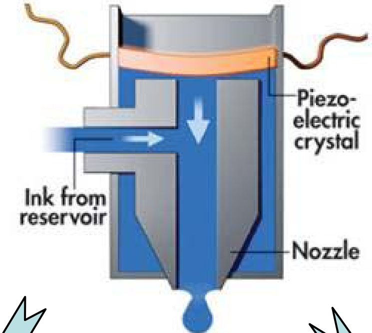
Curie Family (Jacques and Pierre in back, discoverers of the piezoelectric effect)

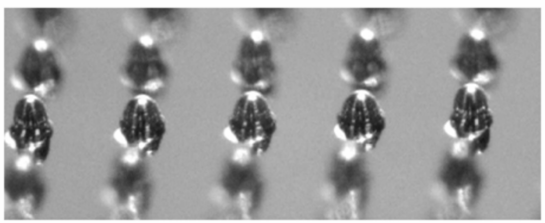
Paris, France, circa 1880

Piezoelectric Nozzle Technology



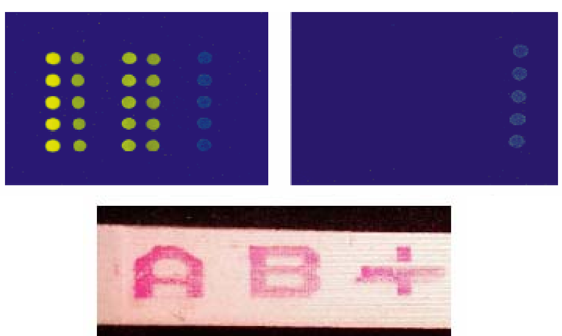
Aerosol Generation

Edgewood Aerosol Science



Solder Deposition – MEMS Devices

(MicroFab Technologies)



Bioactive Arrays

(MicroFab Technologies)

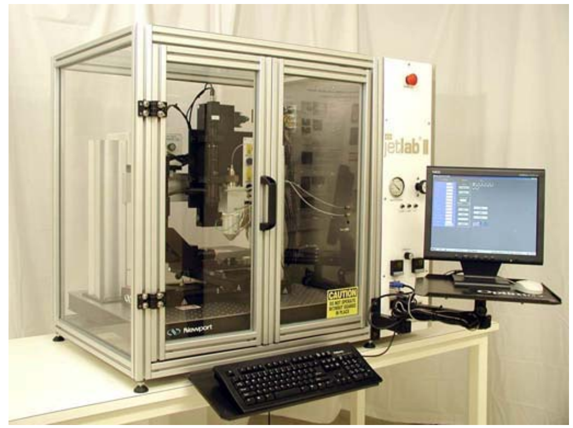
Aroma Generation

(MicroFab Technologies)

Trace Explosive Standards Using InkJet Printing Technology

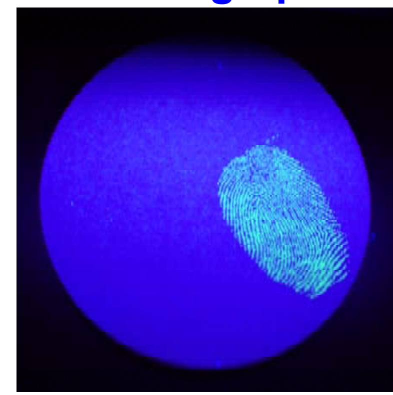
Fluorescein + TNT

2.5 cm



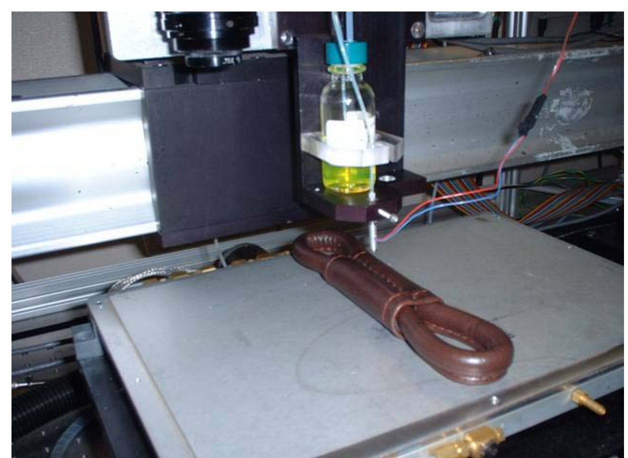
NIST JetLab II Printer System

RDX Fingerprint



2.5 cm

(pending)



NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Vaporjet Calibrator for IMS-Based Trace Explosive ^ Detectors

(and CWA)

Mike Verkouteren, Greg Gillen

Surface and Microanalysis Science Division
National Institute of Standards and Technology
Gaithersburg, Maryland, USA

and

David Taylor
MicroFab Technologies
Austin, Texas, USA

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

CHATEAU MAFFLIERS
ISIMS 2005

Why a Calibrator?

- Tens of thousands trace detectors deployed
- Multiple venues (e.g. airports, embassies, consulates, check-points, sports stadiums, courthouses, federal buildings, ports/harbors)
- Given improvements in sensitivity, vapor detection more practical and preferable
- Vapor processing important in particle detection
- Reliable standards needed to maintain and improve throughput, accuracy, and sensitivity

Outline

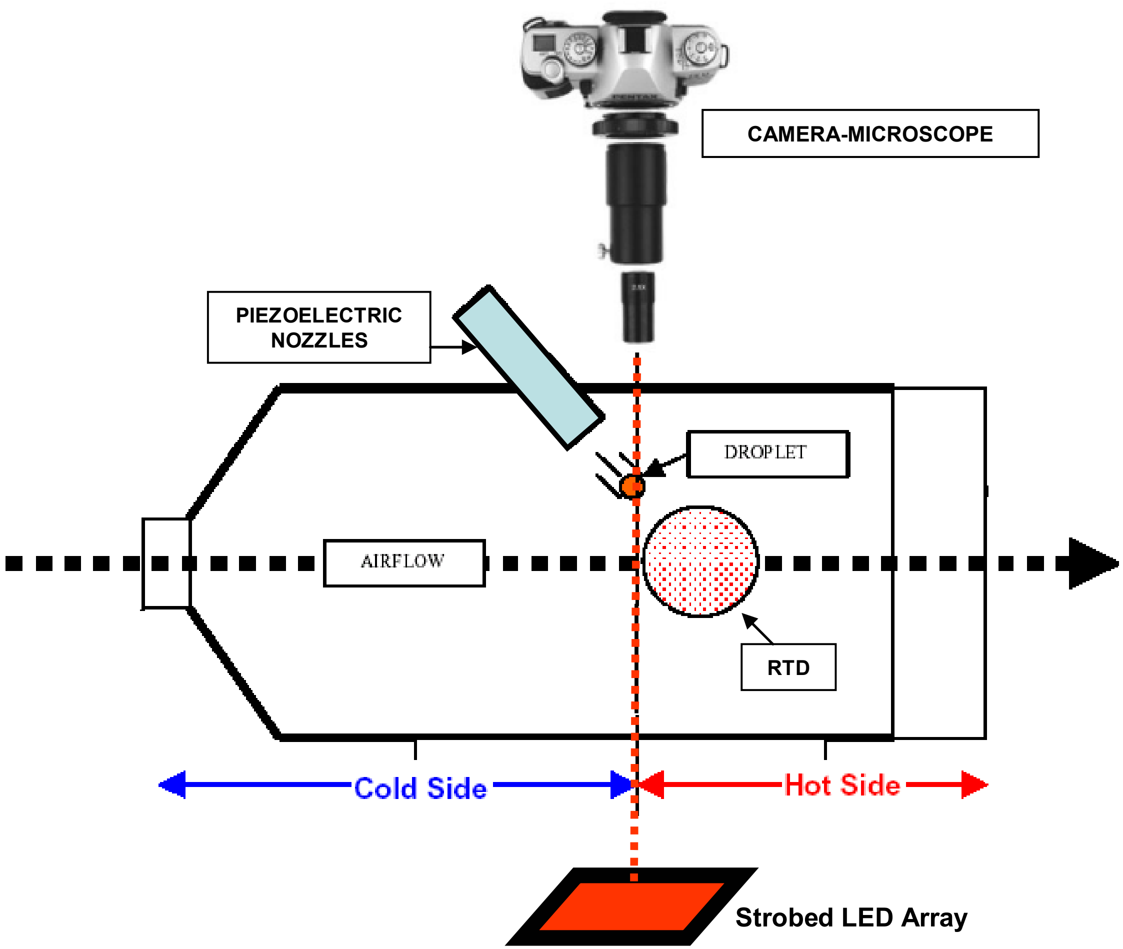
Vaporjet Calibrator

- ***Description***
  - *Design*
  - *Droplet formation*
  - *Droplet vaporization*
- ***Application***
  - *Testing IMS detectors*
  - *Testing portal filters*
- ***Summary***

