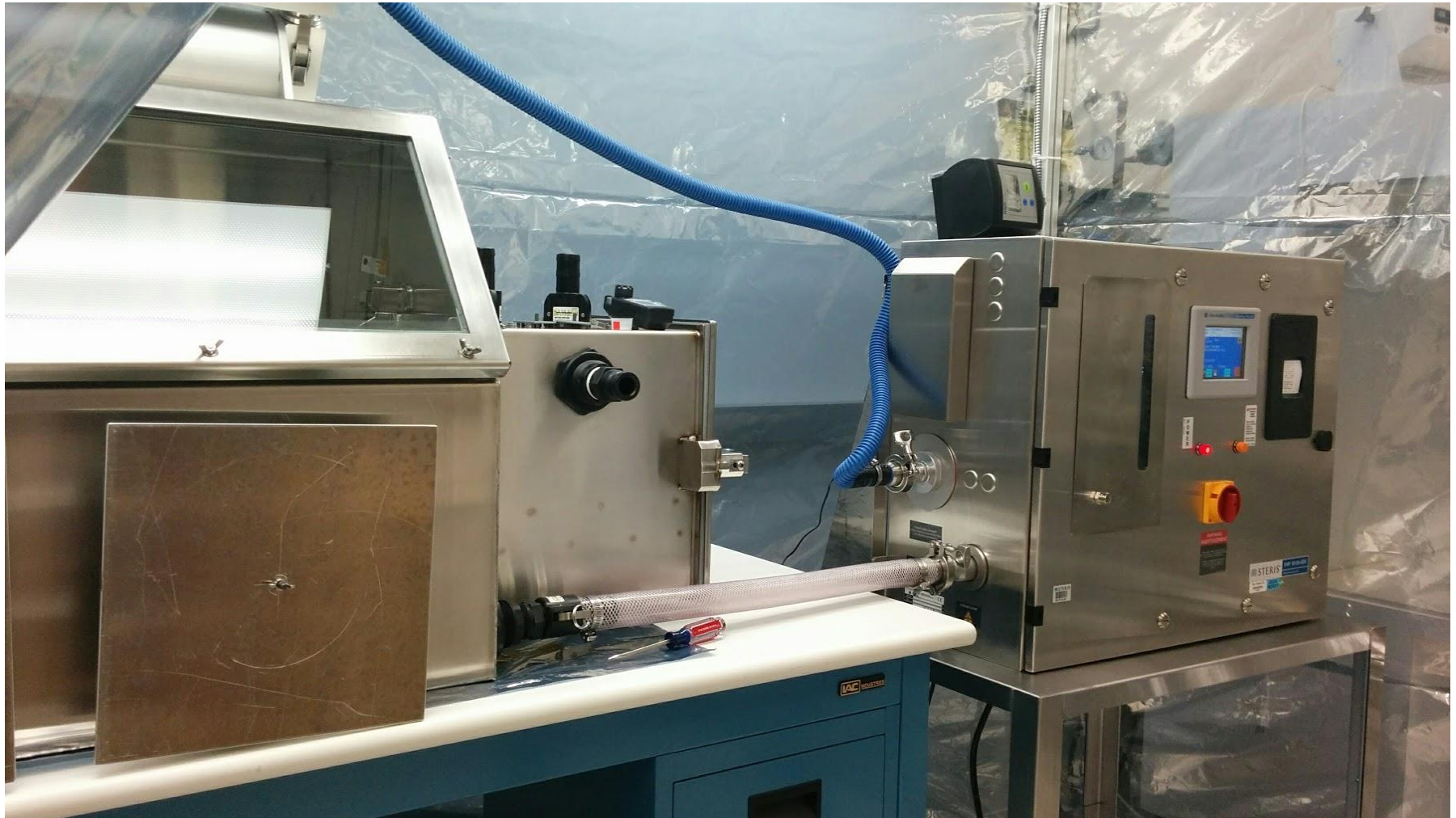
- Evaluate vapor hydrogen peroxide (VHP) for surface sterilization of temperature-sensitive electronic boards after assembly and testing
- Can conformal coating protect electronic components from VHP?
- VHP Sterilization
 - Cycle runs 1-2 hours at temperatures below 50°C
 - Damages biological macromolecules



