Scientists lay the groundwork for a reliable marijuana breathalyzer

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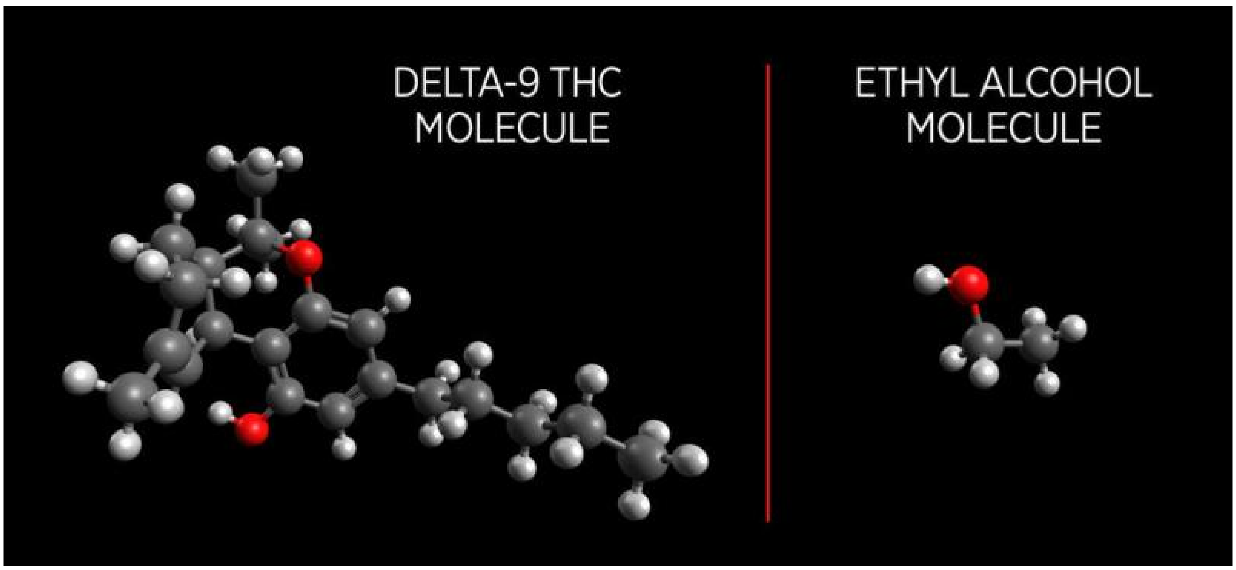

One reason it is difficult to design a reliable marijuana breathalyzer is that delta-9 tetrahydrocannabinol (THC), the primary psychoactive compound in marijuana, is a large molecule with many loops and spurs. That makes the molecule "sticky," and less likely to enter the vapor phase so that it can be measured by a breathalyzer. This contrasts with ethyl alcohol, which is small and evaporates readily. In these images, carbon atoms are dark gray, hydrogen atoms are light gray, and oxygen atoms are red. 3-D model based on computer rendering, not experimental data. Credit: National Institute of Standards and Technology

Marijuana is now legal for recreational or medicinal use in at least 28 states and the District of Columbia. But driving under the influence of marijuana is illegal no matter which state you're in. To enforce the law, authorities need a simple, rigorous roadside test for marijuana intoxication.

Although several companies are working to develop marijuana breathalyzers, testing a person's breath for marijuana-derived compounds is far more complicated than testing for alcohol.

But scientists at the National Institute of Standards and Technology (NIST) have taken an important step toward that goal by measuring a fundamental physical property of the main psychoactive compound in marijuana, delta-9 tetrahydrocannabinol (THC). Specifically, they measured the vapor pressure of this compound—a measurement that, due to the compound's chemical structure, is very difficult and has not been accomplished before. The results were published in Forensic Chemistry .

"Vapor pressure describes how a compound behaves when it transitions from a liquid to a gas," said Tara Lovestead, a NIST chemical engineer and the lead author of the study. "That's what happens in your lungs when a molecule leaves the blood to be exhaled in your breath. So if you want to accurately measure blood levels based on breath, you need to know the vapor pressure."

Law enforcement agencies are interested in a breathalyzer because roadside collection of blood or urine would be impractical and invasive. Lovestead is not designing a breathalyzer herself. Rather, by measuring this fundamental physical property, she and her colleagues are laying the technical groundwork for manufacturers to develop accurate devices.

While this research is an important step forward, more research will still be needed to understand how breath levels of THC correlate with blood levels, and what blood levels of THC indicate that a person is too impaired to drive.

What is Vapor Pressure?

Vapor pressure tells you how adventurous a molecule is. Even when they are in solid or liquid form, molecules are in a constant state of jiggly motion, and some will escape as a gas. Molecules with a high vapor pressure, such as ethyl alcohol, are constantly escaping. That's why when you open a bottle of whiskey, you can instantly smell the alcohol molecules that have collected in the air space beneath the cap.

Ethyl alcohol escapes so easily because it is a small molecule with a simple shape. But THC molecules are large and complex, with loops and spurs that cause them to stick together. This results in a very low vapor pressure—so low that you can't measure it the usual way, which would involve putting THC in a closed container and waiting for the pressure to equalize.

"You'd be waiting a very long time," Lovestead said.

A New Technique

The researchers overcame that obstacle by using a technology called PLOT-cryo—short for porous layer open tubular cryogenic adsorption. "PLOT-cryo is an extremely sensitive technique for capturing and analyzing things in the vapor phase," said Tom Bruno, a NIST research chemist and co-author of the study. "It was a natural candidate for this type of problem."

Bruno invented PLOT-cryo in 2009 for use with airport puffer machines that blow air onto passengers or luggage, then sniff the air for traces of explosives. At the time, existing technology could detect the explosive traces in the air, but could not precisely identify which compounds were present. PLOT-cryo solved that problem. The technology has since been used to sniff fire debris for evidence of arson and to find clandestine graves by following the faintest scent of decomposition.

PLOT-cryo is so sensitive that it can capture and analyze even the relatively few molecules of THC that escape into the vapor phase. In this experiment, the researchers used pure THC, purchased in compliance with a DEA research license. They swept an inert gas across the sample to capture escaping molecules, then chilled the gas to collect them (that's where the "cryo" part of the name comes from). By measuring the mass of the recovered molecules in a known volume and temperature of sweep gas, the researchers calculated the vapor pressure.

The researchers also calculated the vapor pressure of a second compound, cannabidiol, which is considered less psychoactive than THC.

Measurements are Fundamental

When it comes to alcohol breathalyzers, NIST helps ensure accurate results by manufacturing ampules of ethyl alcohol mixed to extremely precise concentrations. Police agencies use these as reference standards to calibrate their breathalyzers. This ensures that different devices used in different jurisdictions produce consistent results—something that's particularly important when guilt or innocence hangs in the balance.

Similarly, accurate vapor pressure measurements for THC will help ensure that marijuana breathalyzers are calibrated to a consistent standard.

"Fundamental measurements are the basis of standardization," Bruno said. "We're laying the foundation for the reliable systems of the future."

More information: Tara M. Lovestead et al. Determination of Cannabinoid Vapor Pressures to Aid in Vapor Phase Detection of Intoxication, *Forensic Chemistry* (2017). DOI: 10.1016/j.forc.2017.06.003

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