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(Artificial) Aging of SyntheticTurf

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Fig. 1: (Artificial) Aging of Synthetic Turf
Aging of organic materials exposed to climatic conditions is a normal process. The rate at which this occurs varies based on differing climatic conditions and intensity of the exposure. The dominant force in this aging process is the ultraviolet light from solar radiation. The UV-photons exhibit energy levels at the magnitude required to bind the molecules of the polymer itself. Exposed to this force the chemical bonds within the turf fibers can be broken setting off additional radical destructive chemical reactions. As a lot of plastics and particularly paints are used outdoors, these phenomena have a great practical and therefore economic importance.

Fig. 2: European Weathering Symposium / Eduard Pohle and Leo Kranner
In this sense aging of polymers is a very wide field for scientists, who meet periodically at conferences. Our lab is especially involved in the "Colloquium of Danubian Countries on Natural and Artificial Aging of Polymers" (CDC), which has now been renamed in EWS – the "European Weathering Symposium".
My colleagues Mr. Pohle and Mr. Kranner participated last year in the 23rd CDC, from where I´ll show you later on some results.

Fig. 3: Documents and Standards
Concerned with this topic intensively, we can find many national and international standards. Nevertheless these few papers (Fig. 3) are the most important we should be interested in, as they will determine the way we will perform our tests in the future.
These papers have different status:

- The basis of all test procedures for artificial weathering are 4 parts of (EN) ISO 4892.
- The "Specification of synthetic turf" will be a very important EN-document, where (in my opinion) the specific parameters and the requirements of artificial weathering should also be specified. It will perhaps be sent out for enquiry in the near future.
- prEN 14836: This special "weathering" document has already been sent out for enquiry.

Fig. 4: prEN 14836 (german version)
What is special with this draft?
The most important message is the fact that UV lamps are used instead of xenon-lamps. This is the more remarkable as reference is made to ISO 4892, but just part 3 is missing which covers fluorescent UV.

My final remark: All features in red characters (Fig. 4) seem to be questionable. At least in the way that these tests should be specified in detail only in the Specification of the sports surface concerned, e.g. athletic tracks in quite a different way than synthetic turf.

Fig. 5: Discussion of prEN 14836
As you may see from this table, for comprehensive consideration of aging still many questions are open, which can be answered seriously only by additional research.

For the test labs especially the following questions are of essential importance:

- The duration of artificial weathering
- The optimal selection of criteria.
- The knowledge of tolerance variation (which could be very large).

The answer of these questions would be essential for a serious evaluation of the aging stability of a synthetic turf product.

Fig. 6: basics of polymer aging

Sunlight, heat and oxygen are the components that determine the aging process particularly with polyolefins in a synergistic way. Moisture is not so essential as it is for athletic tracks based on polyurethane elastomers.
Embrittlement is by far the most important effect of aging particularly for synthetic turf as abrasion is caused by brittleness to a great extent.

Fig. 7: Test methods for Polyethylene and Polypropylene

The special chemical structure of these two polyolefins determines the mechanism of aging and consequently the special methodology of the artificial weathering.

Fig. 8: Spectrum of sunlight

Regarding artificial aging processes we must know the spectrum of sunlight particularly in band passes of high photon energy. The photon energy in the band pass of visible light is rather low. Consequently the aging process of most polymers is determined primarily by the energetic shorter UV waves. The influence of visible and infrared light is limited to thermal effects, which do not influence the aging process qualitatively ; it only accelerates the process.

Fig. 9: Spectral irradiance of xenon arc lamps

As the filtered xenon-arc-irradiance is very near to the spectrum of sun-light it is the absolutely best reference radiation for artificial weathering. Consequently it supplies “by definition” the best correlation with natural weathering. However testing using xenon arc lamps is quite difficult.

Fig. 10: Spectral irradiance of fluorescent UV-lamps

More economic emitters are various fluorescent UV-lamps. It has been found that the good congruence of the type UV-A 340 with the sun spectrum within the shorter UV band bass can provide a good correlation for natural weathering.

Fig. 11: Principle of a UV-weathering device

Therefore some devices for artificial weathering have been developed using UV-A 340, which are used already as standards for weathering of various polymer products (see paint standards). However particular attention must be paid to the uniformity of irradiation at the face of the specimens as well as to the selection of the correct parameters (temperature, etc).

Fig. 12: Effects of brittleness caused by outdoor weathering

From the results of these outdoor weathering tests (performed in Vienna) we can recognize interesting facts:

- PP-films without absolutely excellent UV stabilizer are destroyed within an exposure time of 1 year.
- The tensile strain (elongation at break) is the most sensitive criterion for aging effects, especially for embrittlement. It is even more important than tensile strength.

Fig. 13: Artificial aging of PP-fibres in QUV-Chamber IST (from Kolitzus)
Here we can see the damages of PP-fibres (from artificial turf), where the quality of the UV-stabilizer seems to be inadequate. It should be pointed out that this kind of exposure the radiation directed perpendicular to the fibre surface is by far the most adequate and most effective one.

Fig. 14, Fig. 15: Artificial weathering of polypropylen materials: Change of tensile strength and tensile strain
These graphs show a good correlation between standard methods of artificial weathering using a xenon arc based device on the one hand and a UV-A fluorescent lamp based device on the other hand. Those results are very important, because it is the optimal way for establishing correlation of the UV-A based device for natural weathering. Why that? Because the artificial weathering (reference) method based on the xenon arc lamp represents a reproducible method, in contrast to natural weathering.
Beyond that a comparison of two graphs confirms again impressively that the tensile strain (elongation at break) indicates the aging process by far more clearly than the tensile strength.

Fig. 16: Austrian Test Method for Artificial weathering
The Austrian testing method is based on the following realizations:

- In order to minimize the actually large range of tolerance, individual steps of the procedure should be as accurate as possible.
- Consequently the incidence of radiation must be clearly defined (90°)
- Consequently the most selective criteria have to be tested (elongation at break and tensile strenght).

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