# Capabilities for Measurements, Materials, Data, Modeling, and Information Processing in the Chemical Sciences Division @ NIST

-or-

## How might we help?

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# *Some Interesting Possibilities*

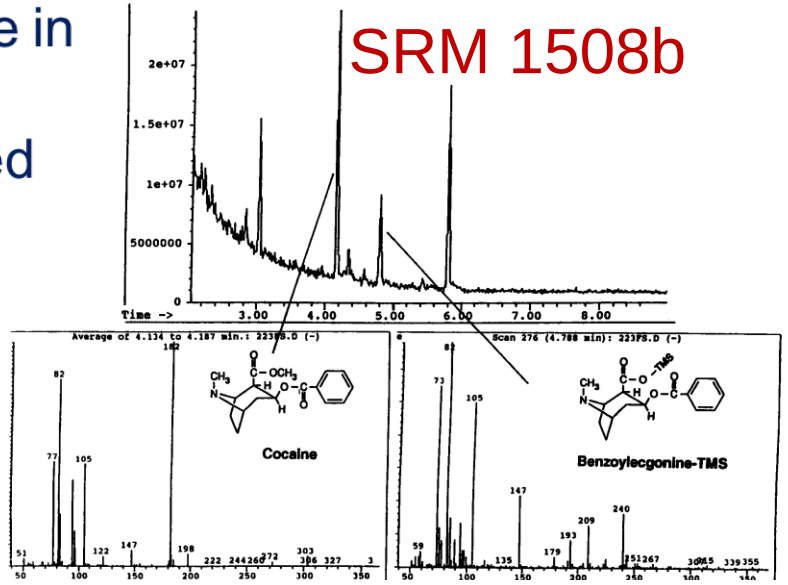
- **Analytical tools insuring accurate measurements**
  - Providing natural-matrix SRMs
  - Assessing material purity
  - Providing NTRMs (NIST-traceable reference materials)
  - Hosting interlaboratory studies
- **Out-of-the-box activities**
  - Inkjet printing calibrants
  - Canine training aids
- **Computational tools and data management**
  - Optimizing the measurement
  - Predicting the data
  - Working with the data
  - Providing All The Information to the customer

# *Natural-Matrix Standard Reference Materials (SRMs) with Forensics Applications*

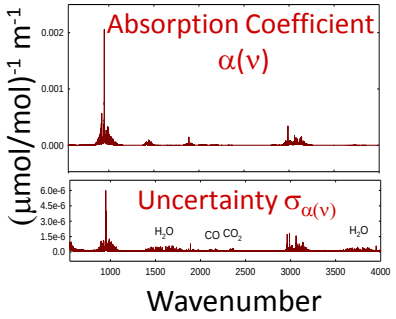
**Used to evaluate the accuracy of an entire analytical method**

- SRM 1507b THC-COOH in Freeze-Dried Urine
- SRM 1508b Benzoylecgonine (Cocaine Metabolite) in Freeze-Dried Urine
- SRM 1959 Drugs of Abuse in Frozen Human Serum
- SRM 2379 Drugs of Abuse in Human Hair I
- SRM 2380 Drugs of Abuse in Human Hair II
- SRM 2381 Morphine and Codeine in Urine
- SRM 2382 Morphine Glucuronide in Urine
- RM 8444 Cotinine in Freeze-Dried Human Urine

