Partnership for Sustainable Textiles

Di(ethylhexyl)phthalate (DEHP)

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Content

1. Identification and classification

The industrial chemical DEHP (CAS no. 117-81-7) is a diester obtained from phthalic acid and racemic 2-ethylhexanol. At room temperature it is a colourless, viscous liquid. DEHP has good gelling properties, low volatility, good resistance to heat and water and excellent electrical properties. As a result, it is widely used in industry as a plasticiser (Ullmanns 2005).

It is mainly used to add flexibility to PVC in products such as cable insulation, tubing, profiles, carpets, wallpapers, car parts, paints and varnishes but it is also found in medical products such as blood bags and dialysis accessories (ECB 2008). The DEHP content of polymer products is often about 30% by weight (Kroschwitz 1998). DEHP is also used in non-polymer products and formulations; here the content varies between 0.2% and 50% (UBA 2010).

According to the European Council for Plasticisers and Intermediates (ECPI), DEHP accounted for about 10% of the 1.3-million-tonne EU plasticiser market in 2015. Globally DEHP is still the most frequently used plasticiser, accounting for more than 37% of the total.

2. Existing regulations

Because of its reproductive toxicity, DEHP was put on the REACH Candidate List in 2008 and in 2011 it was placed on the Authorisation List (REACH Annex XIV). Since the sunset date in 2015, any use of DEHP within the EU must be authorised.

Under Regulation (EC) 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register (PRTR), the thresholds above which the release of DEHP must be reported are as follows: release to air – 10 kg/year; release to water – 1 kg/year; release to land – 1 kg/year. Under Germany's Hazardous Substances Ordinance (*Gefahrstoffverordnung*, GefStoffV) of 2010, there is an occupational exposure limit (OEL) of 2 mg/m³ measured in the breathable fraction (TRGS 900, 2016).

Under Directive 2008/105/EC on environmental quality standards in the field of water policy, DEHP was identified as a priority substance with an annual average environmental quality standard (AA-EQS) of 0.0013 mg/l for inland surface waters and other surface waters.

Directive 98/83/EC does not specify a guideline value for DEHP in drinking water. Under the WHO's Guidelines for Drinking-water Quality the guideline value for DEHP is 0.008 mg/l (WHO 2011).

A risk assessment for DEHP was performed under Council Regulation (EEC) No. 793/93 on the evaluation and control of the risks of existing substances.

3. Use in wet textile production processes

DEHP is used in many different wet processes in the textile industry.

It serves as a plasticiser in the manufacture of accessories such as plastic buttons or the metal aglets of shoelaces.

It is also used as a plasticiser in coatings and is found in printed T-shirts and non-slip socks. It is widely used in outdoor clothing and rainwear, usually as a constituent of polyurethane (PU) coatings, one or more layers of which are applied to the fabric as a thin film to make it waterproof or at least water-resistant. DEHP is added as a plasticiser to provide the necessary flexibility and wear resistance. The emission of DEHP from coating pastes is usually greater than the emission from coating powders (Schönberger and Schäfer 2003).

DEHP is also used as a carrier in the dyeing process. Exhaustion dyeing, which is used in particular for polyester fibres or polyester mixtures, can be performed either at high temperature and pressure (HT dyeing at 130°C) or at low temperature (95°C) with the aid of a carrier (Schönberger and Schäfer 2003).
The carrier improves the way in which the dye is taken up by the PES fibres. Carriers must be used with wool mixtures, because the sensitivity of the wool means that it cannot be processed at high temperatures. After dyeing, some of the carrier enters the wastewater, with the result that the amount of carrier remaining on the textile can be between 0.5% and 3.7% (BfR 2012). The majority of this is removed with the extracted air during subsequent stages such as fixing, while a smaller proportion remains on the textile. If the processes are performed using state-of-the-art technology, the residual content in the final product is likely to be less than 0.2% (BfR 2012), but poor processing can result in up to 2.7% of the carrier remaining in the end product (BfR 2012). This assessment is hampered by the fact that there is often a lack of experimental data on release from textiles (Friedlipartner 2005).