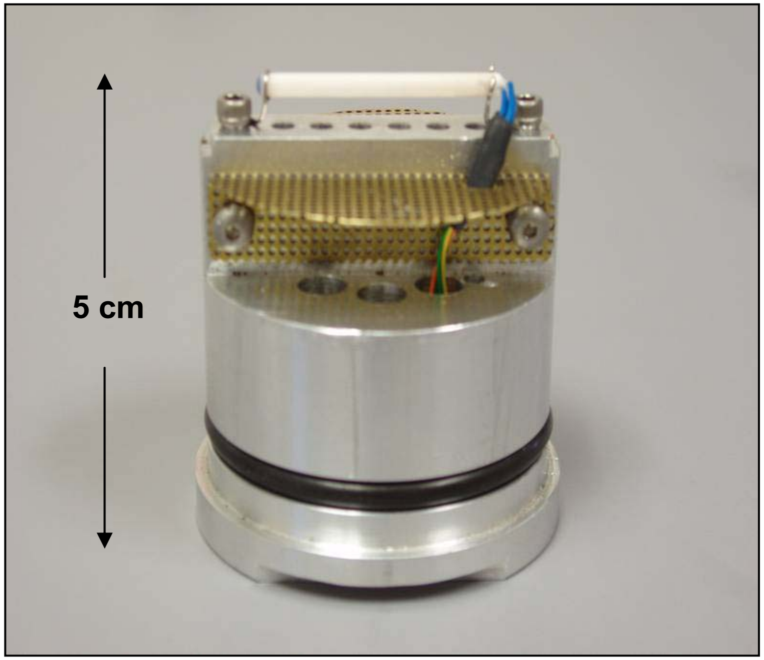
NIST Vaporjet Calibrator

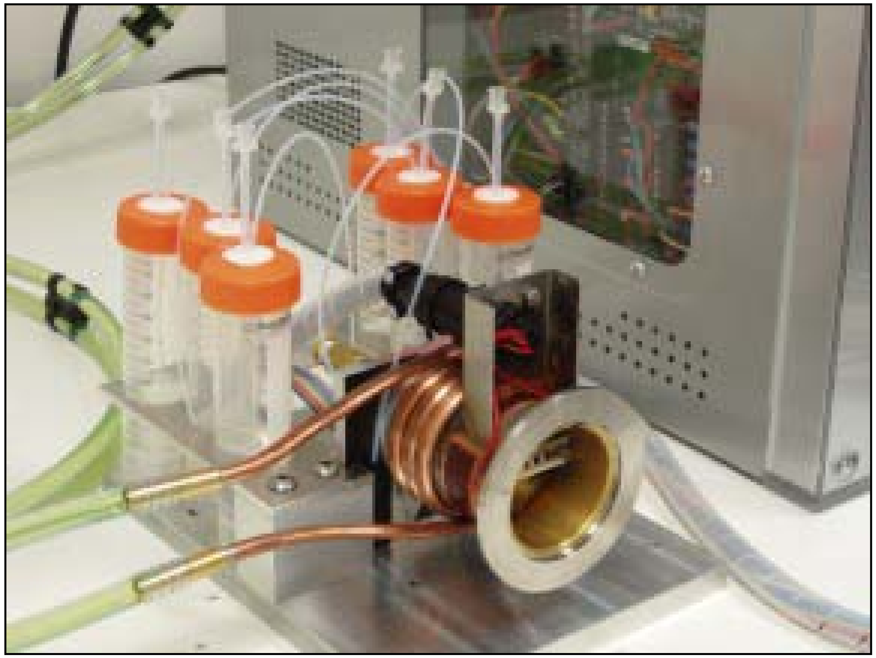
Objectives

- Reliable and dynamic, on-demand trace compound delivery
- Pulsed or steady-state
- Programmable concentration-time profiles (6 independent jet nozzles)
- Transfer standard, traceable to primary standards
- Basis for future improvement of vapor detection technology

