POPs & PBTs

Persistent Organic Pollutants (POPs) and Persistent, Bioaccumulative and Toxic (PBT) substances are carbon-based chemicals that resist degradation in the environment and accumulate in the tissues of living organisms, where they can produce undesirable effects on human health or the environment at certain exposure levels. POPs, specifically, are PBT substances likely to be transported and deposited long distances from their original source.

Persistence: A persistent substance resists physical, biological and chemical degradation. A measure of a substance's persistence can be determined from laboratory tests and from measurements in the environment. It is difficult to extrapolate laboratory degradation tests to the real world due to their complex nature. In addition, most current standard tests are relatively short and have to be extrapolated to give an indication of persistence over longer periods. Tests often rely on indirect measures of degradation, such as oxygen consumption, rather than the direct measurement of a substance's disappearance. Ideally, realistic laboratory tests to determine persistence should give an indication of the time it takes to reduce a substance's concentration in the environment through any degradation process, called the disappearance time (DT). The time it takes to reach 50% of the original concentration is referred to as the DT_{50} or half-life.

Bioaccumulation: A bioaccumulative substance builds up in tissues of living organisms as a result of direct exposure to polluted water, air or soil, or through consumption of contaminated food. A measure of the ability to bioaccumulate is expressed as a ratio of the substance's concentration in the organism and the medium to which it is exposed, termed the bioaccumulation factor (BAF). If consumption of contaminated food is not relevant, the ratio is called the bioconcentration factor (BCF). A correlation is found between BCFs and the relative solubility of the substance in octanol (representing fat) compared to water, known as the log K_{ow} value. For a number of chemicals a good correlation has been established, but there are limitations. Additionally, such a relationship ignores the metabolic degradation of substances within a living organism. As a result, the log K_{ow} value can be used as a screening tool to indicate a bioaccumulation potential, but only direct measurement of the BAF or BCF gives a reliable indication of a substance's ability to bioaccumulate.

Toxicity: A toxic substance has the potential to generate adverse human health or environmental effects at specific exposures. The intrinsic toxicity of a substance can be identified by standard laboratory tests. For the environment, these properties include short-term (acute) or long-term (chronic) effects. For human health, the properties include toxicity through breathing or swallowing the substance, and effects such as cancer, reproductive and neurological effects.

Long-range Transport: Some organic chemicals have been found far away from their original source, for example PCBs (polychlorinated biphenyls) and dioxins. The atmosphere is considered to be the main route for such transportation of substances, with marine and surface water playing lesser roles. Once transported, substances may be deposited on land or water and potentially affect water, soil or sediments. Long-range transport is dependent on a substance's volatility, water solubility, and its longevity in air and water, usually expressed as the half-life. For some chemicals the potential for long-range transport can be predicted from its intrinsic properties, but monitoring provides the most reliable evidence. Long-range transport may also occur through a successive migration of short-range leap frog movements.

Human health and environmental concerns relating to POPs and PBTs

POP and PBT chemicals are of particular concern if their rate of release is higher than their rate of disappearance as over time they will build-up in the environment. The concern is that such a build-up could result in effects that are difficult to reverse and to detect at an early stage.

When a toxic substance is persistent and also able to bioaccumulate, the duration and the level of exposure of living organisms to the substance is increased. This leads to a higher risk of harm. Potential chronic effects resulting from long-term exposure to low levels of a toxin are relatively difficult to predict from current laboratory tests. As a result there is a higher uncertainty in risk evaluation. This explains why PBT criteria have been used in the Water Framework Directive and by OSPAR to prioritise hazardous chemicals.

International Conventions to control POPs and PBTs

National, regional and international bodies are developing ways to manage PBT and POP chemicals to better protect human health and the environment. Criteria to select and processes to characterize PBT or POP substances are being established so that risk can be assessed and, if necessary, managed. At present there is little coordination or consistency between the approaches and the criteria defined by different authorities (*see annexe: Overview of main POP/PBT criteria*).

The **United Nations** has two POPs initiatives -the UN-ECE Protocol (Aarhus Protocol) and the UNEP POPs Convention (Stockholm Convention). The initiatives aim to control specific POPs.

The **OSPAR** Convention for the Protection of the Marine Environment of the North-East Atlantic on the Marine Environment aims to prevent pollution by continuously reducing discharges, emissions and losses of hazardous substances (identified by specific PBT criteria), with the ultimate aim of achieving concentrations in the marine environment near background values for naturally-occurring substances or close to zero for man-made substances.

