VOLATOLOMICS – 2020 UPDATE

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INTRODUCTION

This IFCC Emerging Technology Division (ETD) is dedicated to providing current awareness for emerging technologies likely to have important clinical diagnostic applications in the near future. One of those technologies is volatolomics (breathomics) (*i.e.,* breath analysis).

This is the first update to the volatolomics survey (https://www.ifcc.org/media/478026/2019-06-volatolomics.pdf) and a further update is planned for 2021.

1. VOLATOLOMICS AND BREATH ANALYSIS IN THE NEWS

General

2019

Owlstone Medical Enters Partnership with Thermo Fisher Scientific to Advance Early Disease Detection Using Non-Invasive Breath Biopsy. Nov 7, 2019 Press release. https://www.owlstonemedical.com.

Clinical

2019

BOYDSense diabetes device places among top innovations at 2019 RESI Innovation Challenge. PR Newswire. Oct 29 2019. https://finance.yahoo.com/news/boydsense-diabetes-device-places-among-110000930.html.

Cleveland Clinic, Owlstone Medical Partner, Establish Early Disease Detection Center. 360 Dx. Oct 15 2019. https://www.360dx.com/cancer/cleveland-clinic-owlstone-medical-partner-establish-early-disease-detection-center#.Xkn37cLsbb0.

Ferguson SR. Breath Diagnostics, Mayo Clinic Laboratories Announce Collaboration to Develop New Diagnostic Test That Detects Lung Cancer Using Patients' Exhaled Breath. Mayo Clinic Laboratories. 2019. https://news.mayocliniclabs.com/2019/03/26/breath-diagnostics-mayo-clinic-laboratories-announce-collaboration-to-develop-new-diagnostic-test-that-detects-lung-cancer-using-patients-exhaled-breath/?linkId=65319564.

Iyer V. Owlstone, Actelion Team Up to Develop Breath-based Test for Diagnosing PH. Pulmonary Hypertension News. May 30 2019.

https://pulmonaryhypertensionnews.com/2019/05/30/owlstone-actelion-develop-breath-based-test-for-diagnosising-ph/.

Loeffler J. Scientists hope to develop breath test to detect multiple sclerosis. Interesting Engineering. July 25 2019. https://interestingengineering.com/scientists-hope-to-develop-breath-test-to-detect-multiple-sclerosis.

Mraz S. Portable breath analyzer spots deadly lung disease faster than doctors. Machine Design. Aug 2 2019. https://www.machinedesign.com/mechanical-motion-systems/article/21838016/portable-breath-analyzer-spots-deadly-lung-disease-faster-than-doctors.

Owlstone Medical to Contribute Breath Biopsy to 3TR, the Largest-ever IMI2 Immunology Project to Improve Disease Management Across Seven Immune-Mediated Diseases. 29 Oct 2019 Press release. https://owlstonemedical.com.

University of Manchester and Owlstone Medical Partner on £250,000 grant from asthma UK and innovate UK for asthma diagnostic development. Mar 7 2019. https://www.selectscience.net/industry-news/university-of-manchester-and-owlstone-medical-partner-on-250000-grant-from-asthma-uk-and-innovate-uk-for-asthma-diagnostic-development?artID=48693.

Blog/Press Release

2020

Dini J. Chemophopbia in Europe and elsewhere. Bios and Archives. Canada Free Press. Jan 22 2020. https://canadafreepress.com/article/chemophobia-in-europe-and-elsewhere.

Lo C. A nose for trouble: the bio-sensor aiming to sniff out disease. Verdict Medical Devices. Jan 22 2020. https://www.medicaldevice-network.com/features/biosensor-tech/.

MacDonald A., Lansdowne LE. Detecting the presence of cancer in patients' breath. Diagnostics from Technology Networks. Jan 15, 2020. https://www.technologynetworks.com/diagnostics/blog/detecting-the-presence-of-cancer-in-patients-breath-329256.

2019

Atmospheric chemists move indoors. C&EN Dec 4, 2019. https://www.acs.org/content/acs/en/pressroom/presspacs/2019/acs-presspac-december-4-2019/atmospheric-chemists-move-indoors.html.

Brackley P. University of Cambridge involved in £55m transatlantic alliance to research early detection of cancer. Cambridge Independent. Oct 21 2019. https://www.cambridgeindependent.co.uk/news/university-of-cambridge-involved-in-55m-transatlantic-alliance-to-research-early-detection-of-cancer-9086677/.