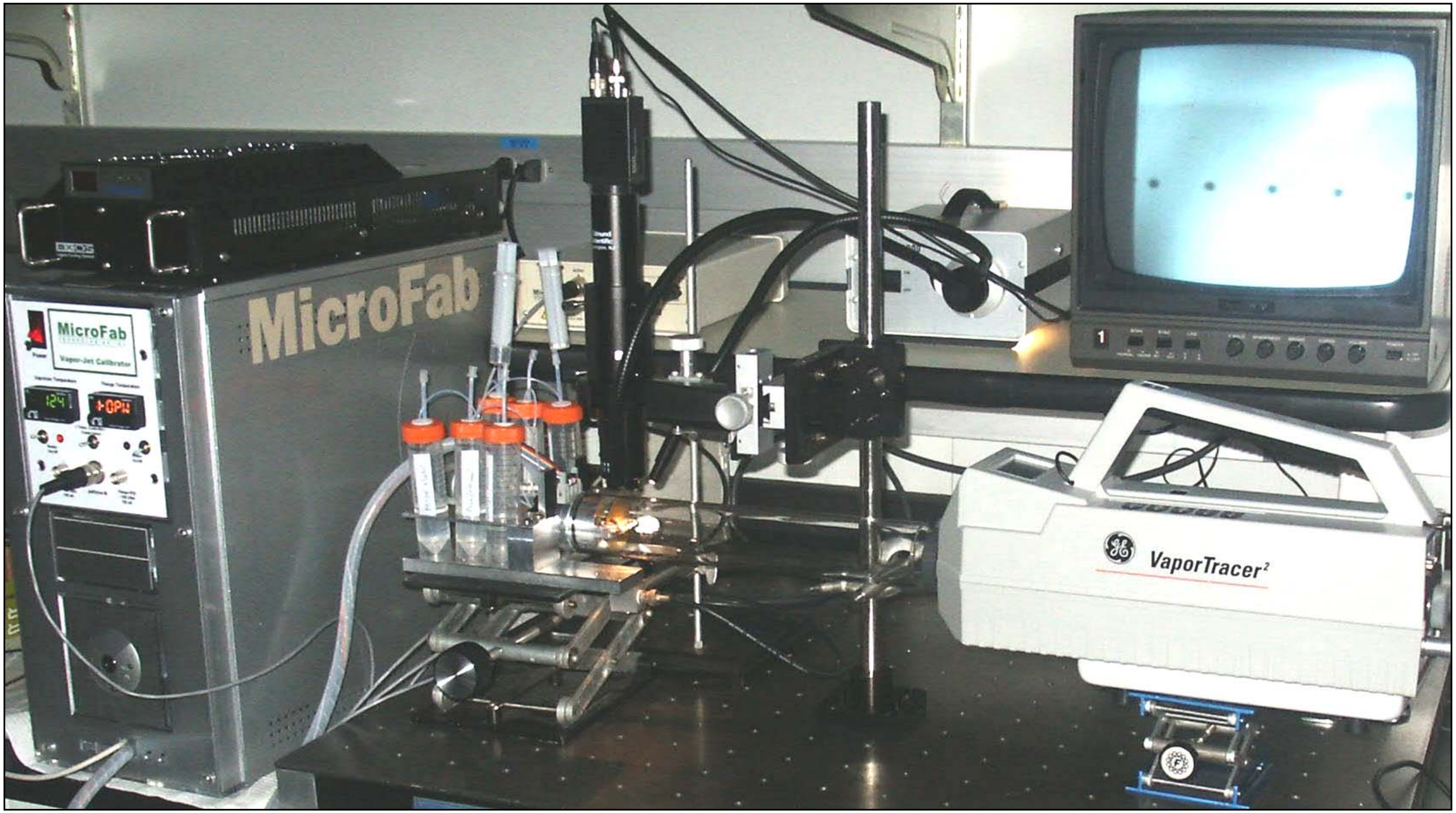


Vaporjet Components



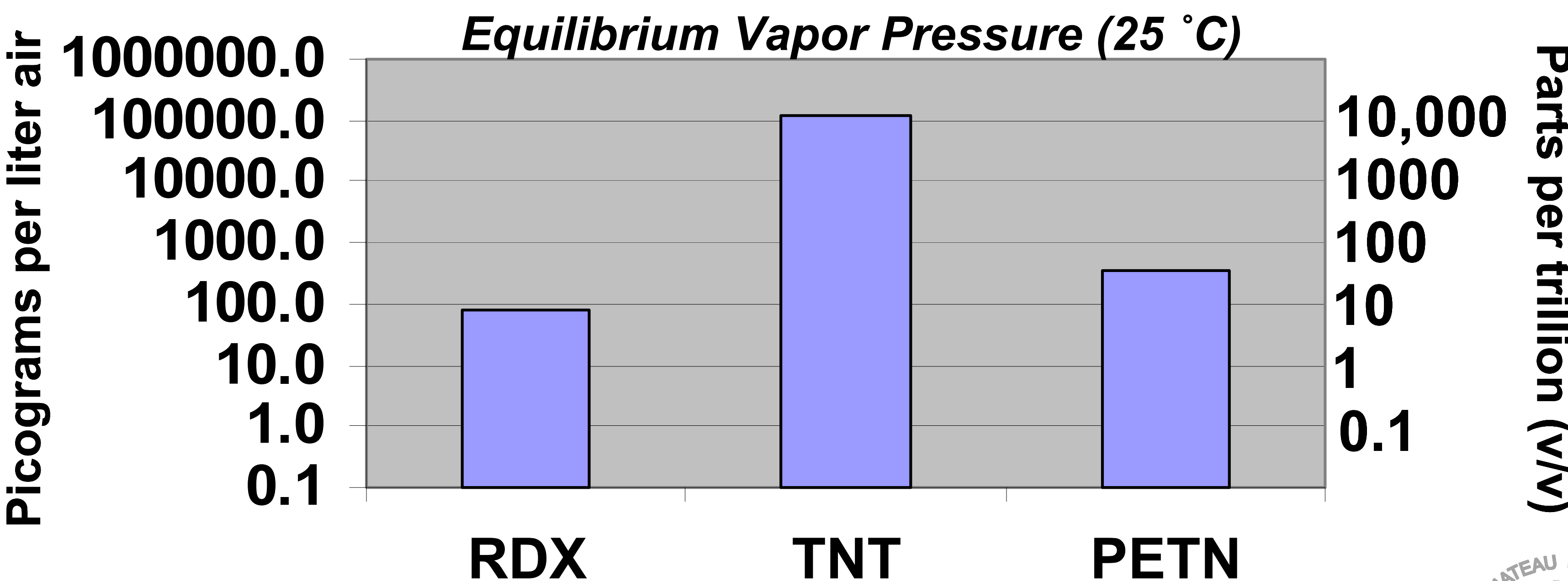


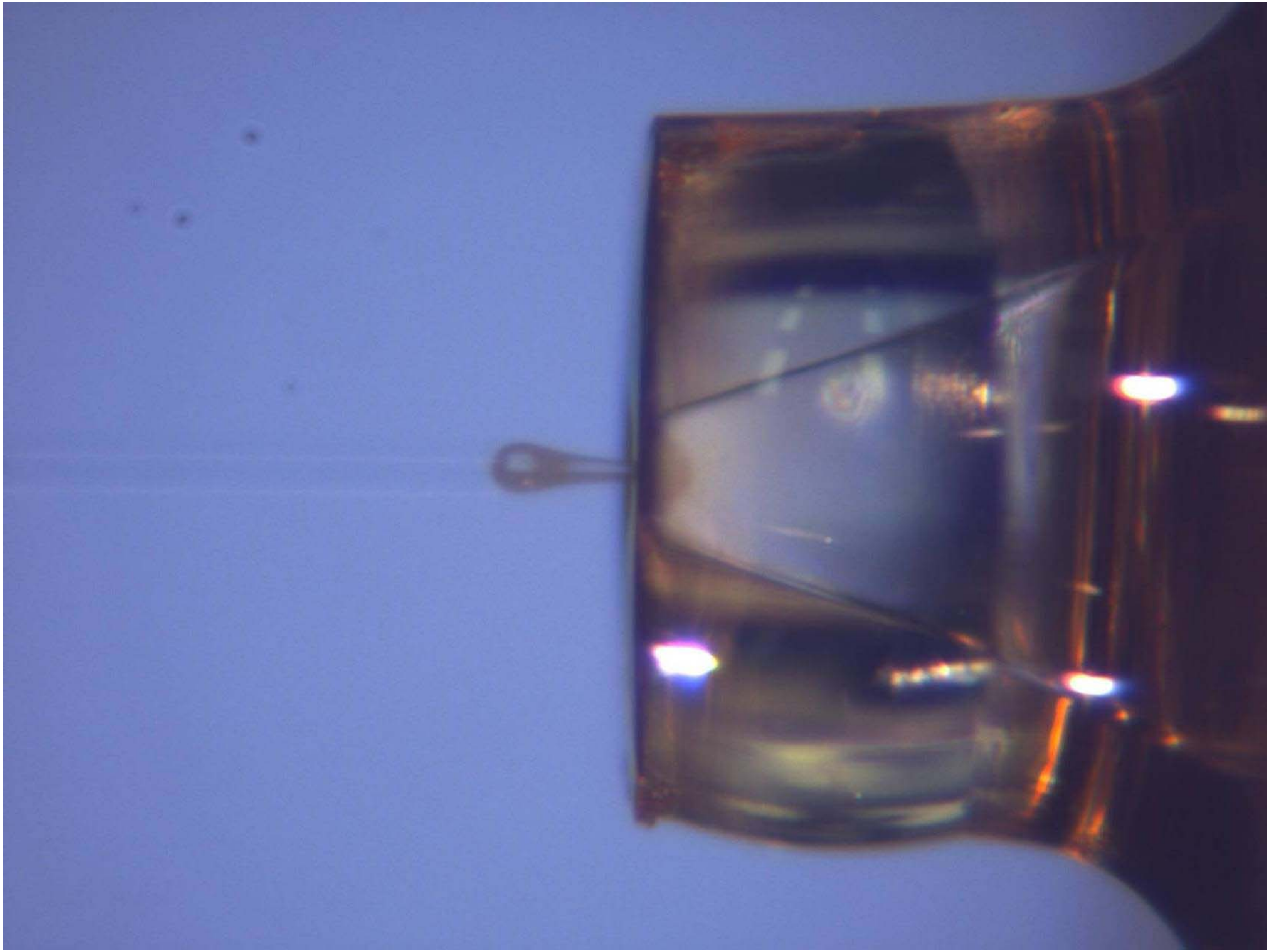
Vaporjet System



Projected Range in Delivered Trace Vapor Concentrations

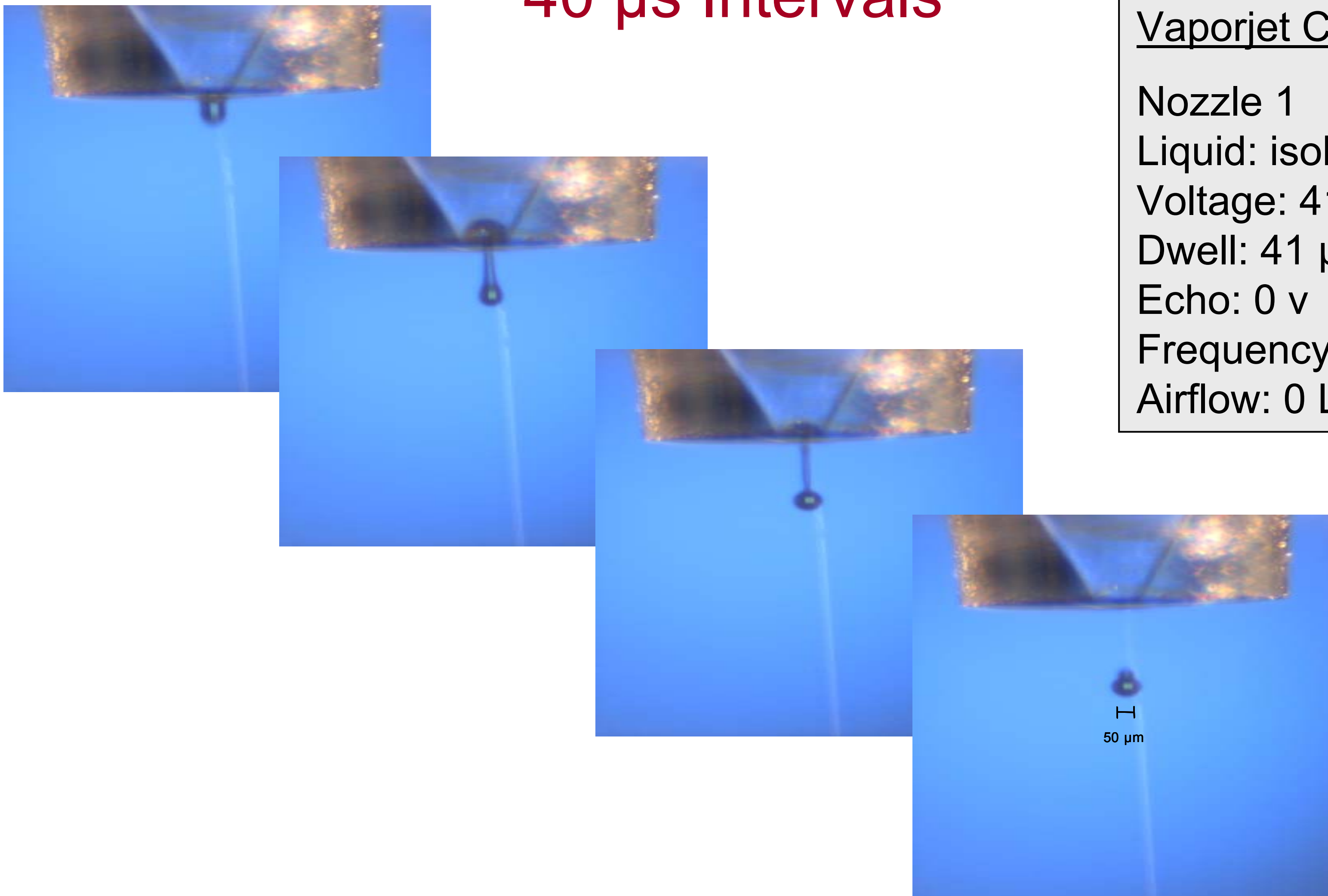
- Compound concentration in solvent (5 to 10000 pg/µL)
- Droplet jetting rate (40 to 4000 Hz)
- Number of nozzles (1 to 6)
- Flow rate of air (1 to 80 LPM)





