

Concentrates

Chemistry news from the week

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CONSUMER PRODUCTS

E-cigarettes' chemistry may explain their popularity

Brands like Juul deliver form of nicotine that is less harsh to inhale than free-base nicotine

Although children under the age of 18 can't legally buy e-cigarettes in most states, the devices have exploded in popularity among teens. According to a 2017 survey conducted by the University of Michigan, almost one-third of high school seniors have used an e-cigarette within the past year. One device, offered by Juul Labs, has risen above hundreds of competitors, capturing 54% of the overall e-cigarette market in just three years. Shaped like a sleek thumb drive, the device can be used discreetly and delivers a nicotine hit by vaporizing liquids containing the drug in flavors such as Cool Mint and Creme Brulee.

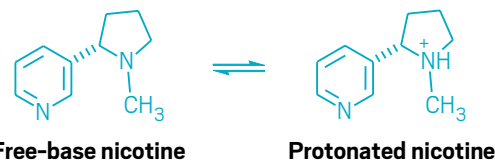
To probe the possible chemical underpinnings of e-cigarettes' popularity, chemists at Portland State University analyzed 11 e-cigarette liquids, or e-liquids, to measure the amounts of two forms of nicotine—protonated nicotine and free-

base nicotine (shown). In particular, the team found that Juul e-liquids contained mostly protonated nicotine, which may make users' vaping experience more pleasant, the researchers suggested (*Chem. Res. Toxicol.* 2018, DOI: 10.1021/acs.chemrestox.8b00097).

Previous methods for measuring the two forms of nicotine in e-liquids have had limitations, the researchers say. For example, those methods require adding cosolvents that may inadvertently shift the equilibrium between the two nicotine forms, leading to inaccurate measurements of their levels. The new method uses nuclear magnetic spectroscopy to deduce the fractions of protonated and free-base nicotine directly in the e-liquid. "The advantage is that the method is quick and does not require any sample preparation steps," says analytic chemist Najat A. Saliba of the American University of Beirut, who was not involved in the study.

The team found that the Juul Fruit Medley and Creme Brulee e-liquids had the highest levels of nicotine but the lowest amounts in the free-base form. The free-base form has long been associated with a harsher experience for the user when inhaled. Study coauthor James F. Pankow, who has been

investigating tobacco products for two decades, says the free-base nicotine sensation has been described as "a scratchy, back-of-the-throat feeling." Juul e-liquids contain added acids, which would favor the formation of protonated nicotine. The authors suggest that the resulting lack of harsh throat sensations could contribute to Juul's appeal among young users who



may not be accustomed to inhaling vapor.

Juul sent a statement to C&EN in which it reiterated its mission to "eliminate cigarettes and help the more than one billion smokers worldwide switch. At the same time, we are committed to deterring young people, as well as adults who do not currently smoke, from using our products."

But many teens and children already use e-cigarettes regularly, picking up a habit that is hard to stop.

For example, just in the past three weeks, Jonathan P. Winickoff, a pediatrician at Massachusetts General Hospital for Children, has treated three teens who showed classic signs of nicotine withdrawal. "The brains of these children become nicotine hungry," says Winickoff, who is the former chair of the American Academy of Pediatrics Tobacco Consortium.

He says the new study's hypothesis, that Juul products' less harsh vapors may contribute to their appeal among youth, has merit. When a product dominates the market so rapidly, Winickoff says, it would make sense that there's some chemical advantage.—TIEN NGUYEN

The Juul e-cigarette is small and produces little vapor.

