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belting

TecInfo

AGEING OF POLYMERS AND THE IMPACT ON HYGIENE

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INTRODUCTION

Repeated constant or intermittent loads change the technical properties in synthetic conveyor belts and can mean that they fail in the long term. The following figures show what factors affect the belts and what happens to polymer materials.

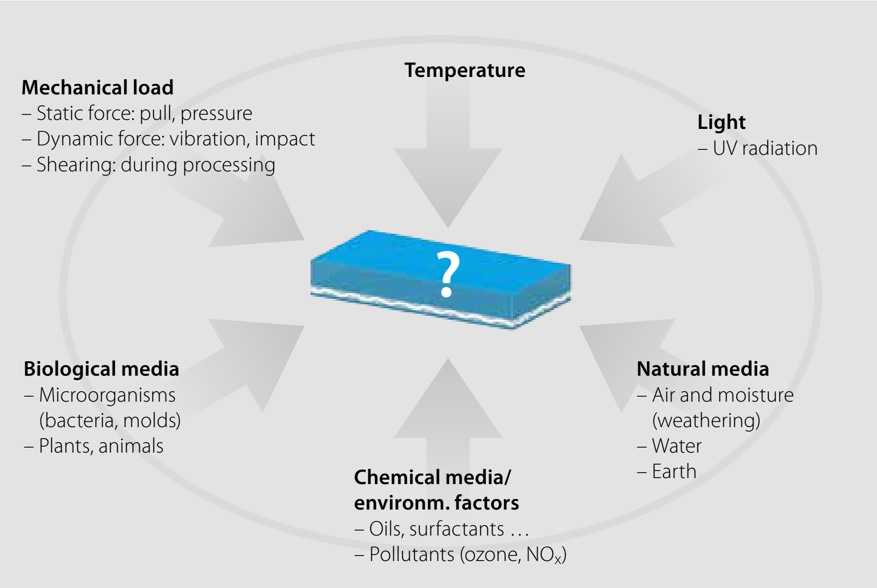

Fig. 1: Factors influencing polymer materials [1]

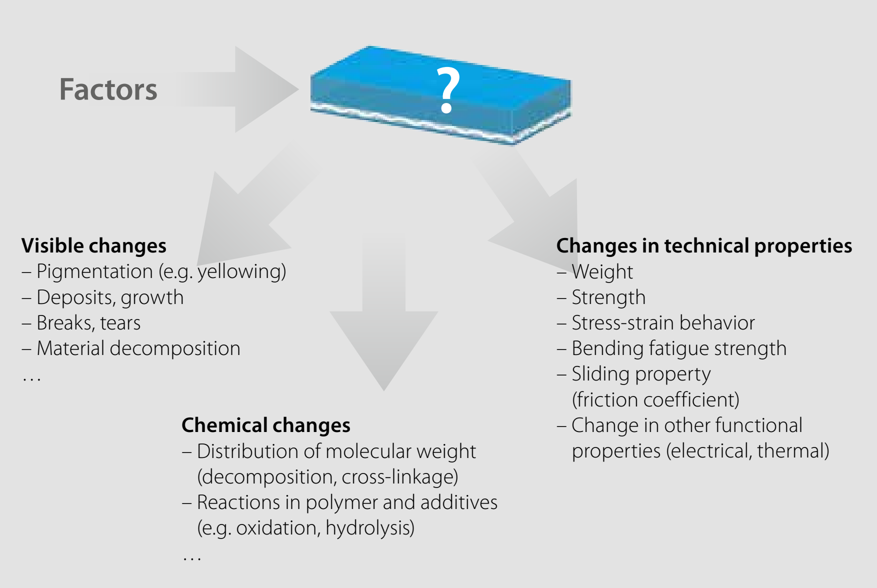

Fig. 2: Effects of factors influencing polymer materials [1]

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Over the next few pages we will be discussing some of the factors that specifically affect conveyor belts in more detail. This also includes the effect of water and moisture (hydrolysis, swelling), microbial attack and UV radiation.

1 The effect of water and moisture on synthetic conveyor belts

1.1 Hydrolysis

Hydrolysis means the breakage of certain molecular bonds after reaction with water. This is caused when they are exposed for a longer period of time to warm water, wet steam or a tropical climate (moisture in conjunction with heat).