Droplet Emergence

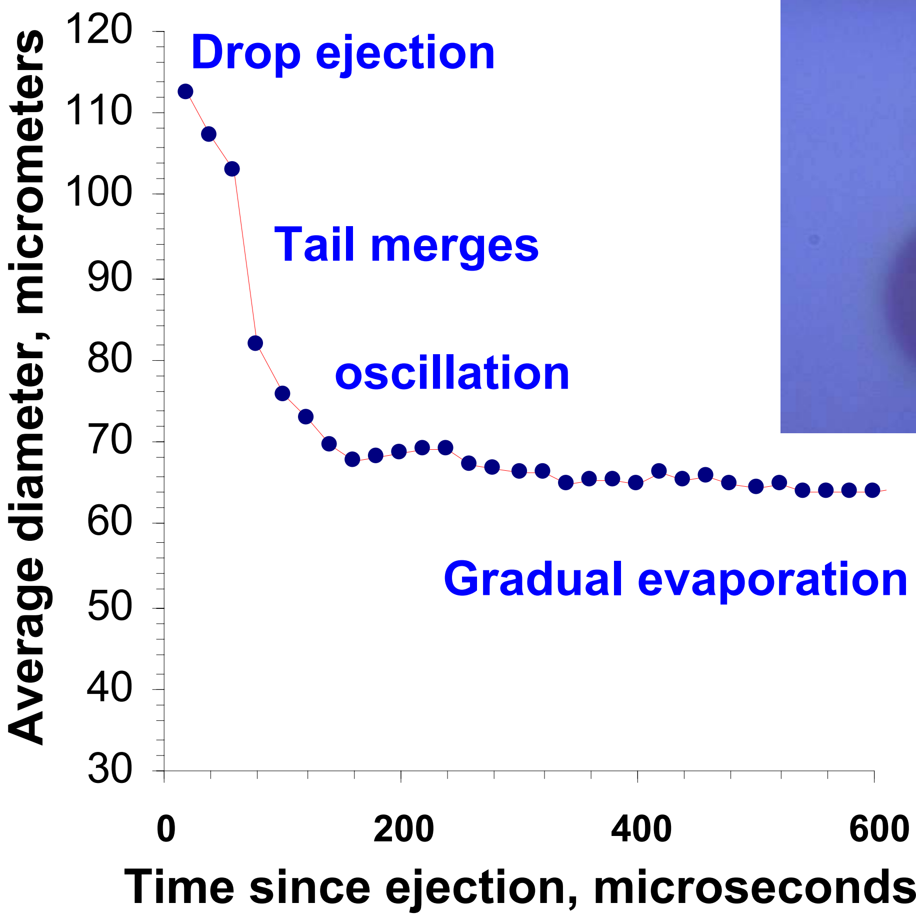
40 μs Intervals

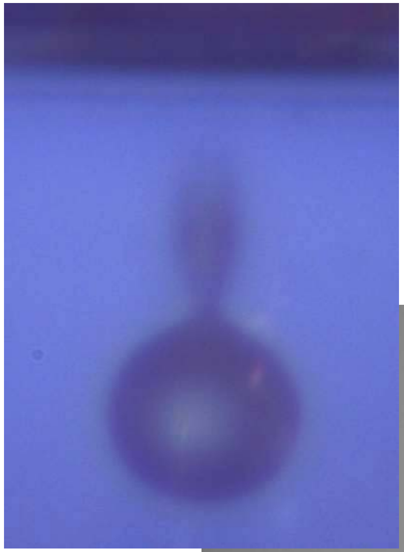


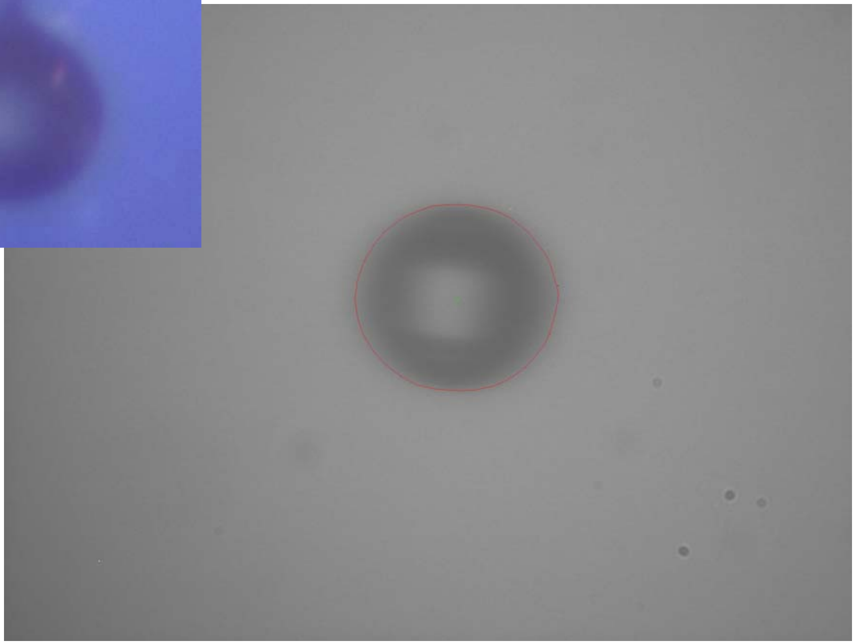
Vaporjet Conditions

Nozzle 1
Liquid: isobutanol
Voltage: 41 v
Dwell: 41 μs
Echo: 0 v
Frequency: 1 kHz
Airflow: 0 LPM