SRM 1508b



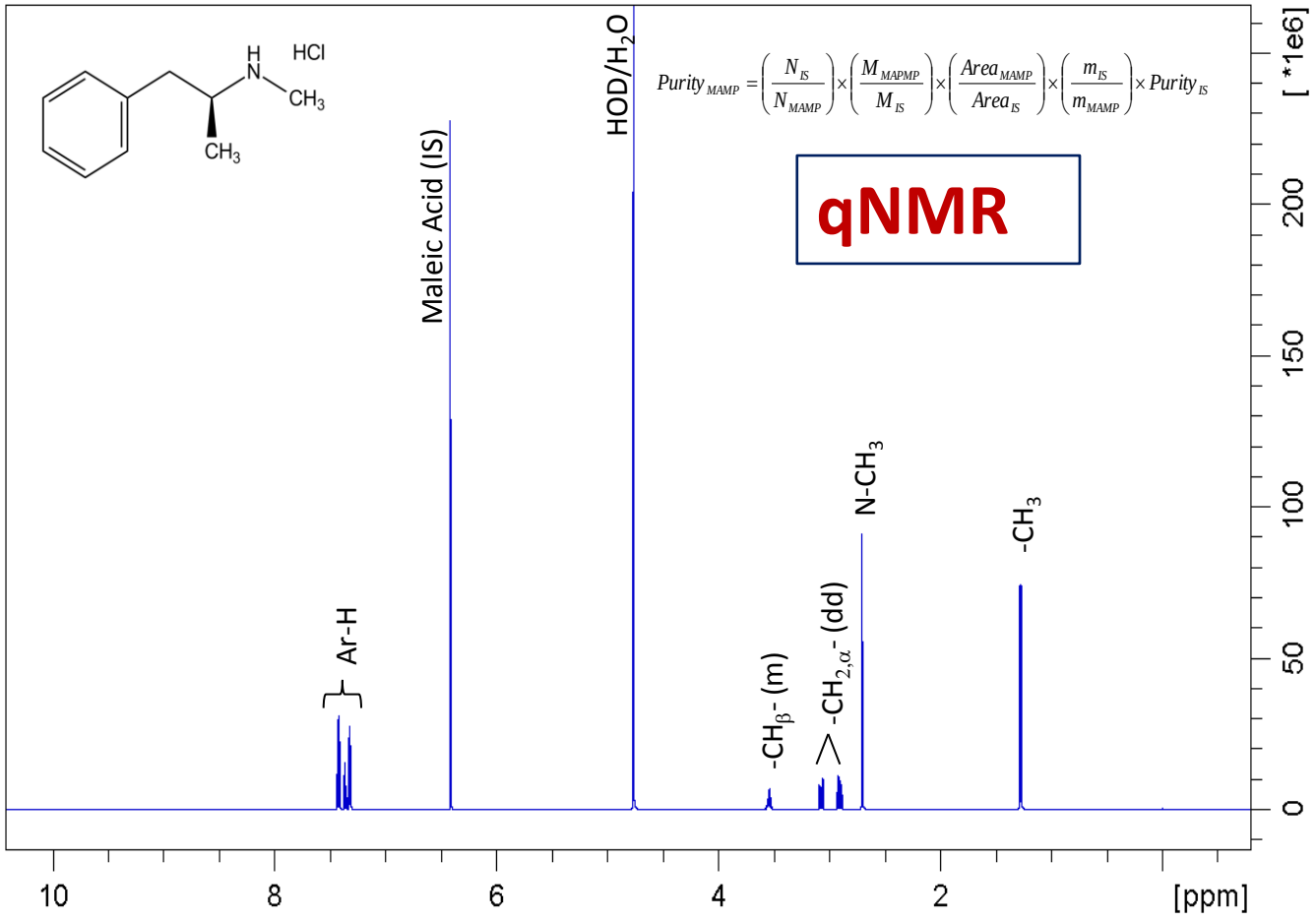
# Determining Drug Purity


**Multiple techniques used to assess purity**

- NMR
- GCMS, GCFID
- LCUV, LCMS
- DSC
- IR, Raman

d-Methamphetamine HCl

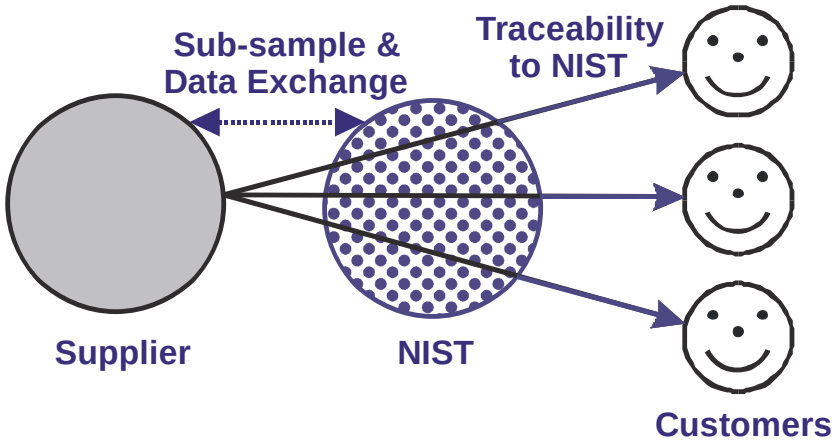



$$Purity_{MAMP} = \left(\frac{N_{IS}}{N_{MAMP}}\right) \times \left(\frac{M_{MAPMP}}{M_{IS}}\right) \times \left(\frac{Area_{MAMP}}{Area_{IS}}\right) \times \left(\frac{m_{IS}}{m_{MAMP}}\right) \times Purity_{IS}$$

d-MAMP
Purity of 0.998 ± 0.002 g/g

# *NTRMs (NIST-traceable reference materials)*

- **Work directly with commercial vendors/DEA for materials**
