Development of a Membrane Inlet Mass Spectrometry-Based Strategy for Environmental Monitoring

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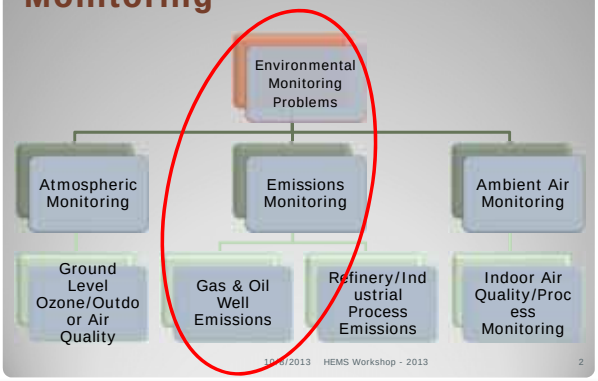
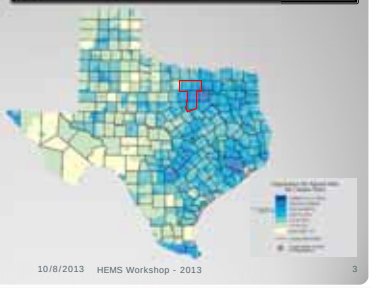
Breadth of Environmental Monitoring



Oil and Gas Well Drilling in DFW

- Increased urban drilling presence has raised environmental impact concerns
- NOAA led studies have shown that wells emit more fugitive effluent than previously estimated

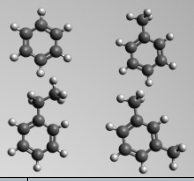


Potential Environmental Impacts

Emissions to be Monitored

BTEX emissions are of great concern to citizens living in the vicinity of urban oil and gas drilling processes

OSHA PEL: Benzene: 1.0 ppmv
Toluene: 200 ppmv
Ethylbenzene: 100 ppmv
Xylenes: 100 ppmv

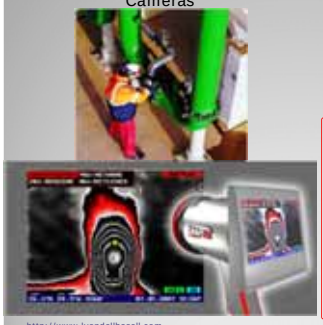


Region	Number of Sites Tested	% of Sites with Visible Emissions
Dallas/Ft. Worth	12	100
Amarillo	17	95
Midland	150	100
Houston	46	90
Corpus Christi	25	95

http://www.tceq.texas.gov/airquality/barnettshale/bshale-faq

Current Monitoring Technologies

Infrared Emission Cameras



Advantages

- Rapid detection of fugitive effluent
- Point and shoot efficiency
- Avoid lengthy training periods

Disadvantages

- Short battery life
- No remote monitoring
- Limited number of emissions can be monitored
- TCEQ claims these cameras are not selective and cannot quantitate

http://www.lyondellbasell.com
http://www.smartldar.com/

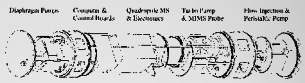
Fugitive Effluent

http://www.tceq.texas.gov/publications/pd/020/2012-NaturalOutlook/making-air-emissions-visible

Proposed Solution

http://www.inficongasanalyzers.com/en/transpectorCPMprocessmonitor.html

- ❑ Inficon Compact CPM 0-300 amu
- ❑ Custom Built Membrane Inlet
- ❑ Static gas dilutions of analytes of interest to determine levels of detection
- ❑ Compare those levels of detection to OSHA PEL levels

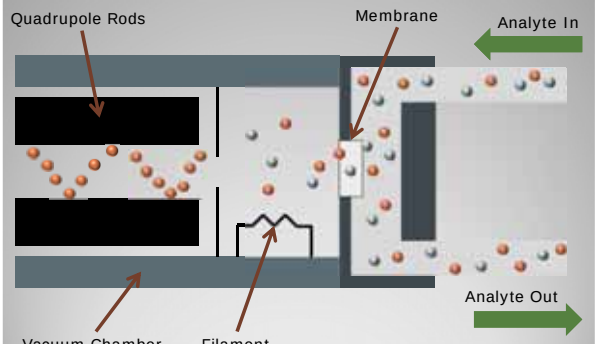


R. T. Short, D. P. Fries, M. L. Kerr, C. E. Lembke, S. K. Toler, P. G. Wenner, and R. H. Byrne, J. Am. Soc. Mass Spectrom., 2001, 12, 676–682.

