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Yuck! Your Breath Has Over 1200 Chemicals

Volatile organic chemicals (VOCs) are high up on the list of chemicals that people fear. They include hydrocarbons which vaporize easily, products from gasoline combustion and from evaporation of liquid fuels, solvents and organic chemicals such as those in some paints, cleaners, barbecue starter and nail polish remover. The list goes on and on, but guess what? We humans are walking, talking, breathing VOC polluters.

The medical community has long recognized that humans exhale volatile organic compounds (VOCs). The major VOCs in the breath of healthy individuals are isoprene (12 - 580 ppb), acetone (1.2 - 1,880 ppb), ethanol (13 - 1,000 ppb), methanol (160 - 2,000 ppb) and other alcohols as shown in Table 1. Minor components include pentane and higher aldehydes and ketones. Besides the compounds listed in Table 1, there are several others which appear to be present from 1 to 10 ppb in breaths, including 1,1,1-trichloroethane, butane, cis-and trans-2-butene, 2-hexene, n-butyl alcohol, isobutyl alcohol, capryl alcohol, methyl isobutyl ketone, butyl acetate, ethyl benzene, indene, pentanal and propanal.[1] Add heavy smoking and high occupational exposure to the mix and the list grows.

In the 18th century, the French chemist Antoine Lavoisier proved that the body produces carbon dioxide, emitted with each exhalation of breath (40,000 to 50,000 ppm). And in the early 1970s, Linus Pauling demonstrated that breath is a complex gas, containing well over 1,200 different compounds.[2]

Breath can reveal exposure to pollutants such as benzene and chloroform, providing a measure of internal dose that is missed by sampling polluted air. But it can also hold clues to our health, revealing much more than just what we ate for lunch.[3] It's long been known that some characteristics smells have been associated with certain diseases. The rotting apple odor of acetone can signal diabetes. A sulfurous smell can mean cirrhosis of the liver. Other odors can hint at lung infection, kidney disease or simple dental decay. However, as Amanda Schaffer reports, "Still, only recently have researchers begun to mine the elaborate chemical signature of breath to explore whether shifting patterns might be used diagnostically to detect conditions like lung cancer or tuberculosis. The most advanced test so far is one that

Table 1
Concentrations of Volatile Organic Compounds in Exhaled Human Breath*

Compound	Weighted Average	
	ppb**	ug/m^3
Acetaldehyde	18	35
Acetone	985	2,330
Butanone	16	47
1-Butene	63	140
Dimethyl sulfide	12	30
Ethanol	770	1,400
Ethyl acetate	17	62
Ethylene	23	26
Furan	14	39
Hexanal	11	45
Isoprene	210	590
Isopropanol	150	370
Methanol	330	430
Methyl ethyl ketone	10	29
Pentane	12	35
1-Pentene	21	60
n-Propanol	130	320

* J.D. Fenske and S.E. Paulson, *Journal of the Air & Waste Management Association*, **49**, 594 (1999).
** Parts per billion

can suggest whether heart transplant patients are rejecting their new organs. The technique, called the Heartsbreath test, received approval from the Food and Drug Administration in 2004. It bears a superficial resemblance to the Breathalyzer tests used by the police to test drivers for drunkenness, but it is 'a billion times more sensitive,' says Dr. Michael Phillips, developer of the Heartsbreath test."[2]

Volatile compounds in breath are produced by metabolic processes at various organs and places in the body, by bacteria in the gut or both. Nitric oxide is a particularly interesting and instructive example. It was detected as endothelium-derived relaxing factor (EDRF) and identified later as NO. These discoveries led to the award of the Nobel Prize in Physiology and Medicine in 1998. Nitric oxide arises in virtually all organs of mammals, and is, in particular, produced in the airways and the paranasal sinuses.[4] Nitric oxide can be used for therapeutic monitoring of asthma patients. Nine different alkanes (*e.g.*, 7-methyl-tridecane) have been identified as being important for detection of lung cancer patients.[5]

Capnography - real-time measurement of carbon dioxide - is the most widely used clinical breath test and provides important information on cellular metabolism, and pulmonary ventilation, critical to monitoring the "well-being" of a patient.[6]

Lung cancer is a leading cause of cancer death, with the prognosis adversely affected by late diagnosis. Early diagnosis of lung cancer is desirable, but current evidence does not support the application of screening with techniques such as chest radiography, sputum cytology or computed tomography. Breath analysis has been proposed as a non-invasive and simple technique to investigate neoplastic processes in the airways.[7] The analysis is done with a so-called electronic nose which is a newer version of a sensor that has been used in the food, wineand perfume industries. It is also being used as an aid against terrorism, to sniff out explosives or toxic chemicals in the air. The electronic nose responds to a given odor by generating a pattern, or "smell print," which is analyzed and compared with stored patterns. An electronic nose has been developed that can diagnose respiratory infections such as pneumonia by comparing smell prints from the breath of a sick patient with those of patients with standardized readings.[8]

Breath analysis also offers promise in diagnosing a number of other areas; pneumonia in critically ill, mechanically ventilated patients;[9] monitoring blood sugar levels in diabetes;[10] detecting damaging lung-bacteria growth seen in cystic fibrosis;[11] liver disease[12] and scleroderma.[13]

Summary

In modern medicine, diagnosis based on smells has been suppressed for many years as being subjective and unreliable. Due to new or improved analytical methodology, smell-based diagnostics is undergoing a revival. Having quantitative and very sensitive analytical methods at hand, it has become possible to develop smell-based medical diagnoses. Anton Amann predicts, "The fast development of analytical techniques will lead to reliable, miniaturized devices useful for the clinical practitioner in many medical fields in the next years."[4] P&SF

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