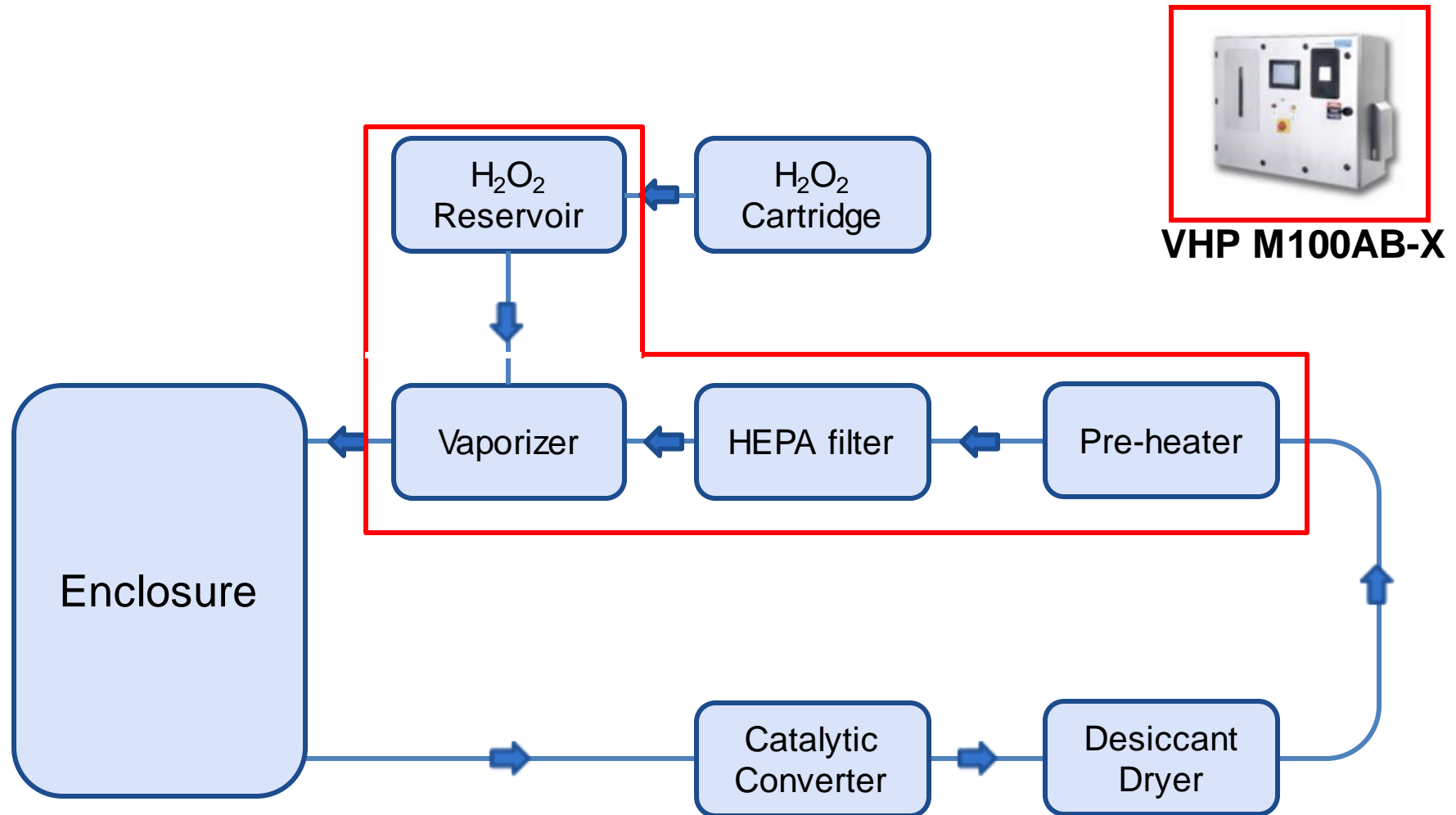
Image: <https://www.miller-stephenson.com/wp-content/uploads/2016/10/Coating>

Bottom Line: If conformal coating is an effective barrier for VHP, no need for material compatibility examination for each electronic component with VHP!

