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The Myth of Reciprocity

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Reciprocity is the notion that if you increase irradiance in a weathering test, you can decrease your exposure time by a reciprocal amount and still get the same results. Said another way, reciprocity states that the amount of degradation in a weathering exposure is strictly proportional to total light dosage (i.e. irradiance x time), regardless of how much time it took to deliver that dosage. For example, you get the same total dosage from an irradiance of 1.1 W/m^2 for 1,000 hours as you get from an irradiance of 0.55 W/m^2 for 2,000 hours. So one might assume that the two exposures would produce the same degradation. However, this is almost never the case.

> **Reciprocity** [res-uh-**pros**-*i*-*tee*] ***(noun)***
> The notion that if you increase irradiance in a weathering test, you can decrease exposure time by a reciprocal amount and still get the same results.

At Q-Lab we talk to hundreds of engineers every year who have been "sold" by others on the myth of reciprocity. It takes a major effort to convince them that this type of blind calculation is bad science.

Sometimes higher irradiance does give faster degradation. But reciprocity is an extremely rare occurrence. The calculation is almost always wrong.

Reciprocity can only occur when all of the following 15 conditions are met:

1. The material contains only one compound that is affected by light.
2. There is only one photo-chemical pathway within that compound.
3. That pathway is not affected by heat.
4. That photochemical pathway is not subject to saturation effects. In other words the compound can absorb and utilize an unlimited amount of instantaneous irradiance.
5. Byproducts of the photochemical reaction do not accumulate and interfere with future photochemical reactions.
6. Byproducts of the primary reaction do not engage in secondary reactions with other compounds within the material.
7. UV absorbers and UV stabilizers do not deplete over time.
8. There are no dark-time reactions.
9. There are no oxidation reactions that are independent of light.
10. There are no reactions of any kind that are independent of light.
11. There is only one kind of degradation that occurs.
12. Exposure to water has no effect on degradation of any component of the material.
13. Wet / dry cycling has no effect on degradation of any component of the material.
14. Absorbed humidity has no effect on degradation of any component of the material.
15. Thermal cycling has no effect on degradation of any component of the material.

The effect of irradiance on a few different material types are graphed on the following page. Looking at these examples, you can see that relying on a reciprocity calculation will almost always provide erroneous results.

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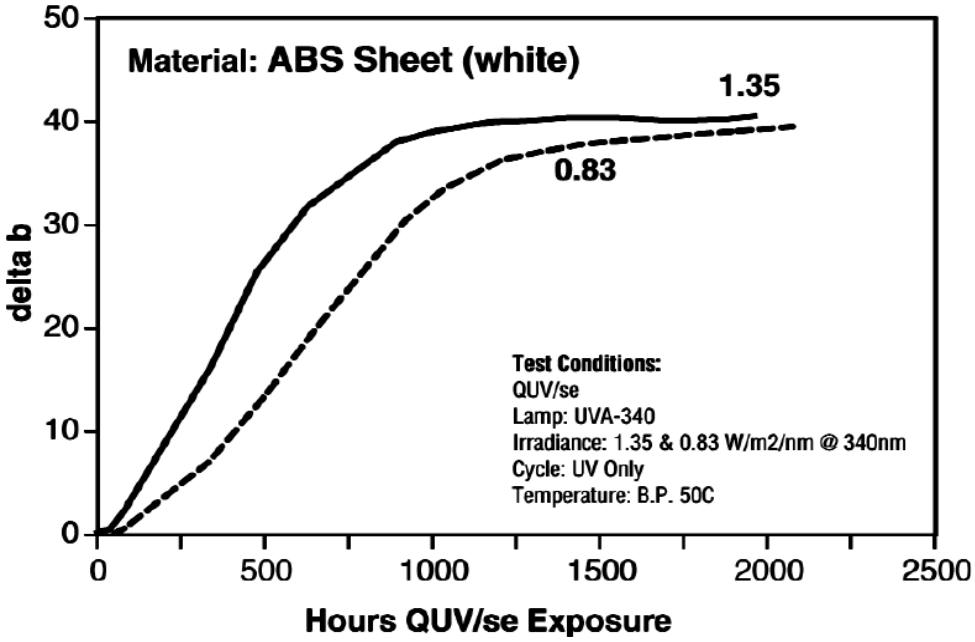
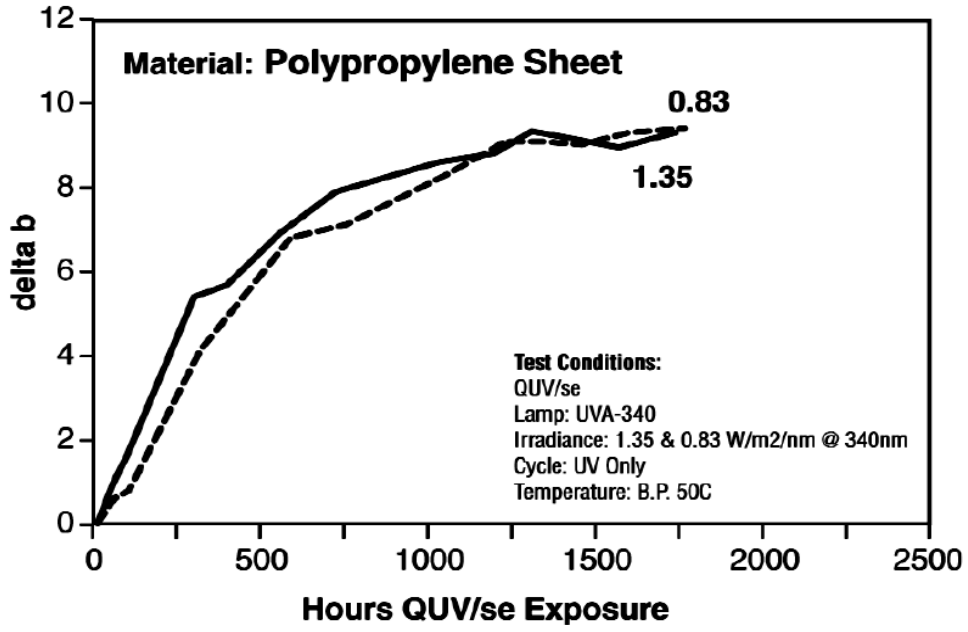
The Effect of Irradiance Level on Delta b





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