

The real thing

Novel sensors for monitoring condition of books and archives

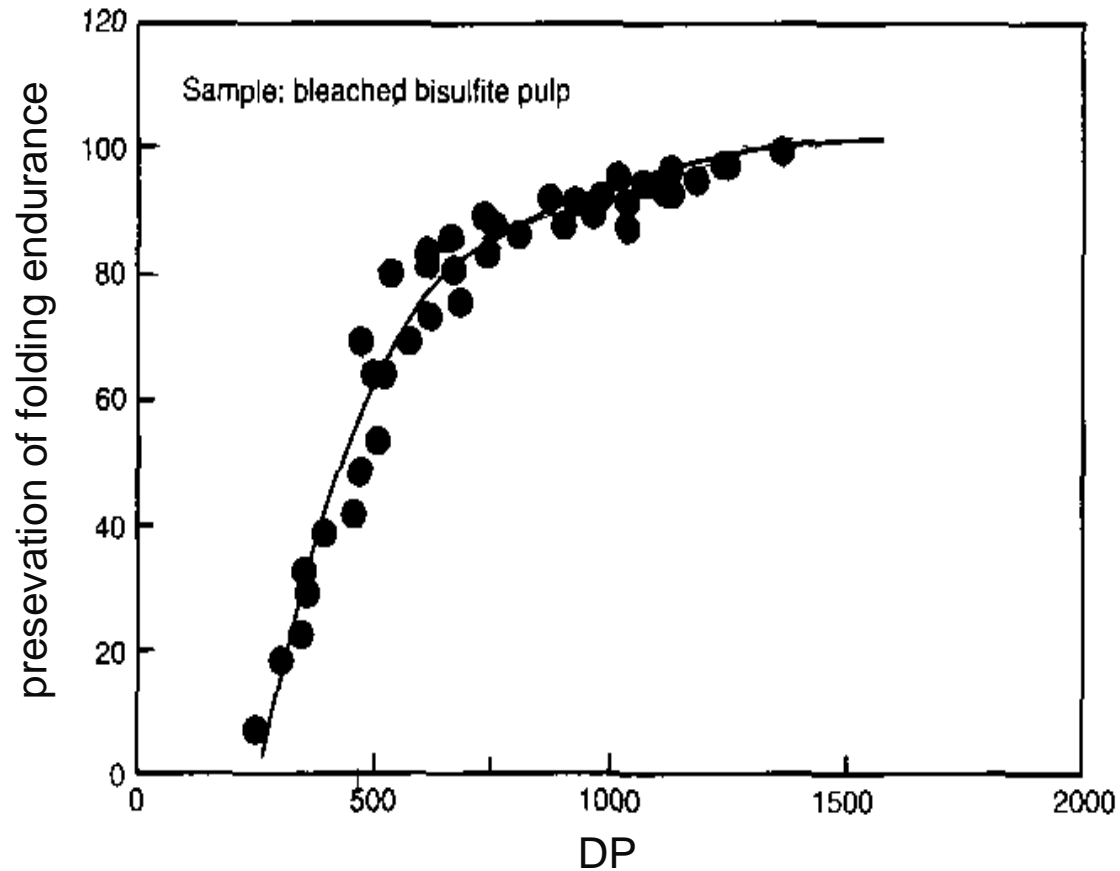
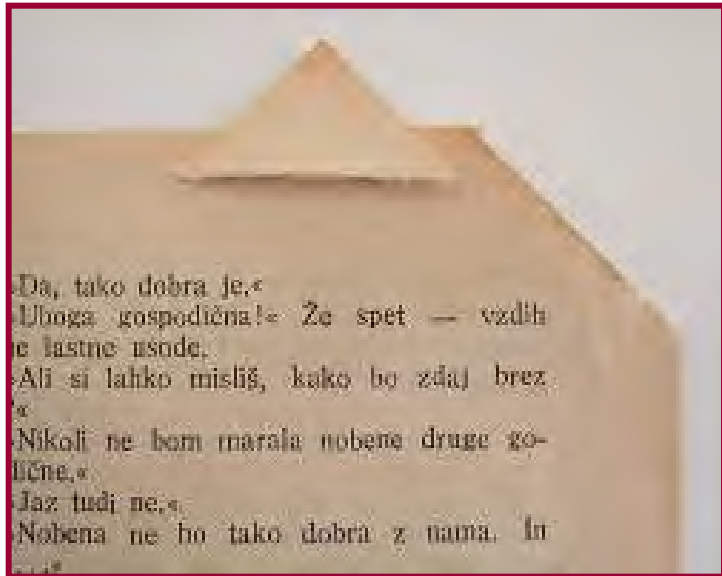
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What is happening to our books?