Breath-based tests could benefit from modeling of the underlying biology. News Medical Life Sciences. Sept 13, 2019. https://www.news-medical.net/news/20190913/Breath-based-tests-could-benefit-from-modeling-of-the-underlying-biology.aspx.

Breath biopsies 2019: a revolutionary approach for noninvasive diagnosis - researchandmarkets.com. Business Wire. Nov 22 2019. https://www.businesswire.com/news/home/20191122005194/en/Breath-Biopsies-2019-Revolutionary-Approach-Noninvasive-Diagnosis.

CORDIS. Sniffing out disease with smartphones. Medical Xpress. May 14 2019. https://medicalxpress.com/news/2019-05-sniffing-disease-smartphones.html.

Kant K. No finger pricks - New breath analyser to monitor blood sugar. Medical Dialogues. https://speciality.medicaldialogues.in/no-finger-pricks-new-breath-analyser-to-monitor-blood-sugar?infinitescroll=1.

Mumal I. Owlstone launches new generation of tools to support id of disease biomarkers on person's breath. Pulmonary Hypertension News. Sept 20 2019. https://pulmonaryhypertensionnews.com/2019/09/20/owlstone-medical-launches-new-generation-of-tools-to-id-disease-biomarkers-on-breath/.

Molloy F. Invention: a breath test to detect asthma, diabetes and lung cancer. The Lighthouse. Macquarie University. Aug 10 2019. https://lighthouse.mq.edu.au/article/august-2019/Invention-a-breath-test-to-detect-asthma,-diabetes-and-lung-cancer.

Optical Society. Sensitive new laser technique detects volatile organic compounds. Phys Org. June 3 2019. https://phys.org/news/2019-06-sensitive-laser-technique-volatile-compounds.html.

Vermeer J. Sniffing out respiratory disease through breath analysis (Spironose). Bits&Chips. Dec 5 2019. https://bits-chips.nl/artikel/sniffing-out-respiratory-disease-through-breath-analysis/.

Virginia Mason experts will assess esophageal cancer breath test. Neighbor News. Dec 17 2019. https://patch.com/rhode-island/cranston/virginia-mason-experts-will-assess-esophageal-cancer-breath-test.

2018

Ronson J. AerBetic announces wearable alert device for people with diabetes. LifePulseHealth. Dec 21 2018. https://www.aerbetic.com/news/2018/12/20/aerbetic-announces-wearable-alert-device-for-people-with-diabetes.

Webinars

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2. A-Z DIRECTORY OF COMPANIES ACTIVE IN THE CLINICAL DIAGNOSTIC APPLICATIONS OF VOLATOLOMICS (BREATH ANALYSIS)

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3. CLINICAL TRIALS

2019

Mesothelioma Early Detection by VOCs (MED-VOC), research study, June 5, 2019 – March 2022. https://clinicaltrials.gov/ct2/show/NCT04106973?term=%22malignant+mesothelioma%22#contacts.

PAN Cancer Early Detection Study. A study looking at breath samples to detect cancer early (PAN Cancer Early Detection Study). https://www.cancerresearchuk.org/about-cancer/find-a-clinical-trial/a-study-looking-at-breath-samples-to-detect-cancer-early-pan-cancer-early-detection-study.

4. ANALYZERS AND REGULATORY APPROVALS

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5. LITERATURE BY TOPIC – DIAGNOSTIC APPLICATIONS

5.1. ANALYZERS, SENSORS AND METHODS

Analyzers

2019

Amon N. PLOT-cryo: A high tech sniffing device. Labroots 2019. https://www.nist.gov/news-events/news/2019/09/can-high-tech-sniffer-help-keep-us-safe.

Geggel L. One breath into this breathalyzer can diagnose 17 diseases. Live Science. 2016. https://www.livescience.com/57345-breathalyzer-detects-17-different-diseases.html.

Iitani K, Toma K, Arakawa T, Mitsubayashi K. Transcutaneous blood VOC imaging system (Skin-Gas Cam) with real-time bio-fluorometric device on rounded skin surface. ACS Sens. 2019 Dec 24 - doi: 10.1021/acssensors.9b01658.

Mentana A, Camele I, Mang SM, De Benedetto GE, Frisullo S, Centonze D. Volatolomics approach by HS-SPME-GC-MS and multivariate analysis to discriminate olive tree varieties infected by *Xylella fastidiosa*. Phytochem Anal 2019;30:623-634. 2019 - doi: 10.1002/pca.2835. Epub 2019 Apr 24.

