



**“In and Out Air Strategies.
From Climate Change to Microclimate.
Library, Archives and Museum
Preservation Issues”**

5-6 March 2009

Bibliothèque nationale de France

<http://www.ifla.org/VI/4/pac.htm>

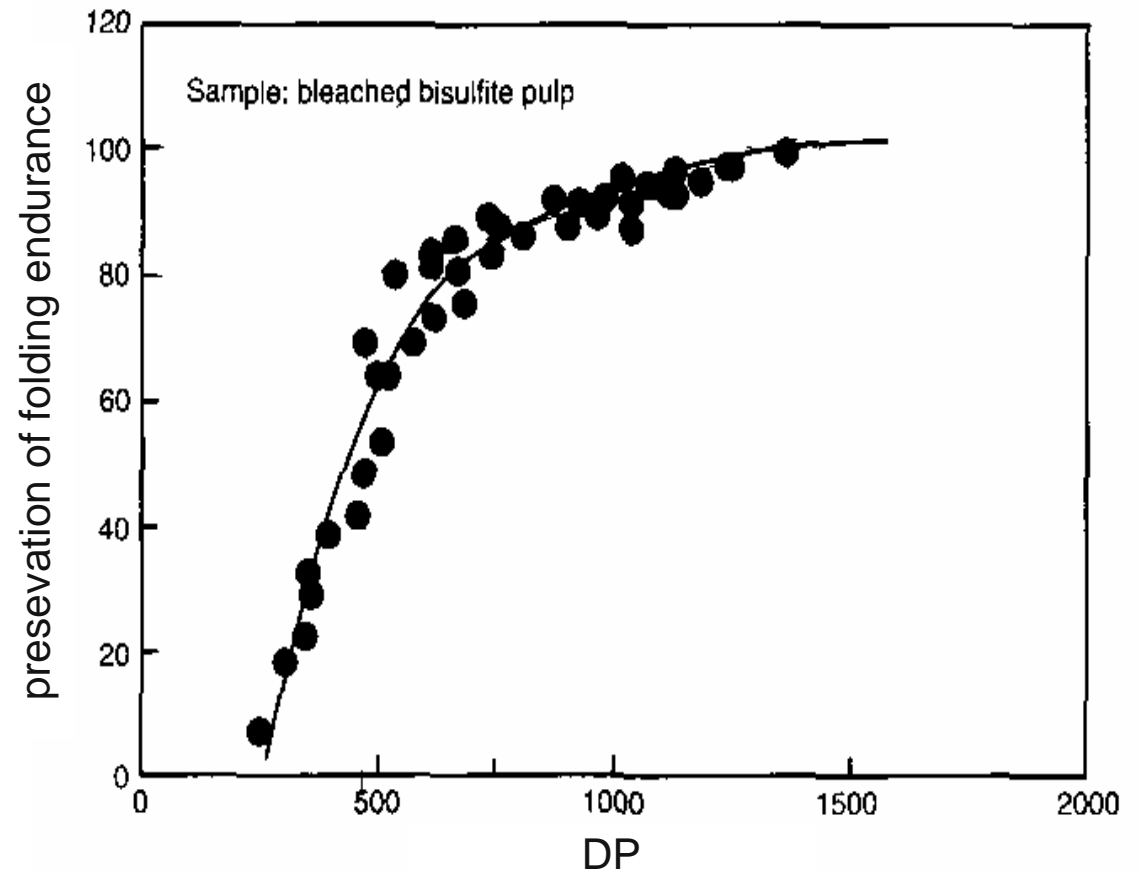
Measuring the emission of volatile organic compounds from books

Velson Horie

Research Project Manager

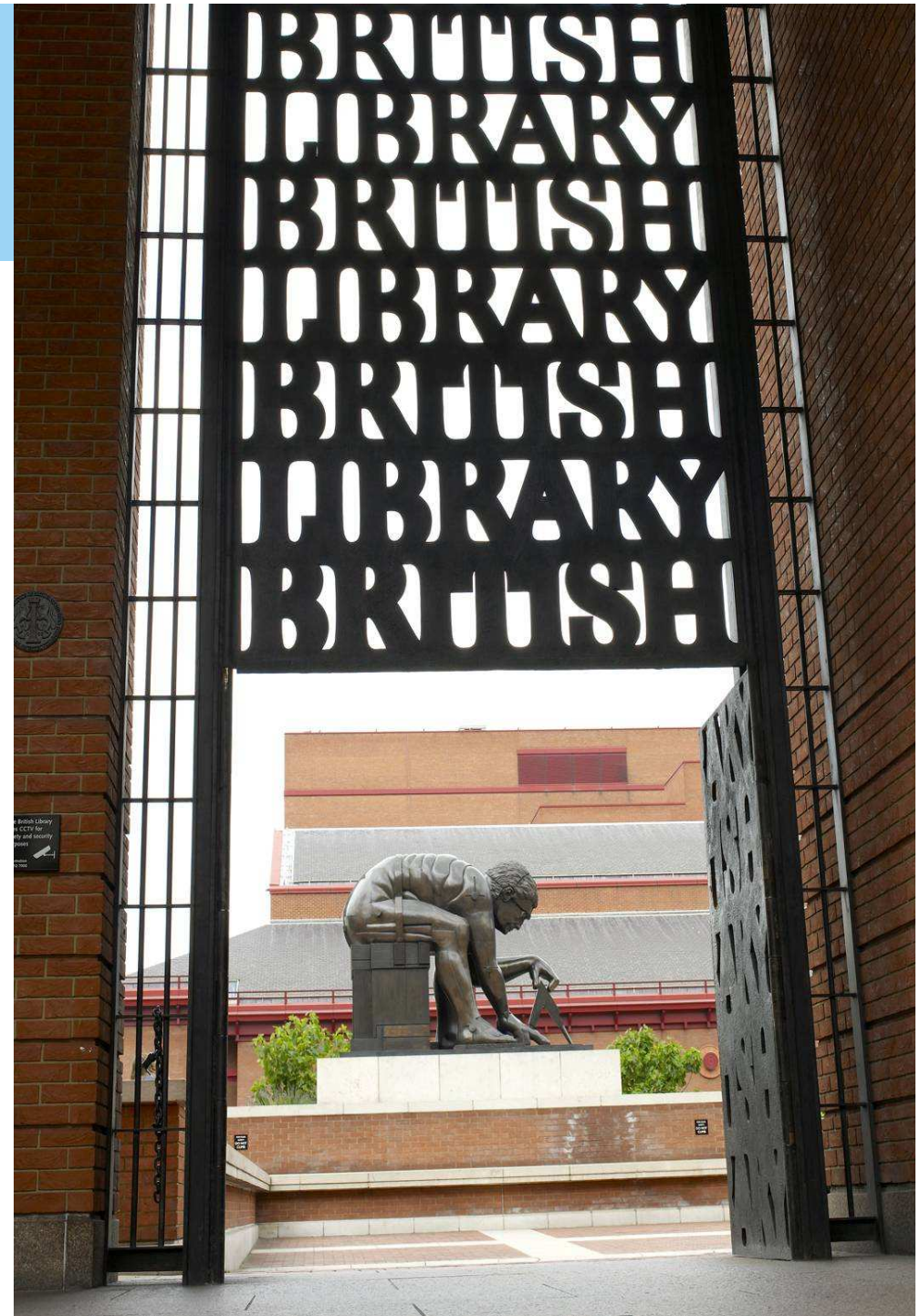
The British Library

What is happening to our books?



