UV Photopolymer Additive Manufacturing

Sponsor: Boeing

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INTRODUCTION

UV Degradation Mechanism

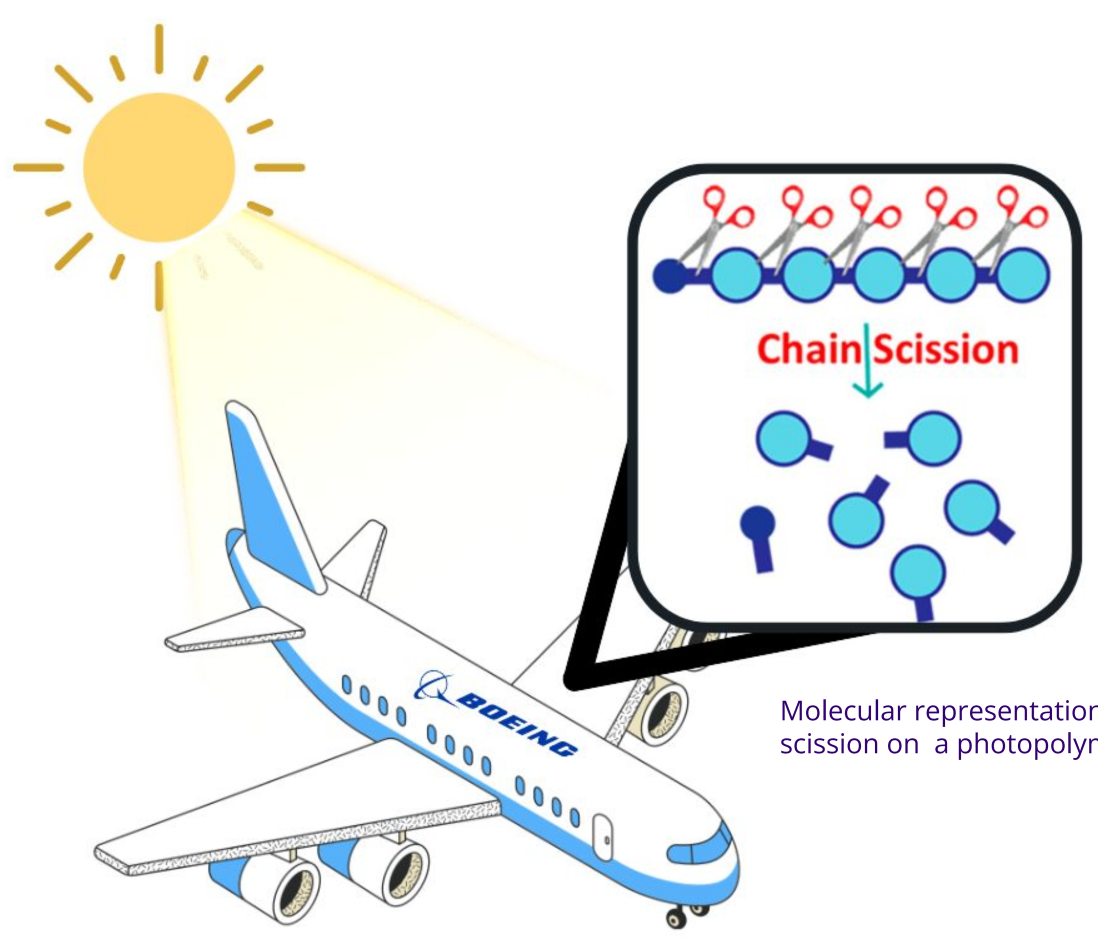
1. High-energy photons are absorbed
2. Radical Formation
3. Photopolymer covalent bonds break
4. Leads to degradation of mechanical properties

Motivation

Photopolymers are easy to use and capable of creating complex parts, yet susceptible to UV light → Test and evaluate protective capabilities of different coatings on photopolymer.

Objectives

- Knowledge of the mechanism of UV degradation in photopolymers
- Design test matrix
- Evaluate protective capabilities of coatings

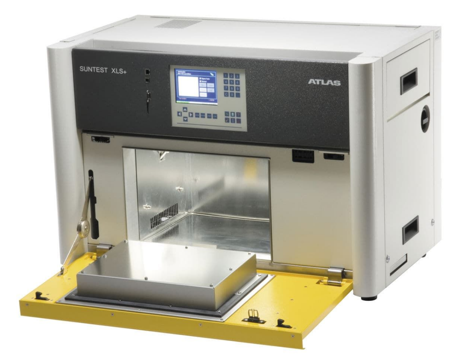


Molecular representation of chain scission on a photopolymer part

METHODS

Resources required

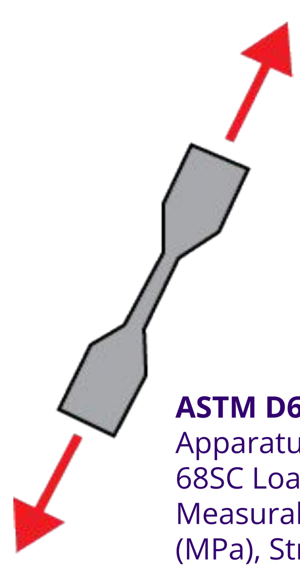
- UV chamber (672 hours)
- Coupons (71)
- Photopolymer coatings (4 types)
- Testing equipment



