Industrieverband
Halbzeuge und Konsumprodukte
aus Kunststoff e.V.

pro-K group
Thermoplastic Sheets

Technical Leaflet

To provide a fundamental explanation of the terms lightfastness, weather resistance UV resistance

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1. Introduction to the subject matter and definition of terms

As plastics age, their mechanical properties often change until the material fails. For plastics used outdoors, the long-term stability test takes the form of weathering tests. In addition to mechanical properties being tested, the change is colour quality over the ageing period is also examined. The starting point for these tests is the influence of solar radiation (= the electromagnetic spectrum with the greatest intensity in the range of visible light, see Figure 1) on plastics and their ageing behaviour. Damage that typically occurs is for example fading, chalkiness, colour change and a loss of strength. At the same time, there is also a relationship between the ambient moisture and solar radiation, which can cause material damage [i].

The main form of radiation that is responsible for ageing is ultraviolet radiation (UV radiation, wavelength range <380nm). This is a shorter-wave form of radiation than can be perceived by the human eye. We distinguish between UV-A, UV-B or UV-C radiation, depending on the wavelength. The shorter-wave the radiation, the more high-energy it is and the more pronounced its effects.

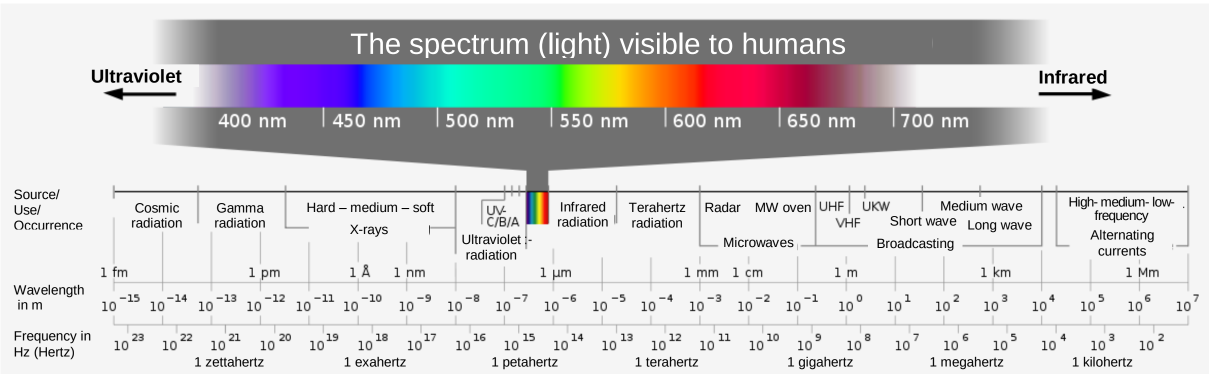

Figure 1: Overview of electromagnetic radiation and the range visible to humans [ii]

2. Lightfastness (resistance to light)

Lightfastness (resistance to light) describes the resistance of colours (in paints, plastics) when subjected to prolonged irradiation, particularly sunlight with a high UV light component. The absorption of damaging radiation triggers a chemical process that results in colour changes.
There is no such thing as complete lightfastness. Generally speaking, all materials fade under the direct or indirect influence of UV radiation, some more so than others.

Lightfastness is determined according to special standards, e.g. DIN EN ISO 105-B01 (daylight) or DIN EN ISO 105-B02 (xenon arc lamp).

The wool scale is the most common method used to determine the lightfastness of a paint. It extends from Level 1 to Level 8, with 8 corresponding to very lightfast. The wool scale[iii] is based on the tendency of various pigments to fade at different rates in sunlight. A material's lightfastness is determined on the basis of a blue scale. Eight blue wool strips of decreasing lightfastness are exposed to UV irradiation along with the sample being examined, with part of both the sample and the wool strip being covered. When the most lightfast wool strip shows signs of fading, the samples and wool strips are compared. The sample then displays the same level of lightfastness as the wool strip that has a similar fading intensity.

