The application of ESPT ionization technology on VOC biomarkers

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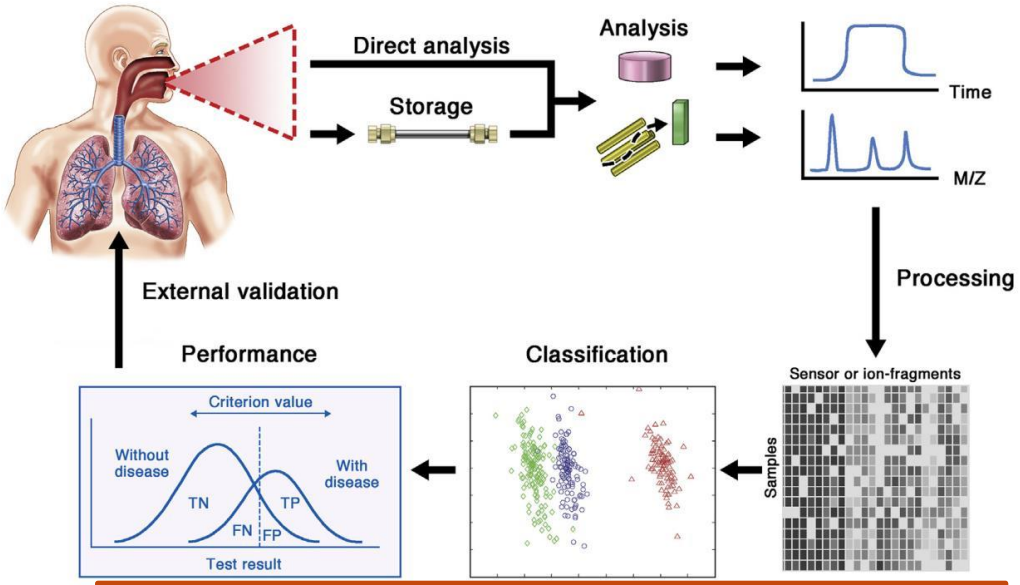
1. Traditional methods and limitations

Traditional methods:

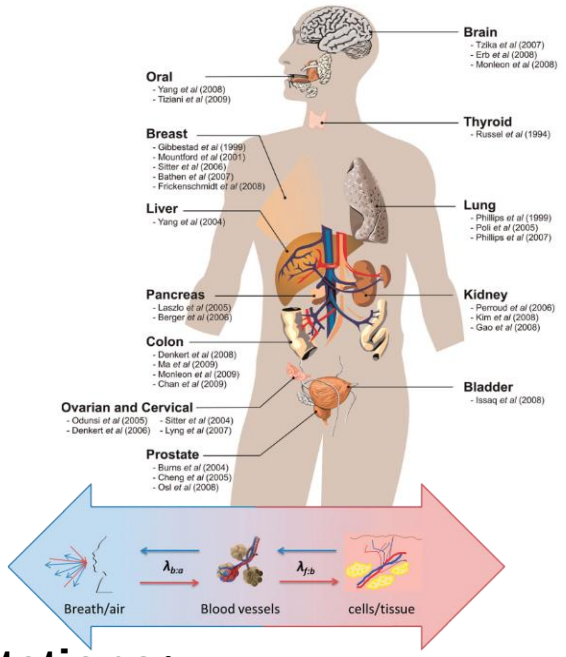
GC-MS, PTR-MS, SIFT-MS, Sensors, etc.