A Few Statistics

- Formal beginning in 1753 as the library of The British Museum
- The British Library formed in 1973 from many collections
- New St Pancras building opened in 1998
- 150m collection items on 640km of shelves,
- £131m budget, 1900 staff



Additional Storage Programme - Boston Spa

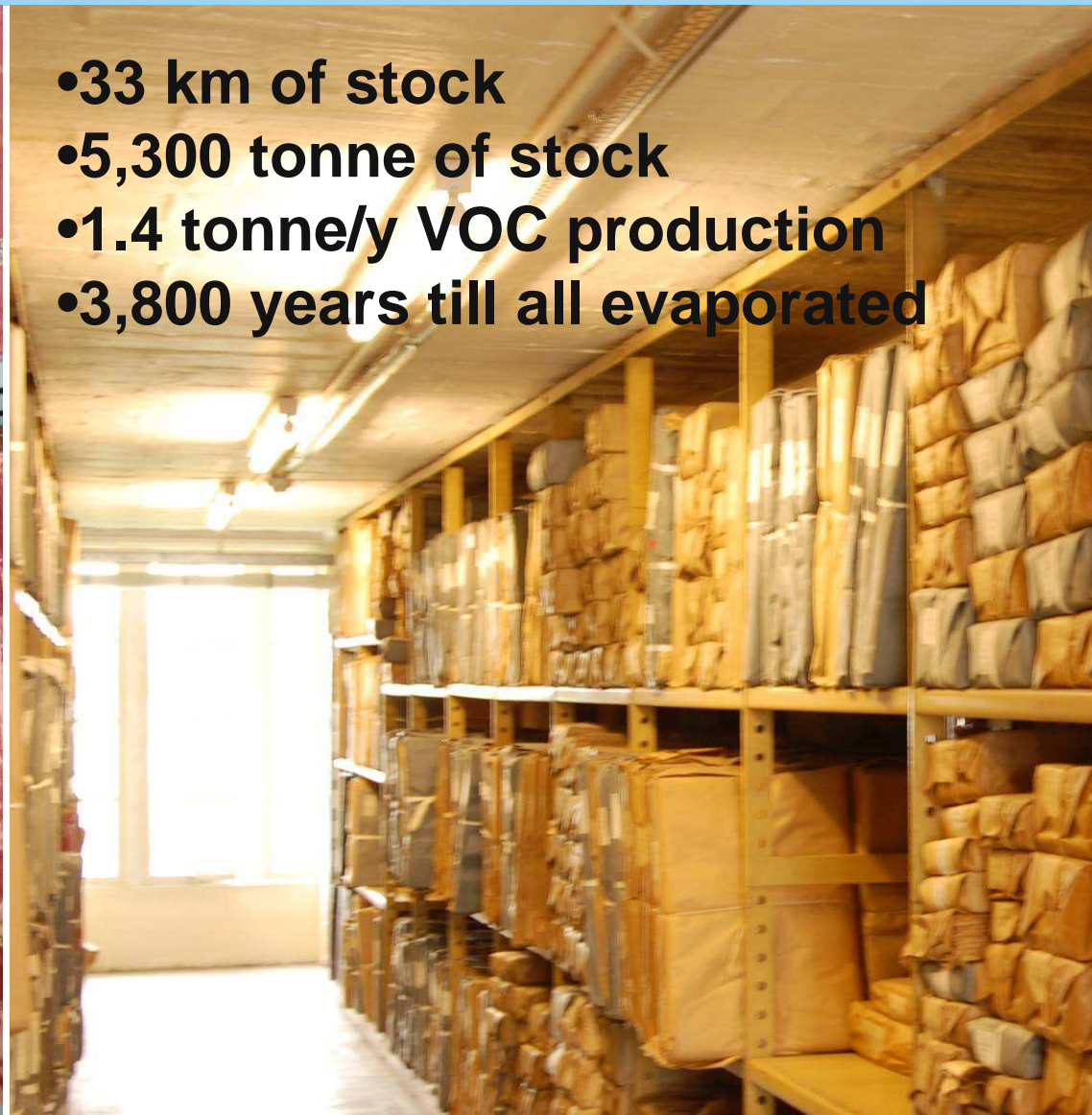
- 7 million collection items
- 263 km, 12,000 tonne of stock
- Reduced oxygen (16%)
- Robotic book handling
- What are the long term effects?



Preserving Newspapers



- 33 km of stock
- 5,300 tonne of stock
- 1.4 tonne/y VOC production
- 3,800 years till all evaporated



Major UK libraries and archives

- Cambridge University Library (CUL) 7m printed items
- The British Library (BL) 150m items
- National Library of Scotland (NLS) 14m items
- National Library of Wales (NLW) 6m printed items
- Oxford University Library (OULS) 11m items
- Trinity College Dublin Library (TCD) 4m printed items
- The National Archives (TNA)
- National Archives of Scotland (NAS)

Condition assessment

- Preservation Assessment Survey
- Strength
- Colour
- pH
- Molecular weight
- Furnish
- SurveNIR
- VOCs

The “real thing” is important to people

E-books sales have been slow to take off.

CafeScribe is sending every e-textbook purchaser a scratch and sniff sticker with a musty “old book” smell.

By placing these stickers on their computers, they can give their e-books the same musty book smell they know and love from used textbooks.

109 VOCs identified from books (so far)

acetaldehyde	cyclohexyl carbinol	butyl-cyclohexane	1-dodecanol
acetic acid	2,4-dimethyl hexane	nonanal	tetradecane
butyl alcohol	3-methyl heptane	4-isopropyl cyclohexanol	pentadecane
butanoic acid	hexanoic acid	3-ethyl-2-methyl heptane	hexadecane
acetoin	isobutyl acetate	3-methyl nonane	heptadecane
pentyl alcohol	butyl acetate	decane	1-methylethyl ester dodecanoic acid
isoamyl alcohol	2-heptanol	octanoic acid	acid
1,3-butylene glycol	1-heptanol	2-ethyl hexanoic acid	dodecanoic acid, 1-methylethyl ester
2-ethoxy ethanol	diethyl acetal	hexyl acetate	octadecane
toluene	acetophenone	2,6-dimethyl heptanol	nonadecane
phenol	trimethyl-benzene	isononyl alcohol	tetradecanoic acid, 1-methylethyl ester
furfural	cumene	benzyl acetate	dibutyl phthalic acid
methyl cyclohexane	benzoic acid	vanillin	eicosane
ethyl acrylate	p-ethyl phenol	isoborneol	heneicosane
methylisobutyl ketone	propyl-cyclohexane	decanal	docosane
heptane	1-ethyl-2-methyl cyclohexane	4-t-butyl cyclohexanol	decamethylcyclopentasiloxane
2-hexenol	octanal	undecane	pentyl-cyclohexane
pentanoic acid	ethyl cyclohexanol	nonanoic acid	d-limonene
1-hexanol	1-octen-3-ol	pentyl butyrate	3,7-dimethyl octanol
2,3-dimethyl butyl alcohol	methyl heptenol	1-decanol	t-butyl benzene
styrene	2,4-dimethyl heptane	hexylcyclohexane	
benzaldehyde	3-methyl octane	undecanal	
o-,m-p-xylene (isomers)	ethyl acetoacetate	dodecane	
ethyl benzene	heptanoic acid	decanoic acid	
benzyl alcohol	2-ethyl-1-hexanol	undecanol	
anisole	3-octanol	3-butyl-4-hydroxy anisole	Sources: Buchbauer 1995,
5-methyl-furfural	α -pinene	heptylcyclohexane	Lattuati-Derieux 2004, Lattuati-
1,4-dimethyl cyclohexane	camphene	dodecanal	Derieux 2006
1,3-dimethyl cyclohexane	3-methyl pentanol	tridecane	
heptanal	dimethoxy benzene	5,9-dimethyl dec-8-en-3-ol	

Volatile organic chemicals (VOCs)



Analysis of VOCs collected on diffusion tubes, Tenax tubes, SPME fibres, elastomer strips