Droplet Diameter Measurement

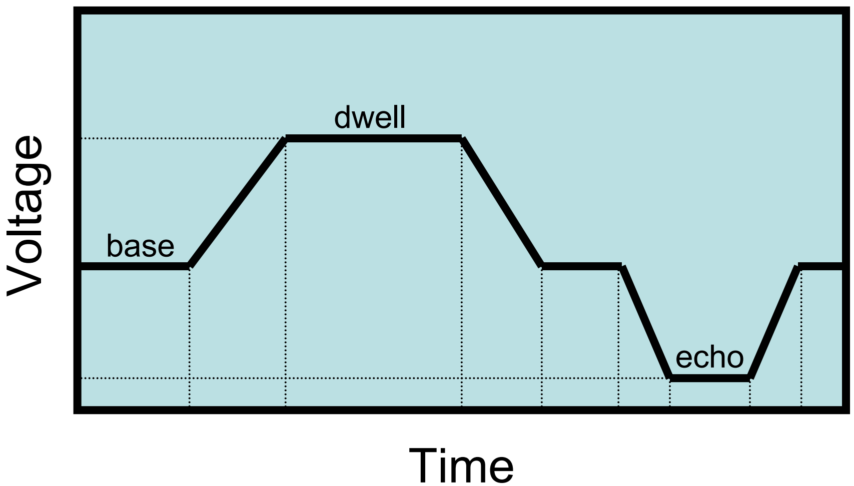


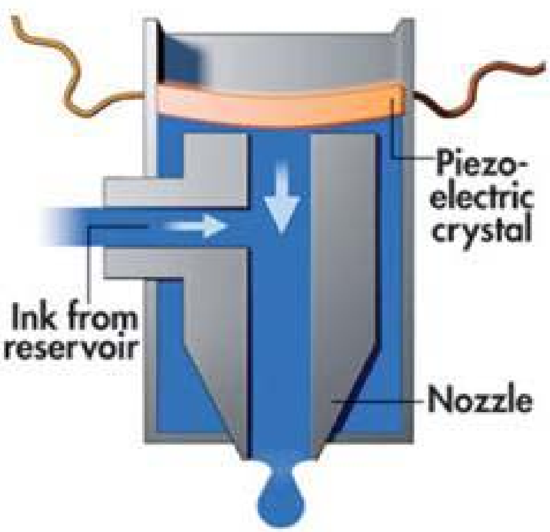


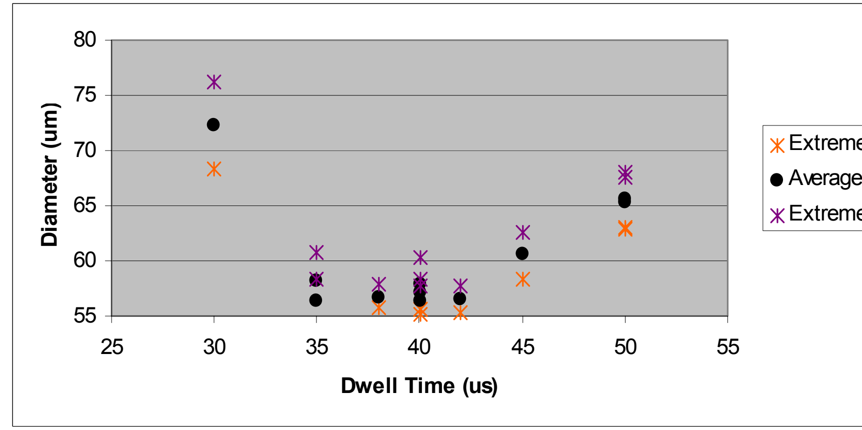


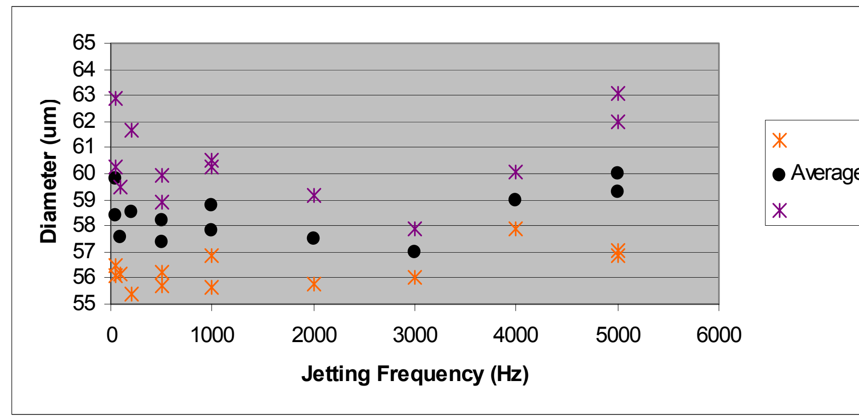
Droplet Formation

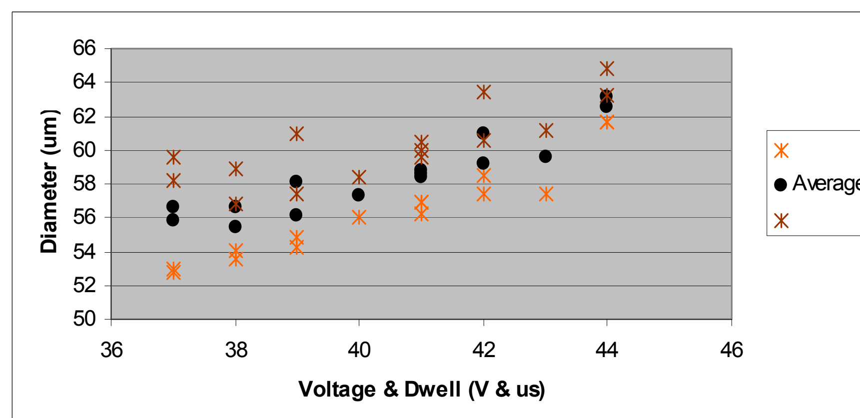
Piezoelectric Parameters







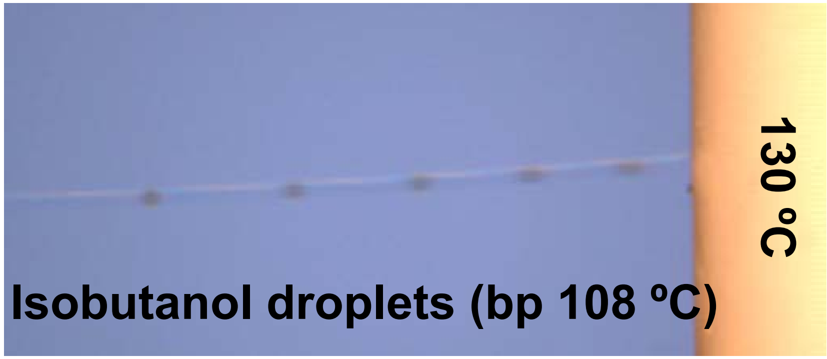


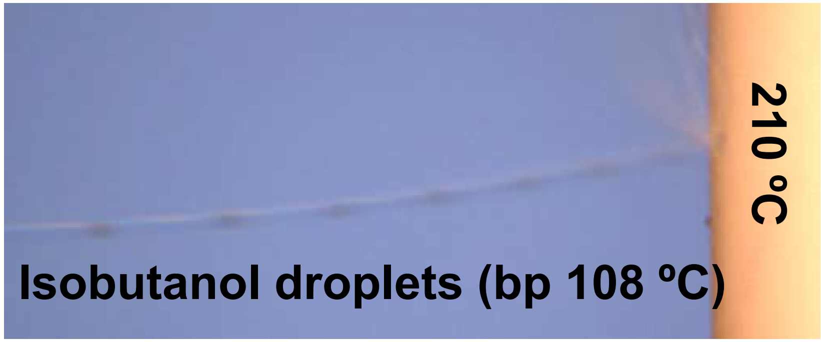


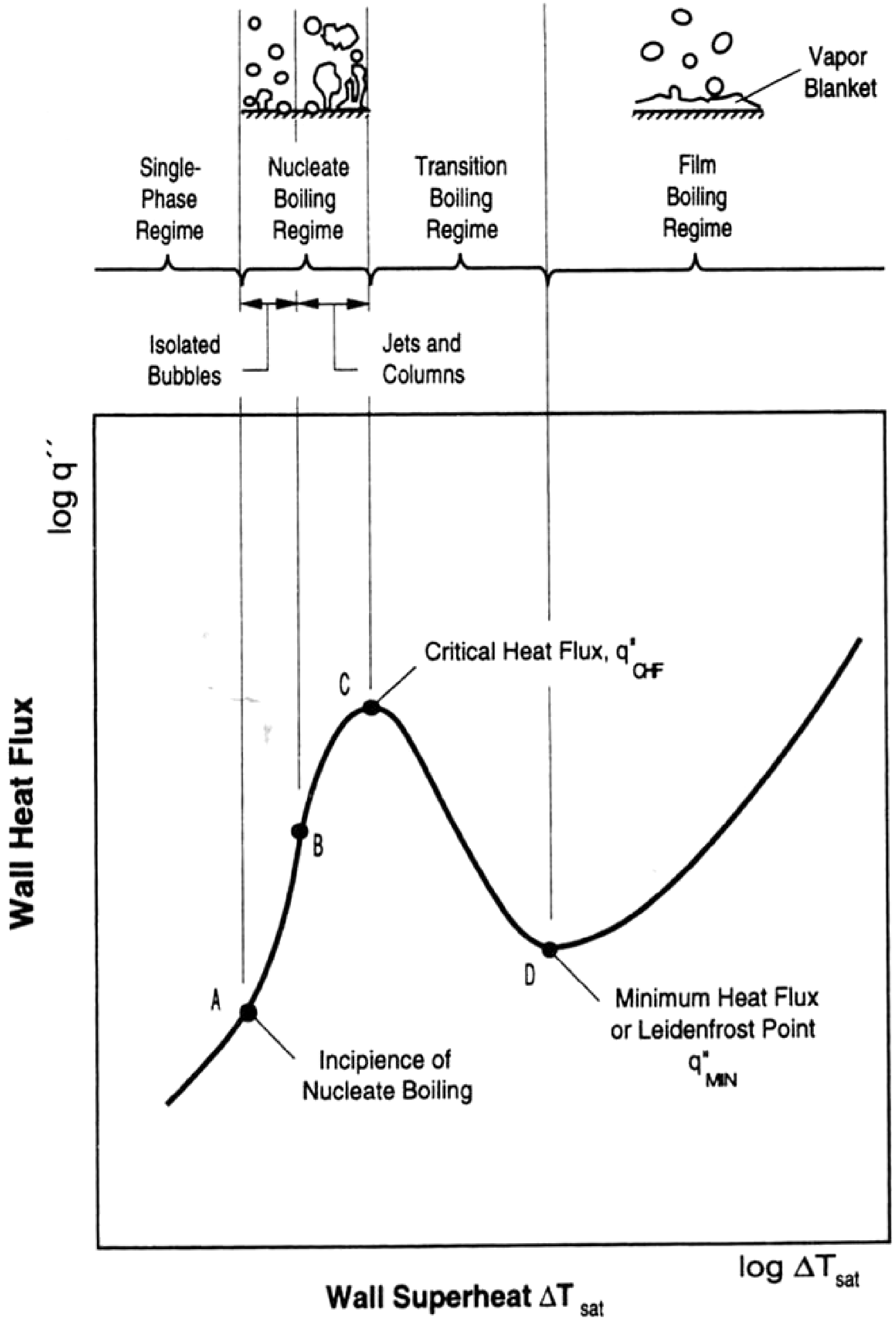
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

Surface-to-Droplet Heat Transfer Regimes

Avoiding "the Bounce" during Vaporization







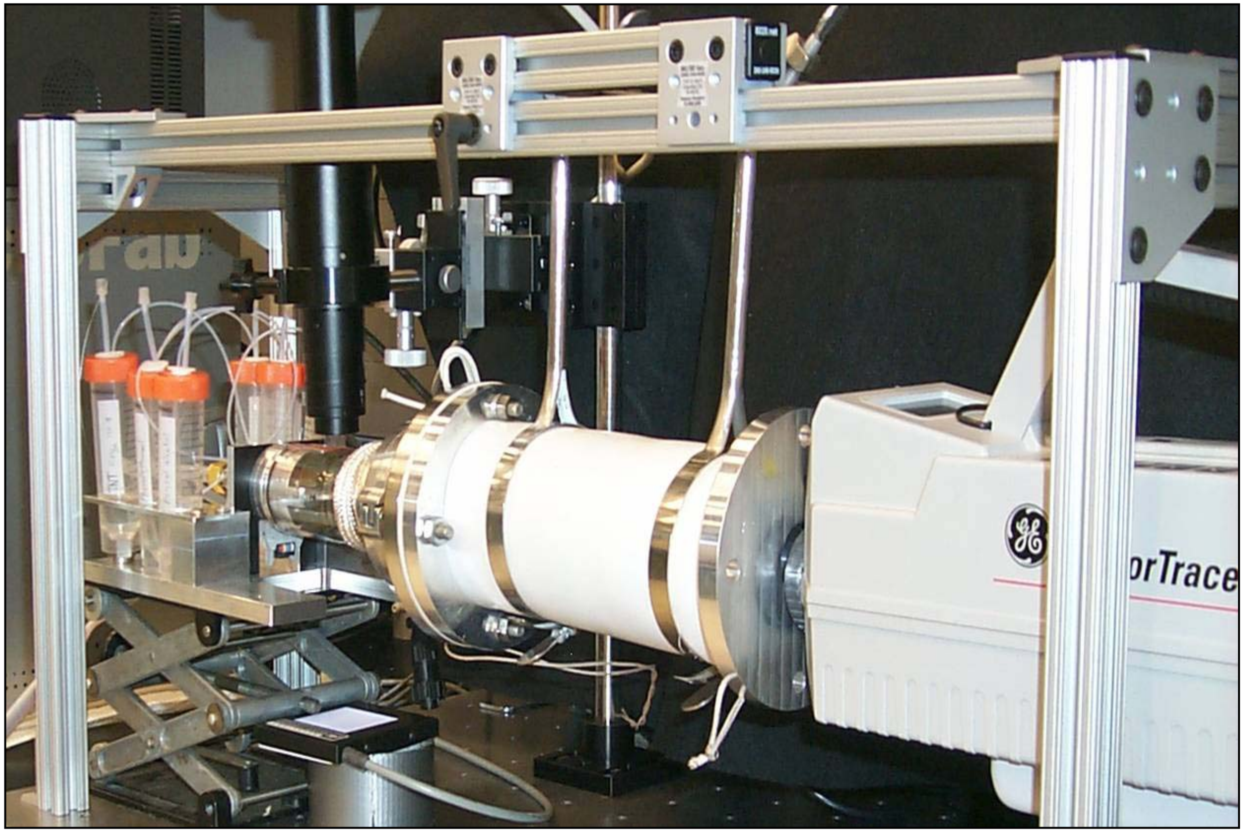
Bernardin et al. 1997 *Int J. Heat Transfer* **40**, 247

