Are phosphorous containing lubricants and flame retardants emitted in the Norwegian environment?- A pilot study

1 Project objectives

1.1 Main aim

A pilot study of indoor sources, concentrations and compound pattern of organic phosphorus compounds.

1.2 Sub-goals

- establish a trace analytical method for organic phosphorus compounds
- analyse key-samples such as indoor air and dust
- results obtained will be used for estimation of possible intake routes and consequences for the daily human life

2 Scientific background

By 2001, the world wide usage of flame retardants was estimated at 1 217 000 tons of which 186 000 tons are organophosphate based (Davenport et al., 2002). With 15 % of the world consumption of flame retardants, organic phosphorus containing flame retardants (OPFR) represent a comparable market volume as the brominated flame retardants (BFR) (Danish Environmental Protection Agency, 1999). While the BFR are in the focus of scientific research and public attention little information is available on phosphor containing organic flame retardants and plasticizers.

OPFR (Figure 1) are often used as alternatives to brominated flame retardants. Different phosphor containing flame retardants can be either simply mixed into plastics or be reactive, chemically bound into the plastic molecules during polymerisation. This depends on the properties required of the plastic and flame retardancy. We can distinguish halogenated and non-halogenated OPFR. The majority of the phosphorus organic compounds have been on the market since the 1950s (Freudenthal, 2000). Many of them have consequently not been studied according to modern, more rigorous standards (Hedemalm et al., 2000). Little data exists about degradation and end-of-life issues, like deposition, mobility, long-term effects or bioaccumulation.

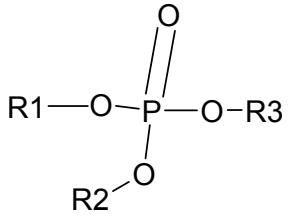

Figure 1: General structure of organophosphate esters. R_1, R_2 and R_3 are either similar or different organic substituents

Chlorinated phosphate esters are mainly used in polyurethane foam whereas aryl phosphates are present in plastic parts of electrical and electronic equipment and in

PVC-based products working as flame retardants as well as plasticizers. Car and computer industries represent a growing marked for OPFR. Ecotoxicological considerations

The OPFR have come under intense environmental scrutiny, due to their acute toxicity to algae, invertebrates and fish (Danish Environmental Protection Agency, 2001). A wide range of biological effects of organophosphate esters has been reported, indicating substantial differences between the various organic phosphates (Carlsson et al., 2000).

Subsequent to their use as flame retardants in furniture, electronic devices and building products, indoor air is of importance concerning working and living conditions. In a study evaluating the oral and inhalative intake of OPFR, TCEP was stated as the most important compound regarding inhalative exposure (Salthammer, 2002). Organophosphates are to be considered as ubiquitous indoor air pollutants, because of their continuous release from e.g. office equipment (Carlsson, 1997; 2000).

3 Scope of the work

In the initial part, the analytical method for selected OPFR (Table 1) will be established and further developed at NILU. Additionally, suitable air sampling devices will be set up in selected office and home environments where residents are potentially exposed to OPFR. The target compounds were selected based on their eco-toxicological relevance (e.g. TPP) and marked volume.

Table 1: A selection of target OPFR

Substituents R_x	***CAS-no.***	***Chemical Name***	***Abbreviation***
$-C_2H_5$	78-40-0	Triethylphosphate	TEP
$-C_4H_9$	126-73-8	Tributylphosphate	TBP
$-C_6H_{13}O$	78-51-3	Tris(2-butoxyethyl)phosphate	TBEP
$-C_8H_{17}$	78-42-2	Tris(2-ethylhexyl)phosphate	TEHP
$-C_6H_5$	115-86-6	Triphenylphosphate	TPP
$-C_6H_5$, $-C_7H_7$	26444-49-5	Diphenylkresylphosphate	DCP
$-C_7H_7$	563-04-2	Tris(m-tolyl)phosphate	TMTP

The air will be sampled by using an active air sampling device equipped with polyurethane foam plugs (PUF) combined with glass fibre filters investigating working conditions as well as covering blank contamination issues. PUF in combination with the filters will be prepared by ultrasonic extraction, followed by GC/MS analysis. The exposure of residents in their home and working environment will be studied by analysing both air and dust samples, to assess volatile as well as particle bound compounds. The dust samples will be collected with a vacuum cleaner.