Data processing, Model building & optimization

Physiological assessment & Diagnosis



Demand for: Ultrahigh-Sensitivity Analysis technology

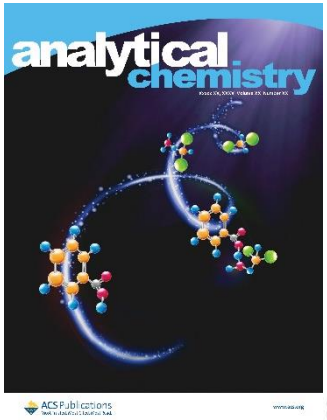


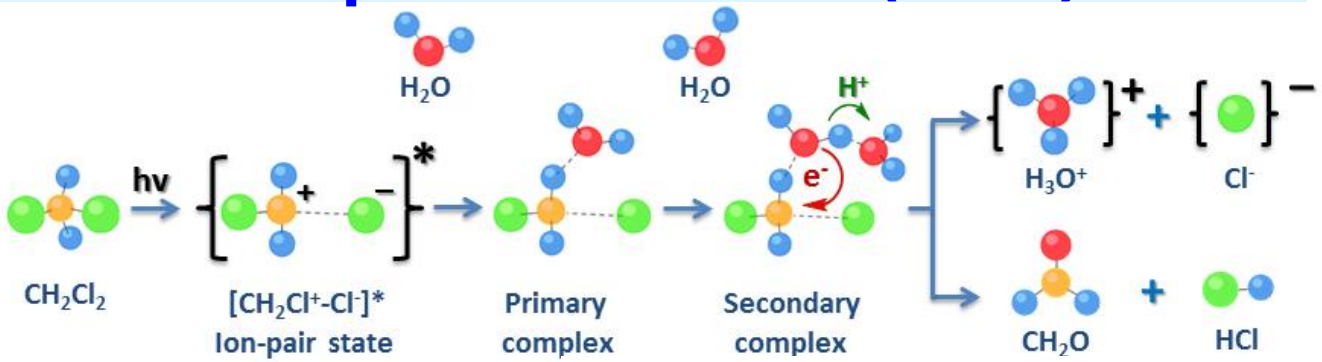
Limitations:

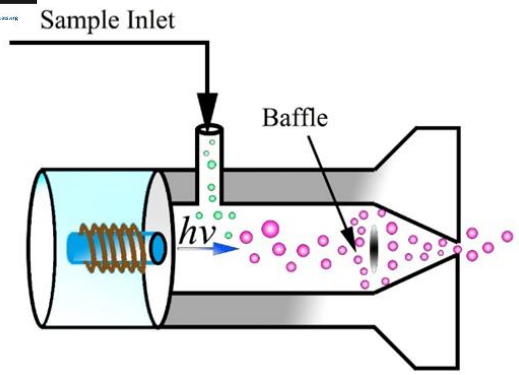
1. Without standard method for on-line detection of VOC biomarkers;
2. Exploring more potential VOC biomarkers limited by the performance of instruments;
3. Hard to detect OVOCs, which have higher blood-gas distribution coefficients ($\lambda_{blood/air}$);

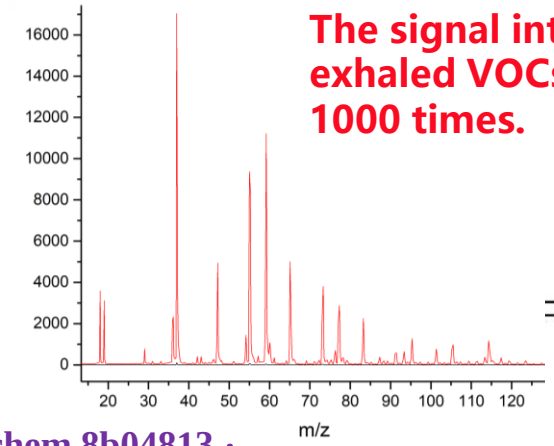
2. Noninvasive assessment based on ESPT technology

Mechanism of the new ionization process: Excited state proton transfer (ESPT)

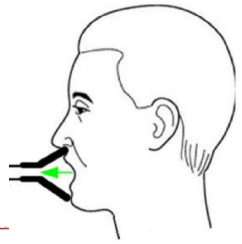








The signal intensities of exhaled VOCs enhanced about 1000 times.



