Exposure to Phthalate Emitted from Vinyl Flooring and Sorbed to Interior Surfaces, Dust, Airborne Particles and Human Skin

John Little[1,*], Ying Xu[1], Elaine Cohen Hubal[2], and Per Axel Clausen[3]

[1]Virginia Tech, 418 Durham Hall, Blacksburg, VA 24061-0246, USA
[2]National Center for Computational Toxicology, Environmental Protection Agency, Research Triangle Park, North Carolina, USA
[3]Indoor Environment Group, National Research Centre for the Working Environment, Lersø Parkallé 105, DK-2100 Copenhagen Ø, Denmark

[*]*Corresponding email: jcl@vt.edu*

There is an urgent need to characterize potential risk to human health and the environment that arises from the manufacture and use of tens of thousands of chemicals. Computational tools and approaches for characterizing and prioritizing exposure are required: to provide input for selection of chemicals; to select doses for toxicity tests; and to interpret and extrapolate results of in vitro tests. In this paper, a three-room model is developed to estimate di(2-ethylhexyl) phthalate (DEHP) emission from vinyl flooring in a realistic residential environment. There are serious health concerns associated with phthalate esters. Hardell et al. (1997) conducted a case-control study of 163 patients in Sweden and observed a surprisingly high risk of testicular cancer associated with exposure to PVC plastics. When administered orally to pregnant experimental animals, Gray et al. (2000) found that certain phthalate esters have significant effects on the developing male reproductive system. Some studies have also shown that inhalation exposure to phthalates adsorbed to suspended particles increases the risk of asthma (Bornehag et al. 2005). As phthalates are not chemically bound in polymers, slow emission from the products to air or other media usually occurs. Phthalate esters have been recognized as major indoor pollutants (Wensing et al. 2005). In the recent EPA-sponsored CTEPP (Children's Total Exposure to Persistent Pesticides and Other Persistent Organic Pollutants) study (EPA 2005), concentrations of over 50 target compounds were measured in multimedia samples from the homes and daycare centers of 260 pre-school age children. The two phthalates targeted in the CTEPP study were detected in residential air and house dust, and on interior surfaces and dermal wipe samples. Measured phthalate concentrations in the CTEPP study were amongst the highest of any of the targeted compounds, including pesticides, PAHs and PCBs.

Adsorption isotherms for plasticizers on several indoor surfaces, including human skin, were obtained by analyzing the CTEPP data as well as experimental data from a chamber study. Relationships between adsorption isotherms and vapor pressures were developed. A screening-level exposure analysis shows that for children, oral ingestion of dust is the primary exposure pathway for DEHP. A sensitivity analysis is used to identify the factors that most strongly influence exposure (concentration of DEHP in vinyl flooring, surface area of vinyl flooring, air exchange rate, vinyl flooring/air partition coefficient, rate of mass transfer through external boundary layer, total suspended particle concentration, dust/air partition coefficient, dust ingestion rate, skin surface area, and air inhalation rate) while an uncertainty analysis reveals the expected range of exposure in the general population. The approach is used to link the emitting source to the metabolic sink and provides valuable insight on the determinants of exposure. Because it is based on fundamental mechanisms, simply variants of the model should be able to predict exposure to other SVOCs, such as flame retardants and biocides, emitted from a wide range of building materials and consumer products.