APL's Facility

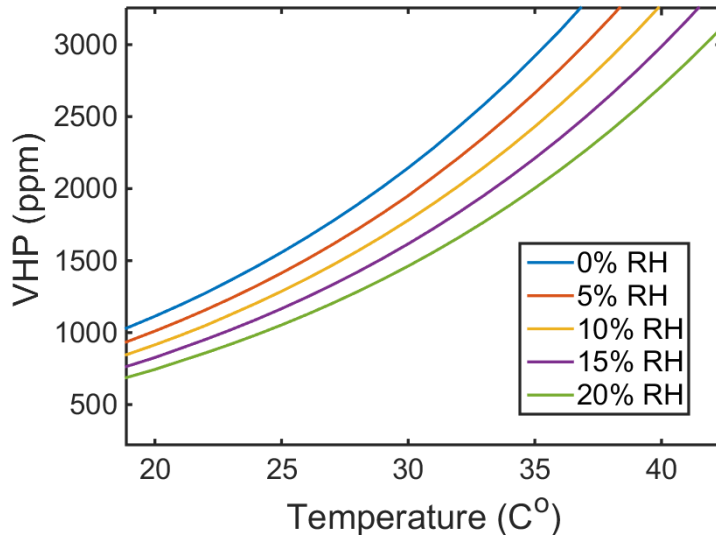


VHP and APL's Facility

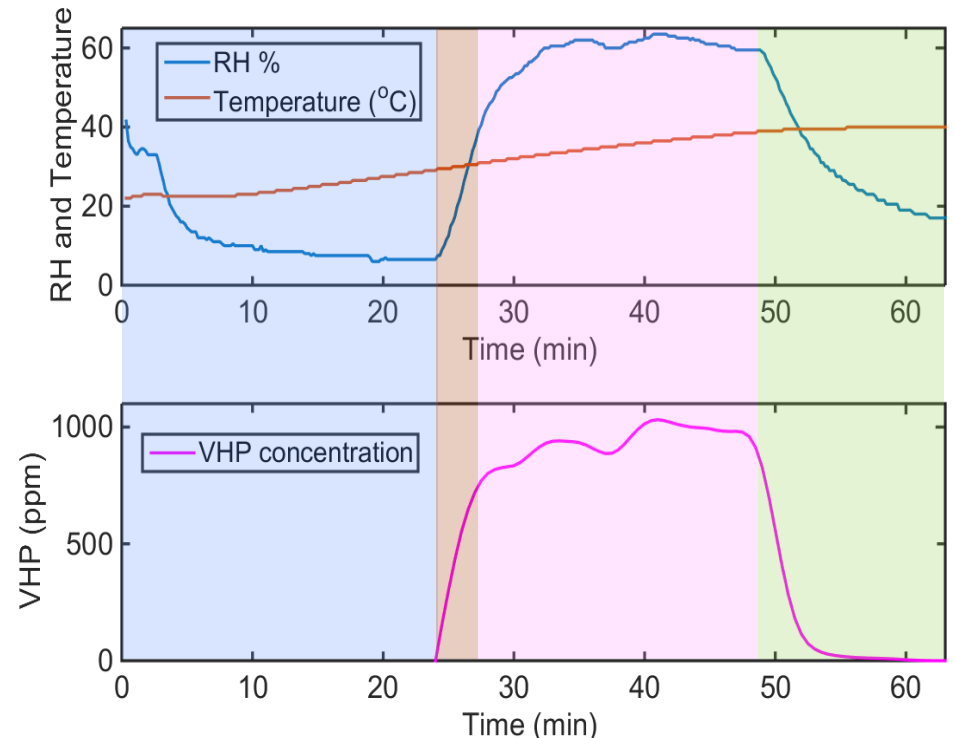


VHP Cycle

Effect of Temperature and Humidity on VHP Concentration at Injection