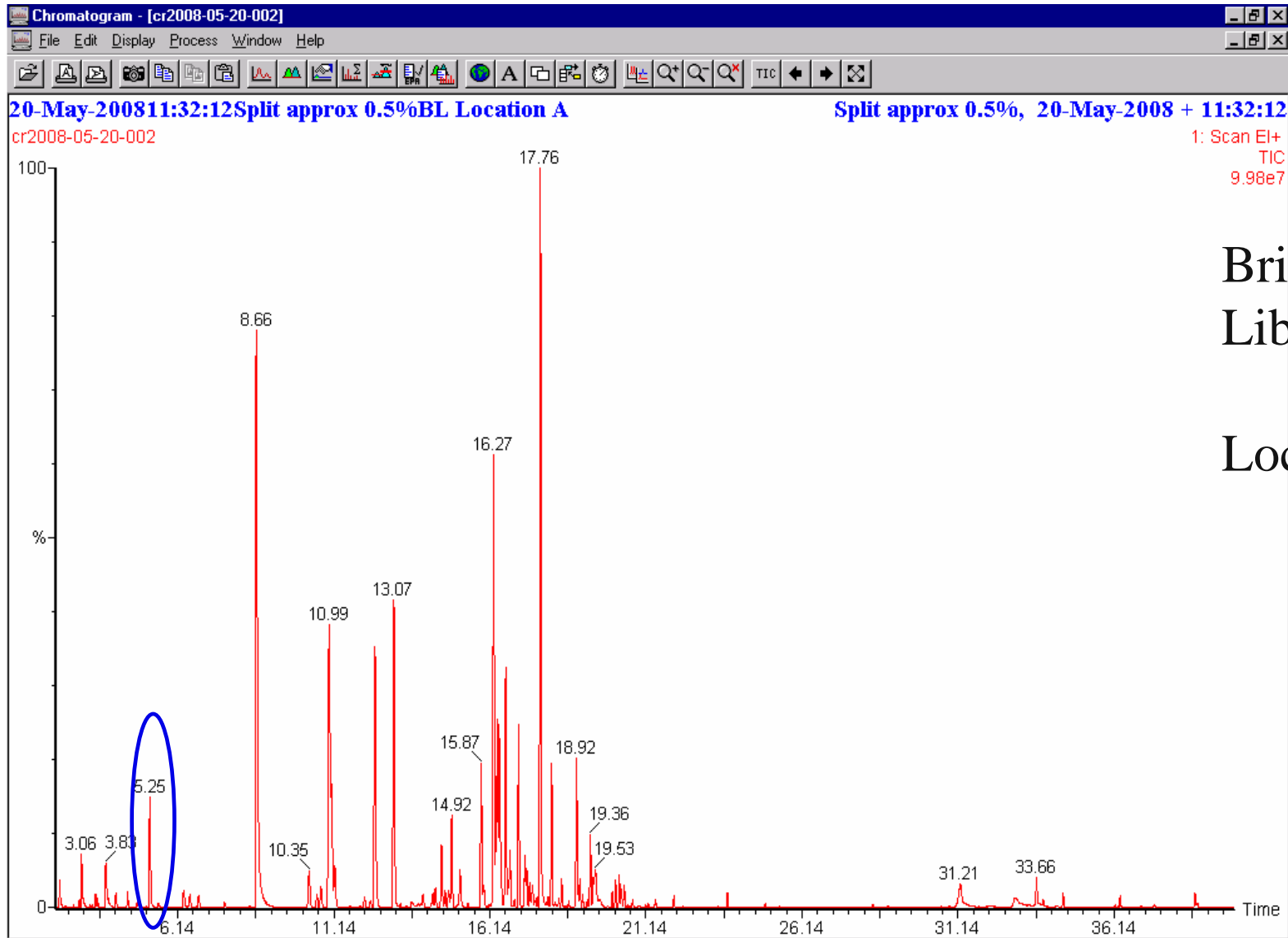
- Off-line sample preparation and analysis
- Uses the thermal desorption – gas chromatography – mass spectrometry
- More complex analysis than the organic acids and aldehydes
- Each sample run is 60 minutes

Sampling concerns

- Are we going to see any analytes?
- Have we used a long enough sampling time?
- Can we match the peaks to the chemical – with confidence



Sampling Results - VOCs



British
Library

Location A

Identifying the peak

NIST MS Search 2.0 - [Ident, Presearch Default - InLib = -501, 100 spectra]

File Search View Tools Window Help

1. D:\adam\FERMENTATION.PRO\Data\cr20

#	Lib.	Match	R.Match	Prob.	Name
1	M	803	803	15.2	Spiro[2.4] hepta-4,6-diene
2	M	802	828	14.6	Bicyclo[3.2.0] hepta-2,6-diene
3	M	801	801	14.0	1,3,5-Cycloheptatriene
4	M	786	788	8.50	Cyclobutene, 2-propenylidene-
5	R	785	785	8.17	Toluene
6	M	782	838	7.22	Benzene, (propoxymethyl)-
7	M	775	775	8.17	Toluene
8	M	772	775	5.09	Spiro[3.3] hepta-1,5-diene
9	R	769	769	8.17	Toluene
10	R	767	767	14.0	1,3,5-Cycloheptatriene
11	R	766	766	8.17	Toluene
12	R	765	765	8.17	Toluene
13	R	765	765	8.17	Toluene
14	R	758	763	14.0	1,3,5-Cycloheptatriene
15	R	756	756	2.93	Tetracyclo[3.2.0.0(2,7).0(4,6)] heptane
16	R	741	744	1.77	Benzyl 2-chloroethyl sulfone
17	R	738	741	1.77	Benzyl 2-chloroethyl sulfone
18	M	738	741	1.57	Benzene, 1-nitro-4-(phenylmethoxy)-
19	M	736	738	1.45	Benzeneethanol, α -methyl-
20	M	736	736	2.93	Tetracyclo[3.2.0.0(2,7).0(4,6)] heptane
21	R	734	736	1.33	2,5-Norbornadiene
22	R	733	737	1.28	Benzaldehyde, 4-(phenylmethoxy)-
23	R	731	741	1.18	4-Benzyloxybenzotrile
24	M	729	762	1.09	5-(Benzyloxy) dihydro-1,3,5-dioxazin
25	R	728	728	1.33	2,5-Norbornadiene
26	M	725	729	0.92	Benzene, 2-benzyloxy-1-methoxy-4-(2-
27	M	724	726	0.88	Benzene, [(methylsulfonyl)methyl]-
28	M	720	722	1.77	Benzyl 2-chloroethyl sulfone
29	M	720	720	1.33	2,5-Norbornadiene
30	M	718	720	0.69	Benzyl isopentyl ether
31	M	715	715	0.61	Bicyclo[2.2.1] oct-7-en-2-one, 5-methyl-

Name: D:\adam\FERMENTATION.PRO\Data\cr20
 Formula:
 MW: N/A CAS#: N/A NIST#: N/A ID#: 4 D
 Other DBs: None

(Text File) D:\adam\FERMENTATION.PRO\Data\cr20

Plot/Text of Search Spectrum | Plot of Search Spectrum | Plot/Text of Spec List

D:\adam\FERMENTATION.PRO\Data\cr20 Spiro[2.4] hepta-4,6-diene

Difference | Head to Tail | Side by Side | Subtraction 803 803R 15.2P

Name: Spiro[2.4] hepta-4,6-diene
 Formula: C₇H₈
 MW: 92 CAS#: 765-46-8 NIST#: 152867 ID#: 45
 Other DBs: None
 Contributor: Chemical Concepts

10 largest peaks:

91 999	92 387	65 141	39 58
66 40	51 37	89 30	93 26

Synonyms:
 1. Spiro[2.4] hepta-4,6-diene

Sampling the partners

- 8 partners
- 2 collection store rooms and a non-collection area, each partner
- Diffusion tubes for acetic and formic acids, formaldehyde and sulfur dioxide, 2 tubes each at each site, exposed 28 days
- Tenax TA adsorption tubes, ca 144 litre drawn through in 24 hours

Findings

- Diffusion tubes: Acetic acid and formic acid usually higher in store rooms. SO_2 at low levels and formaldehyde had no apparent pattern of concentration
- Tenax tubes (21+ analytes): Furfural was the only analyte consistently higher in store rooms. Concentrations highly affected by activities in the area, e.g. door opening and carpet laying