- **Evaluate each lot of material using NIST/combined measurements**
- **May include spectral or property data**
- **Vendor/DEA provides materials to customers**
- **Provides direct traceability to NIST**



# *Interlaboratory Studies*

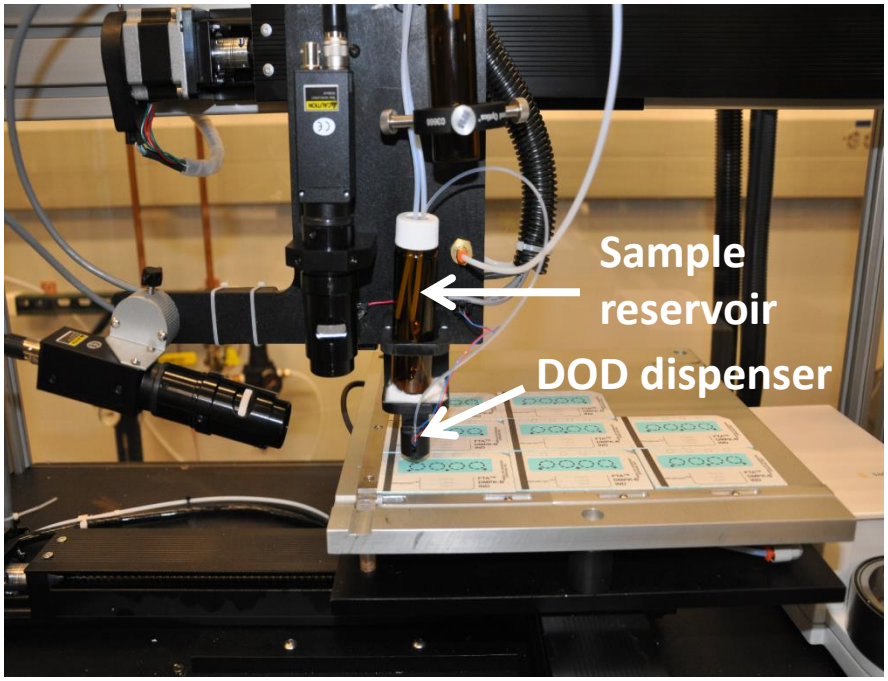
## ***Mode 1***

- **NIST provides pre-qualified test materials to participants, they return data**
- **NIST determines mean and uncertainties, provides report to participants**
- **We learn about methods used by practitioners**