Concentration of VHP, Temperature, and Humidity During a VHP Cycle

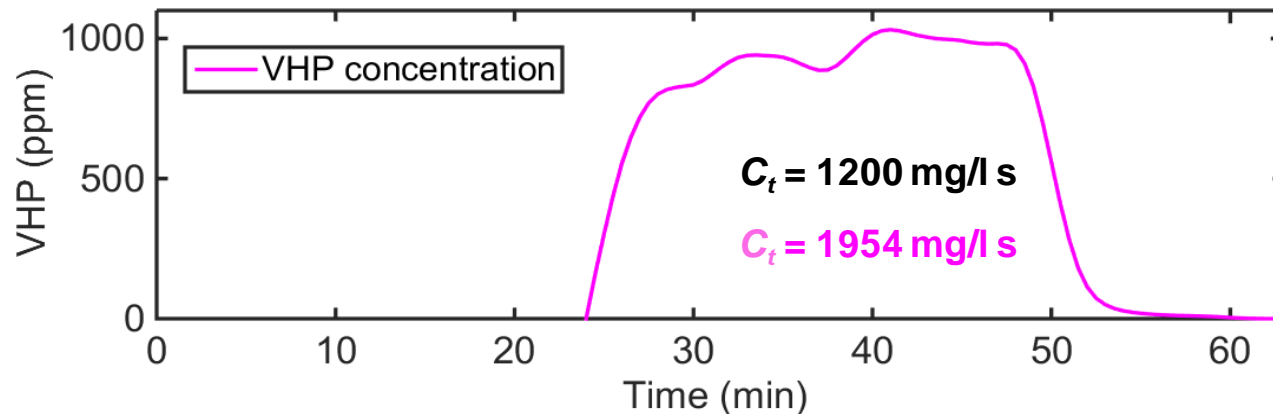
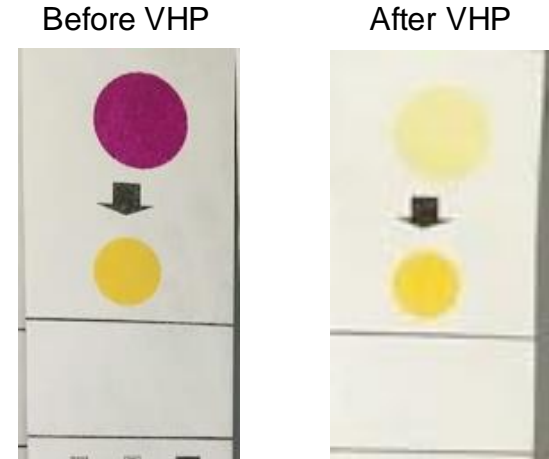


I Dehumidification III Bio-decontamination
II Conditioning IV Aeration

Want to avoid VHP condensation!