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

IMS Detector Response to Vapors

VaporJet + IMS Detectors

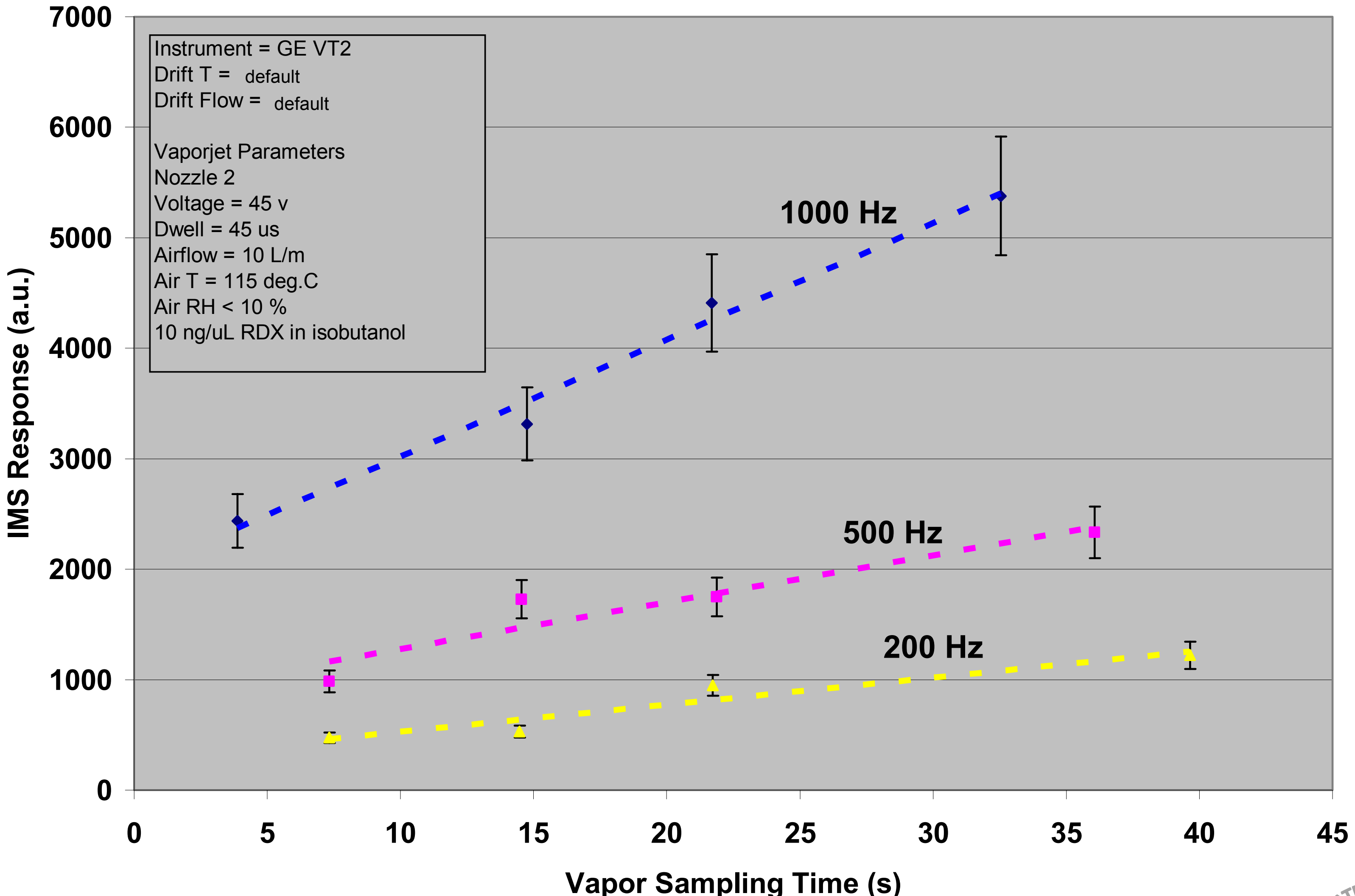
Continuous Jet Mode



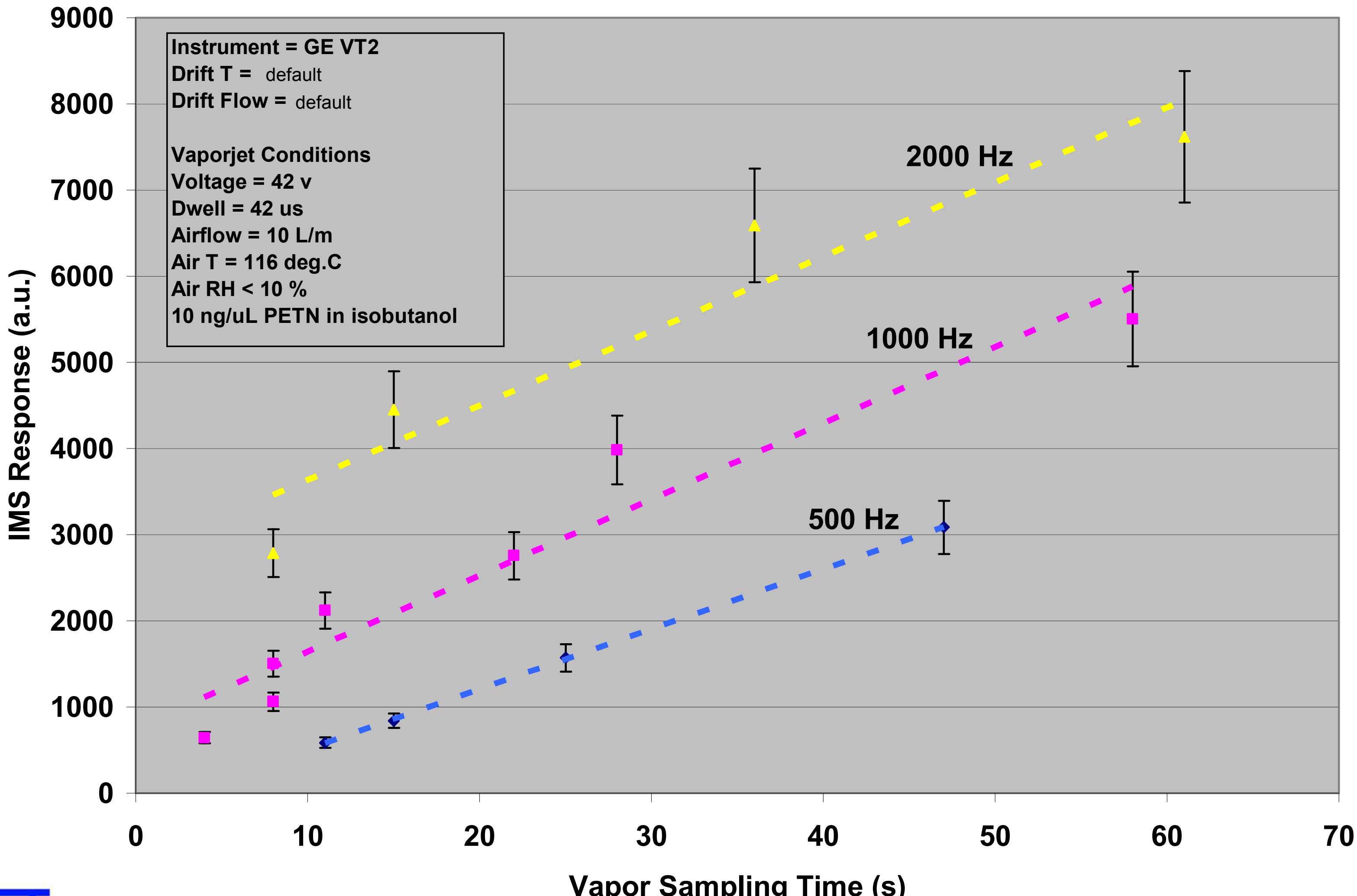
Conditions

- **Air flowrate: 10 LPM**
- **Rel. humidity < 10 %**
- **Sheath: 80 to 150 ºC**
- **Sampled air: 116 ºC**
- **PETN: 500-2000 Hz**
- **RDX: 200-1000 Hz**
- **TNT: 500-3000 Hz**