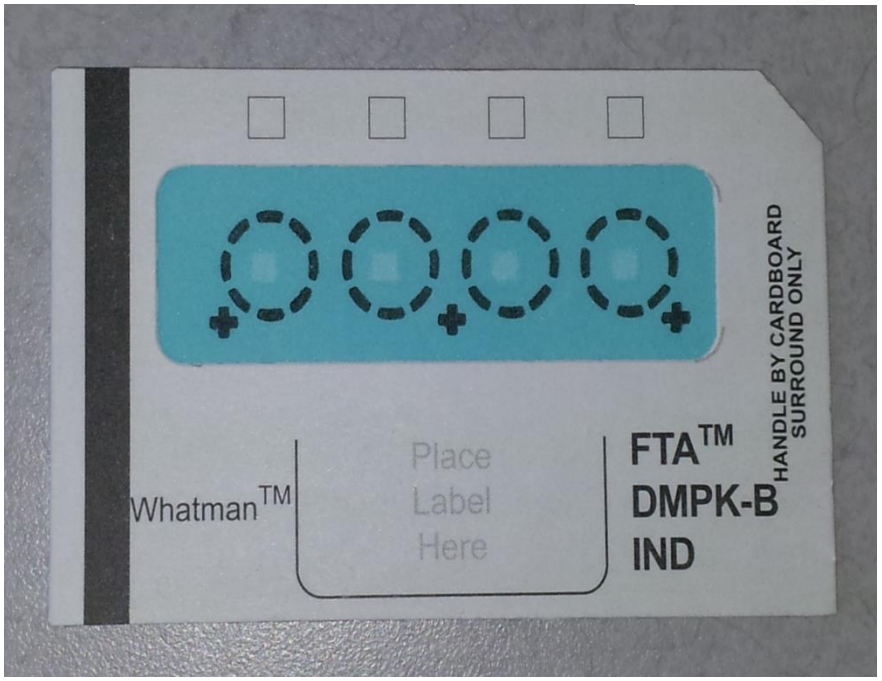
## ***Mode 2***

- **NIST provides pre-qualified materials to participants**
- **Participant results are used to ‘qualify’ their data**
- **Qualified participants are allowed to enter data into database**
- **NIST provides yearly qualification challenges**

# *Inkjet printing illicit materials as instrument calibrants*




Inkjet printing apparatus

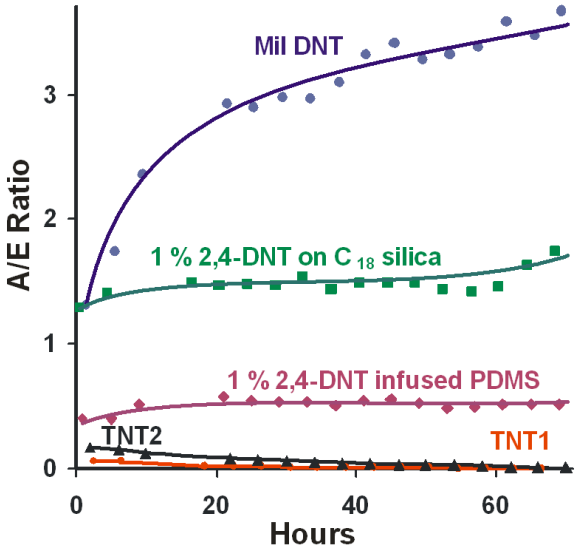



4 single-use samples printed on a dried blood spot card (2.4 mm x 2.6 mm/spot)

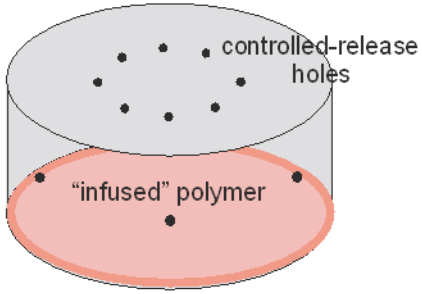
- Deposit sub-µg of material onto an test surface
- Desorb with solvent containing internal standard (derivatize if necessary)
- Analyze using GC/MS or LC/MS/(MS)