Process Verification

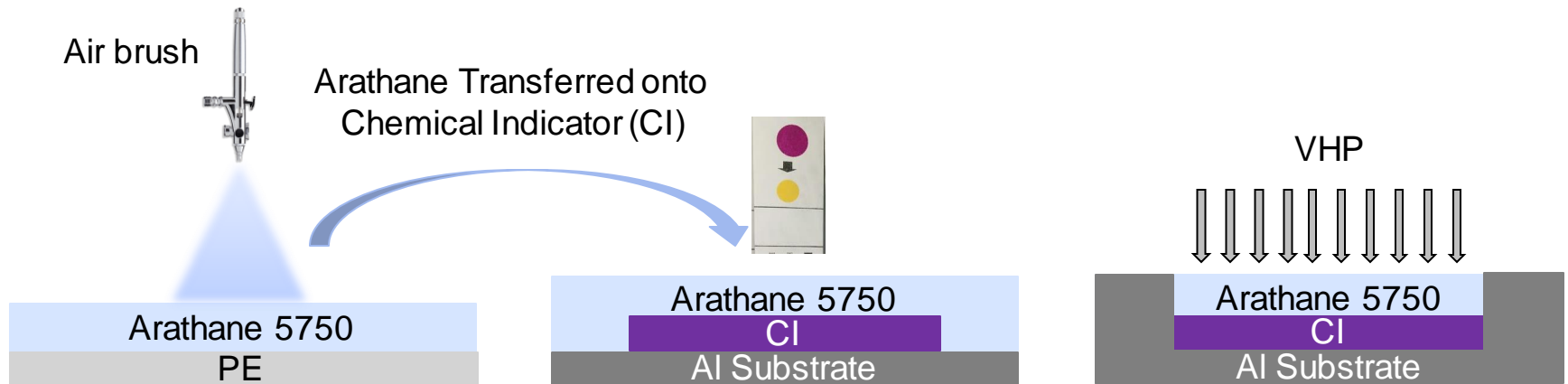
- **Chemical Indicators (CI)**
 - Can be placed in any accessible area
 - +/- result
- **VHP Concentration**
 - Log the concentration of VHP in the chamber during the decontamination phase
 - 6-log reduction (sterilization) considered at $C_t = 1200 \text{ mg/l s}$



Sample Summary

- **Detect if VHP affects the conformal coating or what is underneath it**
- **Conformal coating peeled from a substrate and placed over a CI**
 - **Arathane 5750 (urethane)**
 - **Lord 3135 (epoxy)**
 - **Typical thickness for conformal coating is 2-5 mil for spaceflight applications**

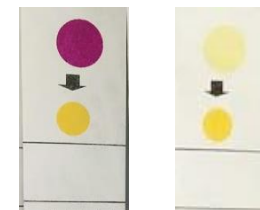
Film Preparation



Sample Packaging for Controlled VHP Exposure



Chemical Indicator Before and After VHP Exposure



Sample Analysis

- **Sample Analysis**

- **Physical Penetration**

- **Visual inspection of the CI for a color change**

- **Chemical Modification of the Conformal Coating**

- **FT-IR analysis before and after VHP exposure**

- **Infrared radiation can be used to analyze molecular vibrations and resolve a chemical structure**

