Fact or Fiction?

Jack W. Dini
1537 Desoto Way
Livermore, CA 94550
E-mail: jdini@comcast.net

Volatile Organic Compounds in Foods and Beverages

Many folks worldwide live in constant fear of chemicals. High up on the list are volatile organic compounds (VOCs), such as hydrocarbons which vaporize easily. VOCs come from gasoline combustion and from the evaporation of liquid fuels although emissions from cars and truck have declined by 73.8% since 1970.[1] Other sources of VOCs include solvents and organic chemicals, such as those in some paints, cleaners, barbecue starter and nail polish remover, some plants and some bacterial processes in soils. The smell of a pine forest comes from a VOC named alpha-pinene.[2]

Do you like the leathery, plasticky aroma that hits you when you slide behind the wheel of a new car? If so, you are enjoying a complex mixture of VOCs, primarily alkanes and substituted benzenes along with a few aldehydes and ketones.[3] VOCs have the potential for causing substantial human exposure from indoor uses of contaminated water by noningestion routes, namely, inhalation following volatilization from water. Measurements in homes have shown that VOCs can be detected in indoor air following the use of contaminated water.[4]

Neil Ryan and his colleagues report, "Public awareness of volatile compounds (VOCs) in drinking water has focused much media attention on their presence and potential health risks. Reports of solvent-contaminated groundwater in town water supplies have brought national attention to the problem. The SDWA (Safe Water Drinking Act) was amended in 1986, directing EPA to establish primary drinking water standards for 83 specific drinking water contaminants (including 22 volatile organic chemicals) and to increase monitoring for currently unregulated compounds."[5]

One could go on and on about VOCs and their potentially harmful effects. But here are little reported facts that you don't hear about: (1) we create VOCs and expel them via our breath and (2) foods and beverages are loaded with VOCs.

Let's look at our breath first. The medical community has long recognized that humans exhale VOCs. The major VOCs in the breath of healthy individuals are isoprene (12 to 580 ppb), acetone (1.2 to 1,880 ppb), ethanol (13 to 1,000 ppb), methanol (160 to 2,000 ppb) and a variety of other alcohols. Minor components include pentane and higher aldehydes and ketones.[6]

VOCs in food and beverages provide a flavor fingerprint that helps humans and animals recognize appropriate foods and avoid poor or dangerous food choices. More than 7000 flavor volatiles have been identified and catalogued from foods and beverages.[7] Here's a listing of the number of volatiles found in various foods and beverages - the number in parenthesis is the number of different VOCs in the item:

orange (203)
cheddar cheese (213)
banana (225)
butter (257)
baked potato (259)
raw mango (273)
apple (356)
roasted peanut (366)
heated chicken (381)
tomato (385)
grape (466)
boiled or cooked beef (486)
cognac (486)
cocoa (503)
black tea (541)
rum (550)
beer (562)
white wine (644) (790)[8]

Fleming-Jones and Smith analyzed foods over a five-year period (1996-2000) and found total VOC concentrations to range from 24 to 5,328 parts per billion (ppb).[9] They report: "Benzene was found in all foods except American cheese and vanilla ice cream. Benzene levels ranged up to 190 ppb, with the highest level found in fully cooked ground beef. Benzene was found (1 to 190 ppb) in samples of cooked ground beef, with an average of 40 ppb. Benzene levels about 100 ppb were also seen in at least one sample each of a cola (139 ppb), raw bananas (132 ppb) and cole slaw." Note that this compares to a maximum contaminant level of 5 ppb set by the EPA for drinking water.[9]

Goff and Klee observe, "The most abundant volatiles in tomato fruits are derived from catabolism of essential fatty acids. A second class of volatiles that contribute positively to tomato flavor is derived from the essential amino acids leucine, isoleucine and phenylalanine. A third class of tomato volatiles, the apocarotenoids, is derived from oxidative cleavage of carotenoids. Carotenoids have been reported to serve as antioxidants in the human diet and are implicated in many aspects of human health, although these benefits remain controversial.[7]

Do you enjoy a nice glass of wine? If so, do you realize that the bouquet and entry from a newly opened battle partly depends on the relative assortment of VOCs in the wine? Lund and Bohlmann note, "The most important grapevine compounds contributing to flavor are organic acids, proanthocyanidins (tannins), terpenoids (monoterpenoids, sesquiterpenoids and C13-norisoprenoids) and various precursors of aromatic aldehydes, esters and thiols detectable in finished wines."[10] Rocha and colleagues add, "Two white Portugal white wines had volatile contents of 199 and 188 ppm, respectively. Both varieties contained aliphatic and aromatic alcohols, terpenoids, esters, aliphatic acids and lactones."[11]