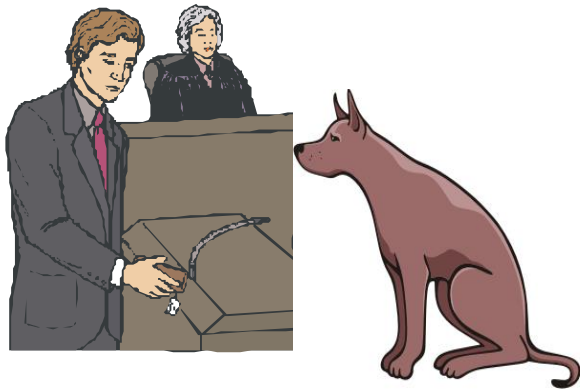
# *Reference Canine Training Aids*

NIST-developed quantitative vapor-time measurements are being used to develop non-hazardous training aids




Controlled Vapor-Release Canister



Assure uniformity of canine detection for court defensibility of evidence

# *Working with the instrument before the data is collected*

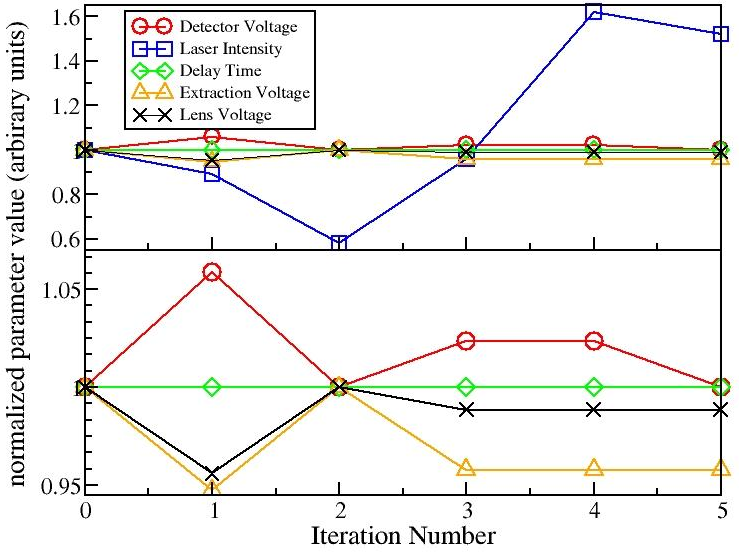
***"Help! If I set the instrument up for the best sensitivity then repeat measurements give wildly different answers."***

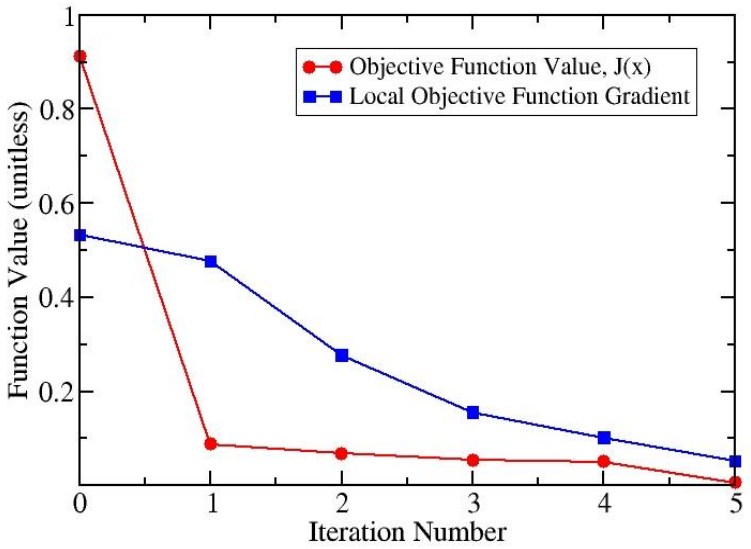
***"What are the best instrument settings to optimize both sensitivity and repeatability?"***