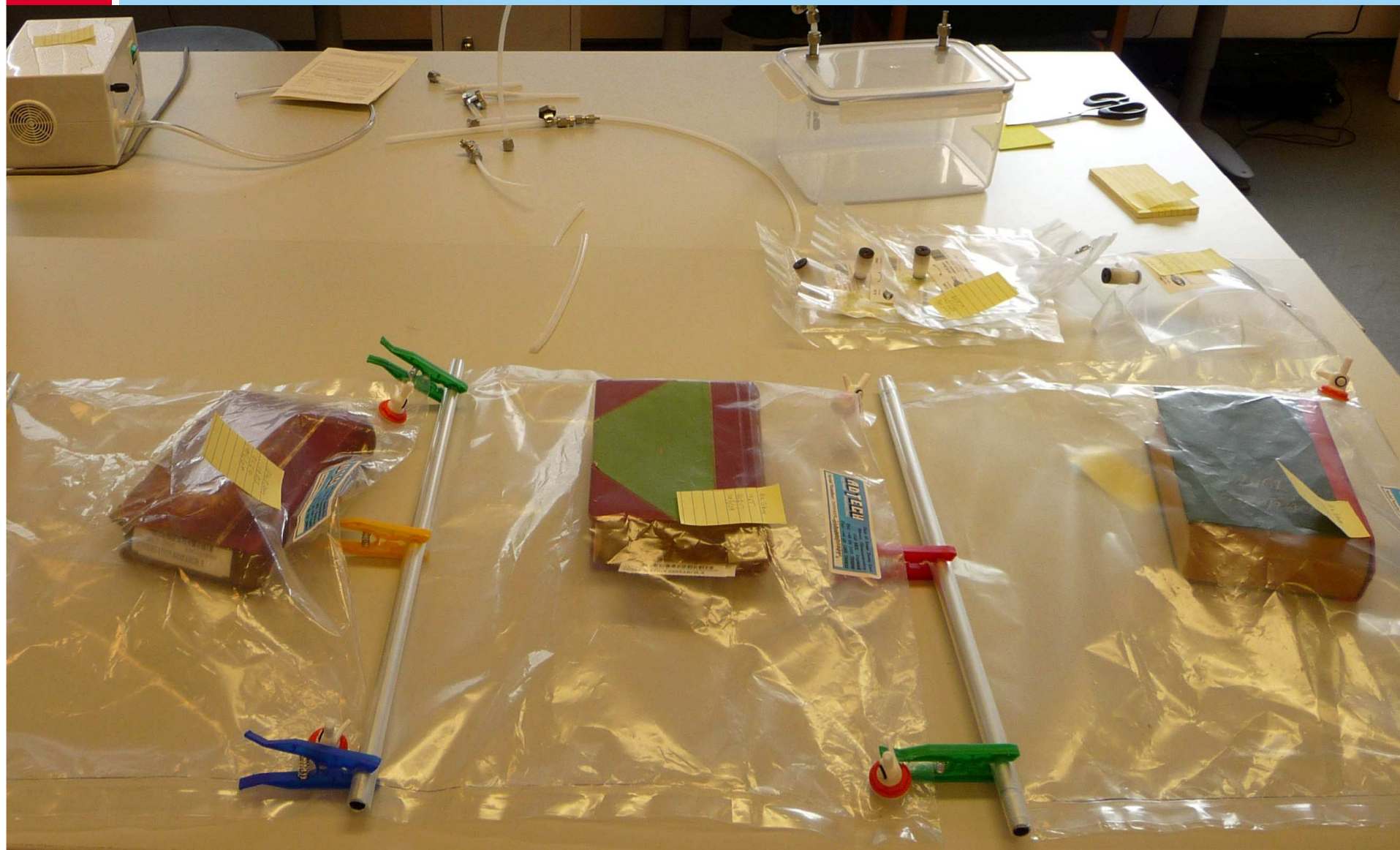
What does this tell us?

- VOCs are present in collection and non-collection areas
- Useful information about the likely load on the carbon filters in the AHU
- Not a lot about the condition of the collection.

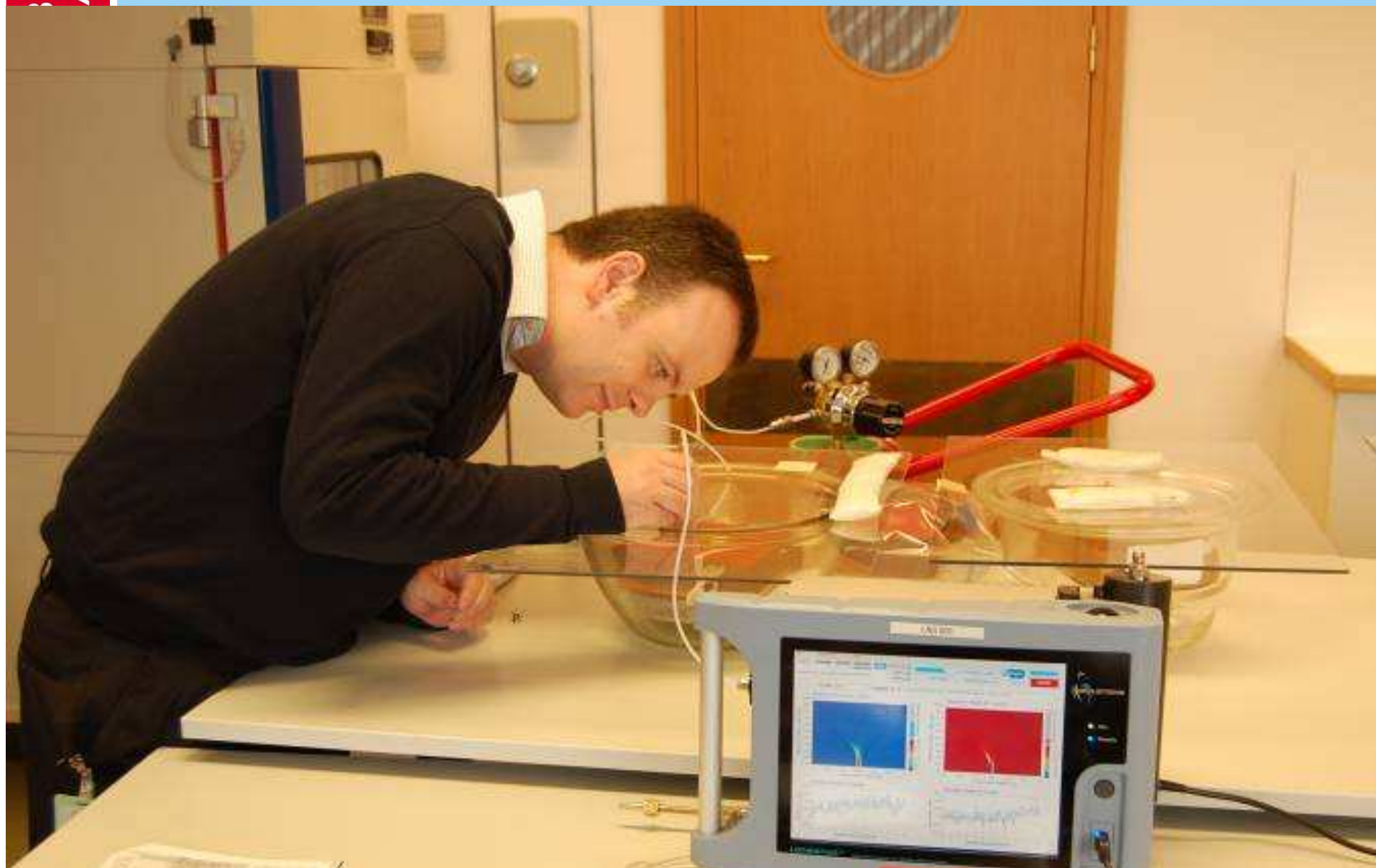
Next steps

- Need to tie the VOC measurements to the books, preferably individual books.
- The condition of the collection can thus be measured by sampling individual items in the collection.

