Mass Spectrometry and Biosensing Research

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WTEC Biosensing Workshop: May 13, 2003
Sponsored by NIH (NIBIB), NSF, NASA, ARO, and USDA of the U.S. Government

Purpose

Fourier transform mass spectrometer

- Identify new concepts
- Clarify research opportunities and needs
- Identify opportunities for international collaboration
- Compare directions of U.S., Japanese, and European research

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Relevant Biosensor Characteristics

- Specificity (MS yes)
- Sensitivity (MS yes)
- Stability (MS yes)
- Wide applicability (MS yes)
- Portability (MS no)
- Low cost (MS no)

Research Opportunities

- Development of compact new mass spectrometry technology
- Development of portable MS instruments
- Analytical exploitation of MS sensitivity specificity, and selectivity advantages

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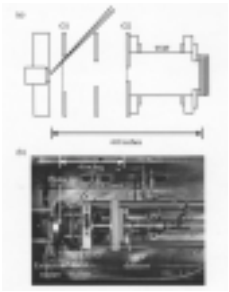
Compact MS Research - U.S.

A honey of a trap. A miniaturized cylindrical ring electrode (at the center) in a plastic holder with a bee for size comparison.
J. Michael Ramsey/Oak Ridge National Laboratory

C. Henry, *Anal. Chem.*, *71*, 264A-268A (**1999**)

Compact MS Research - U.S.



A miniaturized time-of-flight mass spectrometer showing the sample probe, the end cap, and the coaxial detector.
Robert J. Cotter, Johns Hopkins University

R.D. English and R. J. Cotter, *J. Mass Spectrom., 38*, 296-304 (2003)

Compact MS Research - U.S.

A miniaturized cylindrical ion trap (right) with a commercial ion trap (left) for comparison.
R. Graham Cooks, Purdue University

C. Henry, *Anal. Chem.*, *71*, 264A-268A (**1999**)

Compact MS Research - U.S.

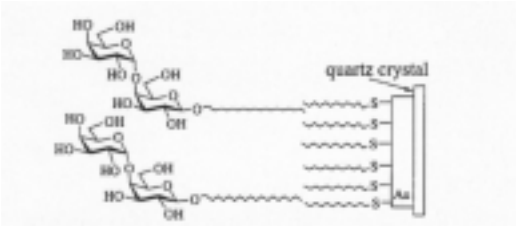
A miniaturized FT-ICR cell using a 0.44-T permanent magnet
Dan Dietrich, Lawrence Livermore National Laboratory

C. Henry, *Anal. Chem.*, *71*, 264A-268A (**1999**)

Typical Parameters

Analyzer Type	Dimension	Mass Range	Resolution
Cooks QIT	2.5 mm radius	250 m/z	100 m/Δm
Whitten-Ramsey QIT	0.5 mm radius	135 m/z	700 m/Δm
Quadrupole	0.5 mm radius 10 mm long 4 x 4 array	300 m/z	600 m/Δm
FT-ICR	38 cm long	300-500 m/z	500-1000 m/Δm
Cotter TOF	7.5 cm long	66,000 m/z	300-1200 m/Δm
Double-Focusing EB	17 x 37 x 57 cm instrument	39-255 m/z	131 m/Δm

Mass-based Analysis - Japan



Uzawa, H.; Kamiya, S.; Minouta, N.; Dohi, H.; Nishida, Y.; Taguchi, K.; Yokoyama, S.; Mori, H.; Shimizu, T.; Kobayashi, K. A Quartz Crystal Microbalance Method for Rapid Detection and Differentiation of Shiga Toxins by Applying a Monoalkyl Globoside as the Toxin Ligand, *Biomacromolecules* **2002**, *3*, 411-414.

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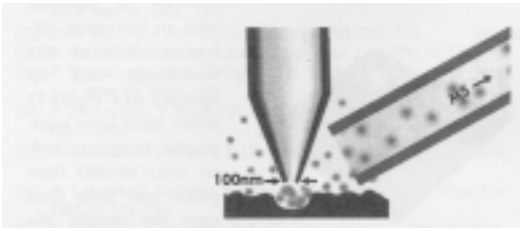
MS Instrument Developments - Europe

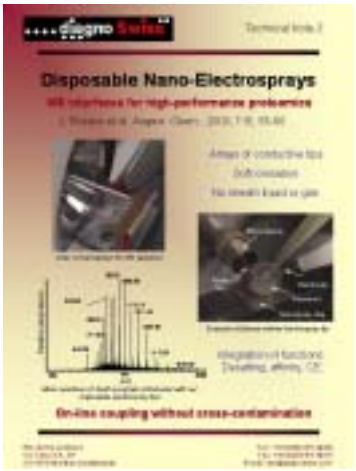


Laser ablation MS through scanning near-field optical spectroscopy (SNOM) tips (200 nm spatial resolution)

Renato Zenobi, Swiss Federal Institute of Technology (ETH)

R. Stöckle, et. al. *Anal. Chem., 73*, 1399-1402 (**2001**)

MS Instrument Developments - Europe



Example of a current commercial ESI interface for proteomics

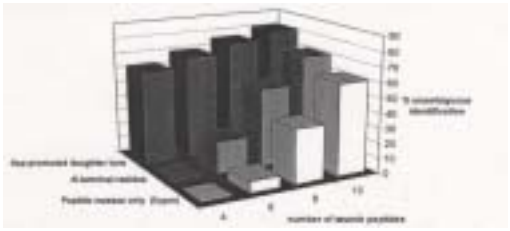
Proteomics

"the analysis of complete complements of proteins. Proteomics includes not only the identification and quantification of proteins, but also the determination of their localization, modifications, interactions, activities, and, ultimately, their function."

Stanley Fields, University of Washington

Science, 291, 1221 (**2001**).

Proteomics - Europe



Simon Gaskell, Manchester Institute of Science and Technology (UMIST)

Sidhu, K.S., Sangvanich, P., Brancia, F.L., Sullivan, A.G., Gaskell, S.J. Wolkenhauer, O., Oliver, S.G., Hubbard, S.J., *Proteomics, 1*, 1368-1377 (**2001**).

Mass Spectrometry in Biosensor Research

- MS Miniaturization is being Actively Pursued in U.S.
- Proteomics is a Major Emphasis in both the U.S. and Europe
- MS applications in Biosensing is not a Major Activity in Japan

Possible International Collaboration Areas

- Proteomics Research - Europe and U.S.
- MS Miniaturization - Europe and U.S.
- Novel MS Interfaces - Europe and U.S.

Research Strengths

- M.S. Instrumentation Development - U.S.
- Proteomics Research and Novel M.S. Interfaces - U. S. and Europe
- Non-MS Mass-based Biosensors - Japan

Research Status- 2003

	Topic	Knowledge Base	Work to Date	Leading Region
Mass sensors, MEMS, and microfluidics	Mass Sensors	Excellent	Europe, USA, Japan	Equally advanced, Commercialized
Mass spectrometric methods	Compact Instrument Development	Excellent, problems remain	Europe, USA	Europe, USA
	Portable MS Development	Excellent, problems remain	Europe, USA	Europe, USA
	Novel MS Interfaces	Excellent, problems remain	Europe, USA	Europe, USA
	Proteomics	Excellent, very active research area	Europe, USA	Europe, USA

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