Vaporjet RDX – IMS Response

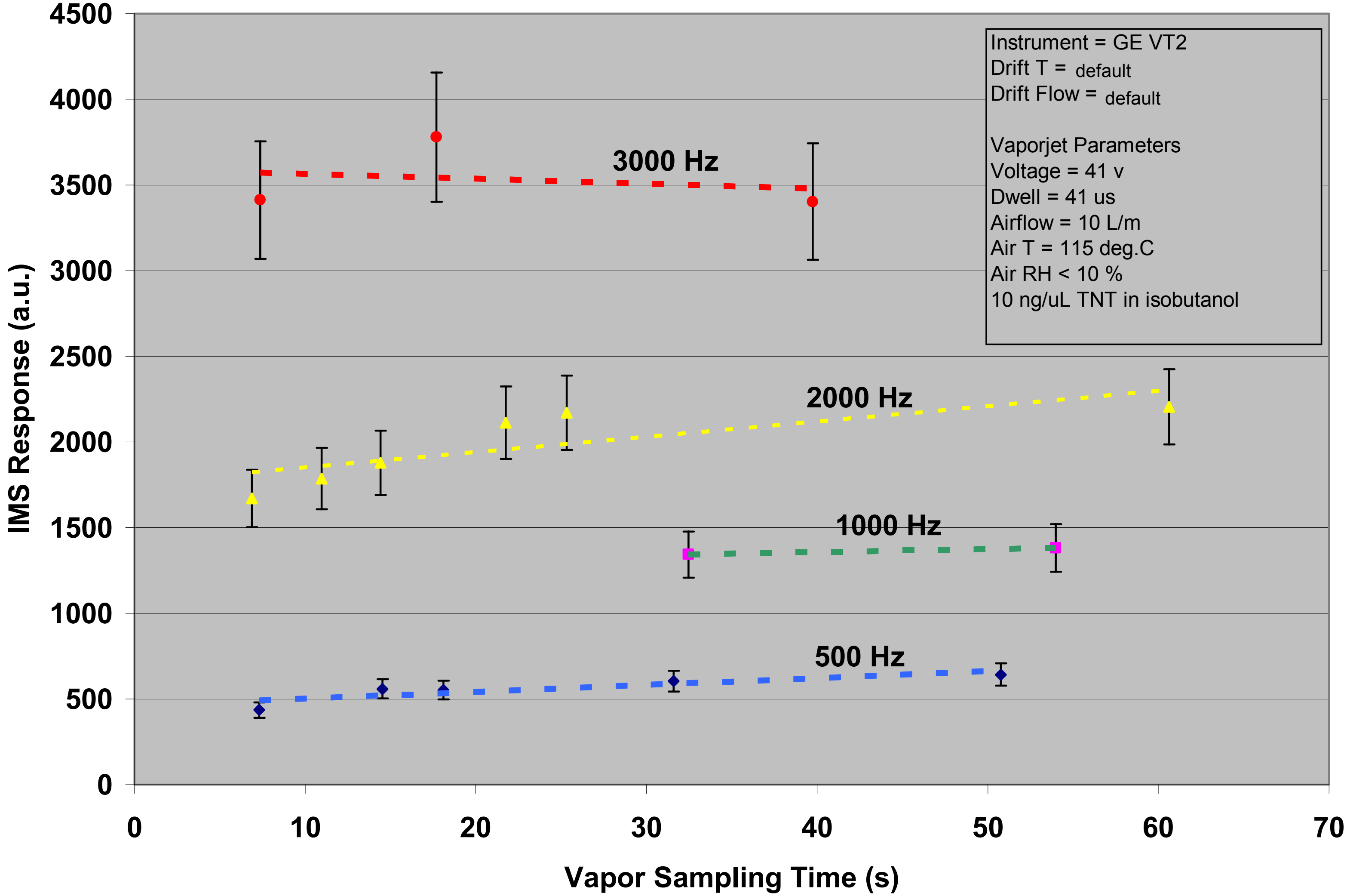


Vaporjet PETN - IMS Response



NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

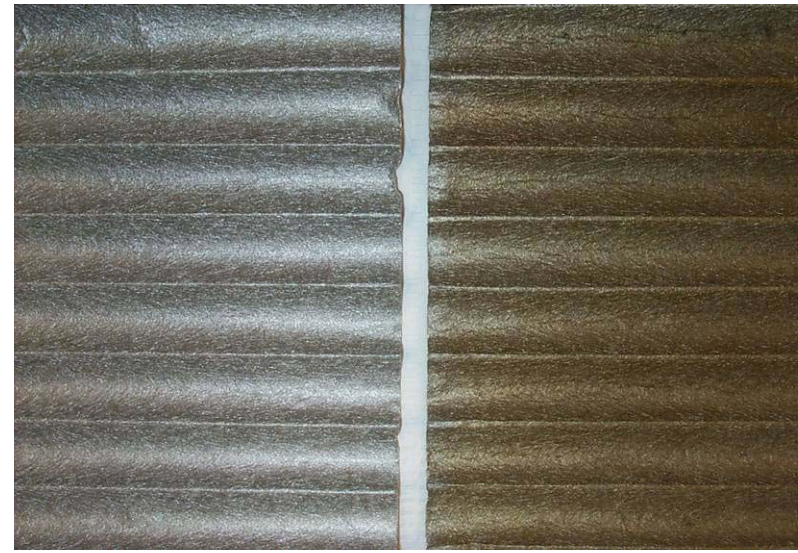
Vaporjet TNT - IMS Response

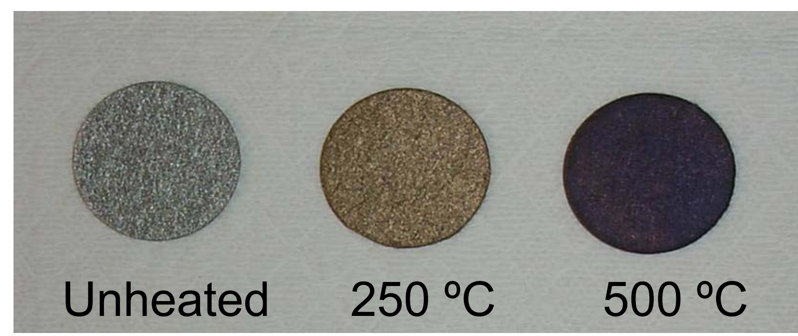


Portal Vapor Collection Efficiency

“Heat Tint” on Portal Collector Filters

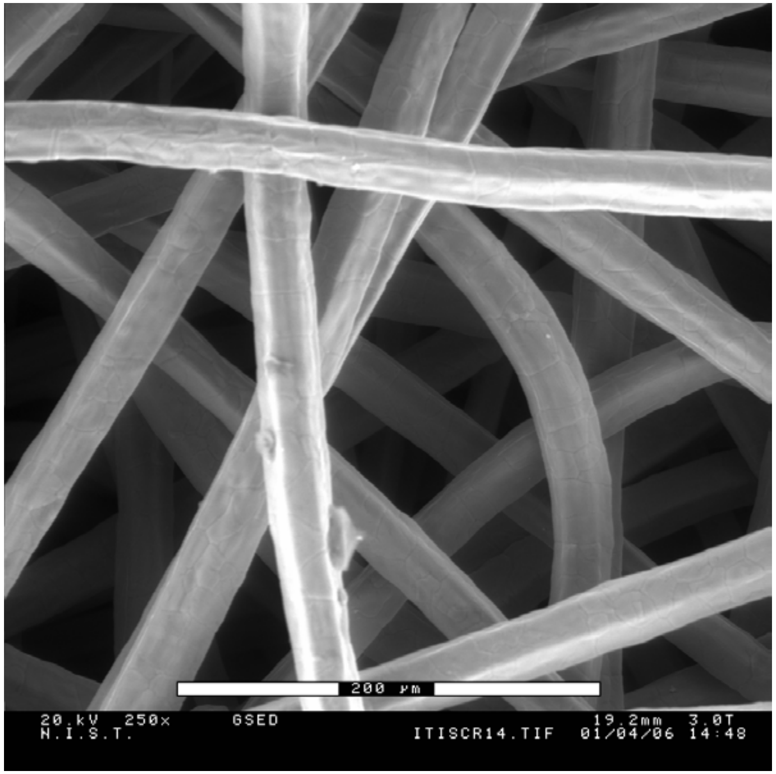
- During heating, oxide coating forms on stainless steel
- Does this affect collection performance of vapor stage?