VOCs in individual IBs - ?diagnostic of condition



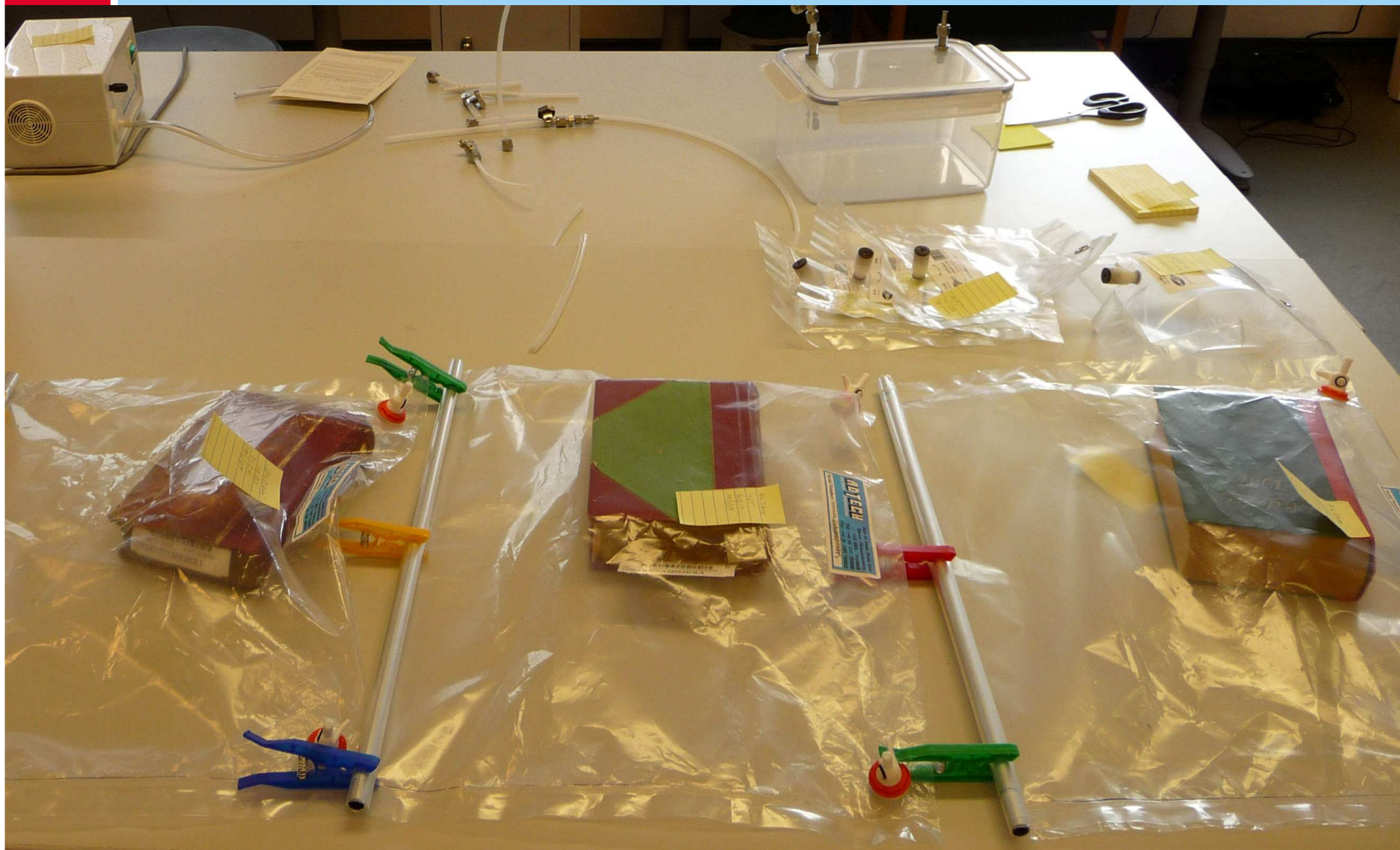
Field Asymmetric Ion Mobility spectrometer (FAIMS) Owlstone



Analysis in ca 2 minutes, using Lonestar



Whitakers Almanack 1903, 1957, 1965

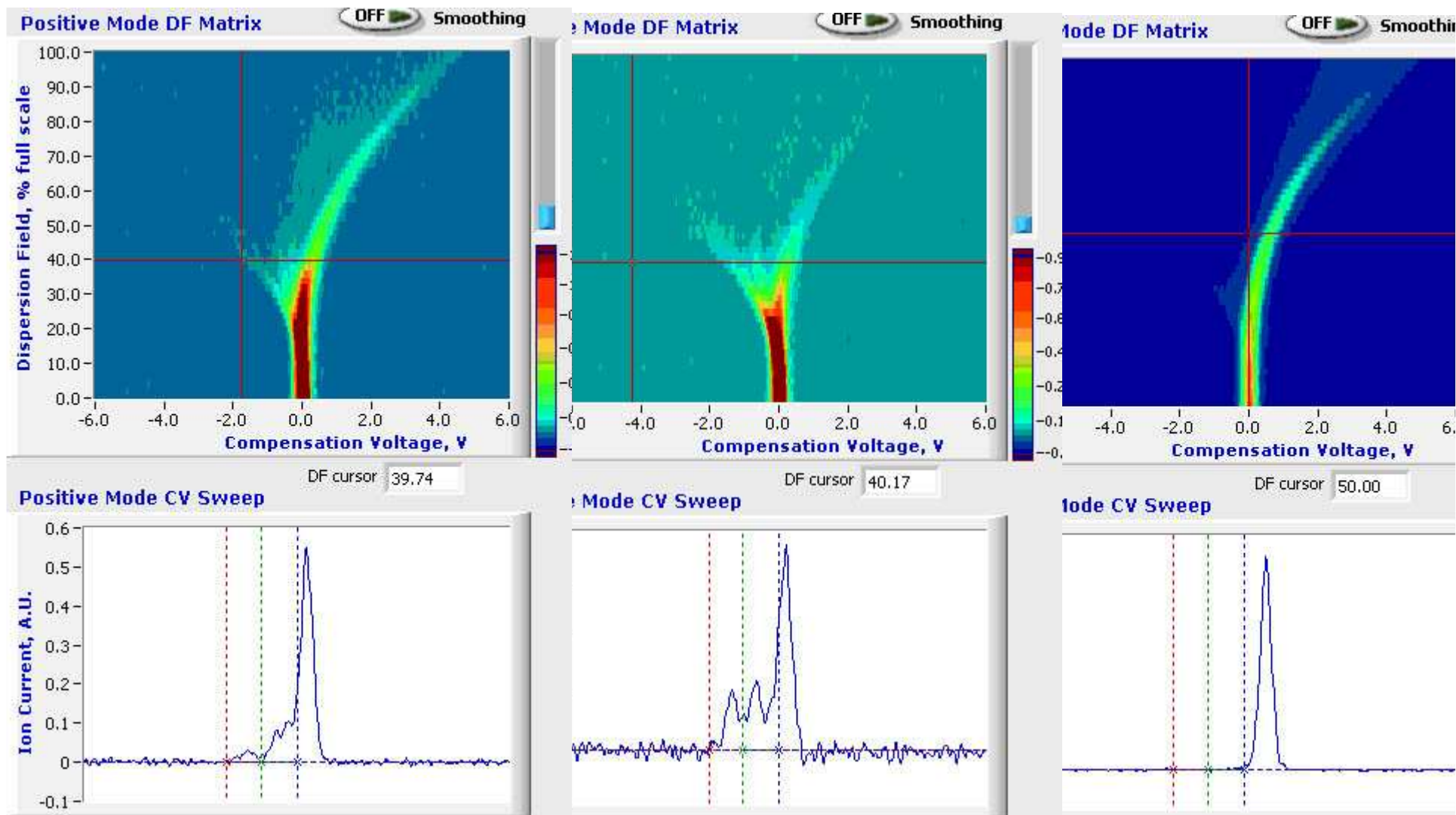


FAIMS (Lonestar) analysis

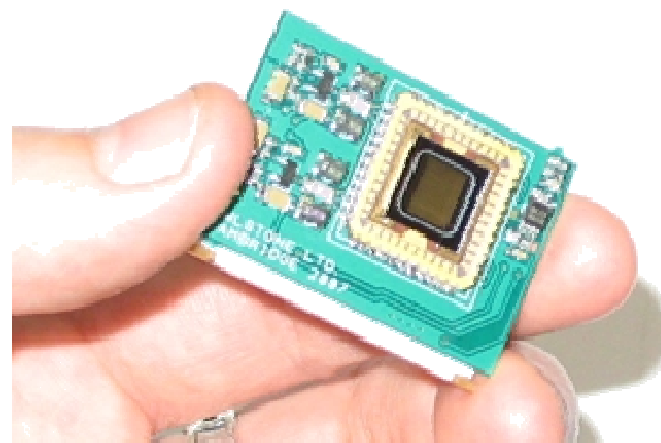
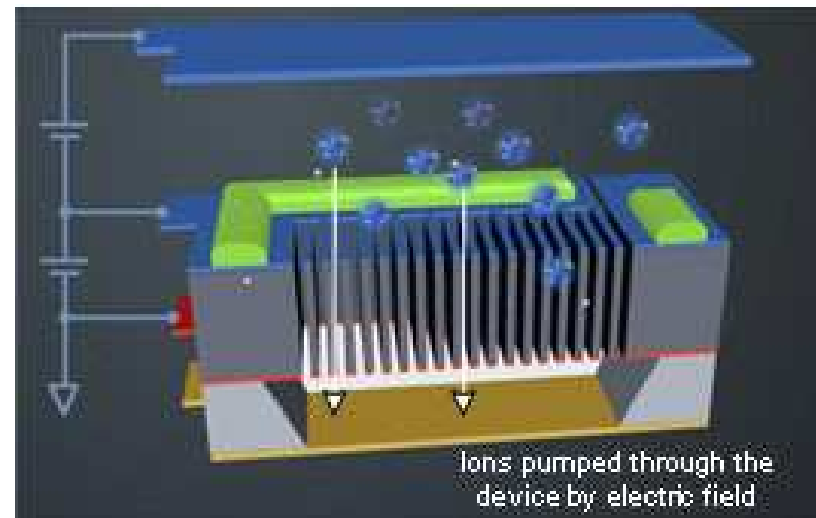
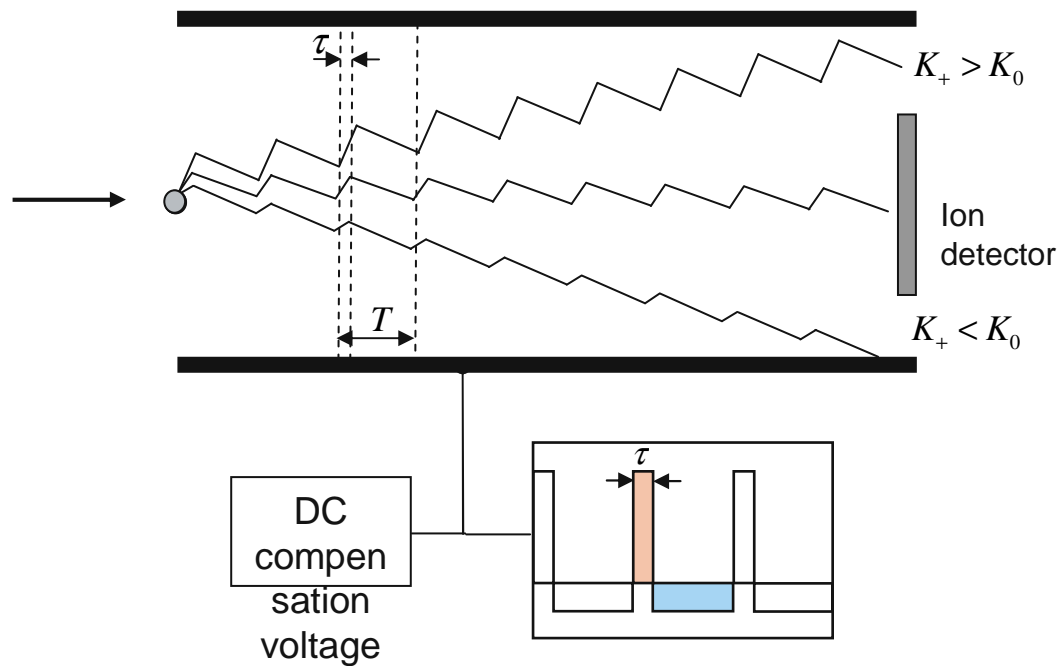
Whitakers almanack 1903

