





NC Department of Health and Human Services

PFAS Dermal Exposures

August 5, 2026

Overview

- **Background**
  - **Foam, bathing & showering**
- **Literature Review**
- **Current Status**

Background on PFAS Dermal Concerns

- NCDHHS is frequently asked by the public about health risks from dermal exposures to PFAS
- Clean Cape Fear and Jeff Enders (NCSU) published recent study showing high levels of PFAS in sea foam collected in the lower Cape Fear
- Sampling of private wells near some fire departments by DEQ has showed high levels
- Limited data exist to help interpret dermal exposures to PFAS

Background on PFAS Dermal Concerns

- There are currently no dermal thresholds from federal agencies or other states to guide health recommendations
- Toxicity values (reference doses, cancer slope factors) only exist for a few PFAS and this limits are ability to estimate dermal (and other) risks from exposures
- Dermal permeability coefficient is primary missing piece
- PFOA is currently the most studied PFAS compound with respect to dermal exposure

Literature Review

- Fasano et al. (2005)
  - Used rat and human epidermal membranes as models
  - Used the ammonium salt of PFOA, ammonium perfluorooctanoate (AFPO) as the test material
  - Used an infinite dosing procedure, applied 100 µL of 20% aqueous solution of APFO
  - The solution had a larger permeability coefficient in the rat models vs. the human models
  - Human model permeability coefficient measured as 9.5×10^{-7} cm/h
  - Determined that dermal exposures could be relevant in occupational settings with high concentrations

Fasano, W. J., Kennedy, G. L., Szostek, B., Farrar, D. G., Ward, R. J., Haroun, L., & Hinderliter, P. M. (2005). Penetration of ammonium perfluorooctanoate through rat and human skin in vitro. *Drug and chemical toxicology*, *28*(1), 79–90. https://doi.org/10.1081/dct-39707

Literature Review (Cont.)

- Franko et al. (2012)
  - Used mice, mouse epidermis, and human epidermis models
  - Serum PFOA levels increased with increasing dose; statistically significant
  - In human skin models, full thickness and epidermis models, total absorbable PFOA was 69% and 48%, respectively
  - pH shown to impact permeability significantly (3 orders of magnitude difference)
    - Physiologically relevant permeability measured as $5.8x10^{-5}$ cm/h
  - PFOA not significantly different from acetone controls when measuring inflammatory response
  - Overall, concluded the PFOA exposure via the dermal route may be a concern

Franko, J., Meade, B.J., Frasch, H.F., Barbero, A.M., Anderson, S.E., 2012. Dermal penetration potential of perfluorooctanoic acid (PFOA) in human and mouse skin. Journal of Toxicology and Environmental Health. 75 (1), 50–62. https://doi.org/10.1080/15287394.2011.615108.

Literature Review (Cont.)

- Hall et al. (2024)
  - Used porcine skin models to measure dermal permeability of PFOA, PFHxA, and PFBA.
    - 10 replicate samples for PFOA and PFHxA, 6 for PFBA
    - Used a flow-through dosing system, similar to Franko et al (2012)
    - 8-hour exposure duration to replicate occupational exposure scenario.
    - Measured a dermal permeability of $8.28x10^{-5}$ cm/h
  - Concluded that the three PFAS measured permeate the skin during an 8-hour exposure and may represent an exposure risk

Hall, A. S., Baynes, R., Neumann, L. M., Maibach, H. I., & Ormond, R. B. (2024). Skin Permeability of Perfluorocarboxylic Acids Using Flow-Through Diffusion on Porcine Skin. *Toxics*, *12*(10), 703. https://doi.org/10.3390/toxics12100703

Literature Review (Cont.)

- Ragnarsdottier et al. (2024)
  - Used *in vitro* 3D-human skin models for exposures
    - 500ng/cm^2 of each target PFAS was applied to each skin tissue, based on the exposed surface area; via methanol
    - Receptor fluid was sampled at fixed intervals and tissues removed and stored after 36 hours
  - Distribution of target PFAS based on measurements of absorbed, un-absorbed, and retained within skin tissue
  - Found that shorter chain PFAS are more readily absorbed
  - Dermal permeability of PFOA measured to be 3.82 x 10^{-3} cm/h

Ragnarsdottir, O., Abou-Elwafa Abdallah, M., Harrad, S., 2024. "Dermal bioavailability of perfluoroalkyl substances using in vitro 3D human skin equivalent models.". Environment International. 188, 108772. https://doi.org/10.1016/j.envint.2024.108772.

Literature Review (Cont.)

- Yeh et al. (2025)
  - Review article, specifically evaluating measured dermal permeability of PFOA
  - Summarized the strengths and limitations of four human model studies
  - Identified Franko et al. (2012) as having the most physiologically relevant permeability factor.
    - Primarily based on the appropriateness of pH and solvent selection employed in the Franko et al. methodology

Yeh, A., Prueitt, R. L., Kerper, L. E., & Beck, B. D. 2025. Evaluating dermal absorption of perfluorooctanoic acid (PFOA) and implications for other per- and polyfluoroalkyl substances (PFAS). Regulatory Toxicology and Pharmacology, 156. https://doi.org/10.1016/j.yrtph.2024.105766

Current Status

- Recent scientific publications suggest that dermal absorption may represent an important route of exposure in some scenarios
- DHHS is drafting qualitative language to address questions regarding potential for PFAS exposures, especially PFOA, to occur via dermal contact
- Coordinating information and messaging with DEQ to ensure consistent and usable information is being delivered to impacted individuals

Questions?