Hydrolysis is catalyzed by acid or lye and accelerated by high temperatures (steam). In polyurethanes it occurs above all from lyes. The cleavage products that are produced during this reaction again have a catalytic effect on subsequent hydrolysis reactions. At room temperature hardly any damage from hydrolytic decomposition can be observed in polyurethanes. Hydrolysis results in a reduction in mechanical strength.

Tab. 1: Reaction of different polymers in contact with water

Hydrolysis-sensitive polymers	Polymers not sensitive to hydrolysis
Polyamide (Nylon®, Perlon®)	Polyethylene
Polyester	Polypropylene
Polyurethane	Polyvinylchloride (PVC)

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1.2 Change in synthetic material (polymer) properties due to hydrolysis

Mechanical material properties in standard polyurethanes show an increasing decline at temperatures higher than +40 °C (fig. 3). With this in mind, Forbo Movement Systems provides products made of hydrolysis-resistant TPU which can usually provide permanent resistance to hydrolytic decomposition. The following diagrams show the impact of hydrolysis on tensile strength and elongation at break when comparing standard TPUs and hydrolysis-resistant TPUs when kept in water at 80 °C.

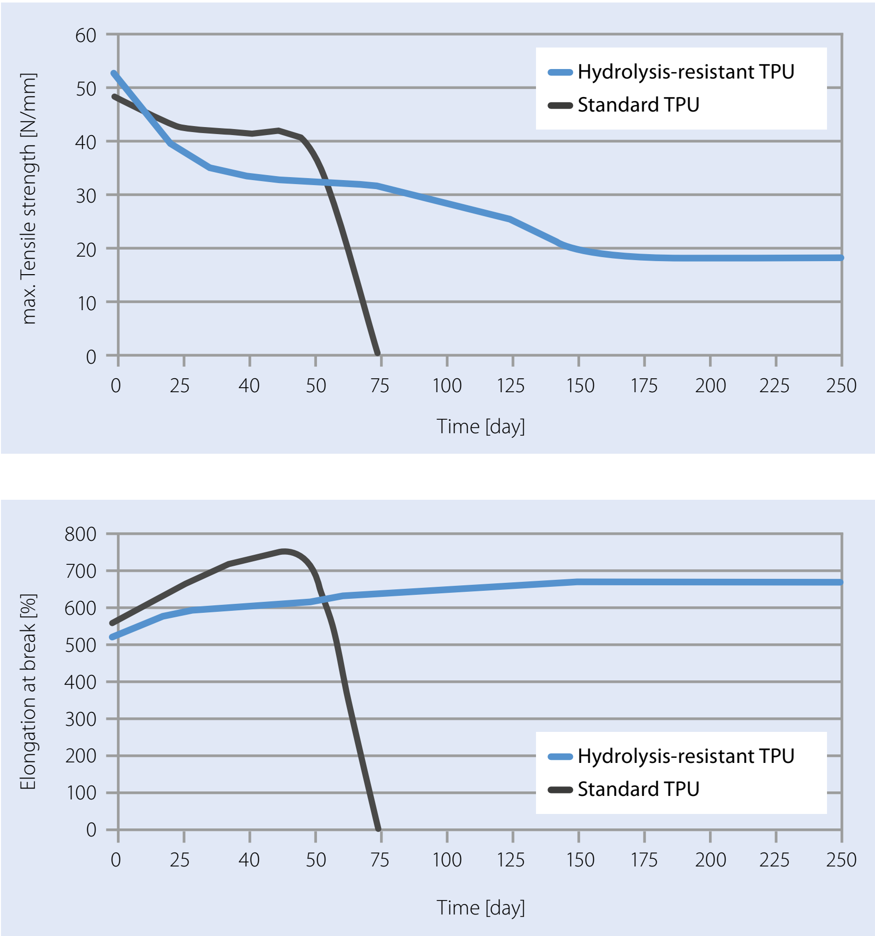

Fig. 3: Influence of hydrolysis (80 °C) on tensile strength and elongation at break