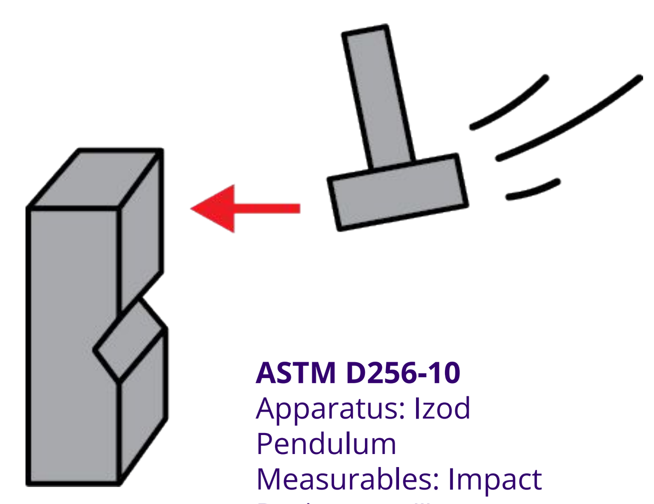
Clean Energy Institute's UV exposure chamber

Container of the Cerakote Coating

Bulk Measurements

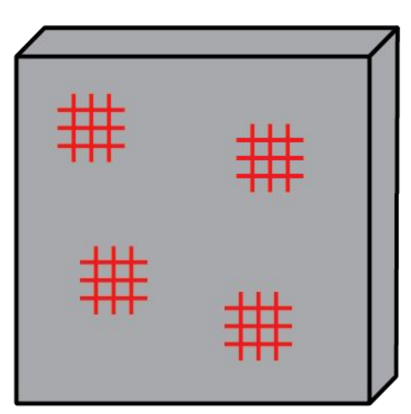


ASTM D638-22
Apparatus: Instron 68SC Load Frame
Measurables: Stress (MPa), Strain (mm/mm)

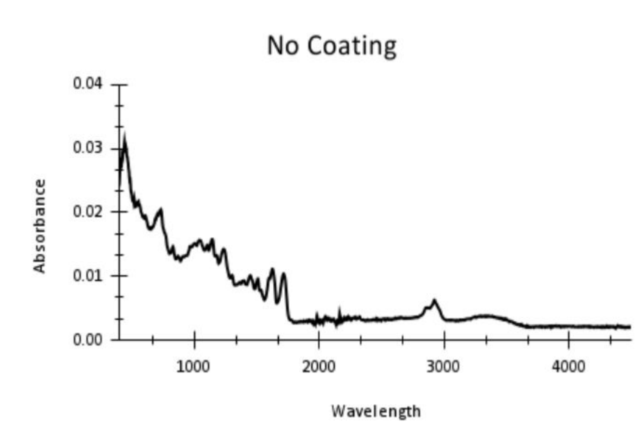


ASTM D256-10
Apparatus: Izod Pendulum
Measurables: Impact Resistance (J)

Surface Measurements



ASTM D3359
Measurables: Adhesion Rating



FTIR Spectroscopy Analysis
Objective: Compare samples before and after aging

RESULTS

UNIAXIAL TENSION
Maximum Load

Coating	Before Aging	After Aging	
None	2880 N	1352 N	- 53.1%
Mankiewicz	2952 N	1461 N	- 50.5%
PPG	2926 N	1636 N	- 44.1%
Cerakote (White)	2787 N	1317 N	- 52.7%
Cerakote (Black)	2751 N	1420 N	- 48.4%