4. Hazard potential

Acute and chronic human toxicity

In the workplace DEHP is probably absorbed mainly via the respiratory tract; animal experiments show that percutaneous absorption of DEHP is of only secondary importance (GESTIS). Irrespective of the method of application, DEHP has been found in animal experiments to have very low acute toxicity: experiments on rabbits' eyes and human subjects confirm that it does not have skin-sensitising potential, and animal experiments also show that the risk of acute inhalation toxicity is low. However, there is a possibility of respiratory sensitisation by phthalic acid anhydride or maleic acid anhydride present in DEHP as an impurity (GESTIS). There is insufficient information on the chronic toxicity of DEHP in humans (GESTIS).

A risk to human health arises from the effect of DEHP as an endocrine disruptor. The male reproductive toxicity of DEHP has been amply demonstrated in rodents: depending on the dose and exposure time, DEHP leads to reduced fertility, lower weight of the male reproductive organs and histopathological changes in the testicles of young and mature animals (OEHHA 2009). Female reproductive toxicity and developmental toxicity have also been demonstrated in rodents (OEHHA 2009). On account of its reproductive toxicity, DEHP is classified as H360FD 'May damage fertility. May damage the unborn child.' and as toxic to reproduction (Category 1B) (Regulation (EC) no. 1272/2008).

The International Agency for Research on Cancer (IARC, 1989) classified DEHP as 'possibly carcinogenic to humans' (Group 2B).

Environmental toxicity

DEHP does not pose any environmental hazards (H400 series) specified in the CLP Regulation. In-vivo toxic effects in aquatic organisms are difficult to prove; in vitro they occur only at exposure levels above the water-soluble DEHP concentration of around 3 µg/l.
The derived maximum concentration in food for which it can be assumed that there is no effect on fish is 16 mg/kg (PNEC). The PNEC for mammals is 3.3 mg/kg, while for birds it is 17 mg/kg (ECB 2008).

5. Environmental behaviour

DEHP has a relatively high water/octanol partition coefficient (logKow) of 7.5 (ECB 2008). This means that it adsorbs strongly on organic substances such as sewage sludge and accumulates in fatty tissues such as milk or meat.

Because of the limited oxidation in sediments and the strong adsorption of DEHP on organic matter, particularly high concentrations of DEHP are present in sediments. It also accumulates in the food chain, although mainly at low trophic levels in aquatic environments (Inchem 2001).

In the atmosphere, DEHP is broken down by photodegradation with a half-life of one day (ECB 2008). In the other environmental media DEHP is biodegradable; however, abiotic degradation does not occur (ECB 2008). Because it is not persistent or bioaccumulative, DEHP is therefore not classed as a PBT (Regulation (EC) no. 1272/2008) despite its reproductive toxicity.

6. Possible substitutes

In the past and to some extent still, DEHP has usually been replaced with other phthalates (KEMI 2015).

For coating textiles it may be possible to use DIDP (diisodecyl phthalate) or DINP (diisononyl phthalate). However, an EU risk analysis found that DIDP poses a health risk to children if used in similar circumstances to DEHP (ECB 2008). Other possible substitutes are adipate (di(ethylhexyl) adipate (DEHA)) and trimellate (trioctyl trimetallitate (TOTM)), but these are rarely used.

Possible substitutes for the use of DEHP in carriers are systems based on carboxylic acid esters/benzyl benzoate and n-alkyl phthalimides (Schönberger and Schäfer 2003).

In the case of phthalates it is particularly important to ensure when searching for substitutes that sufficient information is available on the human and environmental toxicity and environmental behaviour of the substitute. Otherwise there is a risk that the DEHP that gives cause for concern may be replaced with an even more hazardous alternative.

7. Summary

The widespread industrial uses of DEHP include use in textile coatings or as a carrier in exhaustion dyeing processes.

DEHP is a threat to human health mainly on account of its reproductive toxicity and its classification as possibly carcinogenic for humans. Acute toxicity for humans and the environment is less significant.

When used in the textile industry, discharge into the environment via wastewater is a concern and one that is heightened by the tendency of DEHP to bind to the sediment, which means that the substance may remain in water bodies long-term. In addition, continuous exposure of the end user must be borne in mind; because of the endocrine-disrupting effect of DEHP, this is particularly significant for the development of children.

In connection with substitution, steps should be taken to ensure that the chosen alternative does not have properties that give equal or greater cause for concern. This is a particular hazard if the substitutes come from similar groups, such as other phthalates.

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