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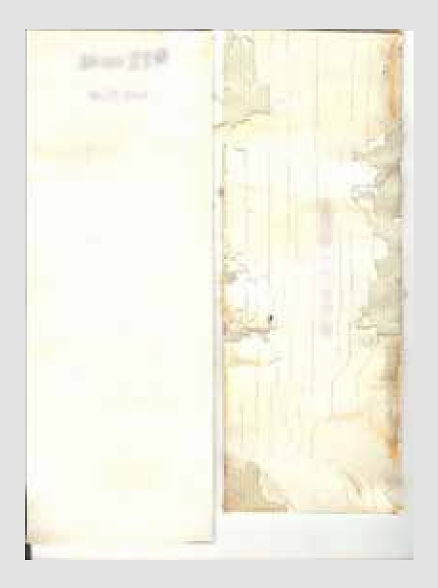

Fig. 4: Comparison of hydrolysis-resistant TPU and standard TPU after constant exposure to water, 100 °C over a longer period of time (static)

Figure 4 shows the decomposition of the coating after constant exposure over several days to hot water.
The reaction that occurs with water (hydrolysis) in standard polyurethanes and the consequent changes in mechanical properties, can also be observed in polyamides and polyesters. The polyamides used by Forbo Movement Systems have been stabilized against hydrolysis.

1.3 Swelling

Apart from bonds breaking because of water (hydrolysis), water can also deposit itself in polymer materials (causing a swelling). Polyamides are an example of this. In comparison to other thermoplasts they can absorb a lot of water (up to approx. 10%) independently of time and the amount of water vapor. An equilibrium is formed between polyamide and water depending on external conditions. If in normal ambient conditions (20/50) the water level in polyamides is around 2%, the level decreases in a much drier atmosphere and increases in a moister one.

Depending on the water level, various properties in the polyamide can change. Its hardness and mechanical strength decrease the more the water level increases, but on the other hand it becomes substantially tougher. It only becomes really tough once the material has absorbed a certain amount of moisture, so that articles made of polyamide should contain a certain amount of moisture before use.

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2 Microbial growth

Microbial organisms must not be allowed to grow on surfaces for a variety of reasons. Microbes cause decomposition, are a hygiene risk and/or damage objects. Under certain conditions, i.e. where a nutrient base is provided (chemical bonds, plasticizers that can be attacked …), suitable ambient conditions (temperature, oxygen, moisture…), microbial damage to polymers is possible.

Biogenic ageing does not necessarily automatically mean the conveyor belt is destroyed. The following might occur:

- The material is inert
- Growth occurs on the material and it discolors; no changes in its ability to function properly
- Microbes decompose the material, making the coating brittle or decomposing it totally.

In synthetic conveyor belts used for unpackaged foodstuffs, there is also the danger, apart from affecting the belt's ability to function properly, of contamination of the foodstuff meaning a risk to consumer health.
In order to stop these annoying side effects, Forbo Movement Systems makes the polymer surfaces of the belts so that the growth of microorganisms is usually prevented (Siegling Transilon HACCP types).

2.1 Microbial resistance in coating materials

2.1.1 Polyurethane
Standard thermoplastic polyurethanes run the risk of decomposing where microbial contamination occurs over a longer period of time. Moisture combined with heat (e.g. in a nutrient-rich environment where food residues are present), can accelerate this process. In these types of environments microorganisms multiply very quickly. The enzymes they release cause ester bonds to break (see hydrolysis) and the synthetic materials become brittle and can even decompose. In this case decomposition in just some areas can be observed, in contrast to hydrolytic decomposition which occurs over the whole area. Forbo Movement Systems' hydrolysis-resistant TPUs are largely resistant to decomposition following microbial growth, but may have different release properties than standard polyurethanes.

2.1.2 PVC

The resistance of the PVC depends on its composition. Here it is above all the type and amount of the plasticizer used that plays a role. Pure PVC or hard PVC is resistant as it does not provide the microorganisms with a habitat.

Some of the plasticizers for soft PVC on the market are not resistant so that the resistance of soft PVC products is also at risk. In this case molds are a problem. Because the plasticizer decomposes, its concentration in the PVC decreases, which also causes changes in the mechanical properties. There are however resistant plasticizers that are not, or only to a small extent, attacked by microbes.