Whitakers almanack 1957

Whitakers almanack 1964



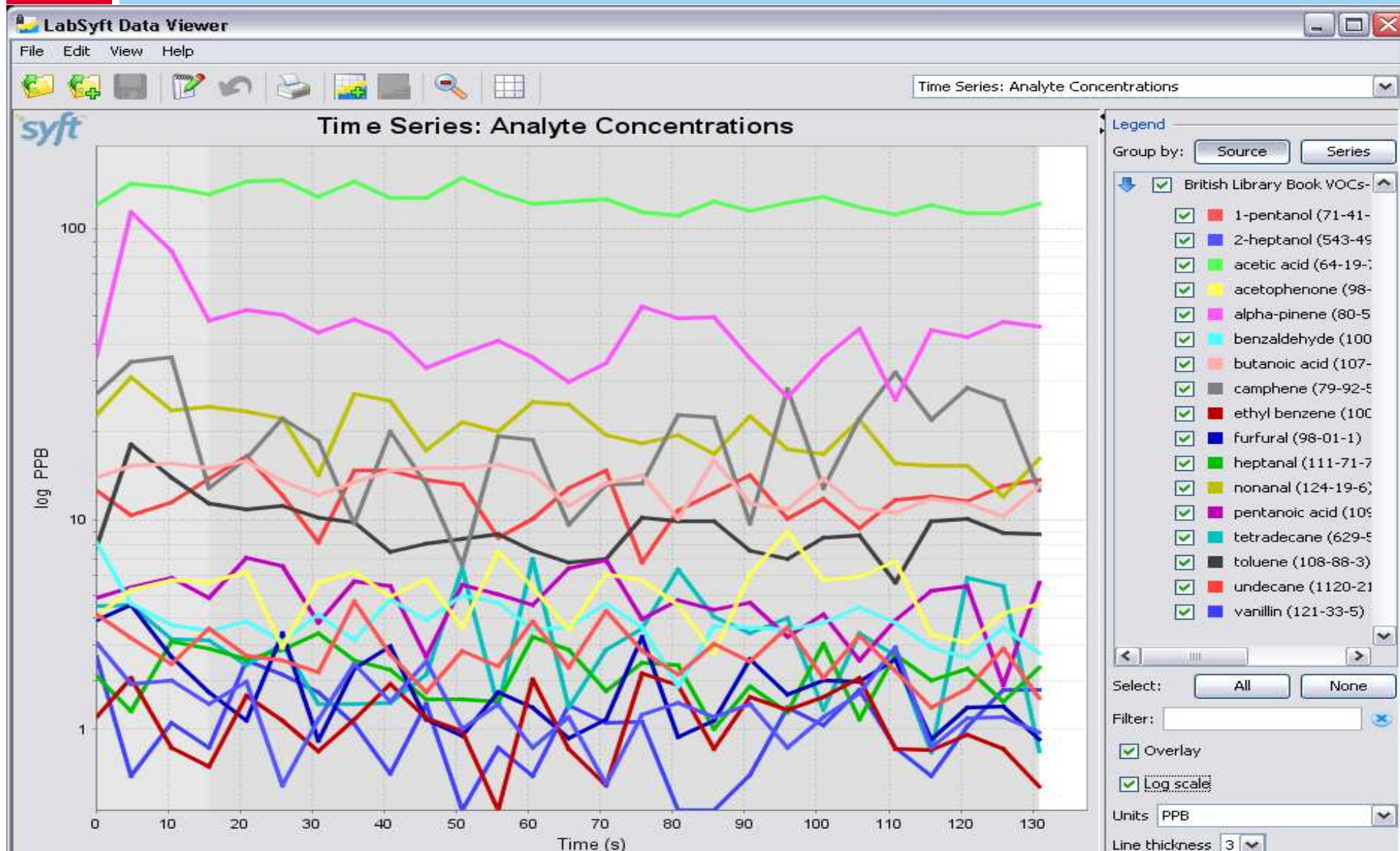
FAIMS – How does it work



Selected Ion Flow Tube Mass Spectrometry (SIFT-MS) SYFT Technologies (UK) Limited