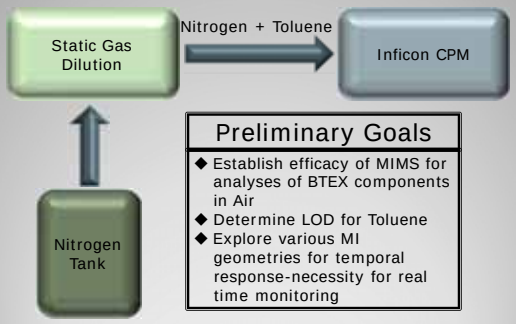
Inficon CPM

Linear Quad PPA/RGA

MIMS



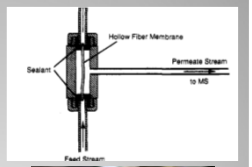
Instrumental Workflow

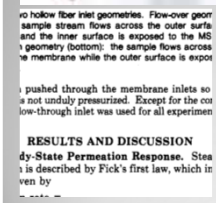


Preliminary Goals

- Establish efficacy of MIMS for analyses of BTEX components in Air
- Determine LOD for Toluene
- Explore various MI geometries for temporal response-necessity for real time monitoring

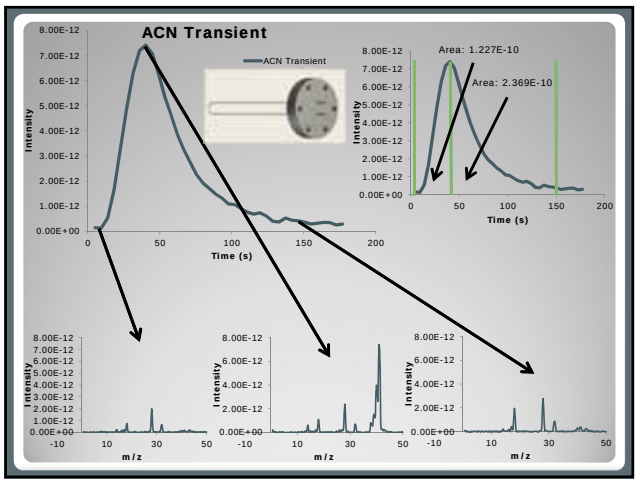
Membrane Inlet Geometries

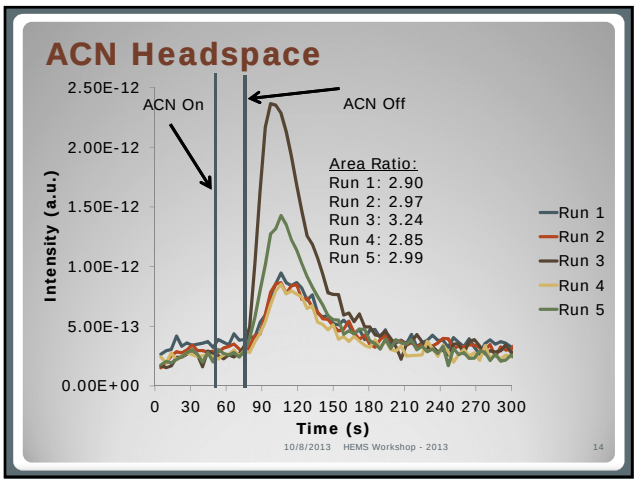




RESULTS AND DISCUSSION

LaPack, M. A.; Tou, J. C.; Enke, C. G. Anal. Chem. 1990, 62, 1265–1271.


ACN Transient
ACN Transient
Area: 1.227E-10
Area: 2.369E-10
Intensity
Time (s)
m/z