2.1.3 Polyolefins

Current research leads us to believe that polyolefins are highly resistant to microbial attack.

3 UV radiation

This is an abbreviation for ultra violet radiation, which is electromagnetic radiation between the visible limit of short-wave light from the sun's rays and X-rays which range between 100 nm to 400 nm.

The rays' ranges are classified as follows:

- UV-A 400 – 315 nm
- UV-B 315 – 280 nm
- UV-C 280 – 200 nm
- UV vacuum < 180 nm

UV-C radiation is, in particular, used for disinfecting and sterilizing in the healthcare sector to prevent infections. Microorganisms are deactivated almost immediately.

3.1 UV resistance in synthetic materials

All synthetic materials chemically decompose (age) when subjected to intense radiation such as UV-A, B and C (sunlight) – depending on how long for and how intensively. UV light causes the long molecular chains to split up into shorter chains and causes changes in pigmentation (yellowing).
Resistance to these types of radiation depends, amongst other things, on the amount of radiation, type and dimensions of the product, ambient conditions and atmosphere of the place it is being used in. Normally several factors have an effect at the same time, for example light and oxygen or light and moisture. By adding stabilizers (light protection agents), UV resistance in conveyor belts can be increased.

3.1.1 UV resistance of polyurethanes

The degradation of polyurethanes in the atmosphere by UV radiation is a very complicated process which has not yet been fully understood. Yellowing, which occurs after a relatively short period of weathering, is a typical degradation feature. The main cause of changes to the characteristics of polyurethanes is photooxidative degradation through UV-A radiation.

UV-C radiation, which is increasingly used for disinfection purposes, also causes cracks to form in non-resistant or non-stabilized material (see fig. 5). In addition to these reactions, hydrolysis can also occur in polyurethanes. Photooxidation of the standard polyurethanes is accelerated by moisture [2]

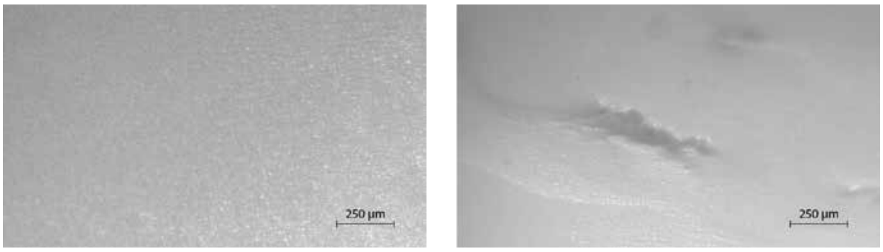

Fig. 5:
Comparison of a UV-C TPU (on the left) and standard TPU (on the right) after weathering with UV-C radiation over 120 hours. (Lab test).

3.1.2 UV resistance of PVC

The main cause of changes in property in PVC during weathering is UV light. Above all it causes discoloration, decomposition of the polymer molecules and changes in the mechanical properties and brittleness. Resistance depends to a large extent on the quality and quantity of the composition. Forbo Movement Systems achieves excellent resistance to UV radiation by using suitable feedstock and stabilizers.

3.1.3 UV resistance in polyolefins

Polyolefins are synthetic materials that are the least resistant to UV light. After a short space of time, decomposition occurs changing the mechanical properties and gradually leading to destruction of the synthetic material.

3.2 Use of UV stabilizers in Forbo Movement Systems products

All of Forbo Movement Systems' belt coatings are subjected to thorough UV-stability checks. The recipes for PVC and TPU coatings have been consistently improved over the past few years. Premature ageing due to the impact of UV radiation (with cracks forming and a tendency to rupture) is now reliably prevented. The belt surface remains intact, is not contaminated and stays easy to clean. As a result, it is exceptionally hygienic, even when UV-C disinfection systems are used all the time.

[1] Based on:
Affolter, S.: Langzeitverhalten von Thermoplasten, Interstaatliche Hochschule für Technik NTB, Buchs, Schweiz

[2] Dolezel, B.: Die Beständigkeit von Kunststoffen und Gummi; wCarl Hanser Verlag, München