Coatings for Improved UV-Protection of Additively Manufactured Photopolymers

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BACKGROUND

Aerospace industry interested in AM photopolymers:
- >Lightweight
- >Durable
- >Environmentally friendly

Use limited by:
- >Poor mechanical properties at elevated temperatures
- >Flammability

Problem of interest:
Susceptibility to UV degradation

PROPOSED SOLUTION

Design a sprayable paint coating that limits photopolymer's tendency to denature under constant UV exposure

SCOPE

- Done within a 5-month planning/experimental period
- $2000 budget
- Test viability of designed multiple UV-protective paint coatings
    - Zinc Oxide
    - Titanium Oxide
    - Controls

METHOD

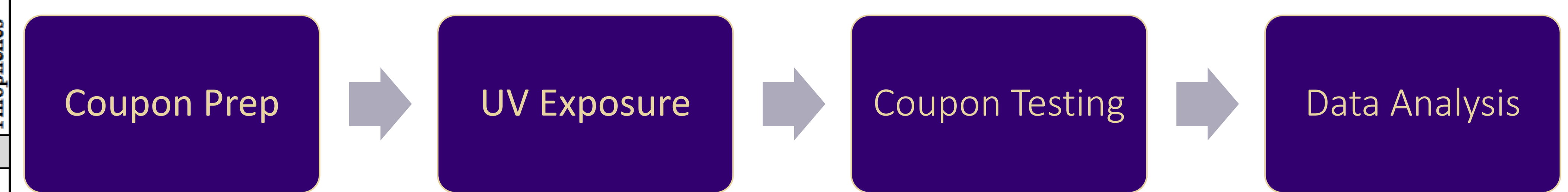
> Trade study analysis was completed to evaluate effectiveness and impact of each additive. Shown in Fig 1, Titanium Dioxide, Zinc Oxide, and Lignin were selected

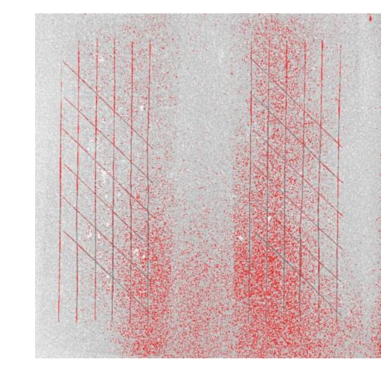
Trade Study for additives		Enter Scores	Carbon Black	Titanium Dioxide (Aqueous form)	Zinc oxide	Lignin	Thiophenes
Criteria	Weight	Scale					
Environment	15	5 = Least impactful 1= Most impactful	2	2	5	5	2
Cost	20	5 = Least expensive 1= Most expensive	3	1	4	4	2
Safety	15	5= Most safe 1= Least safe	3	3	5	3	1
Risk	25	5= Least risk 1= Most risk	4	4	4	3	1
Schedule	25	5= Shortest 1= Longest	1	3	4	2	3
Weighted Total %	100%		52	54	86	65	37

Fig 1. Trade study for down selection of additives

Upon down selection of additives, coupon preparation was performed as follows:

> Coupons prepped by sanding, measuring thickness, coating, and curing
> Coupons exposed to UV in chamber for 2 weeks, rearranging midway
> Qualitative testing using cross hatch adhesion. Quantitative testing using ImageJ
> Adhesion was ranked using the ASTM classification. ImageJ gave % surface removal





RESULTS

> Standard Adhesion rankings of 4 to 5 were the most commonly occurring ranking in both Zinc Oxide and Titanium Dioxide
> Variance in surface analysis is consistent across each additive highlighted in Figure 3.