ACN Headspace
ACN On
ACN Off
Area Ratio:
Run 1: 2.90
Run 2: 2.97
Run 3: 3.24
Run 4: 2.85
Run 5: 2.99
Intensity (a.u.)
Time (s)
Run 1
Run 2
Run 3
Run 4
Run 5
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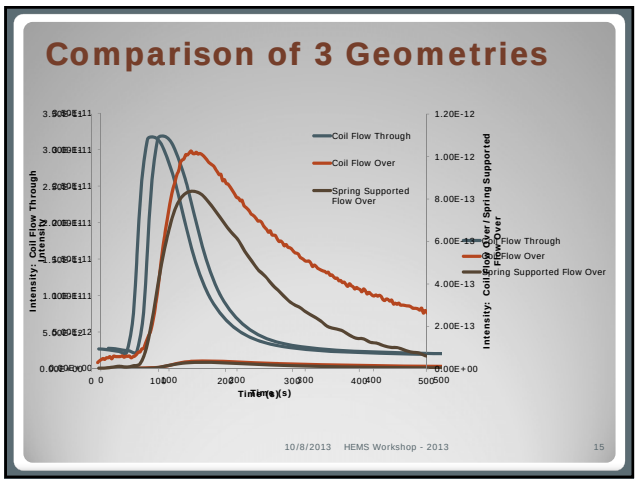
Comparison of 3 Geometries
Coil Flow Through
Coil Flow Over
Spring Supported Flow Over
Intensity: Coil Flow Through
Intensity: Coil Flow Over / Spring Supported Flow Over
Time (s)
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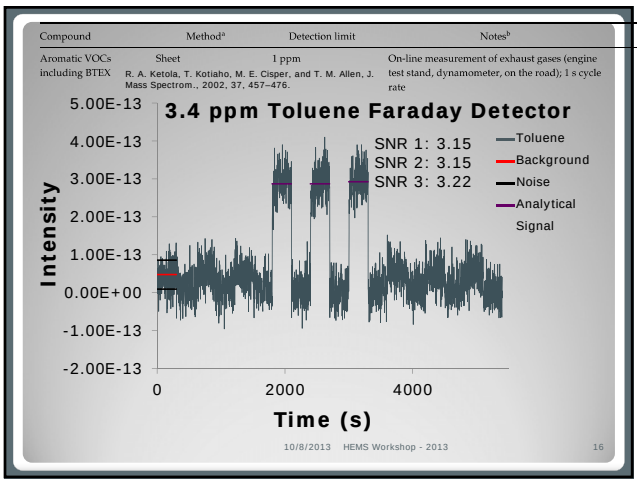
Compound
Method[a]
Detection limit
Notes[b]
Aromatic VOCs including BTEX
Sheet
R. A. Ketola, T. Kotiaho, M. E. Cisper, and T. M. Allen, J. Mass Spectrom., 2002, 37, 457–476.
1 ppm
On-line measurement of exhaust gases (engine test stand, dynamometer, on the road); 1 s cycle rate
3.4 ppm Toluene Faraday Detector
SNR 1: 3.15
SNR 2: 3.15
SNR 3: 3.22
Toluene
Background
Noise
Analytical Signal
Intensity
Time (s)
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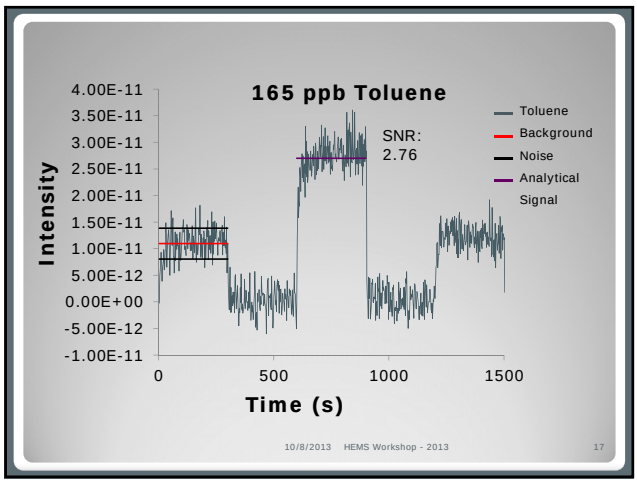
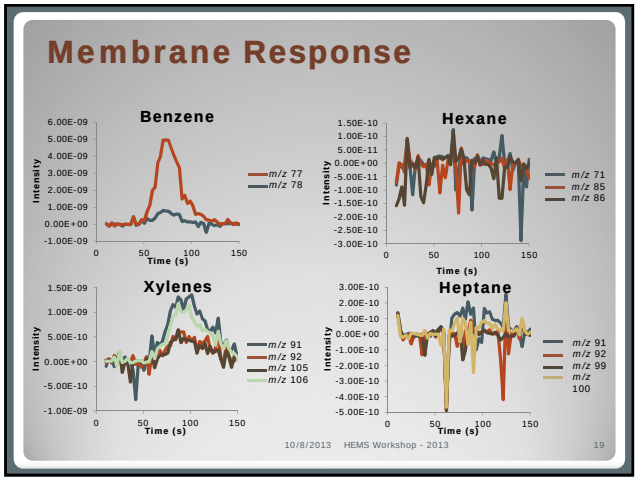
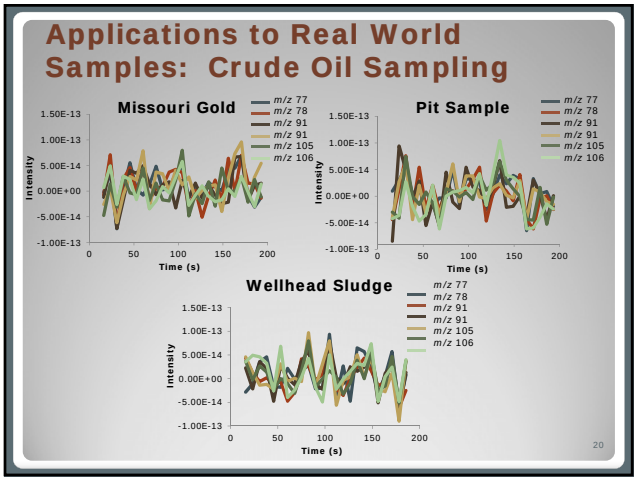


