ExpoDat: Tier 2 Chemical Screening

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Models that can be applied to a large number of chemicals are needed for chemical exposure and risk assessment. High-throughput screening (HTS) tools are being developed for exposure, hazard and risk-based objectives. The ExpoDat initiative has led to the development of a Tier 1 risk-based HTS framework that compare high-throughput (HT) estimates of exposure with HT estimates of toxicity potential from in vitro bioactivity. The Tier 1 framework was parameterized with currently available models and data to identify chemicals for potential health concerns or for which additional information is needed (Shin et al, 2015). This framework was applied to 180 organic chemicals as a case study. The result from this study shows that 38 of the chemicals (~21 percent) have exposures estimates (intake rates in mg/kg/day) that meet or exceed toxicity estimates (oral equivalent doses in mg/kg/day) extrapolated from in vitro bioactivity (Shin et al., 2015). Tier 1 uses maximum estimates of total production volume (TPV) data as an initial estimate of chemical quantities used in the various exposure sub-modules. Parallel rapid progress has also been achieved in the near-field exposure research conducted by the U.S. Environmental Protection Agency’s (EPA) ExpoCast team (e.g., SHEDS-HT), but there is still substantial improvement that can and needs to be performed in a cooperative effort between the ExpoDat team and EPA. There is, therefore, a need to develop the scientific basis for a Tier 2 framework to refine exposure models and to obtain refined estimates of chemical quantity and use information to improve exposure estimates for chemicals flagged as priorities in Tier 1.

The general objective of this project is to develop a Tier 2 framework and demonstrate the framework for selected direct and indirect exposure pathways identified in Tier 1, starting by applying and refining process-models for cosmetic ingredients and chemicals encapsulated in articles/objects.

Tier 2 Framework: The proposed preliminary Tier 2 framework starts by identifying potential product-chemical combination, building on the NIH’s Household Product Database, EPA’s Chemical and Product Categories (CPCat) database, looking at specific use scenarios and related exposure pathways. The second step focuses on the collection of product usage data and chemicals concentrations data to determine the mass of chemical applied or used per day for the considered specific product-chemical combination. The third step is to determine the exposure dose, calculating the product intake fraction (PiF), i.e., the chemical mass taken in by humans per mass unit of chemical applied in the product (Jolliet et al., 2015), refining the Tier 1 exposure models. Updated PiF values can also be fed back to Tier 1. For consistently coupling far-field (ambient air, water, soil), near-field (e.g. objects, indoor air), and human compartments (epidermis, respiratory or GI tract), we have developed a flexible mathematical framework that builds on mass balance principles across all inter-compartment chemical transfers and exposure pathways. We first calculate the fraction of the chemical introduced in a compartment that is transferred to the other compartments in direct contact. These first-order transfer fractions are then introduced in a transfer matrix. Cumulative transfers are then obtained by inverting this matrix, directly yielding exposure pathway specific product intake fractions, Doses are obtained by multiplying PiF and can then be compared to toxicity data such as the ToxCast oral equivalent doses (OEDs) as well as to Tier 1 results.

Cosmetic ingredients: We demonstrate the application of a HT modeling framework to estimate exposure to hundreds of chemicals used in personal care products (PCPs). The PiF was found to range over several orders of magnitude as a function of product archetype and PCPs properties, with dominant near-field exposures. Jolliet et al. (2015) provide further illustrative examples of exposure to VOC and SVOC encapsulated in such material.

Chemicals encapsulated in flooring: Chemicals encapsulated in materials/products can be a major emission...
source in the use phase. Previous models describing such emissions require complex analytical or numerical solutions which consist of an infinite sum of exponential terms. We have developed a parsimonious model consisting of a sum of only two exponentials with parameters which can be predicted from physicochemical properties using explicit equations. Results of this simple two-exponential model agree well with the original full model over a 15-year time period with R-square greater than 0.99 for a wide range of 264 compounds and material thicknesses. Moreover, the chemical concentration at the material surface can be simply calculated from the derivative of this two-exponential model, which also agrees well with the surface concentration calculated using the original full model. The approach will now be tested on 14 chemicals with OEDs plus another 465 chemicals found in flooring materials for which chemical concentrations are available in the Pharos database.

Collaborations: EPA, The Hamner Institute for Health Sciences

Implications: We expect that the present ExpoDAT Tier 2 project will set the scene for its further systematic extension to a more comprehensive number of relevant products and exposure pathways. It will constitute an important contribution to the development of scientifically sound High Throughput Exposure modelling effort.

Key words: Consumer products, exposure models, encapsulated chemicals, indoor environment, personal care products, flooring, near-field exposures, product intake fraction

Project start and end dates: February 2015 – December 2015

Presentation(s): None.

Peer-reviewed publication(s):


In addition to these ExpoDat directly related publications, the previous phase of the project (USEtoxPI and Tier 1) has also enabled the publication of the following 2015 publications:


Other publication(s): None to date.

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This abstract was prepared by the principal investigator for the project. Please see www.americanchemistry.com/lri for more information about the LRI.