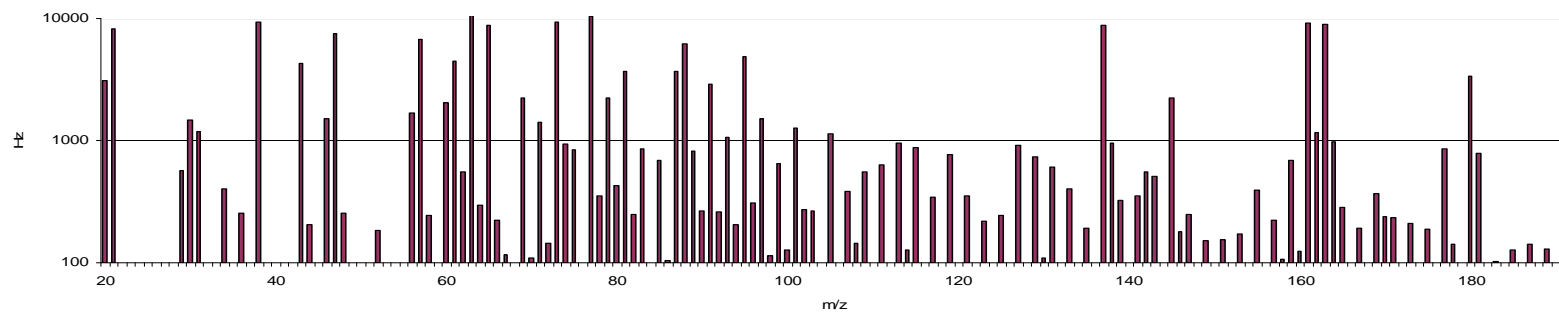


SYFT analyses

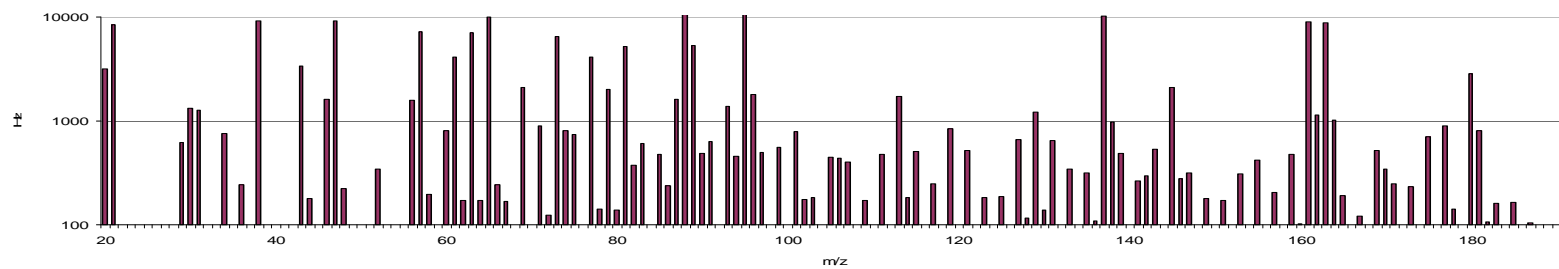


Whitakers Almanac - similarities

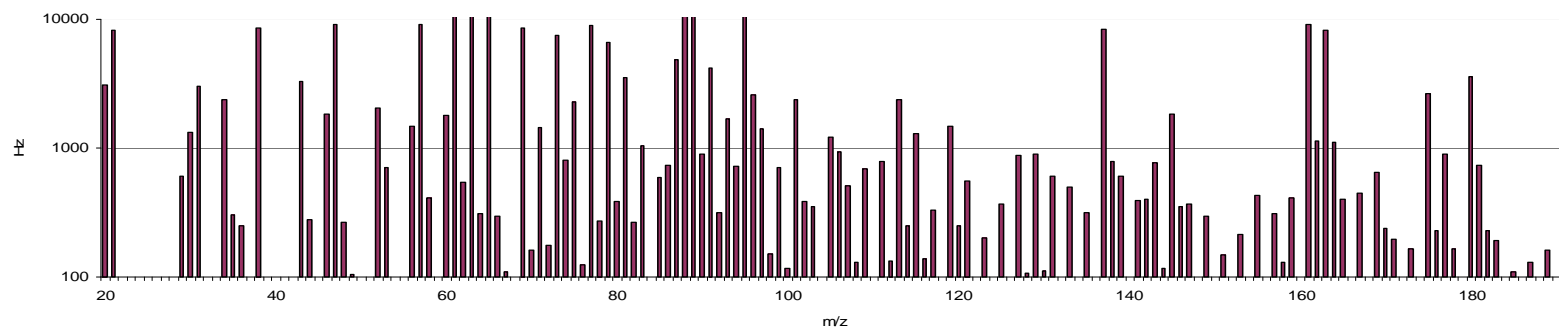
Whitakers Almanac 1903



Whitakers Almanac 1957

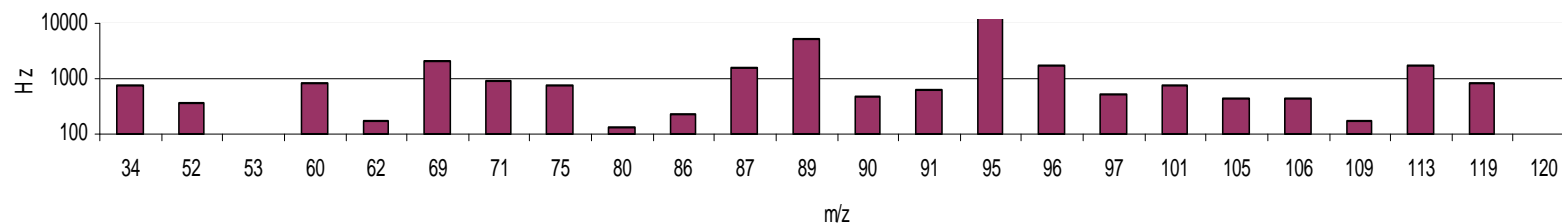


Whitakers Almanac 1965

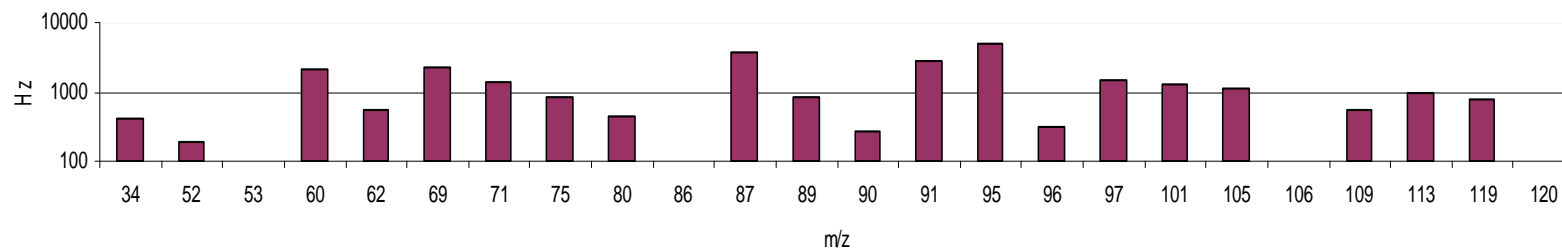


Whitakers Almanac - differences

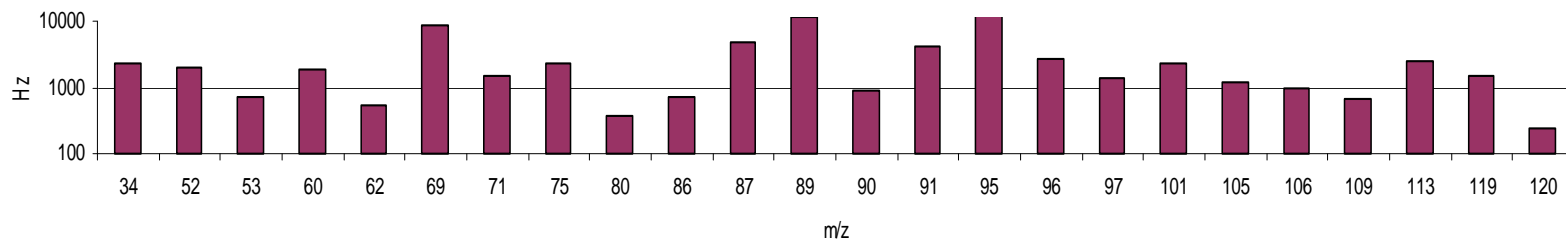
Whitakers Almanac 1957



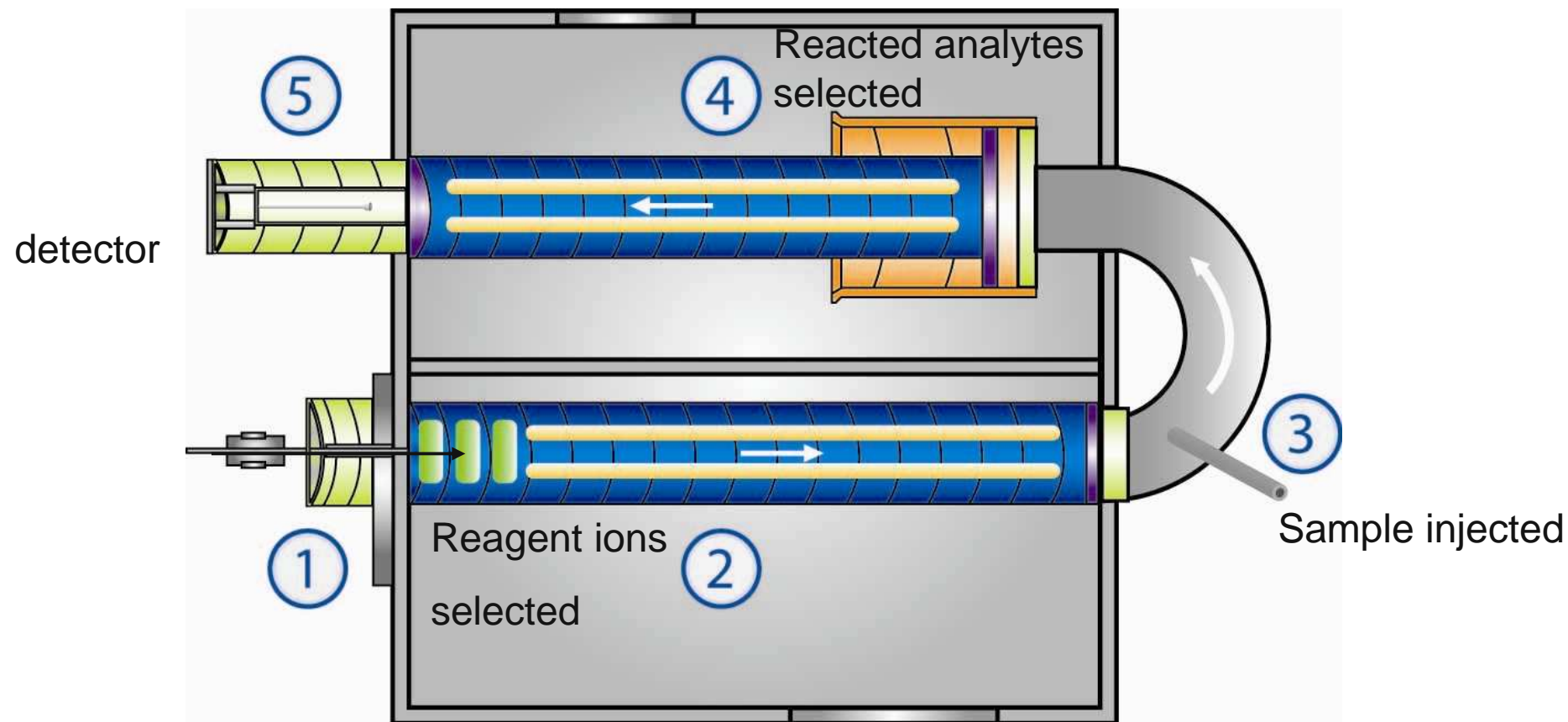
