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Short communication

Exposure of aircraft maintenance technicians to organophosphates from hydraulic fluids and turbine oils: A pilot study

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ABSTRACT

Hydraulic fluids and turbine oils contain organophosphates like tricresyl phosphate isomers, triphenyl phosphate and tributyl phosphate from very small up to high percentages. The aim of this pilot study was to determine if aircraft maintenance technicians are exposed to relevant amounts of organophosphates.

Dialkyl and diaryl phosphate metabolites of seven organophosphates were quantified in pre- and post-shift spot urine samples of technicians ($N = 5$) by GC–MS/MS after solid phase extraction and derivatization.

Pre- and post shift values of tributyl phosphate metabolites (dibutyl phosphate (DBP): median pre-shift: 12.5 μg/L, post-shift: 23.5 μg/L) and triphenyl phosphate metabolites (diphenyl phosphate (DPP): median pre-shift: 2.9 μg/L, post-shift: 3.5 μg/L) were statistically higher than in a control group from the general population (median DBP: <0.25 μg/L, median DPP: 0.5 μg/L). No tricresyl phosphate metabolites were detected.

The aircraft maintenance technicians were occupationally exposed to tributyl and triphenyl phosphate but not to tricresyl phosphate, tri-(2-chloroethyl)- and tri-(2-chloropropyl)-phosphate. Further studies are necessary to collect information on sources, routes of uptake and varying exposures during different work tasks, evaluate possible health effects and to set up appropriate protective measures.

Introduction

Organophosphates are used in engine turbine oils and hydraulic fluids in the hydraulic system of aircrafts. Due to their anti-wear, anti-corrosion, anti-foaming, lubricating and flame retardant properties they are broadly applied as additives (Okazaki et al., 2003; WHO, 1991).

Within the last two years a large discussion was raised in the media on a suspected contamination of aircraft cabin air with turbine oil during so-called fume events. The additive tricresyl phosphate (TCP) was implicated as one possible agent for the described non specific discomfort and possible health effects. Today, commercial turbine oils contain less than 5% of tricresyl phosphate isomers with an o-TCP content of below 0.01% (Craig and Barth, 1999; BP, 2005). TCP isomers with o-cresyl moieties, the only TCP isomers with neurotoxic properties, were of high interest during this discussion (Henschler, 1959; IPCS, 1990).

Since aircraft maintenance technicians are responsible for the exchange or refilling of the turbine oils in engines, they may be exposed to comparably high quantities of turbine oil and the additive tricresyl phosphate, respectively.

Furthermore, these technicians maintain the pressurized hydraulic system of the aircrafts, e.g. at the gears and the landing flaps. The base stock of the hydraulic fluids, used in aircrafts, contains various fire resistant phosphate esters (Okazaki et al., 2003). The most frequently used phosphate esters are tri-n-butyl phosphate (TBP up to 80%), tri-i-butyl phosphate (8–12%) and triphenyl phosphate (TPP up to 5%) (Wolfe, 2009; Exxon Mobil, 2009; Skydrol, 2008). Exposure to these organophosphates can therefore be assumed as well. Data on toxicology of tributyl- and triphenyl phosphate in humans is scarce or even completely missing in literature (IPCS, 1991a,b).

Polyurethane foams are present in the insulation and seats inside aircrafts and may also be a source of exposure for chlorinated organophosphates during long-term maintenance.

So far nothing is known about the relevant routes of uptake (inhalation, dermal absorption and/or ingestion) in occupational settings. One recent study used air monitoring for exposure

