Indoor surfaces act as massive sponges for harmful chemicals, UC Irvine-led study shows

Permeable materials in homes can retain volatile organic compounds for up to a year

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“This discovery has significant implications for human health. It means people can be exposed to harmful chemicals long after their initial introduction into indoor spaces, and compounds can later be released back into the air or transferred to humans through direct contact with contaminated surfaces,” says the study’s corresponding author, Manabu Shiraiwa (right), UC Irvine professor of chemistry,

shown with project scientist Pascale Lakey.

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Steve Zylius / UC Irvine

- Scientists injected volatile organic compounds into a test house and found large reservoirs for the potentially hazardous chemicals in porous surfaces such as wood, concrete and paint.
- VOCs contained in insecticides, cigarette smoke and wildfire smoke can remain on indoor surfaces for as long as one year.

Irvine, Calif., Sept. 22, 2025 — Indoor surfaces have an unexpectedly strong ability to absorb and hold harmful chemical compounds that can threaten human health for as long as a year, according to air chemistry researchers at the University of California, Irvine.

In a paper published today in *Proceedings of the National Academy of Sciences*, the UC Irvine scientists quantify how various indoor surfaces absorb volatile organic compounds, which can result in unhealthy conditions for people and animals when inhaled or absorbed through skin contact.

The sources of VOCs are many, such as cooking, spray cleaning, personal care and other consumer products. Additional significant contributors include tobacco smoke and, increasingly, air pollution caused by wildfires. The researchers note that health risks come from inhaling compounds when they “off gas” from surfaces and through dermal uptake when contaminated surfaces are touched.

In the spring of 2022, co-author Jonathan Abbatt, professor of chemistry at the University of Toronto, led the Chemical Assessment of Surfaces and Air study, which utilized simulation chambers in the National Institute of Standards and Technology’s Net-Zero Energy Residential Test Facility. Contaminants were injected into a structure mimicking a home environment, with typical building materials. The research team used mass spectrometry instruments to track the movement and persistence of VOCs in the controlled indoor environment.

“Scientists in the air chemistry research community have known for a long time that many indoor contaminants can be absorbed by indoor surfaces, but the size of indoor surface reservoirs inside homes and buildings had not been established,” said Manabu Shiraiwa, UC Irvine professor of chemistry, who was responsible for modeling observations and is a corresponding author on the *PNAS* paper. “Our modeling found that surfaces inside homes have a much greater size to absorb and hold chemicals than previously realized. We can think of these surfaces as massive chemical sponges that soak up VOCs.”

Before this study, thin organic films with nanometer thickness were thought to be main surface reservoirs. However, this work proves that permeable and porous materials such as painted surfaces, concrete and wood are likely the major surface reservoirs in a home.

“This discovery has significant implications for human health,” Shiraiwa said. “It means people can be exposed to harmful chemicals long after their initial introduction into indoor spaces, and compounds can later be released back into the air or transferred to humans through direct contact with contaminated surfaces.”

He added, “This result significantly impacts our understanding of VOC fate and human exposure in indoor environments. With such a large partitioning capacity, organic contaminants will have much longer indoor residence times than previously predicted.”

The research explains why certain odors and contaminants persist indoors even after their sources are removed. For example, it provides scientific evidence for why tobacco smoke odors linger in rooms long after smoking has stopped: The residual compounds, known as “thirdhand smoke,” slowly partition back into the air from surface reservoirs.

The findings suggest that regular ventilation alone may be insufficient to remove many indoor contaminants. Physical cleaning activities such as vacuuming, mopping and dusting are necessary to effectively remove compounds with high partition coefficients from surface reservoirs.

Joining Shiraiwa and Abbatt in this study were Pascale Lakey, project scientist in chemistry at UC Irvine; Jie Yu and Xing Wang at the University of Toronto; Jenna Ditto at Washington University in St. Louis, Missouri; Han Huynh and Marina Vance at the University of Colorado Boulder; Michael Link, Dustin Poppendieck and Stephen Zimmerman at the National Institute of Standards and Technology; and Delphine Farmer at Colorado State University.

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About the University of California, Irvine: Founded in 1965, UC Irvine is a member of the prestigious Association of American Universities and is ranked among the nation’s top 10 public universities by *U.S. News & World Report*. The campus has produced five Nobel laureates and is known for its academic achievement, premier research, innovation and anteater mascot. Led by Chancellor Howard Gillman, UC Irvine has more than 36,000 students and offers 224 degree programs. It’s located in one of the world’s safest and most economically vibrant communities and is Orange County’s second-largest employer, contributing $7 billion annually to the local economy and $8 billion statewide. For more on UC Irvine, visit www.uci.edu.

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