Tütüncü E, Mizaikoff B. Cascade laser sensing concepts for advanced breath diagnostics. *Anal Bioanal Chem* 2019;*411*;1679-86. doi: 10.1007/s00216-018-1509-5. Epub 2018 Dec 18.

Sensors

2019

Kovalska E, Lesongeur P , Hogan BT , Baldycheva A. Multi-layer graphene as a selective detector for future lung cancer biosensing platforms. Nanoscale 2019;11(5):2476-83.

2015

Knipp RJ , Li M, Fu X-A, Nantz MH. A versatile probe for chemoselective capture and analysis of carbonyl compounds in exhaled breath. Anal Methods 2015;7:6027.

Artificial intelligence

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Electronic nose

2020

Sturluson A, Sousa R, Zhang Y, Huynh MT, Laird C, York AHP et al. Curating metal-organic frameworks to compose robust gas sensor arrays in dilute conditions. ACS Appl Mater Interfaces 2020;12:6546-64.

2019

Arakawa, T., Suzuki, T., Tsujii, M., Iitani, K., Chien, P. J., Ye, Toma K, Iwasaki Y, Mitsubayashi K. Real-time monitoring of skin ethanol gas by a high-sensitivity gas phase biosensor (bio-sniffer) for the non-invasive evaluation of volatile blood compounds. Biosens Bioelectron 2019;129:245-53.

Iitani K, Toma K, Arakawa T, Mitsubayashi K. Ultrasensitive sniff-cam for biofluorometric-imaging of breath ethanol caused by metabolism of intestinal flora. Anal Chem 2019;91(15):9458-65.

Immunoassay

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Mass Spectrometry

2019

Klein C (on behalf of Agilent Technologies, Inc). Recent Advances to Conquer Analytical Challenges with High-Resolution, Accurate Mass Spectrometry. Chromatography Today. Nov 28, 2019. https://www.chromatographytoday.com/article/bioanalytical/40/agilent-technologies-inc/recent-advances-to-conquer-analytical-challenges-with-high-resolution-accurate-mass-spectrometry/2656.

Nanotechnology

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Surface-Enhanced Raman Scattering

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5.2. APPLICATIONS

Acetone Testing

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Allergy

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Animal Studies

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Antioxidants

2020

Bourgou S, Bettaieb Rebey I, Dakhlaoui S, Msaada K, Saidani Tounsi M, Ksouri R, Fauconnier ML, Hamrouni-Sellami I. Green extraction of oil from *Carum carvi* seeds using bio-based solvent and supercritical fluid: Evaluation of its antioxidant and anti-inflammatory activities. Phytochem Anal 2020;31(1):37-45.

Asthma

2019

Azim A, Barber C, Dennison P, Riley J, Howarth P. Exhaled volatile organic compounds in adult asthma: a systematic review. Eur Respir J 2019;54(3) pii: 1900056.

Cancer

2019

Amor, R. E., Nakhleh, M. K., Barash, O, Haick, H. Breath analysis of cancer in the present and the future. Eur Respir Rev 2019;28(152): pii: 190002.

Cao Y, Li C, Li L. Clinical Application of Volatile Organic Compound-Based Exhaled Breath Tests for Cancer Diagnosis. JAMA Oncol 2019;5(7):1068-9.

Breast cancer

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Colorectal cancer

2019

Francis NK, Curtis NJ, Salib E, de Lacy Costello B, Lemm NM, et al. Feasibility of perioperative volatile organic compound breath testing for prediction of paralytic ileus following laparoscopic colorectal resection. Colorect Dis 2019;22:86-94.

van Keulen KE, Jansen ME, Schrauwen RW, Kolkman JJ, Siersema PD. Volatile organic compounds in breath can serve as a non-invasive diagnostic biomarker for the detection of advanced adenomas and colorectal cancer. Aliment Pharmacol Ther 2019;51:334-6.

Gastric cancer

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Head-and-neck cancer

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Lung cancer

2019

Antoniou SX , Gaude E, Ruparel M, van der Schee MP, Janes SM, Rintoul RC; The LuCID Group. The potential of breath analysis to improve outcome for patients with lung cancer. J Breath Res 2019;13:034002.

de Vries R, Muller M, van der Noort V, Theelen WSME, Schouten RD, et al. Prediction of response to anti-PD-1 therapy in patients with non-small-cell lung cancer by electronic nose analysis of exhaled breath. Ann Oncol 2019;10:1660-6.