## Numerical Instrument Optimization*

- Finding the best instrument parameters to optimize signal-to-noise, sensitivity, repeatability, simultaneously
- New mathematics determines the fewest steps to achieve optimization
- Systematic measurement uncertainties are also provided giving confidence to the measurement reliability

Instrument parameters are varied using the NIST method…… until the objective is achieved




W.E. Wallace, at al., Analytica Chimica Acta **604** (2007) 62

* in conjunction with the NIST Applied and Computational Mathematics Division

# *Predicting the data before the experiment is conducted*

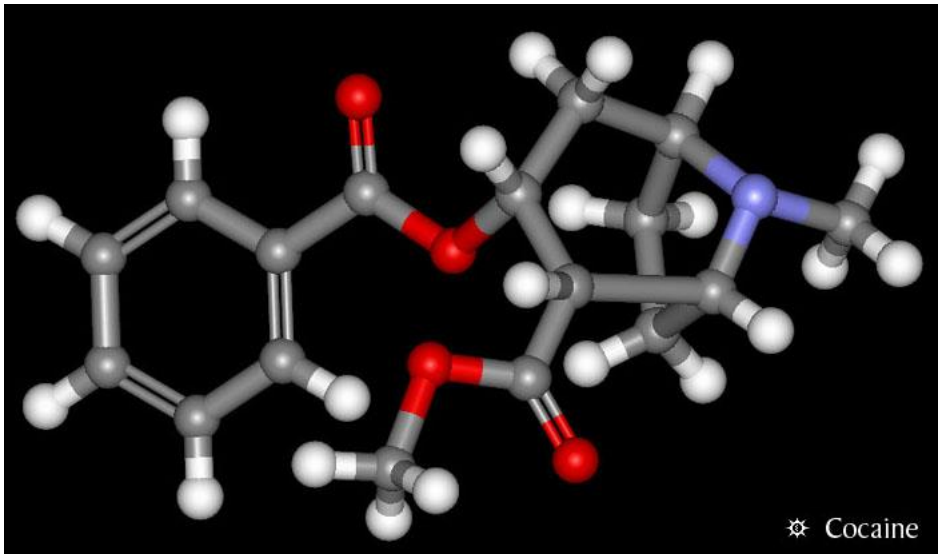
## Computational Quantum Chemistry

- Trends in chemical spectra (NMR, IR, Raman, UV) can be modeled as a function of changes in molecular structure

  ***"If a methoxy group were added at this position how would the infrared spectrum be expected to change?"***

- Mathematically rigorous structural class determinations and similarity scores can be assigned

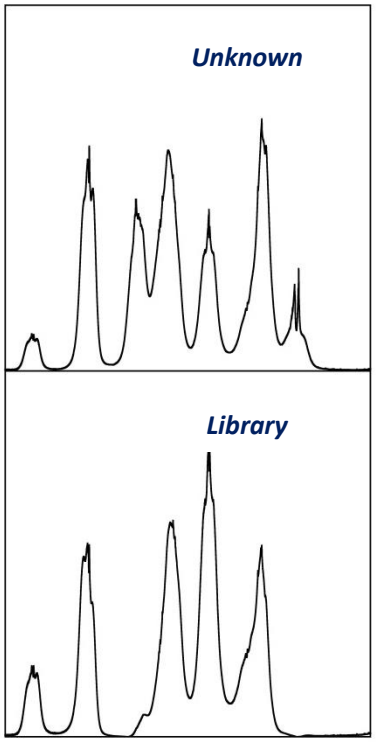
  ***"The proposed structure of the suspect compound has a molecular similarity score of 95% with heroin but only a 70% with codeine"***



