New study confirms forever chemicals are absorbed through human skin

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A study of 17 commonly-used synthetic 'forever chemicals' has shown that these toxic substances can readily be absorbed through human skin.

New research, published in *Environment International* proves for the first time that a wide range of PFAS (perfluoroalkyl substances)—chemicals which do not break down in nature—can permeate the skin barrier and reach the body's bloodstream.

PFAS are used widely in industries and consumer products from school uniforms to personal care products because of their water and stain repellent properties. While some substances have been banned by government regulation, others are still widely used and their toxic effects have not yet been fully investigated.

PFAS are already known to enter the body through other routes, for example being breathed in or ingested via food or drinking water, and they are known to cause adverse health effects such as a lowered immune response to vaccination, impaired liver function and decreased birth weight.

It has commonly been thought that PFAS are unable to breach the skin barrier, although recent studies have shown links between the use of personal care products and PFAS concentrations in human blood and breast milk. The new study is the most comprehensive assessment yet undertaken of the absorption of PFAS into human skin and confirms that most of them can enter the body via this route.

Lead author of the study, Dr. Oddný Ragnarsdóttir carried out the research while studying for her Ph.D. at the University of Birmingham. She explained, "The ability of these chemicals to be absorbed through skin has previously been dismissed because the molecules are ionized. The electrical charge that gives them the ability to repel water and stains was thought to also make them incapable of crossing the skin membrane.

"Our research shows that this theory does not always hold true and that, in fact, uptake through the skin could be a significant source of exposure to these harmful chemicals."

The researchers investigated 17 different PFAS. The compounds selected were among those most widely used, and most widely studied for their toxic effects and other ways through which humans might be exposed to them. Most significantly, they correspond to chemicals regulated by the EU's Drinking Water Directive.

In their experiments, the team used 3D human skin equivalent models—multilayered laboratory grown tissues that mimic the properties of normal human skin, meaning the study could be carried out without using any animals. They applied samples of each chemical to measure what proportions were absorbed, unabsorbed, or retained within the models.

Of the 17 PFAS tested, the team found 15 substances showed substantial dermal absorption—at least 5% of the exposure dose. At the exposure doses examined, absorption into the bloodstream of the most regulated PFAS (perfluoro octanoic acid; PFOA) was 13.5% with a further 38% of the applied dose retained within the skin for potential longer-term uptake into the circulation.

The amount absorbed seemed to correlate with the length of the carbon chain within the molecule. Substances with longer carbon chains showed

lower levels of absorption, while compounds with shorter chains that were introduced to replace longer carbon chain PFAS like PFOA, were more easily absorbed. Absorption of perfluoro pentanoic acid, for example, was four times that of PFOA at 59%.

Study co-author, Dr. Mohamed Abdallah, said, "Our study provides first insight into significance of the dermal route as pathway of exposure to a wide range of forever chemicals. Given the large number of existing PFAS, it is important that future studies aim to assess the risk of broad ranges of these toxic chemicals, rather than focusing on one chemical at a time."

Study co-author, Professor Stuart Harrad, of the University of Birmingham's School of Geography, Earth and Environmental Sciences, added, "This study helps us to understand how important exposure to these chemicals via the skin might be and also which chemical structures might be most easily absorbed.

"This is important because we see a shift in industry towards chemicals with shorter chain lengths because these are believed to be less toxic—however the trade-off might be that we absorb more of them, so we need to know more about the risks involved."

More information: Oddný Ragnarsdóttir et al, Dermal bioavailability of perfluoroalkyl substances using in vitro 3D human skin equivalent models, *Environment International* (2024). DOI: 10.1016/j.envint.2024.108772

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