Determination of aryl-PFRs in indoor dust from different microenvironments in Spain and the Netherlands and assessment of human exposure

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Abstract

Phosphate flame retardants (PFRs) are ubiquitous chemicals in the indoor environment. Among them, aryl-PFRs, such as triphenyl phosphate (TPHP), are frequently detected in indoor dust, which is an important route for human exposure to these contaminants. TPHP is an aryl-PFR and a plasticizer that is widely used in electric and electronic equipment. It has been shown to migrate from materials resulting in environmental contamination and it has been detected in indoor dust worldwide. Diphenyl phosphate (DPHP), the hydrolyzed metabolite of TPHP, has been used as a biomarker for monitoring the human exposure to TPHP. However, a lack of correlation between the levels of TPHP in indoor dust and DPHP in urine has been observed up to date. The high urinary concentrations of DPHP suggests additional sources of TPHP and DPHP and/or other aryl-PFRs that could also be metabolized into DPHP. In this study, DPHP (and TPHP) are measured in indoor dust in samples collected in the Netherlands (n=23) in June 2016 and in Spain (n=57) in March and April 2017 using liquid chromatography coupled with triple-quadrupole mass spectrometry (LC-QQQ-MS/MS). A suitable extraction/clean-up method based on salting-out extraction followed by dispersive solid phase extraction (SPE) was optimized and employed for this purpose. Additionally, the presence of other emerging aryl-PFRs was monitored by target screening of the samples.

TPHP and DPHP were present in all samples analyzed from Spain and the Netherlands (n=80) in the range 169-142459 ng/g and 106-79661 ng/g, respectively. The DPHP concentrations were strongly correlated to the TPHP concentrations (r=0.90, p<0.01). Estimated exposures for adults and toddlers in Spain to TPHP via dust ingestion were much lower than the reference dose, indicating no current health risk to the Spanish population. The estimated urinary DPHP levels for adults and toddlers in Spain as a result of exposure to TPHP And DPHP via indoor dust ingestion were too low to significantly contribute to the high urinary DPHP concentrations reported in the literature, indicating that other sources of DPHP may play an essential role in the urinary levels of DPHP. Other aryl-PFRs, namely Cresyl diphenyl phosphate (CDP), resorcinol bis(diphenyl phosphate) (RDP), 2-Ethylhexyl diphenyl phosphate (EDP), Isodecyl diphenyl phosphate (IDP) and Bisphenol A bis(diphenyl phosphate) (BADP), were all detected in indoor dust, however, with lower frequency.