

# Determination of Tobacco Smoke Using VOC Markers

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Alice E. Delia, Ph.D., Robert D. Freeman, Ph.D.,  
Randall S. Fike, Ph.D., and Martin L. Spartz, Ph.D.

Prism Analytical Technologies, Inc.

# What is Tobacco Smoke?

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- Secondhand smoke or environmental tobacco smoke
  - the mixture of smoke generated by sidestream smoke, i.e., the burning end of tobacco products, and the mainstream smoke exhaled by smokers
- Third hand smoke or stale tobacco smoke
  - the smoke residue from surfaces, including the smoker, still present after smoking has ceased that has off-gassed into the air

# Hazards of Tobacco Smoke

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## 2006 US Surgeon General Report

### The Health Consequences of Involuntary Exposure to Tobacco Smoke

- Secondhand smoke causes premature death and disease in children and adults who do not smoke
- Children exposed to secondhand smoke are at an increased risk for sudden infant death syndrome (SIDS), acute respiratory infections, ear problems, and more severe asthma. Smoking by parents causes respiratory problems and slows long term growth in their children.
- Exposure of adults to secondhand smoke has immediate adverse effects on the cardiovascular system and causes coronary heart disease and lung cancer.
- The scientific evidence indicates that there is no risk-free level of exposure to secondhand smoke.
- Many millions of Americans, both children and adults, are still exposed to secondhand smoke. Separating smokers from nonsmokers, cleaning the air, and ventilating buildings cannot eliminate exposure of nonsmokers to secondhand smoke.

# Exposure

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- **Second hand smoke**
  - Being in vicinity of someone actively smoking
- **Third hand smoke**
  - Being in an area where smoking occurred in the past
- **Multi-unit locations**
  - Being in an office or residence (e.g., apartment, condo, hotel) where someone in a neighboring unit is smoking

# Regulatory Activity

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- **Tobacco use and smoking restrictions are strictly state and local issues**
- **Many public building, as well as restaurants and bars, have banned smoking indoors**
- **Portions of California implementing restrictions in multi-unit dwellings (e.g., apartments, condos, hotels, etc.)**

# Evolution of a Test

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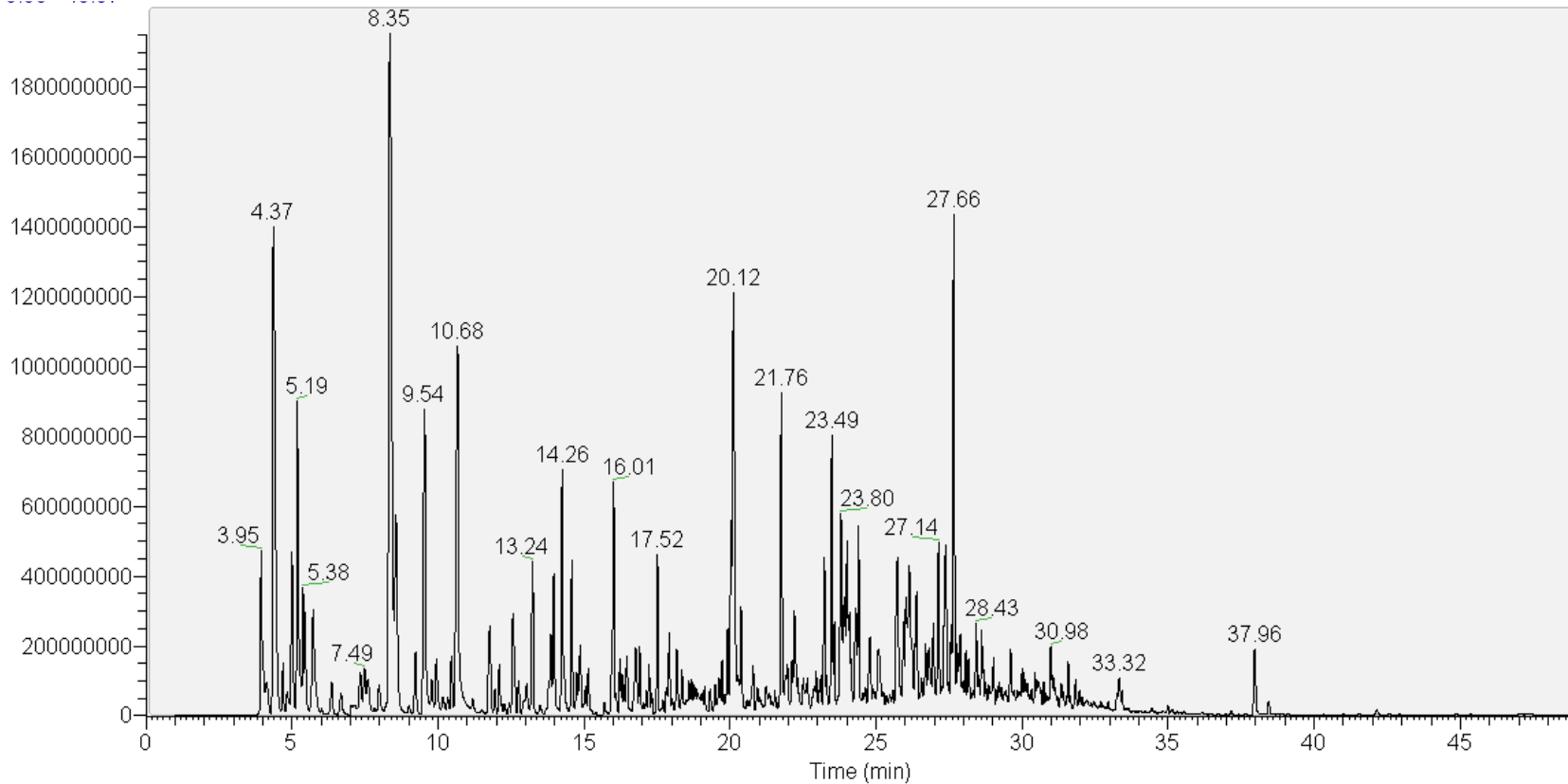
- **Applicability**
- **Literature search**
- **Test samples**
- **Determination of chemical markers**
- **Method development**
- **Data collection**