ASTM D638

IZOD IMPACT
Impact Energy

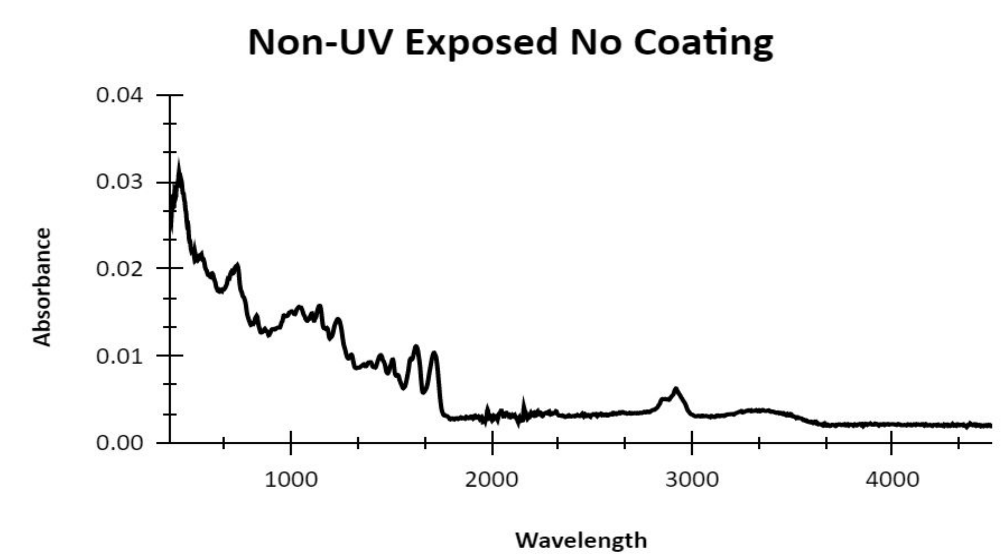
Coating	Before Aging	After Aging	
None	0.298 J	0.247 J	- 17.1%
Mankiewicz	0.278 J	0.217 J	- 21.9%
PPG	0.278 J	0.149 J	- 46.4%
Cerakote (White)	0.210 J	0.185 J	- 11.9%
Cerakote (Black)	0.310 J	0.154 J	- 50.3%

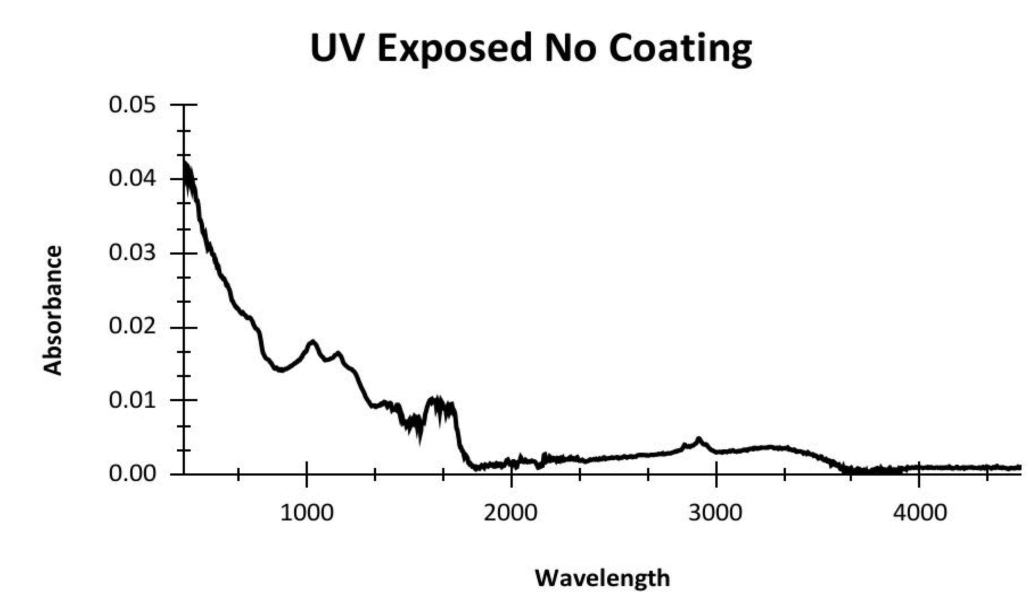
ASTM D256

ADHESION
Rating

Coating	Before Aging	After Aging	
None	N/A	N/A	
Mankiewicz	4B	3B	- 1
PPG	5B	4B	- 1
Cerakote (White)	4B	4B	- 0
Cerakote (Black)	5B	4B	- 1

ASTM D3359





FTIR test of non-coating photopolymer for non-UV exposed versus UV exposed

CONCLUSIONS

Due to an insufficient sample size, impact testing results are misleading and do not accurately represent how the coatings protect samples from degradation.

Based on other results, PPG is the most effective coating as PPG is the most effective coating as it was 3.46 to 22.5 times more effective at inhibiting UV degradation according to obtained tensile data compared to baseline, while performing comparatively well in adhesion testing.

NEXT STEPS / FUTURE WORK

- Acquire a larger sample size for impact testing
- Compare and analyze the effects of coating thickness
- Conduct other surface techniques (AFM, XPS) to get a better understanding of the polymer chain geography
- Age the samples for a longer period of time (1000 hrs) to get a better range of degrading effects and compare

Acknowledgements

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  - Carter Beamish
  - Alex Gray
  - Katie Tang (TA)
- **Boeing technical mentors:**
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  - Angela Davis
  - Zach Renwick
- **Boeing**

TIMELINE

February	March	April	May
Literature studies	Plan + request samples	Age samples, test non-UV samples	Test UV samples, data analysis