Analytical Chemistry, 2019, DOI：10.1021/acs.analchem.8b04813 ;
Analytical Chemistry, 2018, 90 (2), pp 1301–1308 ; *Scientific Reports* 2016, 6, 36820.

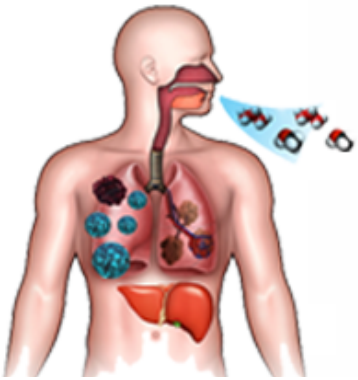
Through VUV excitation, a chemi-ionization reaction occurred to produce substantial H_3O^+ ions and the protonated analyte, and an equal amount of Cl^- can be produced with the aid of the reorganization energy released from the formation of CH_2O and HCl.

2. Noninvasive assessment based on ESPT technology

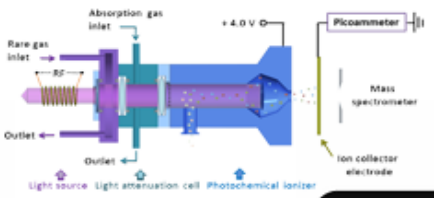
The sensitivity for VOC biomarkers is at least 20 times higher than PTR-MS, for OVOC is as higher as 2 order of magnitude.

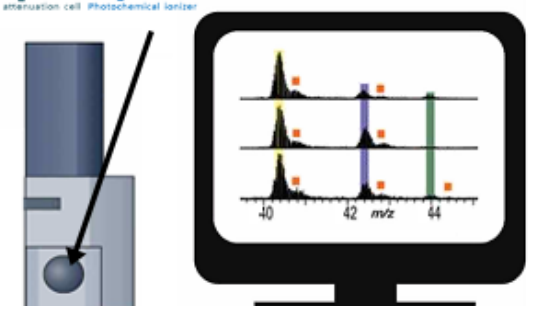


Volunteer



Online breath detection

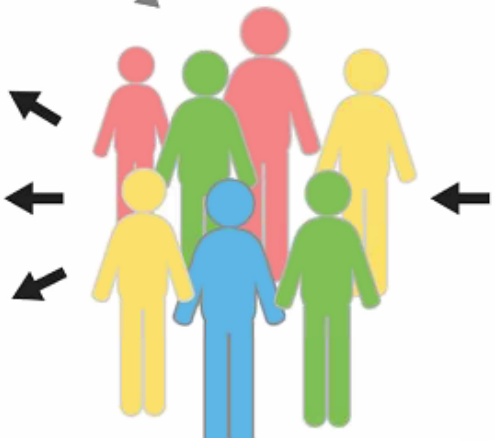




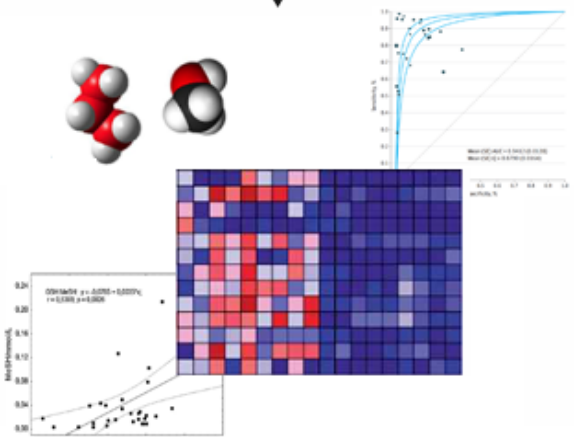
Ultrahigh-Sensitivity Analysis of VOC biomarkers