Results

- **Arathane 5750**

- **Color change of CI was apparent for all thicknesses**



CI Before VHP Exposure



CI After VHP Exposure with 5 mil Arathane



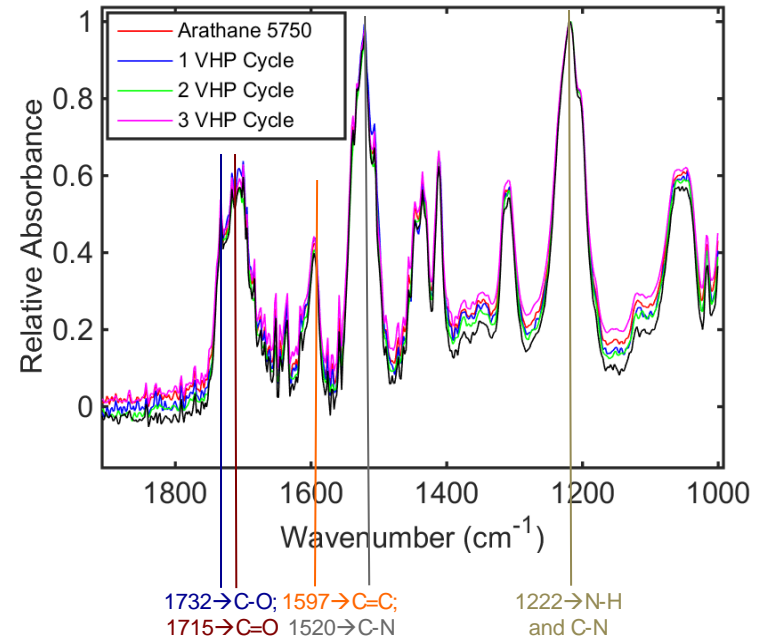
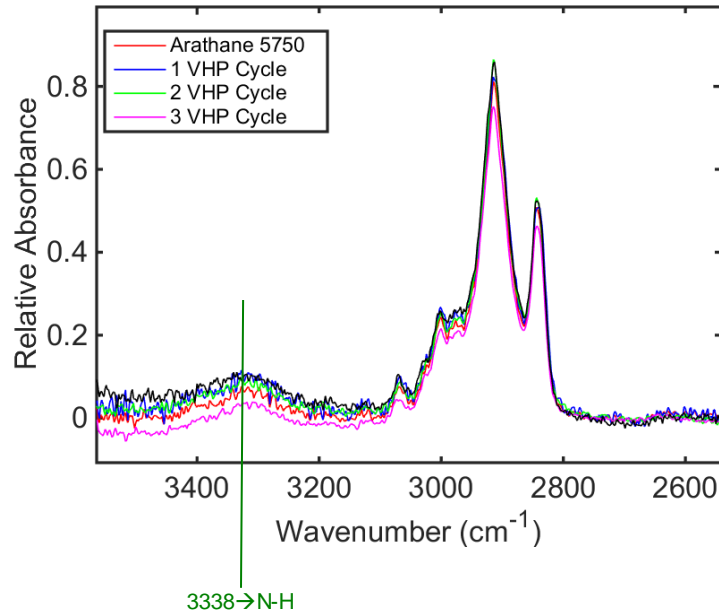
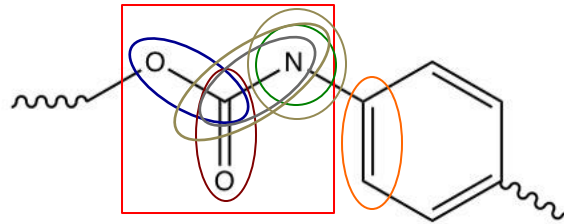
CI After VHP Exposure with 8 mil Arathane



CI After VHP Exposure with 10 mil Arathane

Results

- No chemical change of Arathane 5750 apparent



Results

- **Lord 3135**

- **No color change of the CI was apparent after VHP**
- **No chemical changes observed**



CI Before VHP Exposure



**CI After VHP Exposure
with 5 mil Lord 3135**

Conclusions

- **Arathane 5750 is not an effective barrier for VHP**
 - VHP does not induce chemical changes in the conformal coating
 - VHP permeates through physical pores or defects in the film at 5, 8, and 10 mil of conformal coating
 - Need microstructural analysis to confirm
 - Future work includes determining the encapsulation efficiency of Arathane for bacteria/spores
- **Lord 3135 is a promising alternative conformal coating to prevent VHP exposure**
 - No color change detected for 5 mil of coating
 - Future work includes the creation of thinner films

Acknowledgements

- **Special Thanks To:**
 - **SEP group management for their continued support in the development of our Planetary Protection facility**
 - **Europa Clipper Project Management**



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Other Sample Types

- **Copper film on glass as a resistor**
 - If VHP-induced oxidation, resistance would change
 - Was not successful (no change in resistance observed)
- **Conformal coating sprayed directly onto a VHP CI**
 - Conformal coating did not adhere well to the Tyvek material of the CI
 - Could not be sure that there was no chemical interaction between the indicator and the coating
 - Could affect the CI's ability to change in response to VHP

Sample Creation Images