Whitakers Almanac 1903



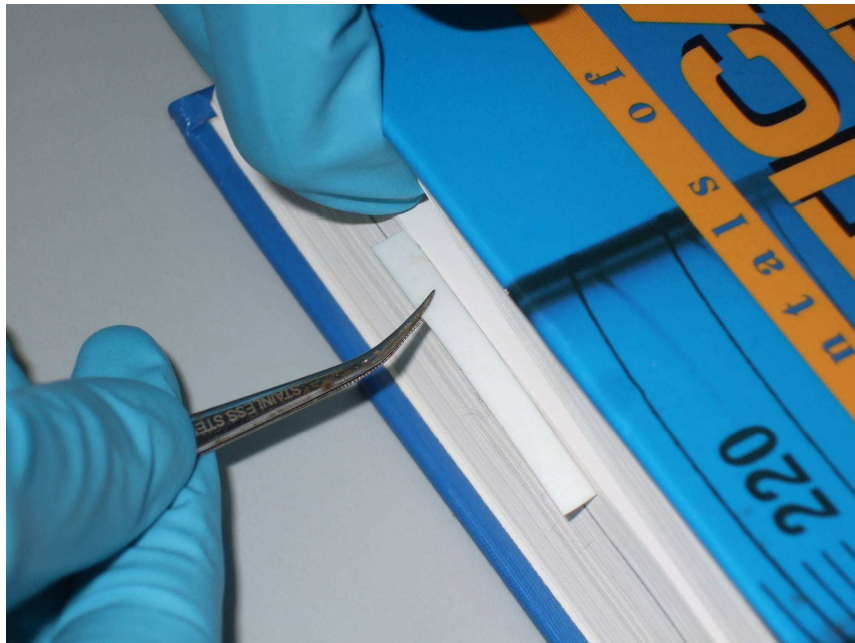
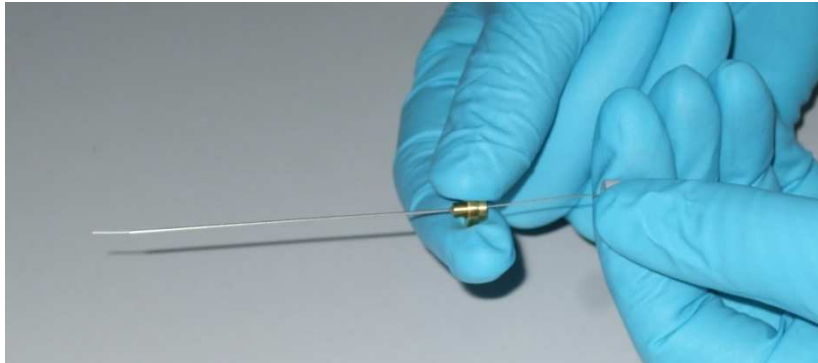
Whitakers Almanac 1965



SYFT –how does it work

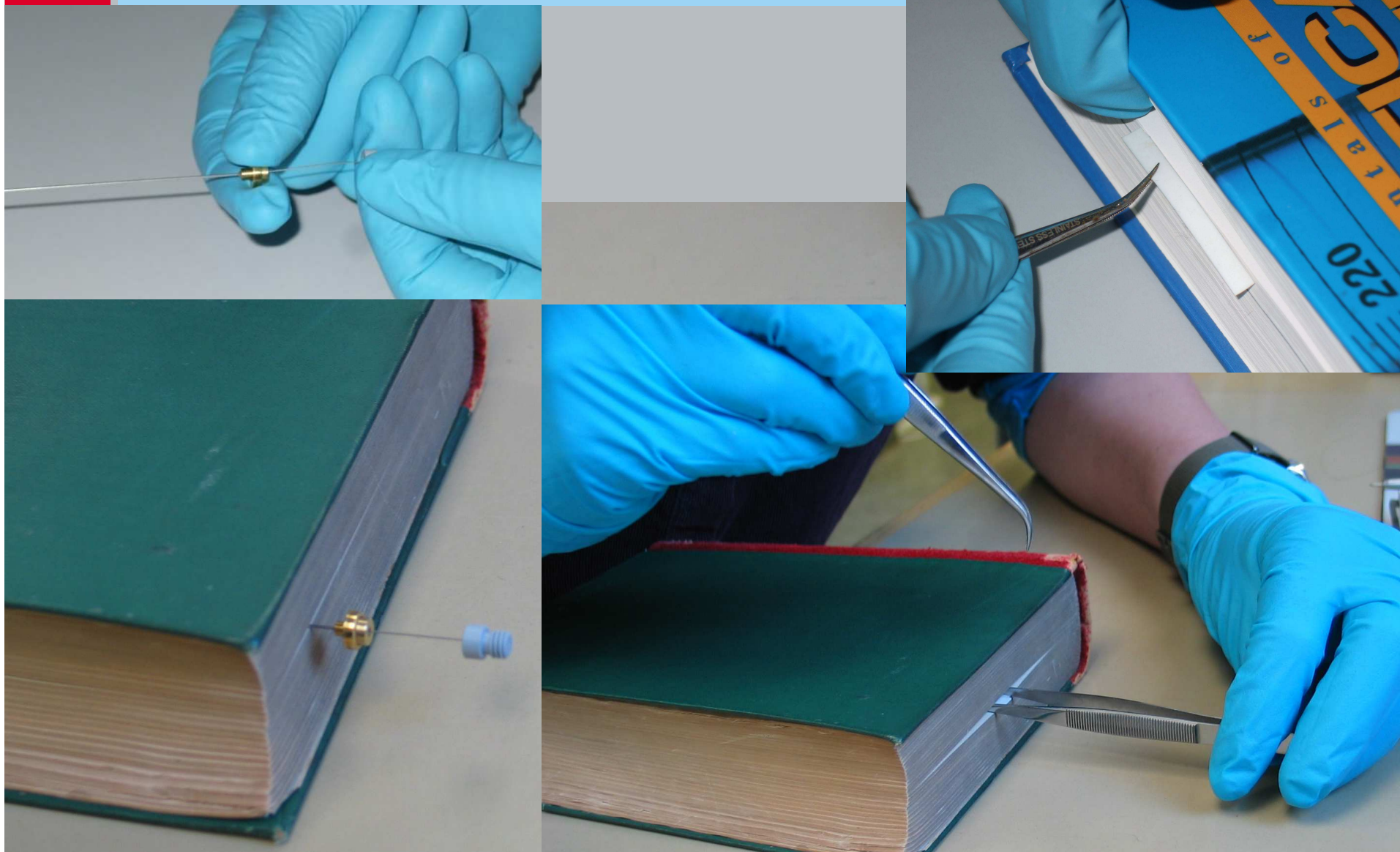


SPME and Elastomer strip in Whitakers Almanack 1903



Analyses of these experiments are being finalised now.

Using SPME fibres and elastomer strips to gather VOCs from Whitakers Almanack 1903



Acknowledgements

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