Precision & personalized Medicine



Physiological assessment & Diagnosis



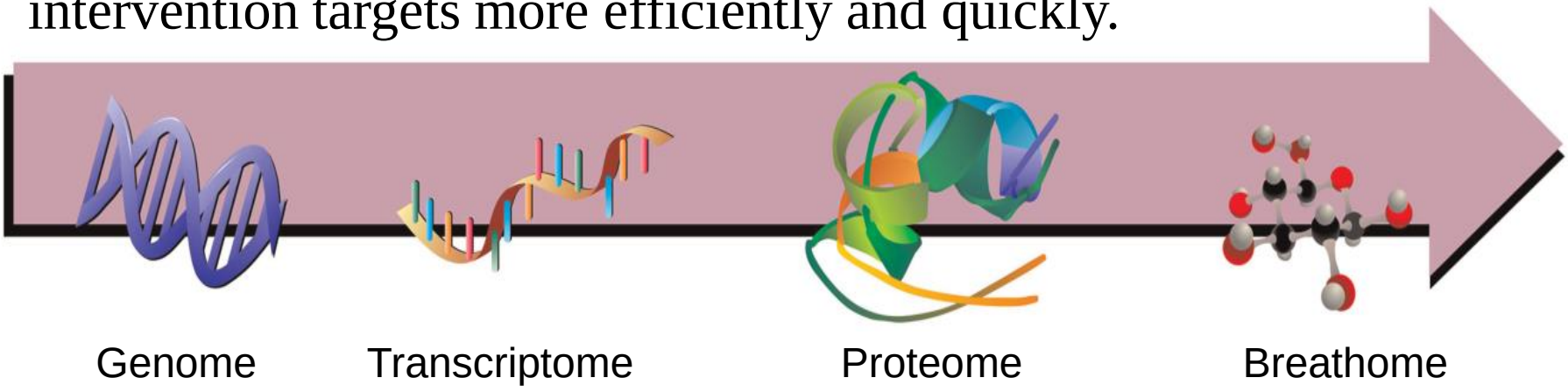
VOCs exhalation pattern analysis and prediction

3. Significance

1. On-line detection of VOC biomarkers based on the new ionization technology breaks through the constraints of the prior art, and will solve many problems of precision medicine；

2. Develop new methods for noninvasive，rapid and accurate detection of diseases, early diagnosis and prognosis based on medicine and omics;

3. Clarify more potential VOC biomarkers, open up connections between multiple omics, and discover other molecular markers and intervention targets more efficiently and quickly.



4. Publications and instruments

1. Jingyun Huang, Bo Yang*, Jinian Shu*, Zhen Li , et al. Kinetic Understanding of the Ultrahigh Ionization Efficiencies (up to 28%) of Excited-State CH2Cl2-Induced Associative Ionization: A Case Study with Nitro Compounds , Analytical Chemistry, 2019, DOI：10.1021/acs.analchem.8b04813.
2. Bo Yang, Haixu Zhang, Jinian Shu*, Zhen Li , et al. A VUV-excited and CH_2Cl_2/H_2O-amplified ionization-coupled mass spectrometry for oxygenated organics analysis, Analytical Chemistry, 2018, 90 (2), pp 1301－1308.
3. Zhen Li, Ce Xu, Jinian Shu* , et al. Detection of sub-pptv benzene, toluene, and ethylbenzene via low-pressure photoionization mass spectrometry, Analytica Chimica Acta 964 (2017) 134-141.
4. Zhen Li, Ce Xu, Jinian Shu* , et al Doping-assisted low-pressure photoionization mass spectrometry for the real-time detection of lung cancer-related volatile organic compounds, Talanta 165 (2017) 98－106.
5. Jinian Shu*, Yao Zou, Ce Xu, Zhen Li. Protonation enhancement by dichloromethane doping in low-pressure photoionization, *Sci. Rep*. 6, 36820 (2016).
6. Li Z, Shu J, Zhang P, et al. Real-time ultrasensitive VUV-PIMS detection of representative endogenous volatile markers in cancers. Cancer Biomarkers, 2016, 16(3):477-487.
7. Z Li, J Shu, B Yang, et al. Evaluating the relationship between cell viability and volatile organic compound production following DMSO treatment of cultured human cells. Pharmazie, 2016, 71(12):727.