Volume Equivalents at LOD

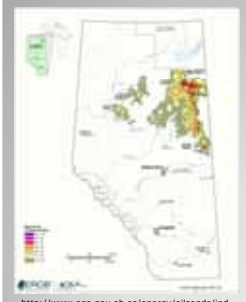
Compound	Minimum Measured Leak Rate (g/hr)	Volume Equivalent at OSHA PEL (m^3)
Benzene	3.5	1005.7
Toluene	3.8	4.6
Ethylbenzene	1.5	3.2
Xylenes	1.9	4.0
Compound	**Minimum Measured Leak Rate (g/hr)**	**Volume Equivalent at Inficon CPM LOD (m^3)**
Benzene	3.5	6095.5
Toluene	3.8	5610.9
Ethylbenzene	1.5	1922.3
Xylenes	1.9	2434.9

http://www.tceq.texas.gov/airquality/barnettshale/bshale-faq

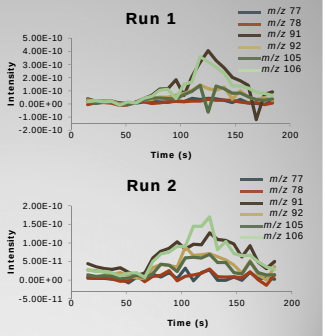




Applications to Real World Samples: Athabasca Oil Sands

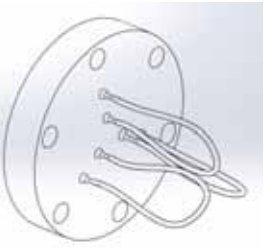


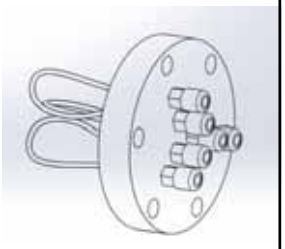
http://www.ags.gov.ab.ca/energy/oilsands/index.html#.UGSVofI250M



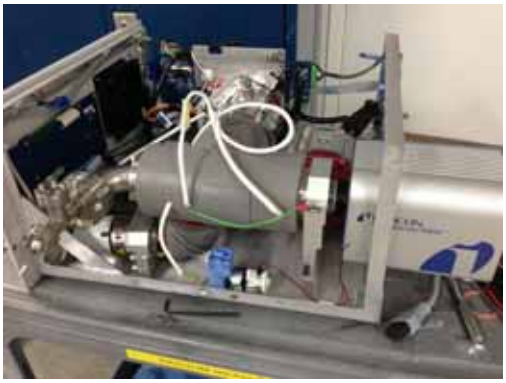
INFICON Rack Mount MIMS Eng Prototype w/ MPH

Acknowledgement: Jaime Winfield and Les Volles, INFICON Inc

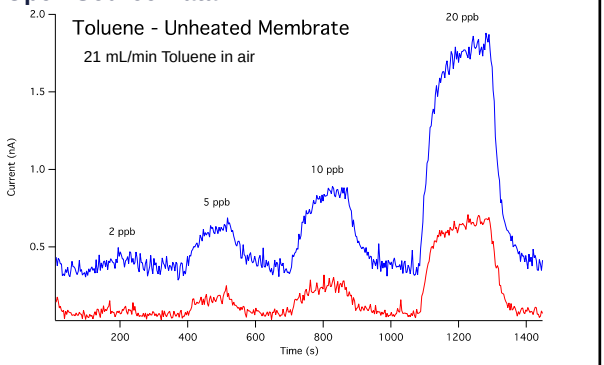




INFICON Rack Mount MIMS Eng Prototype w/ MPH



Open Source Data



Next Steps

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Conclusions / Future Work

- ◆Proof of concept with MeCN shows that MIMS can be successfully applied to air quality monitoring problems
- ◆Membrane inlet has proven to be a viable technique for monitoring BTEX components
- ◆Evaluation of multiple inlet geometries shows that active flow through provides optimal sensitivity and response time
- ◆Active flow through geometry provides LOD significantly below OSHA PEL levels for toluene
- ◆Evaluations will be made with MS mounted in vehicle for remote monitoring of oil/gas well processes

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Acknowledgements

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