	Coupon #	Weight %	Surface Removal (%)	Subjective Ranking
Zinc Oxide	13	10	7.66	4
	14	10	8.7	4
	25	10	0.78	3
	26	10	1.18	3
	7	5	1.23	5
	8	5	1.31	5
	9	5	1.86	5
	10	5	2.23	5
	11	5	1.45	5
	12	5	1.69	5
	3	0	0.77	5
	5	0	1.17	5
	6	0	4.23	5
	4	0	10.34	3
Titanium Dioxide	27	5	1.9	5
	28	5	2	5
	29	5	1.22	5
	30	5	1.89	5
	37	7	1.69	5
	33	5	1.15	4
	34	5	2.04	4
	38	7	1.99	4
	39	7	1.71	3
	40	7	5.9	3
	19	10	0.59	3
	20	10	1.13	3
Controls	21	0	0.96	3
	22	0	1.22	3
	23	0	1.17	3
	24	0	2.32	4

Fig 2. Net Testing Comparison between Titanium Dioxide, Zinc Oxide, and controls

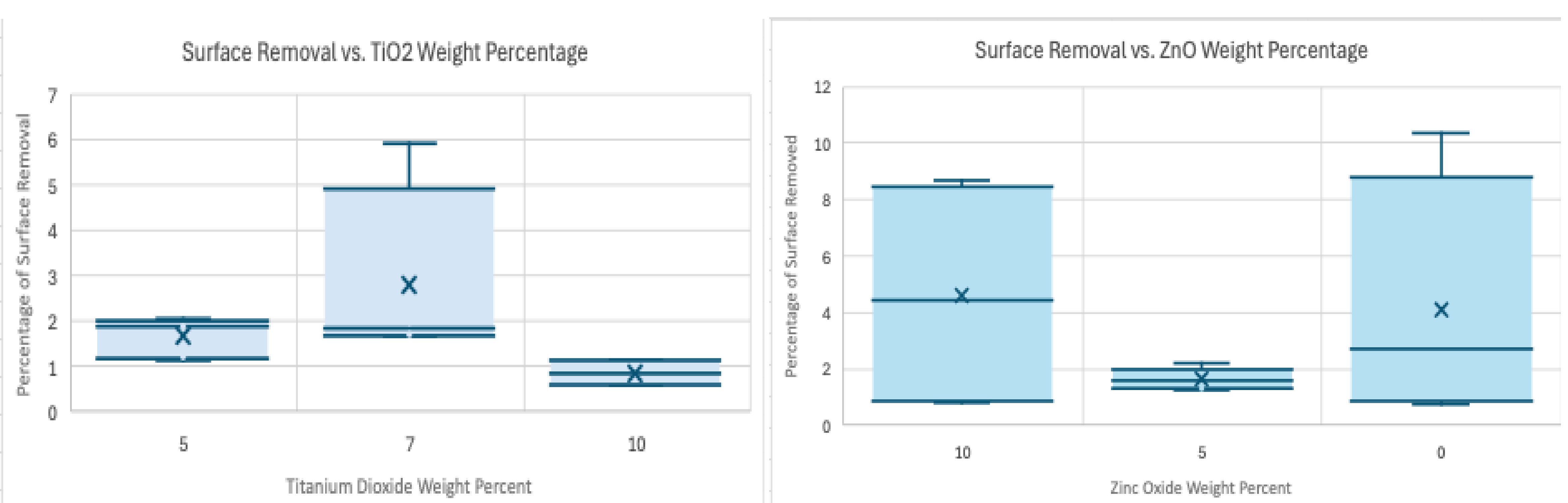


Fig 3. Histogram Plots of Surface Removal per Weight Percentage

CONCLUSIONS

- 5-10 wt. % zinc oxide is the most promising additive
- Several limitations to this project
- Due to spray coating issues and lack of agitation equipment, our team struggled to produce smooth, consistent coatings.
- Recommend testing the accuracy of our results

Future work:

> **Experimental Validation:** Validate findings through further experimentation at Boeing using state-of-the-art equipment.
> **Sustainability:** Characterize the recycling properties of the additives for renewability.
> **Expand testing:** (1) Test other potential additives like carbon black and lignin, (2) implement longer UV exposure, and (3) utilize a chamber with a weathering function.

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