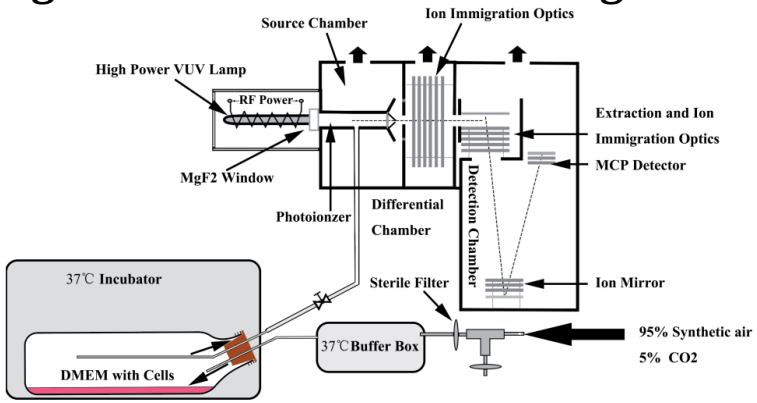
5. Related pre-experiments

Pre-Experiment 1:
Sampling influence factors

1. Storage time: 0 h-72 h
2. Temperature: 37℃ / 0℃

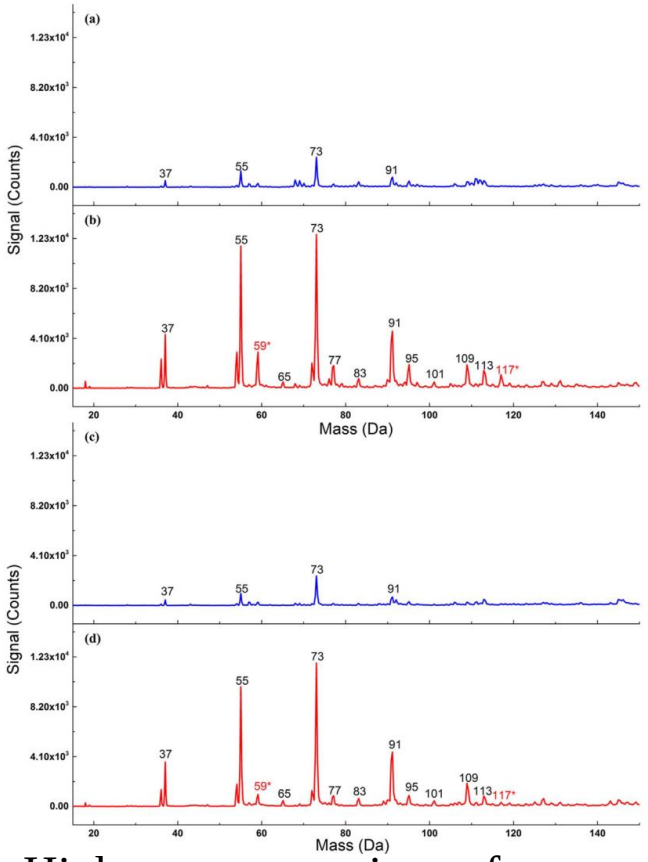
Result: Pre-heated is needed; storage time and temperature have no significant effects.

Pre-Experiment 2:
Distinguish cancer cells from benign cells



Result: Based on the ultrahigh-sensitivity analysis technology and machine learning, diagnosis accuracy >95%.

Pre-Experiment 3:
Distinguish smokers from non-smokers



Result: Higher concentrations of acetone in the breath of smokers.
A consequence of the higher oxidation rate of fatty acids derived from tobacco stress.



Thanks for your attention

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