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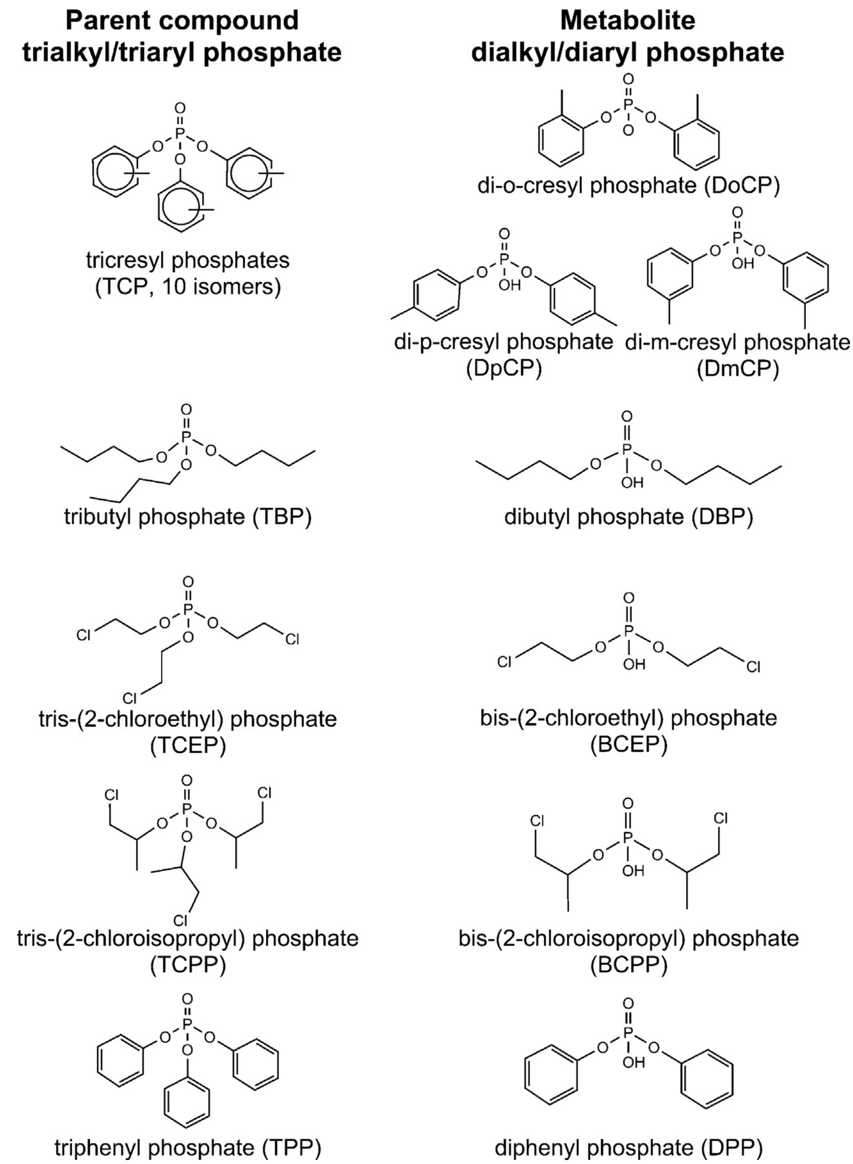

Fig. 1. Chemical structures of the trialkyl/triaryl phosphate flame retardents and the corresponding dialkyl/diaryl phosphate metabolites.

assessment of aircraft maintenance technicians (Solbu et al., 2010). However, air monitoring solely covers uptake via inhalation and may therefore underestimate exposure, particularly if dermal or oral uptake contributes significantly.

This pilot study aims to evaluate, if aircraft maintenance technicians are occupationally exposed to biologically relevant levels of organophosphate flame retardants. To cover all possible routes of uptake, human biomonitoring was applied to quantify individual exposure. The human biomonitoring approach is based on the rapid hydrolysis of the trialkyl and triaryl phosphates to the corresponding dialkyl and diaryl phosphates (Schindler et al., 2009a,b). The dialkyl and diaryl phosphates are the major metabolites of organophosphate flame retardants in animals (WHO, 1991; Burka et al., 1991; Nomeir and Abou-Donia, 1986; Kurebayashi et al., 1985; Abou-Donia et al., 1990; Suzuki et al., 1984; Sazaki et al., 1984). Structures of the trialkyl/triaryl phosphate flame retardants (parent compounds and the dialkyl/diaryl phosphate metabolites are summarized in Fig. 1.

Materials and methods

Pre- and post-shift spot urine samples were obtained in the middle of the week from five male technicians, working in aircraft maintenance facilities (ethics approval 4069-11, Ruhr-University Bochum). Among other tasks, the technicians were responsible for routine maintenance of the hydraulic system and aircraft turbines. The urine samples were stored at −20 °C until analysis. Measuring compounds were: the tri-n-butyl phosphate metabolite di-n-butylphosphate (DBP), the tris-(2-chloroethyl) phosphate metabolite bis-(2-chloroethyl) phosphate (BCEP), the tris-(2-chloroisopropyl) phosphate metabolite bis-(2-chloroisopropyl) phosphate (BCPP), the triphenyl phosphate metabolite diphenyl phosphate (DPP), the tricresylphosphate metabolites di-o-cresyl phosphate (DoCP), di-m-cresyl phosphate (DmCP) and di-p-cresyl phosphate (DpCP).

The urine samples were analyzed as described elsewhere in detail (Schindler et al., 2009a,b). In brief, deuterium-labeled