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Dermal uptake of phthalates from clothing: comparison of model to human participant results

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SUMMARY
In this research, we extend a model of transdermal uptake of phthalates to include a layer of clothing. When compared with experimental results, this model better estimates dermal uptake of diethylphthalate (DEP) and di-n-butylphthalate (DnBP) than a previous model. It also demonstrates that uptake is sensitive to both the gap between skin and clothing and the time clothing is allowed to adsorb phthalates. The model predictions are consistent with the observation that exposed clothing increases dermal uptake when compared with uptake observed in bare-skin participants. Extension of this model beyond the cotton-phthalate system will be challenging until data on partition coefficients are quantified for other combinations of SVOCs, fabric materials and environmental conditions.

PRACTICAL IMPLICATIONS
This model improves dermal uptake predictions for two phthalates as influenced by clothing. Successful extension of this model to other compounds will improve population exposure estimates.

KEYWORDS
SVOC, model, fabric, skin, absorption

1 INTRODUCTION
Clothing can act as both a sink and a source for SVOCs, and this can strongly influence dermal uptake. Morrison et al. (2015) observed substantial uptake of DEP and DnBP for a subject wearing clothing that had been allowed to absorb the phthalates from air in a chamber for 9 days. Uptake observed for the clothed subject was much greater than that observed under otherwise identical exposure conditions for bare-skinned subjects reported in Weschler et al. (2015). Wearing freshly laundered clothing resulted in much lower uptake from chamber air. A recently developed model of transdermal uptake (Morrison et al., 2016) reasonably matches results for bare-skinned subjects. But the model substantially overpredicts DnBP uptake from clothing. We believe this is because the model is mechanistically simple and does not account for transport through and uptake within the cloth itself.

2 MATERIALS/METHODS
The model described in Morrison et al. (2016) is updated with the addition of a more realistic clothing layer. Transport through clothing is assumed to be controlled by gas-phase diffusion that is retarded by adsorption of an SVOC to fibers in the fabric. The geometry of the fabric is considered to be a slab of uniform thickness and composition. Transport from air to clothing is assumed to take place through a thin quiescent air gap by gas-phase diffusion. Advective transport is assumed to be negligible. The model is applied to predict dermal uptake of diethyl phthalate (DEP) and di-n-butyl phthalate (DnBP) for the human subject described in Morrison

et al. (2015). The subject wore cotton clothing for 6 hours that was either freshly washed or had been allowed to adsorb the two phthalates from air in the exposure chamber. After this, the participant changed into fresh clothing. Metabolite excretion was monitored during exposure and 48 hours after exposure. All model inputs are independently determined, measured or estimated (e.g. partition coefficients, thickness of clothing, etc.)

3 RESULTS

Shown in Figure 1 are simulations of DnBP mass delivered to blood vs. the cloth-skin gap, using both the updated model and the Morrison et al. (2016) model. Also shown (dashed line) is the estimated uptake of DnBP based on measurements of urinary metabolites in Morrison et al. (2015). As shown in the figure, the model is sensitive to the gap between skin and clothing. For example, measured cumulative uptake values for diethylphthalate (DEP) and di-n-butylphthalate (DnBP) are 4.7 and 3.3 mg. For tight fitting clothing (0.2 mm gap between skin and cloth), new model predictions of DEP and DnBP uptake are 8.0 and 7.0 mg respectively. For loose fitting clothing (3 mm gap), new model predictions of DEP and DnBP uptake are 5.4 and 2.4 mg respectively.

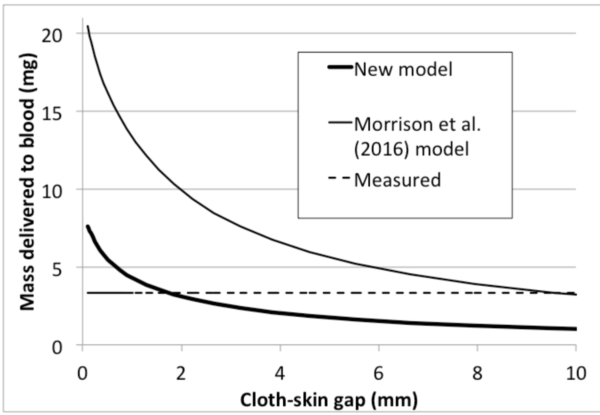

Figure 1. Mass DnBP delivered to blood vs cloth-skin gap for previous and new model

4 DISCUSSION

The updated model accounts for the dynamic adsorption of DnBP onto clothing prior to the subject donning clothing and results in a better match with observed uptake. This accounts for most of the difference observed between the two models. Smaller differences, not apparent from the figure, are due to the dynamic changes in the concentration of DnBP within clothing included in the new model.

5 CONCLUSIONS

This model steps us further towards a full mechanistic model of SVOC uptake as it is influenced by clothing. A key challenge will be improving parameter values for the model, including partition coefficients with clothing as influenced by environmental conditions.

6 REFERENCES

Morrison, G.C., Weschler, C.J., Bekö, G., Koch, H.M., Salthammer, T., Schripp, T., Toftum, J. and Clausen, G. 2015. Role of clothing in both accelerating and impeding dermal absorption of airborne SVOCs, *Journal of Exposure Science and Environmental Epidemiology*, 26, 113–118.

Weschler, C.J., Bekö, G., Koch, H.M., Salthammer, T., Schripp, T., Toftum, J. and Clausen, G. 2015. Transdermal uptake of diethyl- and di(n-butyl) phthalate directly from air: experimental verification, *Environmental Health Perspectives*, 123, 928–934.

Morrison, G.C., Weschler, C.J. and Bekö, G. 2016. Dermal uptake from air under transient conditions: Advances in modeling and comparisons with experimental results for human subjects, *Indoor Air*, doi: 10.1111/ina.12277.