# *Working with the data after it has been collected*

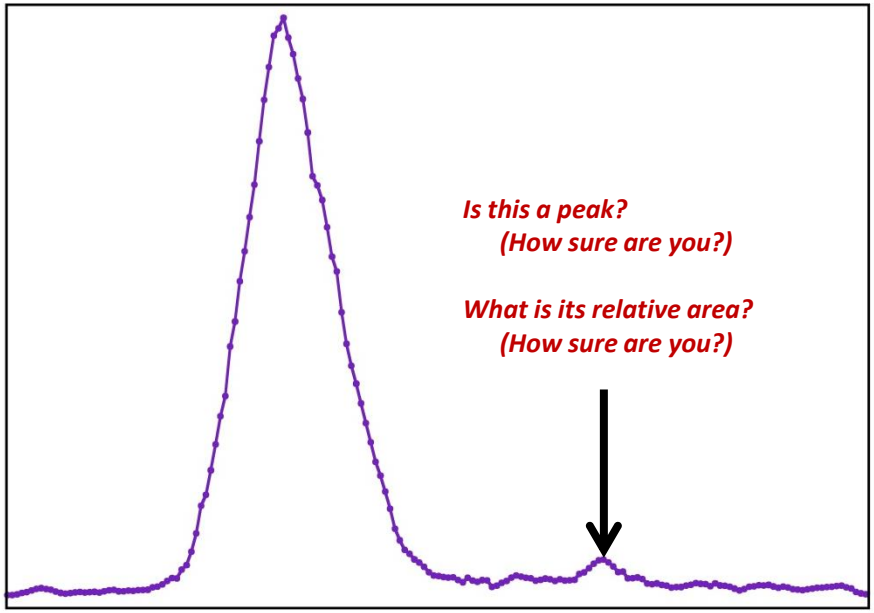
**Novel search algorithms* for complex spectral libraries (MS, NMR, IR)**

- Can 'unknowns' not in the library (e.g., designer drugs) still be identified by spectral similarity measures?
- How can we minimize the likelihood of incorrectly identifying a compound during a library search?




*Do these two FTIR spectra match?*

*How closely?*




**Peak picking statistics***

- operator-independent (unbiased) and statistically-rigorous peak identification and integration methods
- Mathematical uncertainties on peak position and peak area

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# *Making all the data readily accessible*

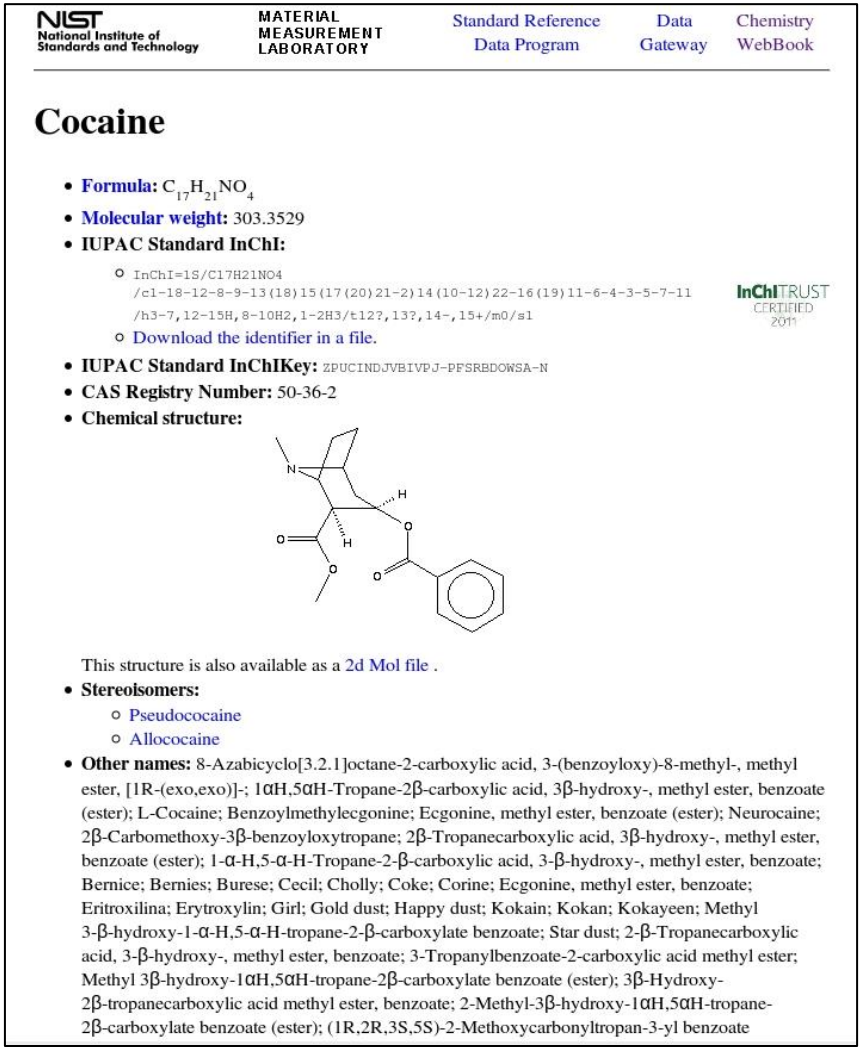
**The NIST *Chemistry WebBook* distributes high quality information**