3. UV resistance

In the case of plastics located outdoors or used in closed rooms with fluorescent light, the high-energy UV component of the radiation triggers physical and chemical processes that can manifest themselves in the form of poorer mechanical properties, a loss of glossiness and discolouration.
The degree of damage depends on

- the sensitivity to light of the plastic in question
- the type of additives
- the wall thickness of the products
- the intensity of the radiation
- the wavelength of the radiation

With plastics, there are great differences in resistance to UV radiation. Some display good resistance (e.g. PMMA) and are deemed to be UV-stable, whereas others have poorer resistance (e.g. HIPS) and can only be UV-stabilised. Additives are used to increase resistance to UV radiation. There are two types of UV-additives: the UV absorbers and the UV stabilisers. The UV absorbers absorb the UV light in a certain spectrum range and convert the absorbed energy into harmless energy e.g. heat [[iv]]. Most UV stabilisers act as so-called radical catchers when the plastic has already been damaged by UV light. In practice, both UV additive groups are used with many plastics because they have synergetic properties. Besides UV absorbers and UV stabilisers, heat stabilisers (antioxidants) are also often used in order to improve resistance to weather.

However, it must be noted that extreme conditions such as UV light and high temperatures significantly accelerate the ageing process. This also applies to areas with a lot of industry, high altitudes in the mountains and south-facing locations.

Processing times and the thickness of the moulded part can have a major influence on the degradation mechanism. Internal stresses and thin walls can accelerate the UV-related degradation of properties. This applies mainly to non-stabilised materials.
However, even with UV-stable and UV-stabilised materials, the wrong processing steps can result in UV damage which will then appear very localised.

4. Weather stability

Weather stability (weathering stability) is defined as the degree of preservation (colour, mechanical properties, gloss) of the material's properties under the influence of light (= radiation) and additional atmospheric conditions. Here, weather stability is distinguished from lightfastness (involving purely a light exposure test) in that not only are the influences of radiation reproduced here, but atmospheric influences (temperature, temperature change, moisture, atmospheric constituents) are also included. The aim of environmental simulation is to determine as precisely as possible the service life of plastics that are exposed to various weather influences.
A distinction is also made here between artificial (laboratory) and natural weathering (outdoor weathering). In the case of natural weathering, a distinction is made between fastness and accelerated weathering (rapid weathering due to a concentration of sunlight aided by mirrors), whereas artificial weathering usually involves accelerated methods.

5. Resistance to weather

Resistance to weather is the resistance of the material to the effects of the weather such as temperature, oxygen content of the air, ozone, relative humidity, UV radiation and environmental contamination (sulphur dioxide, nitrogen oxide etc.). Resistance to light and the weather together give an insight into weatherability.

6. Weathering / testing methods used

The weathering behaviour of plastic can be tested in the following ways:

- Artificial weathering
- Outdoor weathering.

A distinction is made between stress processes caused by “**irradiation**” and by “**weathering**”.
The testing methods for **irradiation** describe the stress from natural or simulated global radiation “behind window glass”, d.h. by radiation <u>without</u> the short-wave UVB component (280-315 nm) under defined climate conditions and <u>without</u> wet periods.

Testing methods for **weathering** describe stress from natural or simulated global radiation (wavelengths less than 450 nm) with dry and wet periods and defined climate conditions during the dry periods.

Weathering in equipment that provides time acceleration has the advantages of shorter test times and a lack of dependency on location, time of year, local climate, air pollution etc. These test results provide the applications engineer information about the resistance to weathering of a plastic formulation under the selected test conditions.

Artificial weathering

- Xenon weathering: artificial weathering with xenon lamps (similar spectrum to sunlight), simulation of daytime to night-time changeover with set humidity, typical values after 1500h, 3000h …
- QUV rapid weathering: artificial weathering with UV lamps, rapid weathering by very high UV exposure, additional influence of moisture, typical values after 1500h, 3000h …

Outdoor weathering

- Florida: natural weathering in southern Florida, very time-intensive up to a period of several years (heat, moisture)
- South Africa (Kalahari Desert) (heat, dryness)
- Arizona (heat, dryness)
- and others …

[I)] *U. Schulz; Kurzzeitbewitterung – Natürliche und künstliche Bewitterung in der Lackchemie, Vincentz Network GmbH & Co. KG, Hannover, 2007*
[II)] *Source Wikipedia: Page "Electromagnetic spectrum". In: Wikipedia, The Free Encyclopedia. Current as of: 29th November 2014, 15:59 UTC. URL: http://de.wikipedia.org/w/index.php?title=Elektromagnetisches_Spektrum&oldid=136296602 (called up: 11th March 2015, 09:14 UTC)*
[iii)] *DIN 53952 is no longer valid and has been withdrawn*
[IV)] *G.W. Ehrenstein, S. Pongratz; Beständigkeit von Kunststoffen – Volume 1, Carl Hanser Verlag, Munich, 2007*