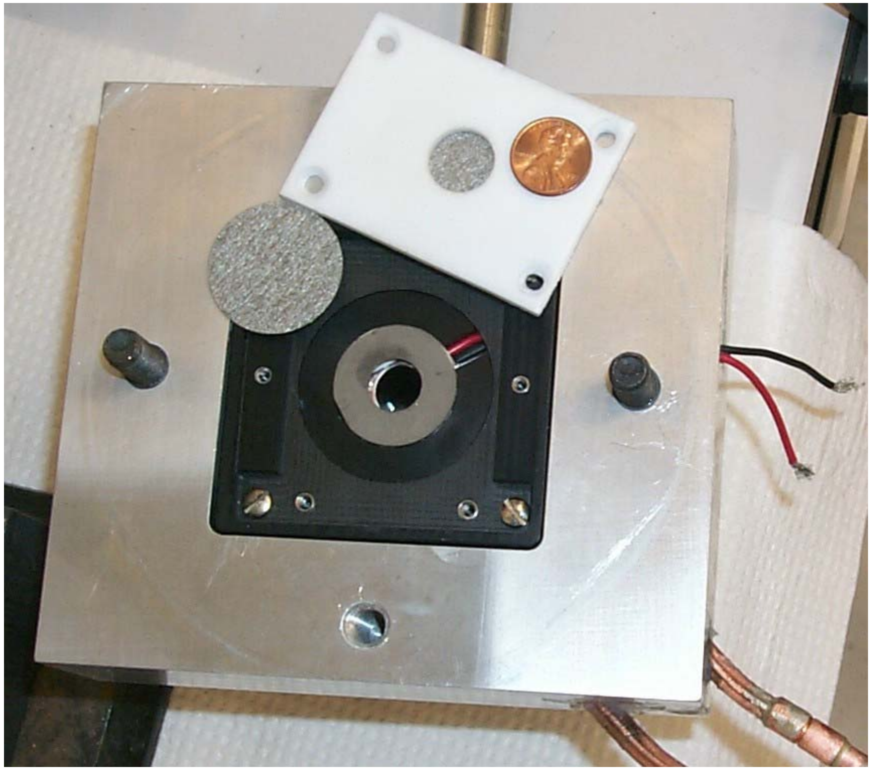


Bekaert Bekipor 316L Stainless Steel

Vapor Collector System



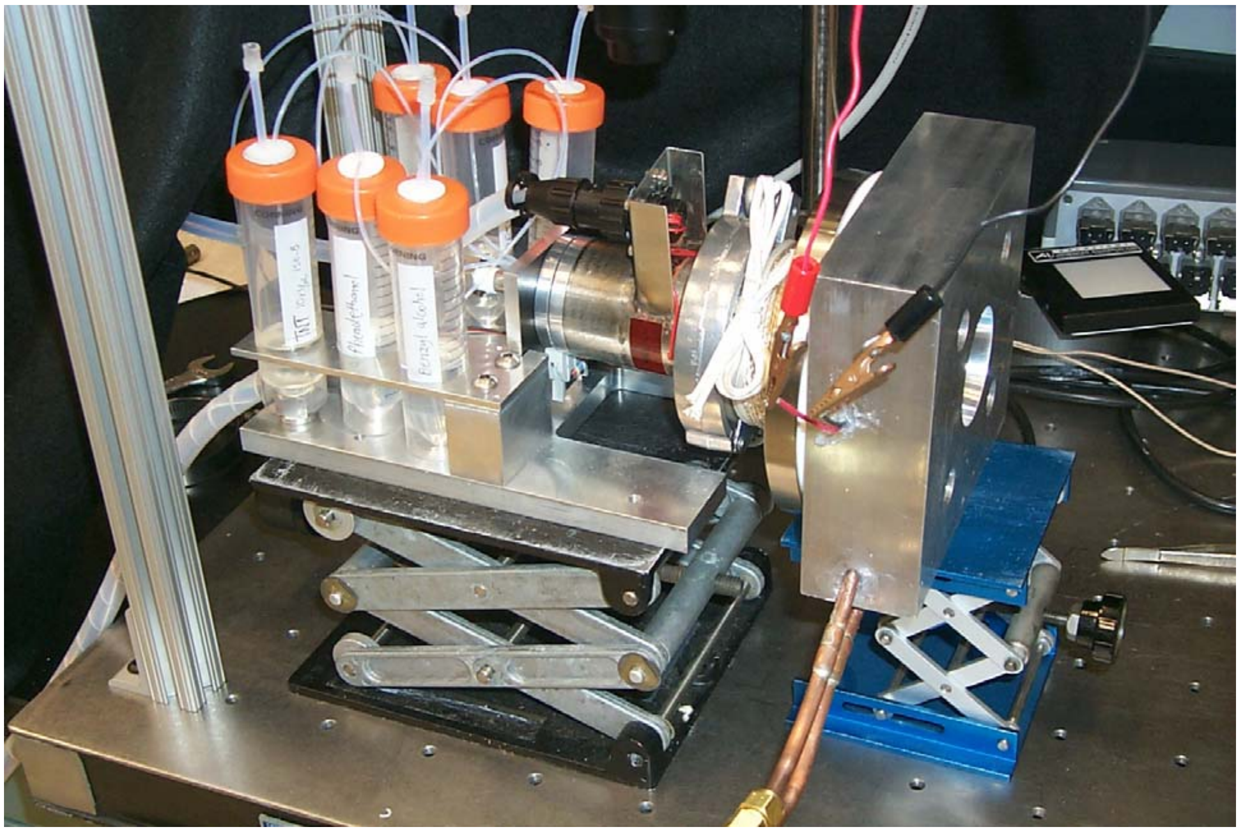
SS 316L Fiber Mesh
Bekaert Bekipor ST 60 AL3



Heat-Sink Block, Thermo-Electric Cooler, Collector Filter, and PTFE Mask

Explosive Vapor Collection System

Pulsed Jet Mode



Conditions

- **Air flowrate: 5 LPM**
- **RH: <10 % to >80%**
- **RTD: 130 ºC**
- **Sheath: 80 to 220 ºC**
- **Collector: 50 ºC**
- **RDX: 2000 droplets**
- **TNT: 10000 droplets**

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

CHATEAU MAFFLIERS
ISIMS 2005

TNT Vapor Collection

Filter Collection Efficiency

4.6 % ± 4.5 %

5.1 % ± 3.4 %

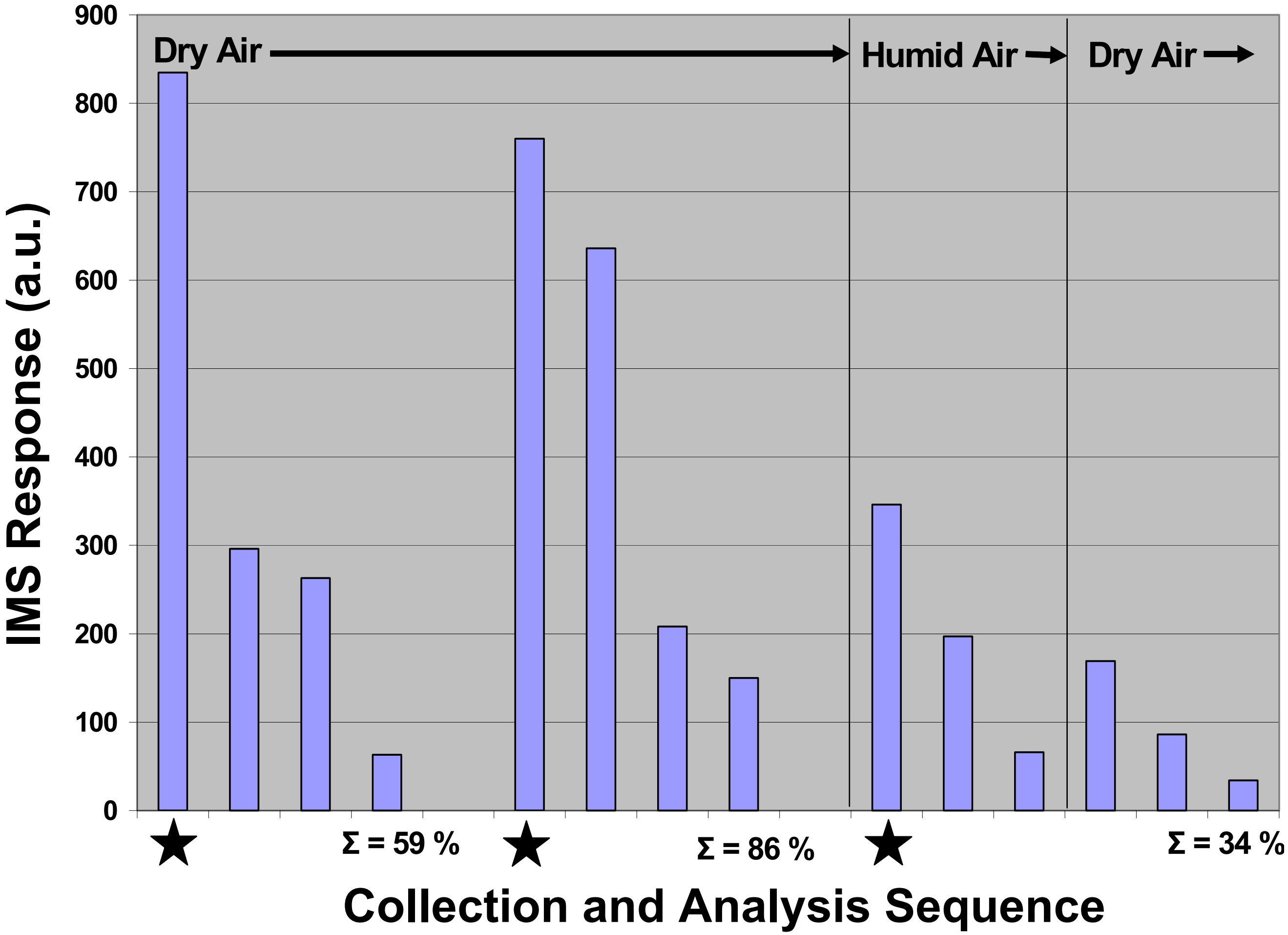
4.7 % ± 3.3 %

Vaporjet Conditions

Nozzle 1: TNT
Voltage: 41 v
Dwell: 41 µs
Sheath: 80 ºC to 220 ºC
Collection: 50 ºC
Air flow: 5 LPM
Rel. humidity < 10%

Instrument: Barringer IonScan 400B
Desorber: 220 ºC
Drift Tube: 168 ºC

RDX Vapor Collection



Vaporjet Conditions

Nozzle 2: RDX
Voltage: 47 v
Dwell: 47 µs
Sheath: 80 to 200 ºC

Instrument: Barringer IonScan 400B
Desorber: 220 ºC
Drift Tube: 168 ºC

★: 2 ng RDX introduced

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

CHATEAU MAFFLIERS
ISIMS 2005

Summary & Challenges

- Promising approach to generating trace vapor airstream standards
  - Reliability…
  - Reproducibility…
  - Solvent effects…
- Memory issues
  - Temperature/solvent optimization…
- Calibrating the Calibrator
  - Orthogonal methods…