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SHORT COMUNICATION

Effects of some HALS, UV Absorber and Antioxidant on yellowing of artificially aged composite laminates

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Abstract: Addition of light stabilizers/UV absorbers can extend the life and hence, improve the appearance of the carbon/epoxy laminates. Selection of a light stabilizer/UV absorber largely depends upon the substrate to be protected, its envisioned functional life and its sensitivity to photodegradation.

Keywords: composites, epoxy, prepreg, UV, aging

1. INTRODUCTION

UV light promotes the formation of radicals on the surface of polymeric materials. These radicals are extremely active in attacking polymeric structures. Other environmental factors including humidity, oxygen, temperature and pollutants can significantly intensify the phenomenon of photodegradation. A UV stabilizer can be added to epoxy resin formulas to mitigate these effects.
To avoid or reduce photodegradation, inorganic and organic UV absorbers, as well as stabilizers
have been employed. The mechanism of these UV absorbers against light varies from one material to another. Inorganic UV absorbers often scatter light, while organic UV absorbers convert UV rays into heat. Radical interceptors (HALS), acronym for Hindered Amine Light Stabilizer, act by capturing free radicals. Compared to inorganic UV absorbers, organic UV absorbers have a higher efficiency, but have a shorter lifespan due to their evaporation and migration to the surface of the polymers. Furthermore while inorganic UV absorbers such as ZnO and TiO2 have broad absorptions in the UV range and even in the visible spectrum, organic UV absorbers only absorb specific wavelengths in the UV range and almost never have absorptions in the visible range.

2. MATERIAL AND METHODS

In this preliminary study we wanted to evaluate the effectiveness of some commercial products in reducing the yellowing of carbon/epoxy laminates, subjected to accelerated aging cycles.

As a reference, was considered an epoxy formulation containing a mix of epoxy novolac resins, + solid bisphenol-A based epoxy resin, + DICY / Urea curing agents (test 1, as reference).
In test 2 has been used a HALS CAS 41556-26-7 & 82919-37-7 to 1.5%, added to the reference.
In test 3 has been used a HALS CAS 41556-26-7 & 82919-37-7 to 3.0%, added to the reference.
In test 4 has been used a UV Absorber CAS 57834-33-0 to 0.5%, added to the reference.
In test 5 has been used a UV Absorber CAS 57834-33-0 to 1.0%, added to the reference.
In test 6 has been used a combination of a HALS CAS 41556-26-7 & 82919-37-7 to 1.5%, and an Antioxidant CAS 6683-19-8 in 0.2%, added to the reference.

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In all cases, the formulations were used to impregnate carbon fiber fabrics, with the same RC and the same manufacturing cycle. The prepregs thus obtained were hardened with the same Hot-in Hot-out press molding cycle.
Then the samples were aged in:
A test) xenotest according to the SAEJ2527 standard for 10 days (240 hours);
B test) ventilated stove at 100°C for 5 days (120 hours).

The degree of yellowing of the samples was determined by colorimetric analysis. The colorimetric analysis was carried out by UV spectroscopy using the CIELab methodology which defines the ΔE parameter as the color difference (or distance between two points in the color space; in this case compared to the unaged specimen).

3. RESULTS AND DISCUSSION

Sample	ΔE after A aging test	ΔE after B aging test
Test 1	11.62	4.00
Test 2	1.22	0.10
Test 3	7.24	5.44
Test 4	0.98	0.45
Test 5	4.59	3.00
Test 6	2.39	0.11

Compared to the reference, the addition of 1.5% of HALS reduced ΔE by about 1/10 in test A, and by about 1/40 in test B. On the other hand, the addition of 3% of the same HALS resulted in a much smaller reduction of the ΔE in test A, and even an increase in test B.
The use of 0.5% of UV Absorber made it possible to reduce ΔE by about 1/12 in test A, and by about 1/9 in test B. The addition of the same product at 1% allowed a much less significant reduction in both tests.
Finally, the combined use of a HALS and an Antioxidant allowed to reduce the ΔE by 1/5 in test A and 1/40 in test B, compared to the reference.

4. CONCLUSION

The addition of HALS, UV Absorber and Antioxidant, has generally made it possible to substantially reduce the degree of yellowing of the materials after prolonged aging cycles. Given the growing demand for carbon/epoxy laminates with high resistance to yellowing, further studies with different combinations of these additives should be considered by prepreg manufacturers.

REFERENCES

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