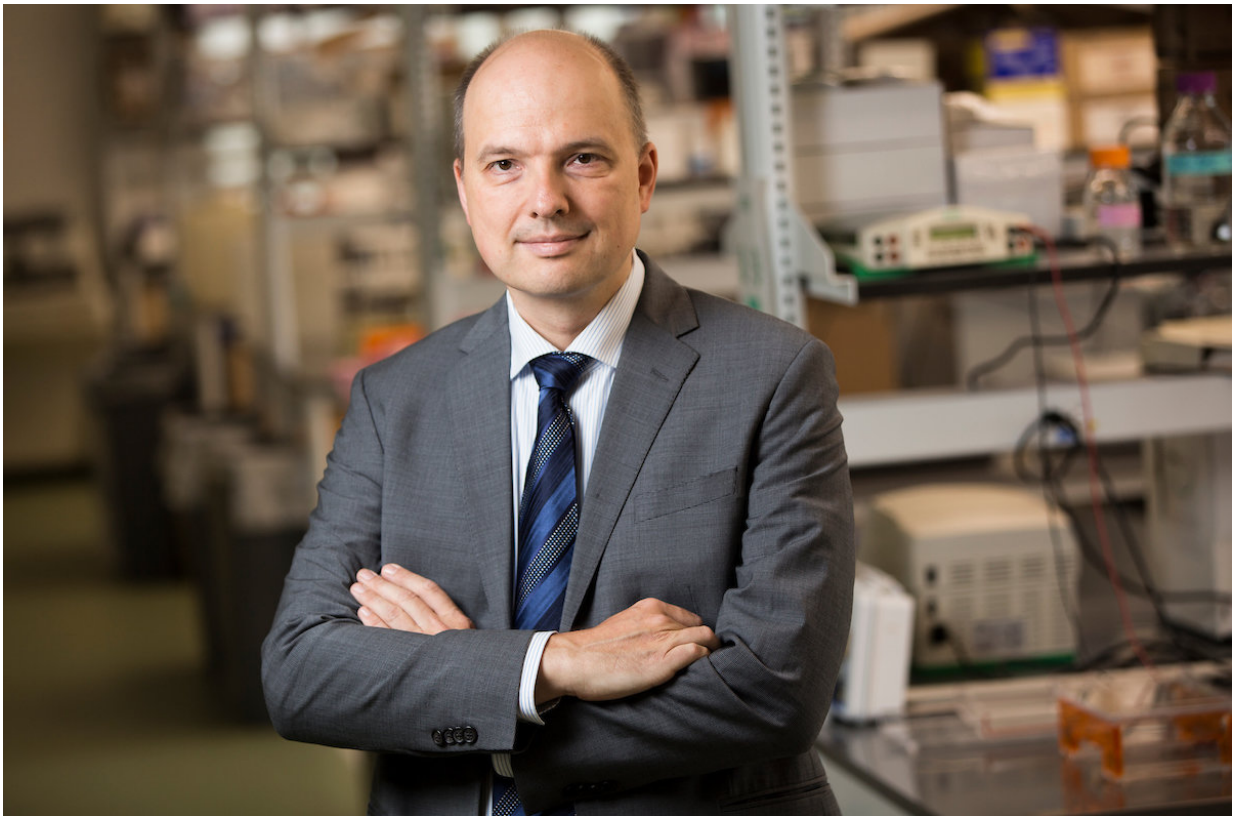


Adding flavors to e-cigarette liquids changes chemistry, creates irritants

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Sven-Eric Jordt is an associate professor of anesthesiology, pharmacology and cancer biology at Duke University. Credit: Shawn Rocco/Duke Health

As e-cigarette use expands among teens in the U.S., so have vaping menus, with manufacturers marketing nicotine-infused liquids that taste like crème brûlée, cotton candy and mango smoothies.

The sweet flavors' appeal to teens is a major concern for Food and Drug Administration officials, who recently declared teen vaping an epidemic. New research from Duke and Yale universities shows flavorings are transforming more than marketing. The [chemical additives](#) react to e-liquid, or e-juice, creating new compounds that could trigger irritation and inflammation when inhaled.

The study, published by the *Nicotine & Tobacco Research*, shows when chemical flavorings for vanilla, cherry, citrus and cinnamon mingle with solvents such as polypropylene glycol and glycerol, they create compounds called acetals.

E-liquid manufacturers have not widely documented or disclosed the presence of acetals in the vapors users are inhaling, said Sven-Eric Jordt, Ph.D., an associate professor of anesthesiology, pharmacology and cancer biology at Duke and a senior author of the paper.

"These individual ingredients are combining to form more complex chemicals that are not disclosed to the user," Jordt said. "When inhaled, these compounds will persist in the body for some time, activating irritant pathways. Over time, this mild irritation could cause an inflammatory response."

Some research on e-cigarettes has suggested higher vaping temperatures increases the risk that vapors will contain potentially harmful chemicals including formaldehyde, a suspected carcinogen. Vaping advocates suggest low-temperature or temperature-adjustable vaporizers minimize those risks.

The new study, a collaboration between Duke and the Yale Tobacco Center of Regulatory Science, shows chemical changes occur even before the liquids are heated, so users may face some risks when inhaling the aerosolized ingredients at any temperature.

"Our findings show that even in the absence of heating and combustion, chemical reactions are occurring in e-cigarette liquids and the resulting compounds could be harmful to the user's airways," said Hanno Erythropel, Ph.D., a postdoctoral associate in [chemical](#) and environmental engineering at Yale and a co-author of the study.

Vaping liquids contain anywhere from 0.5 to 10 percent flavor additives depending on the desired intensity, the researchers said. For this study, they analyzed liquids with 0.8 to 2.5 percent flavor additives.

They found that when mixed with solvents, at least 40 percent of the flavoring substances converted to acetal compounds. Further tests showed half to 80 percent of the acetals in the liquid transferred into the vapor to be inhaled.

Flavor additives are commonly used in foods and cosmetics in the forms of chemicals called aldehydes and even as acetals, the latter of which can provide longer-lasting fragrance in products such as perfumes, Jordt said. The chemicals are approved for these uses, and might not aggravate the gut or skin, which offer more protection against environmental irritants than the delicate airway.

Flavor aldehydes are known to cause irritation when inhaled. But in lab tests, researchers found the acetals they created from mixing flavors into e-liquids were even more effective in triggering molecular receptors involved in lung irritation—the same receptors that maintain irritation and inflammation in people with asthma or those who have inhaled smoke or fumes, the study found.

"Individuals who use e-cigarettes frequently should know they are exposing themselves to these chemicals, and that the long-term effects of these chemicals on the airways are unknown," Erythropel said.

Children and teens may be particularly susceptible to those effects, Jordt said.

"In some countries, there's a consensus that e-cigarettes might help chronic smokers quit traditional cigarettes," Jordt said. "However, in the U.S. we are seeing increasing numbers of adolescents using them. Adolescents with developing lungs are more prone to irritation, allergies and asthma. It's important for families and kids to know about the potential dangers."

More information: Sven-Eric Jordt et al , OUP accepted manuscript, *Nicotine & Tobacco Research* (2018). [DOI: 10.1093/ntr/nty192](https://doi.org/10.1093/ntr/nty192)

Provided by Duke University Medical Center

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