Hanna GB, Boshier PR, Markar SR, Romano A. Accuracy and methodologic challenges of volatile organic compound-based exhaled breath tests for cancer diagnosis: A systematic review and meta-analysis. JAMA Oncol 2019;*5*:e182815-e182815.

Kovalska E, Lesongeur P , Hogan BT , Baldycheva A. Multi-layer graphene as a selective detector for future lung cancer biosensing platforms. Nanoscale 2019;11:2476-83.

Lange J, Eddhif B, Tarighi M, Garandeau T, Péraudeau E, et al. Volatile organic compound-based probe for induced volatolomics of cancers. Angew Chem Int Ed Engl 2019;58:17563-6.

Phillips M, Bauer TL, Pass HI. A volatile biomarker in breath predicts lung cancer and pulmonary nodules. J Breath Res 2019;13:036013.

2018

Serasanambati M, Broza YY, Marmur A, Haick H. Profiling single cancer cells with volatolomics approach. iScience 2018;11:178-88.

2015

Li M, Yang D, Brock G, Knipp RJ, Bousamrad M, Nantz MH, Fua X-A. Breath carbonyl compounds as biomarkers of lung cancer. Lung Cancer 2015;90:92–7.

2014

Bousamra M, Schumer E, Li M, Knipp RJ, Nantz MH, et al. Quantitative analysis of exhaled carbonyl compounds distinguishes benign from malignant pulmonary disease. J Thorac Cardiovasc Surg. 2014;148:1074-81.

Mesothelioma

2020

Brusselmans L, Arnouts L, Millevert C, Vandersnickt J, van Meerbeeck JP, Lamote K. Exhaled Breath Analysis in Diagnosis of Malignant Pleural Mesothelioma: Systematic Review. Int J Environ Res Public Health. 2020;17(3);1110.

Oesophageal cancer

2018

Markar SR, Wiggins T, Antonowicz S, Chin ST, Romano A, Nikolic K., et al. Assessment of a noninvasive exhaled breath test for the diagnosis of oesophagogastric cancer. JAMA Oncol. 2018:1;4:970-6.

Ovarian cancer

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Pancreatic cancer

2019

Uslu HI, Dölle AR, Dullemen HM, Aktas H, Kolkman JJ, Venneman NG. Pancreatic ductal adenocarcinoma and chronic pancreatitis may be diagnosed by exhaled-breath profiles: a multicenter pilot study. Clin Exp Gastroenterol 2019;12:385-90.

2018

Markar SR, Brodie B, Chin S-T, Romano A, Spalding D, Hanna GB. Profile of exhaled-breath volatile organic compounds to diagnose pancreatic cancer. BJS 2018. DOI: 10.1002/bjs.10909.

Prostate cancer

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Chemical Sensibility Disorder

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Cystic Fibrosis

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Cytokines

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Diabetes

2019

Yazbeck R, Jaenisch S, Squire M, Abbott CA, Parkinson-Lawrence E, et al. Development of a 13c stable isotope assay for dipeptidyl peptidase-4 enzyme activity a new breath test for dipeptidyl peptidase activity. Sci Rep 2019;9:4906.

Dementia

2019

Orr ME, Reveles KR, Yeh CK, Young EH, Han X. Can oral health and oral-derived biospecimens predict progression of dementia? Oral Dis 2019; doi: 10.1111/odi.13201.

Environmental Health Science

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Exhaled Breath Condensate

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Exhaled Particles

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Food technology

2019

Mentana A, Conte A, Del Nobile MA, Quinto M, Centonze D. Volatile organic compound data of ready-to-cook tuna fish-burgers: Time evolution in function of different and/or combined mild preservation technologies and relevant statistical analysis. Data Brief. 2019;25:104371.

Forensics

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Gastric Emptying

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Genetics

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Heart Failure

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Hematology

2019

Hamilton BK, Rybicki LA, Grove D, Ferraro C, Starn J., et al. Breath analysis in gastrointestinal graft-versus-host disease after allogeneic hematopoietic cell transplantation. Blood Adv 2019;3:2732-7.

Inflammation

2019

Longo V, Forleo A, Capone S, Scoditti E, Carluccio MA, et al. In vitro profiling of endothelial volatile organic compounds under resting and pro-inflammatory conditions. Metabolomics 2019;15:132.

