DEVELOPMENTS IN REAL TIME, TRACE AIR TOXIC MONITORING: Jet REMPI

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Jet Resonance Enhanced MultiPhoton Ionization

Ionization continuum

Electronic excited states

Electronic ground state

One-color two-photon REMPI

Two-color two-photon REMPI

Ion Reflector

Ion Beam Steering Plates

Pulsed Gas Inlet (out of plane)

(Supersonic Jet Expansion)

Tunable Optical Parametric Oscillator (OPO)

Nd:YAG Laser

Time-of-Flight Mass Spectrometer

Microchannel plate Detector
Jet Resonance Enhanced MultiPhoton Ionization

- Measures a broad array of aromatics, including halogenated organics and PAHs
- Real time to near-real-time
- Sensitive (ppt to ppb)
  - Concentration to ppq
- Selective (can distinguish isotopomers)
- Source or ambient monitor

Jet REMPI system in EPA’s RTP laboratories
High Selectivity: Mass and Wavelength

Test of an aromatic mix (100 ppb each)
High Selectivity: Dioxin Isomer-specific

2,7 dichlorodibenzodioxin  2,8 dichlorodibenzodioxin

TOF mass resolution (0.25 amu)

Laser tuning resolution (0.005 nm)

Ion Signal [a.u.]

Wavelength [nm]

2,7-DCDD  2,8-DCDD
Very High Sensitivity: Benzene and dibenzo-p-dioxin

**Derived detection limit for benzene of 2.5 ppt**

Moderate S/N = 1 at 2.5 ppt

Averaged noise level over 100 laser shots (10 s.)

**Observed detection limit for dibenzodioxin of 14 ppt**

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Linear fit with $R^2 = 0.99964$

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Applications of Jet REMPI: Air Toxics from DoD Diesel Generator Exhaust

Methylated PAHs during start-ups
Applications of Jet REMPI: Air Toxics from DoD Diesel Generator Exhaust

Jet REMPI compares well with conventional GC MS, on-line GC, and AP42 Emission Factors
Applications of Jet REMPI: Air Toxics from USAF Jet Compressor

Turbine Engine Compressor, USAF type A/M32A-95, JP8. Compressor furnishes pneumatic power for ground support of aircraft systems.

Turbine engine emits more (aromatic) pollutants at low load than at high load.
Applications of Jet REMPI: Air Toxics from a Waste Combustor. 
Focus on Chlorinated Dioxins/Furans.

Dec., 2004 Testing
(results pending analysis)
Applications of Jet REMPI: Air Toxics from a Waste Combustor. Focus on Chlorinated Dioxins/Furans.

Method: correlation of indicator or precursor compounds with more trace concentration dioxins
Verification Test Design:

- Boiler cofiring #2 oil and 1,2 dichlorobenzene
- Four EMSs operated simultaneously.
- Collect reference samples using Method 23.
- Range of sampling periods, 4 to 16 h.
- Range of dioxin concentrations.
- Performance parameters evaluated:
  - Accuracy vs. Method 23
  - Ease of use, reliability, maintenance, etc.

Dioxin EMS Technologies

- Automated, long term sampling systems with laboratory analysis
  - AMESA (Becker-Messtechnik, GmbH)
  - Dioxin Monitoring System (MonitoringSystems, GmbH)
- Real and near-real-time analysis with laser ionization and mass spectrometric detection
  - RIMMPA-TOFMS (IDX Technologies, Inc.)
  - JET-REMPI (EPA/SRI International)
Jet REMPI Summary

- Real-time to near-real-time measurement
  - start-ups, load changes, temporal air toxic changes, process monitor/feedback
- Source or ambient monitor
- Highly sensitive
  - ppt to ppb in real time, ppq with concentra.
- Measures broad array of aromatics
- Highly selective
  - isotopomer-specific
- 4 field demonstrations to date
  - Including waste combustor, ETV test of dioxin monitors
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Jet REMPI

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