# Literature relating to Tobacco Smoke

- **Passive Monitoring Method for 3-Ethenylpyridine: A Marker for Environmental Tobacco Smoke, Environ. Sci. Technol. 2001, 35, 1818-1822.**
- **Composition and emissions of VOCs in main- and side-stream smoke of research cigarettes, Atmospheric Environment 41 (2007) 5371–5384.**
- **VOC and Particulate Emissions from Commercial Cigarettes: Analysis of 2,5-DMF as an ETS Tracer, Environ. Sci. Technol., 2008, 42, 1324-1331.**
- **Assessment of Environmental Tobacco Smoke Contamination in Public Premises: Significance of 2,5-Dimethylfuran as an Effective Marker, Environ. Sci. Technol., 2010, 44 (21), pp 8289-8294. DOI: 10.1021/es1016075**
- **The Chemical Constituents in Cigarettes and Cigarette Smoke: Priorities for Harm Reduction, A Report to the New Zealand Ministry of Health, March 2000.**
- **Determination of Volatile Organic Compounds for a Systematic Evaluation of Third-Hand Smoking, Analytical Sciences, 2010, Vol. 26, 569-574.**
- **The Health Consequences of Involuntary Exposure to Tobacco Smoke: A Report of the Surgeon General, U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2006.**
- **Does the Smoke Ever Really Clear: Thirdhand Smoke Exposure Raises New Concerns, Environmental Health Perspectives, 2011, Vol 119, No. 2, A71-A74.**
- **Effect of Sorption on Exposures to Organic Gases from Environmental Tobacco Smoke (ETS), Environmental Energy Technologies Division Lawrence Berkeley National Laboratory, 2002.**

# Initial Tobacco Smoke Results

- **Direct from cigarette (GC-MS)**





# Possible Tobacco Smoke Markers

- Furan
- 2-Methylfuran
- 2-Ethylfuran
- 2-Propylfuran
- Nicotine
- Cresol (m-, p-, o-)
- Vinyl acetate
- Acrylonitrile
- Acrolein
- Triacetin
- Phenol
- Propylene glycol
- Pyridine
- 3-Ethenylpyridine
- Dimethyltrisulfide
- Dimethyldisulfide
- 2,5-Dimethylfuran
- 2,5-Dihydrofuran
- Isoprene
- 1,3-Benzenediol (Resorcinol)
- 2-Furylmethylketone
- Acetamide
- Acrylamide
- 4-Vinylcyclohexene
- 2-Pyrrolidinone
- 1,3-Butadiene
- Formaldehyde
- 2,4-Heptadienal

# Method Development

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- **3 primary marker compounds selected**
  - Nicotine
  - 3-Ethenylpyridine
  - 2,5-Dimethylfuran
- **Few secondary sources**
- **Good GC-MS response**
  - Minimal interferences
  - Low detection limit
  - Good compound recovery

# Case Studies

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- **Case 1: Cigar Tavern**
  - Nicotine: 5.9 ng/L
  - 2,5-Dimethylfuran: 1.0 ng/L
  - 3-Ethenylpyridine: 16 ng/L
- **Case 2: Casino with smoke reduction technologies in place**
  - Nicotine: 5.2 ng/L
  - 2,5-Dimethylfuran: 0.4 ng/L
  - 3-Ethenylpyridine: 1.8 ng/L

# Case Studies Continued

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- **Case 3: Home of active smoker**
  - Nicotine: 3.7 ng/L
  - 2,5-Dimethylfuran: 0.2 ng/L
  - 3-Ethenylpyridine: 3.0 ng/L
- **Case 4: Home 2 months after occupant quit smoking**
  - Nicotine: 4.4 ng/L
  - 2,5-Dimethylfuran: 0.2 ng/L
  - 3-Ethenylpyridine: 0 ng/L

# Conclusions

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- **3 primary quantitative markers selected**
  - Nicotine (2-(1-methyl-2-pyrrolidinyl)pyridine)
  - 2,5-Dimethylfuran
  - 3-Ethenylpyridine (3-Vinylpyridine)
- **Tobacco smoke can be detected**
  - Current smoking activity
  - Past smoking activity
    - Residue remains for several months
  - Current smoking in adjacent locations
    - Variables can affect detection (amount and duration of smoking in neighboring unit, porosity of wall, air flow)
- **Tobacco smoke residue (third hand smoke) can linger for a long time**

# Future Development

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- **Focus on tobacco smoke from adjacent units in multi-unit dwellings**
- **Off gas or wipe testing for bulk materials or surfaces for third hand tobacco smoke residue**
- **Development of intensity scale for results**