The **European Union** Existing Chemicals Regulations and the New Chemicals Policy in development considers PBT chemicals as substances of particular concern due to the uncertainty of predicting exposures and concentrations that cause unwanted effects. As such, the EU is proposing the use of specific criteria to identify PBT substances, and very persistent and very bioaccumulating substances (vPvBs). For this second category, the EU says it is not necessary to demonstrate toxicity as long-term effects can be anticipated.

The **Environmental Protection Agency** (USA) has proposed two sets of criteria for PBTs under the Toxic Substances Control Act. These define substances that will have to be controlled and others that will have to be banned.

The **Canadian Government** is also developing PBT criteria in the context of its Toxic Substances Management Policy. Criteria have been set for persistence and bioaccumulation, and a definition of inherent toxicity is under development.

Challenges ahead

Whilst a substance's intrinsic toxic properties and bioaccumulation potential can be reasonably well defined, one of the key scientific challenges is to develop methods for determining persistence - to link laboratory degradation kinetics with the overall disappearance time of a substance in the environment – without drastically increasing testing costs.

The second major scientific challenge posed by POPs and PBTs is the need to validate predictive models for environmental behaviour and long-term adverse effects with experimental monitoring data at regional and global level. Through its Long-range Research Initiative, the chemical industry is contributing to a better understanding of these key issues.

KEY SCIENCE INFORMATION SHEET

Fourth information sheet in a series Euro Chlor is publishing to improve understanding by non-scientists of scientific issues. Each publication focuses on health or environmental aspects of the production, use and disposal of chlorine and its derivatives. *POPs & PBTs* can be found on the Internet at C*hlorine Online* (http://www.eurochlor.org) with other information sheets.

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Annexe: Overview of main POPs/PTBs criteria

	Persistence	**Bio-accumulation**	**Long-range transport potential**	**Toxicity** [4]
UN-ECE POPs Protocol	Half-life in water > 2 months **or** in sediment >6 months **or** in soils > 6 months	BCF or BAF > 5000 **or** log K_{ow} > 5	Vapour pressure < 1000 Pa **and** half-life in air > 2 days **or** monitoring data in remote area	Potential to adversely affect human health and/or environment
UNEP POPs Convention	Half-life in water > 2 months **or** in sediment > 6 months **or** in soils > 6 months	BCF or BAF > 5000 **or** log K_{ow} > 5 **or** monitoring data in biota	Measured levels far from source **or** monitoring data in remote area **or** multi-media modelling evidence **and** half-life in air > 2 days	Evidence of adverse effect on human health or the environment **or** toxicity characteristics indicating potential damage to human health or environment
OSPAR PBT Criteria	Not readily biodegradable **or** half-life in water > 50 days	log K_{ow}>=4 **or** BCF>=500	Not applicable	Acute aquatic toxicity L(E)C_{50}≤1 mg/l **or** long-term NOEC≤0.1 mg/l **or** mammalian toxicity: CMR or chronic toxicity
EU PBT criteria	Half-life > 60 days in marine water **or** > 40 days in freshwater[1] **or** >180 days in marine sediment **or** > 120 days in freshwater sediment[1]	BCF > 2000	Not applicable	Chronic NOEC < 0.01 mg/l or CMR cat 1&2 or endocrine disrupting effects
EU vPvB criteria	Half-life > 60 days in marine or freshwater **or** >180 days in marine or freshwater sediment	BCF > 5000	Not applicable	Not applicable
US EPA Control Action[2]	Transformation half-life > 2 months	BCF > 1000	Not applicable	Toxicity data based on level of risk concern
US EPA Ban Pending [3]	Transformation half-life > 6 months	BCF ≥ 5000	Not applicable	Toxicity data based on level of risk concern
Canada Toxic Substances Management[5]	Half-life in Air >2 days Water >2 months Sediment >6 months Soil >1 year	BAF or BCF > 5000 or log K_{ow} >5	Not applicable	Inherently toxic

(1) For marine environment risk assessments, half-life data in freshwater and freshwater sediment can be overruled by data obtained under marine conditions.

(2) Testing and release control required.

(3) Commercialization denied except if testing justifies removing chemical from “high risk concern”.

(4) L(E) $C_{50;}$ NOEC - no observed effect concentration; CMR - carcinogenic, mutagenic or toxic to reproduction.

(5) The Canadian Domestic Substances List uses different criteria (water>6 months, sediment>1year, soil>6 months) to define substances which will undergo full elimination (P and B and T and predominantly anthropogenic) and those which will undergo in-depth risk assessment (P or B and T and predominantly anthropogenic).