- Currently includes 70,000 compounds
- Includes physical, chemical, and spectral data
- 7000 unique visitors/day

**Would a NIST *Forensic Webbook* address user needs?**

- Could provide validated properties and spectra on compounds of known purity
- Can be updated on short notice
- Could provide the highest levels of cyber security

**http://webbook.nist.gov/chemistry/**



NIST National Institute of Standards and Technology | MATERIAL MEASUREMENT LABORATORY | Standard Reference Data Program | Data Gateway | Chemistry WebBook

## Cocaine

- **Formula:** $C_{17}H_{21}NO_4$
- **Molecular weight:** 303.3529
- **IUPAC Standard InChI:**
  - InChI=1S/C17H21NO4/c1-18-12-8-9-13(18)15(17(20)21-2)14(10-12)22-16(19)11-6-4-3-5-7-11/h3-7,12-15H,8-10H2,1-2H3/t12?,13?,14-,15+/m0/s1
  - Download the identifier in a file.
- **IUPAC Standard InChIKey:** ZPUCINDJVBIVPJ-PFSRBDOWSA-N
- **CAS Registry Number:** 50-36-2
- **Chemical structure:**



This structure is also available as a 2d Mol file .

- **Stereoisomers:**
  - Pseudococaine
  - Allococaine
- **Other names:** 8-Azabicyclo[3.2.1]octane-2-carboxylic acid, 3-(benzoyloxy)-8-methyl-, methyl ester, [1R-(exo,exo)]-; 1αH,5αH-Tropane-2β-carboxylic acid, 3β-hydroxy-, methyl ester, benzoate (ester); L-Cocaine; Benzoylmethylecgonine; Ecgonine, methyl ester, benzoate (ester); Neurocaine; 2β-Carbomethoxy-3β-benzoyloxytropane; 2β-Tropanecarboxylic acid, 3β-hydroxy-, methyl ester, benzoate (ester); 1-α-H,5-α-H-Tropane-2-β-carboxylic acid, 3-β-hydroxy-, methyl ester, benzoate; Bernice; Bernies; Burese; Cecil; Cholly; Coke; Corine; Ecgonine, methyl ester, benzoate; Eritroxilina; Erytroxylin; Girl; Gold dust; Happy dust; Kokain; Kokan; Kokayeen; Methyl 3-β-hydroxy-1-α-H,5-α-H-tropane-2-β-carboxylate benzoate; Star dust; 2-β-Tropanecarboxylic acid, 3-β-hydroxy-, methyl ester, benzoate; 3-Tropanylbenzoate-2-carboxylic acid methyl ester; Methyl 3β-hydroxy-1αH,5αH-tropane-2β-carboxylate benzoate (ester); 3β-Hydroxy-2β-tropanecarboxylic acid methyl ester, benzoate; 2-Methyl-3β-hydroxy-1αH,5αH-tropane-2β-carboxylate benzoate (ester); (1R,2R,3S,5S)-2-Methoxycarbonyltropan-3-yl benzoate

# That' all folks!

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