Human exposure to semi-volatile organic compounds (SVOCs) via dust ingestion: a review of influencing factors

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SUMMARY
Dust ingestion is a non-negligible pathway of human exposure to several SVOCs. To get a better knowledge on this human exposure, a review of the literature was performed on its influencing factors including (1) the fraction of dust that enters the body via hand to mouth contact: dust with particle size < 100 µm was deemed more relevant to human exposure, and (2) the fraction of pollutant released in the digestive tract, i.e. the bioaccessibility of SVOCs: the composition of the matrix, the dust particle size, the physicochemical characteristics of the pollutant, the way the SVOC has contaminated dust, i.e. through adsorption or material abrasion, and the use of Tenax as a sink were among the main determinants.

PRACTICAL IMPLICATIONS
Taking bioaccessibility into account allows a better estimation of the exposure dose via dust ingestion and thus a more accurate human risk assessment. In vitro studies are proxies of bioavailability data and are easier to implement particularly from an ethical point of view.

KEYWORDS
Bioaccessibility, dust particle size

INTRODUCTION
Humans are exposed to a wide range of indoor chemical pollutants including SVOCs, which are suspected of adverse health effects such as reprotoxic and neurotoxic effects (Fournier et al., 2014). Dust ingestion is a non-negligible pathway of human exposure to several SVOCs (Bekö et al., 2015; Tue et al., 2013). To improve this human exposure assessment, it is necessary to consider the fraction of dust that will enter the body via hand to mouth contact and the quantity of pollutants released in the digestive tract. The present work reviews the literature related to the size of ingested dust particles and the bioaccessibility of indoor SVOCs.

DUST PARTICLE SIZE
The size of ingested dust particle is very important, particularly because SVOC concentrations vary significantly with particle size. First, in general, concentration of toxic chemicals in dust increases as particle size decreases (Lewis et al., 1999). Second, studies show that fine particles adhere better to human's hands than larger ones (Cao et al., 2012). The size of dust particles adherent to hands was measured and a particle size distribution of 29 ± 22 µm was

reported (Cao et al., 2013). Furthermore if < 150 µm was considered as skin adherent dust fraction, 86% of this fraction would be in a 9.3-105 µm range (Kefeni and Okonkwo, 2014).

SVOC BIOACCESSILITY IN DUST

Regarding bioaccessibility, most reported methods simulated the gastrointestinal tract, dust being successively submitted to synthetic gastric and intestinal fluid (Yu et al., 2011). The model was sometimes extended to saliva (Ertl and Butte, 2012) or colon (Abdallah et al., 2012) digestion. The presence of food could be considered with the addition of milk powder (Ertl and Butte, 2012). Tenax beads were also used as an adsorption sink to estimate the dynamic absorption of SVOCs (Fang and Stapleton, 2014).

SVOC bioaccessibility is influenced by several factors related to the matrix: the organic carbon content was often associated with a decrease of bioaccessibility, for example for polybrominated diphenyl ethers (PBDEs) (Yu et al., 2012, 2013) or the more hydrophobic organophosphorous flame retardants and phthalate esters, but no effect was noticed on the less hydrophobic ones (He et al., 2015). A decrease of dust particle size (Wang et al., 2013c; Wang et al., 2013b) or an increase of dust pore volumes (Yu et al., 2013) lead to a larger specific surface area which was linked to an increase of SVOC bioaccessibility. Dust aging was tested for flame retardants and showed a decrease of their bioaccessibility for older dust samples (Fang and Stapleton, 2014).

SVOC bioaccessibility was also influenced by factors related to the compound itself. For example, substances with higher octanol-water partition coefficients (K_{ow}) were less bioaccessible (Kang et al., 2012, 2013; Wang et al., 2013a). For PBDEs, congeners that had integrated dust by adsorption were more bioaccessible than BDE 209 whose presence in dust is suspected to originate from material abrasion (Yu et al., 2013), although this origin could not be confirmed (Abdallah et al., 2012). SVOC bioaccessibility was not influenced by the pollutant's concentration (Yu et al., 2011).

Last, SVOC bioaccessibility was positively influenced by parameters of the method itself such as the use of Tenax (Fang and Stapleton, 2014) or milk powder (Ertl and Butte, 2012) and the increase of the concentration of bile in the intestinal solution (He et al., 2015). This emphasizes the need of a physiologically relevant, standardized measurement protocol (Collins et al., 2015).

Overall, measured bioaccessibilities were subject to a large variability, ranging from < 20% for BDE 209 (Yu et al., 2013), polycyclic aromatic hydrocarbons (Kang et al., 2011) or high molecular weight phthalates (Wang et al., 2013d), up to > 60% for OPFRs, low molecular weight PBDEs (Fang and Stapleton, 2014) or tetrabromobisphenol A and hexabromocyclodecanes (Abdallah et al., 2012). This confirms that taking bioaccessibility into account allows a better estimation of the ingested dose, whereas the latter could be overestimated when the studied pollutants are considered 100% bioaccessible.

CONCLUSIONS

Bioaccessibility data are useful for a better quantification of SVOC exposure doses and thus for a better estimation of associated health risks. However more studies are needed to assess SVOC bioaccessibilities, which should be compared to in-vivo studies for validation.

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