Inflammatory Bowel Disease

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Infectious Diseases

2019

van Oort PM, Brinkman P, Slingers G, Koppen G, Maas A, et al. Exhaled breath metabolomics reveals a pathogen-specific response in a rat pneumonia model for two human pathogenic bacteria: a proof-of-concept study. Am J Physiol Lung Cell Mol Physiol 2019;316;L751-6.

Helicobacter pylori

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Influenza

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Malaria

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Tuberculosis

2019

Saktiawati AMI, Stienstra Y, Subronto YW, Rintiswati N, Sumardi., et al. Sensitivity and specificity of an electronic nose in diagnosing pulmonary tuberculosis among patients with suspected tuberculosis. PLoS One 2019 Jun 13;14:e0217963.

Liver Disease

2019

Germanese D, Colantonio S, D'Acunto M, Romagnoli V, Salvati A, Brunetto M. An E-nose for the monitoring of severe liver impairment: A preliminary study. Sensors 2019;19:3656.

Nitric oxide testing

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Parkinson's Disease

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Pregnancy

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Pulmonary Disease

2019

Hashoul D, Haick, H. Sensors for detecting pulmonary diseases from exhaled breath. Eur Respir Rev 2019;28:190011.

Chronic Obstructive Pulmonary Disease (COPD)

2020

Rodríguez-Aguilar M, León-Martínez LD, Gorocica-Rosete P, Pérez Padilla R, Thirión-Romero I., et al. Identification of breath-prints for the COPD detection associated with smoking and household air pollution by electronic nose. Resp Med 10.1016/j.rmed.2020.105901.

2019

Rodríguez-Aguilar M., Ramírez-García S., Ilizaliturri-Hernández C. et al. Ultrafast gas chromatography coupled to electronic nose to identify volatile biomarkers in exhaled breath from chronic obstructive pulmonary disease patients: A pilot study. Biomedical Chromatogr 2019. doi: 10.1002/bmc.4684.

van Velzen P, Brinkman P, Knobel HH, et al. Exhaled breath profiles before, during and after exacerbation of COPD: a prospective follow-up study [published online October 7, 2019]. COPD. doi:10.1080/15412555.2019.1669550.

Pulmonary Embolism (PE)

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Systemic Sclerosis

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Therapeutic/Gamma Irradiation

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Toxicology

2020

Cruz R, Palmeira JD, Martins ZE, Faria MA, Ferreira H, et al. Multidisciplinary approach to determine the effect of polybrominated diphenyl ethers on gut microbiota. Environ Pollut 2020;260:113920.

2019

Hidalgo K, Ratel J, Mercier F, Gauriat B, Bouchard P, Engel E. Volatolomics in Bacterial Ecotoxicology, A novel method for detecting signatures of pesticide exposure? Front Microbiol 2018;9:3113.

Transplantation

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5.3. PRACTICE GUIDELINE

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5.4. REVIEWS, BOOKS & OPINIONS

2019

Broza YY, Zhou X, Yuan M, Qu D, Zheng Y, Vishinkin R, Khatib M, Wu W, Haick H. Disease detection with molecular biomarkers: from chemistry of body fluids to nature-inspired chemical sensors. Chem Rev 2019;119:11761-817.

Gaude E, Nakhleh MK, Patassini S, Boschmans J, Allsworth M, et al. Targeted breath analysis: exogenous volatile organic compounds (EVOC) as metabolic pathway-specific probes. J Breath Res 2019;13:032001.

Giannoukos S, Agapiou A, Brkić B, Taylor S. Volatolomics: A broad area of experimentation. J Chromatogr B Analyt Technol Biomed Life Sci. 2019;1105:136-47.

2018

Pennazza G, Marco Santonico M. Breath Analysis. New York;Academic Press, 1st Edn, 2018, 212pp.

Wallace AG, Pleil JD. Dataset of breath research manuscripts curated using PubMed search strings from 1995–2016. Data in Brief 2018;18:1711–24.

2017

Lawal O, Ahmed WM, Nijsen TME, Goodacre R, Fowler SJ. Exhaled breath analysis: a review of 'breath-taking' methods for off-line analysis. Metabolomics 2017;13:110. doi: 10.1007/s11306-017-1241-8.

5.5. SPECIMENS, COLLECTION AND SAMPLING

Concentrators

2013

Li M, Biswas S, Nantz MH, Higashi RM, Fu X-A. A microfabricated preconcentration device for breath analysis. Sens Actuators B180 2013;180:130–6.

Confounding factors

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Stability

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Standardization

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Technical standards

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Validation

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