Case study: Accelerated UV-Aging **INFO** Sheet C7.1

Description:	*UV stability* *Ageing tests*
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Introduction

Polymeric materials for solar thermal applications have to be tested thoroughly before they can be used for the construction of novel collectors. Used as absorbers, glazing or framing, just to mention a few applications, polymers are exposed to a broad variation of different environmental influences which may affect physical and mechanical properties of the materials and limit their service life time. Three major environmental influences, so called degradation factors are: temperature, UV radiation and humidity. One of these factors, the UV radiation, is of great impact on all organic macromolecules, like polymeric materials.

UV influence and protection

Around 6% of the intensity of solar radiation reaching the earth´s surface are within the UV range (100-380/400 nm). This high energy radiation can be further distinguished in UVA (315-380/400 nm9, UVB (280-315 nm) and UVC (100-280 nm). As UVC radiation is quantitatively absorbed by earth´s atmosphere the relevant part of the UV spectrum is within the UVA and UVB region, while the amount of UVB varies between 15 and 35% depending on location and definition of the UVA range. The photon energy of radiation in the UVA and UVB range is high enough to induce damage in molecules through photochemical processes. Polymers, as macromolecules, are especially affected by this as a cleavage of the polymer chain can significantly change the materials physical properties, to mention just one effect of UV radiation.

UV radiation is absorbed by the matter it interacts with and therefore has a limited penetration depth into the materials. However damage is induced to the surface, like embrittlement or cracks, can spread through the material and significantly affect the mechanical stability of work pieces. In order to protect polymeric materials and prevent UV induced damage polymers are often, depending on the application, equipped with UV stabilizers. Among others carbon black, a carbon based pigment, is used for UV protection. The broad absorption, from the UV to the infrared range, of carbon black is used to prevent the actual polymer from damage. Other stabilizers, like hindered amine light stabilizers (HALS), are radical scavengers and inhibit radical chain reactions which would lead to degradation of the polymer.

Accelerated aging test methods

In order to simulate the effects of years of UV exposure under laboratory conditions different UV sources are available, but they have to be chosen carefully according to the material and addressed question. Some

light sources emit not only high intensities of UV radiation, but also a large amount of visible light and infrared radiation. Especially by black polymers this additional energy input is largely absorbed and causes a non-negligible increase in temperature of the test specimen. Further, different light sources have different spectral distributions even in the UV range, as illustrated in *Figure 1*, showing a comparison of different UV sources. For polymers, depending on the polymer type, pigments, UV stabilizers and other additives, certain wavelength of the UVA and UVB may have more impact on the materials than others. For material screenings and comparison of different aging intervals it is necessary to take care that the light sources have a high level of spatial homogeneity, even over large irradiation areas.
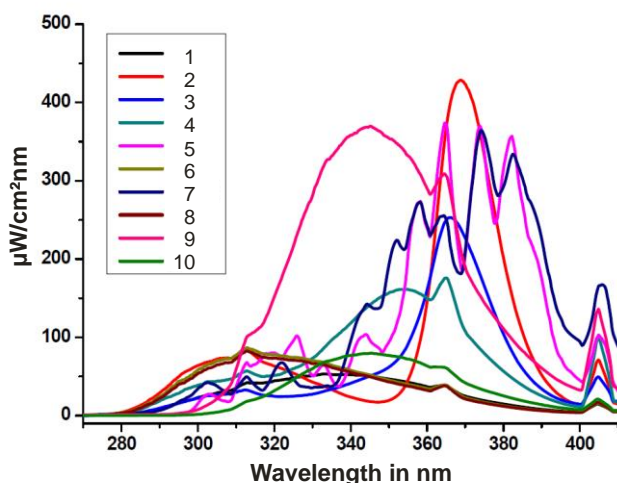

Figure 1: left: Comparison of the spectral intensity distribution of different light sources for UV aging. It shows not only a broad variation in total intensity, but also in regions of the UV range.
Right: Researcher in protective gear sampling different polymer specimen in a UV chamber.

Summary

In order to study solely UV induced degradation effects, light sources with high UV loads and low share of spectral intensity in other regions are to be preferred. Further care has to be taken to eliminate intensity inhomogeneities in the irradiated surface. The choice of the suitable spectral range is essential for the observed effects and should reflect the real environmental conditions. Concerning dose effect correlations a detailed study is necessary as a linear correlation does not always apply as UV induced damage is inflicted on the materials surface and affects the materials properties in various ways.

References

"*Rundvergleich von UV-Prüfeinrichtungen für Photovoltaik Module*", D. Philipp, K.-A. Weiß, M. Köhl, 40. Jahrestagung der GUS, 2011.
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