So what do we do about volatiles in foods and beverages. It looks like we ignore them. If these were synthetic products instead of being natural then all hell would break loose. A case in point is "environmental estrogens," so-called man-made chemicals in the environment that allegedly disrupt hormonal systems, causing every thing from infertility to cancer to attention deficit disorder.[12] What gets overlooked in the haste to blame man-made chemicals as "endocrine disrupters" is that many foods we routinely eat exhibit some of the same characteristics. Chocolate, garlic, celery, coffee, grapefruit, tea and cola have been shown to have antispermatogenic activity.[13] Theo Colborn's book, *Our Stolen Future*,[14] published in 1996, has had a strong impact on public and political interest in environmental risks associated with endocrine disrupters. Although Colborn beats the heck out of man-made chemicals, she skips mention of naturally-occurring foods except for sunflower seeds and oil. By contrast, Edwards[15] discloses that more than 300 plants, in 16 common families, contain estrogens that may bind with the receptors of humans or wildlife. Naturally-occurring estrogens abound in many cereals, legumes, fruits and tubers. He concludes, "The authors of *Our Stolen Future* could probably have developed more frightening endocrine disruption scenarios based on healthy human diets containing cereals, fruits and vegetables!" In effect, endocrine disrupters are all around us and we eat some of them every day in natural foods. Synthetic chemicals are a good whipping-boy to use when you want to excite the public and media, but it's best not to pick on everyday foods mankind has been eating for long periods of time.

So it's the same with volatiles in foods and beverages. These are natural products so its best to accept them for what they are. Thank Heavens they aren't synthetic because if they were we might be without items to eat and drink. ***P&SF***

References

1. Steven F. Hayward, *Index of Leading Environmental Indicators 2006*, Pacific Research Institute, San Francisco, CA, 2006; p. 49.
2. Jeannie Allen, "Chemistry in the Sunlight," *ChemMatters*, **21** (3), 22 (October 2003).
3. Steve Ritter, "New Car Smell," *Chemical & Engineering News*, **80** (20), 45 (May 20, 2002).
4. Julian B. Andelman, "Total Exposure to Volatile Organic Compounds in Potable Water," in *Volatile Compounds in Foods and Beverages*, Henk Maarse, Ed., Marcel Dekker, New York, NY, 1991.
5. *Significance and Treatment of Volatile Organic Compounds in Water Supplies*, Neil M. Ram, Russell F. Christman and Kenneth P. Cantor, Eds., Lewis Publishers, Chelsea, MI, 1990; p. v.
6. J. D. Fenske & S.E. Paulson, *J. Air & Waste Management Assoc.*, **49** (5), 594 (1999).
7. S.A. Goff & H.J. Klee, "Plant Volatile Compounds: Sensory Cues for Health and Nutritional Value?" *Science*, **311** (5762), 815 (February 10, 2006).
8. *Volatile Compounds in Foods and Beverages*, Henk Maarse, Ed., Marcel Dekker, New York, NY, 1991; p. 30.
9. M.E. Fleming-Jones & R.E. Smith, "Volatile Organic Compounds in Foods: A Five Year Study," *J. Agric. Food Chem.*, **51** (27), 8120 (2003).
10. S.T. Lund & J. Bohlmann, "The Molecular Basis For Wine Grape Quality - A Volatile Subject," *Science*, **311** (5762), 804 (February 10, 2006).
11. Silvia M. Rocha, *et al.*, "Effect of enzymatic aroma release on the volatile compounds of white wines presenting different aroma potentials," *J. Science of Food & Agriculture*, **85** (2), 199 (2005).
12. S.J. Milloy, "Junk Science: An Epidemic That Hurts Us All," *Environment & Climate News*, **1**, 20 (January 1998); http://www.heartland.org/Article.cfm?artId=13906
13. J.W. Dini, "Chocolate - Lots of Chemicals," *Plating & Surface Finishing*, **89** (1), 40 (2002).
14. T. Colborn, D. Dumanoski & J.P. Myers, *Our Stolen Future*, A Plume Book, New York, NY, 1996.
15. J.G. Edwards, *21st Century*, 52 (Fall 1996).

Editor's Note:* We would like to mention that Mr. Dini is having so much fun providing these columns that he is churning them out at a rate faster than we can publish them on a monthly basis. Indeed, he has created a blog at http://myblogscience.blogspot.com. If you wish to see more of Mr. Dini's provocative works that might not have appeared in *Plating & Surface Finishing, check it out.

Test Your Plating I.Q. #441

By Dr. James H. Lindsay

Vacuum Deposition by Sputtering

1. Is sputtering a "thermal" or "non-thermal" process? Why?
2. What means are used to generate the bombarding atoms / ions?
3. What is the most commonly used target geometry?
4. An unlimited range of source and film materials can be deposited by sputtering. True or false?
5. In magnetron sputtering, how is the rate of deposition increased?

Answers on page 20.