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, 230 tonne of water
- £131m budget, 1900 staff



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)

BL - Additional Storage Building 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?



BL - Newspaper Storage Building?



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

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.

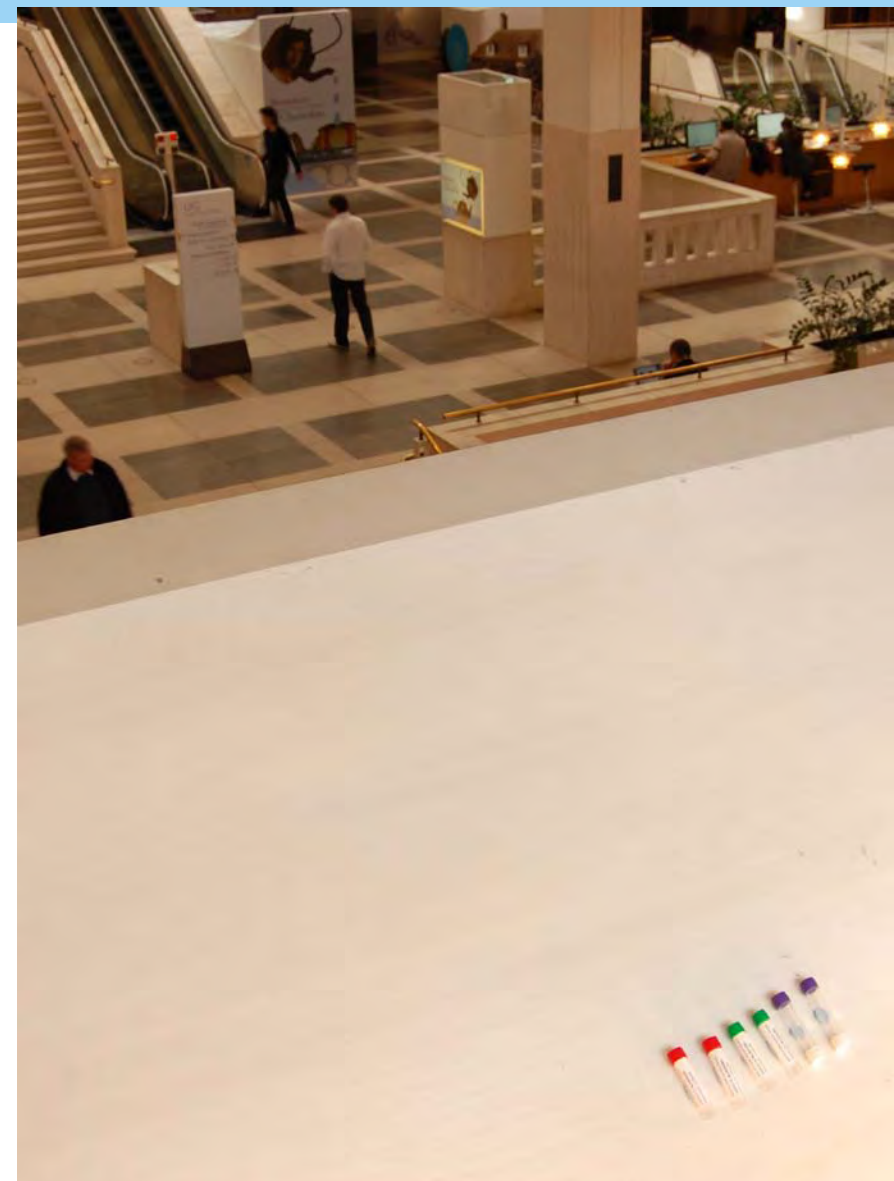
By placing these stickers on their computers, they can give their e-books the same musty book smell they know and love from used textbooks.

<http://www.cafescribe.com/>

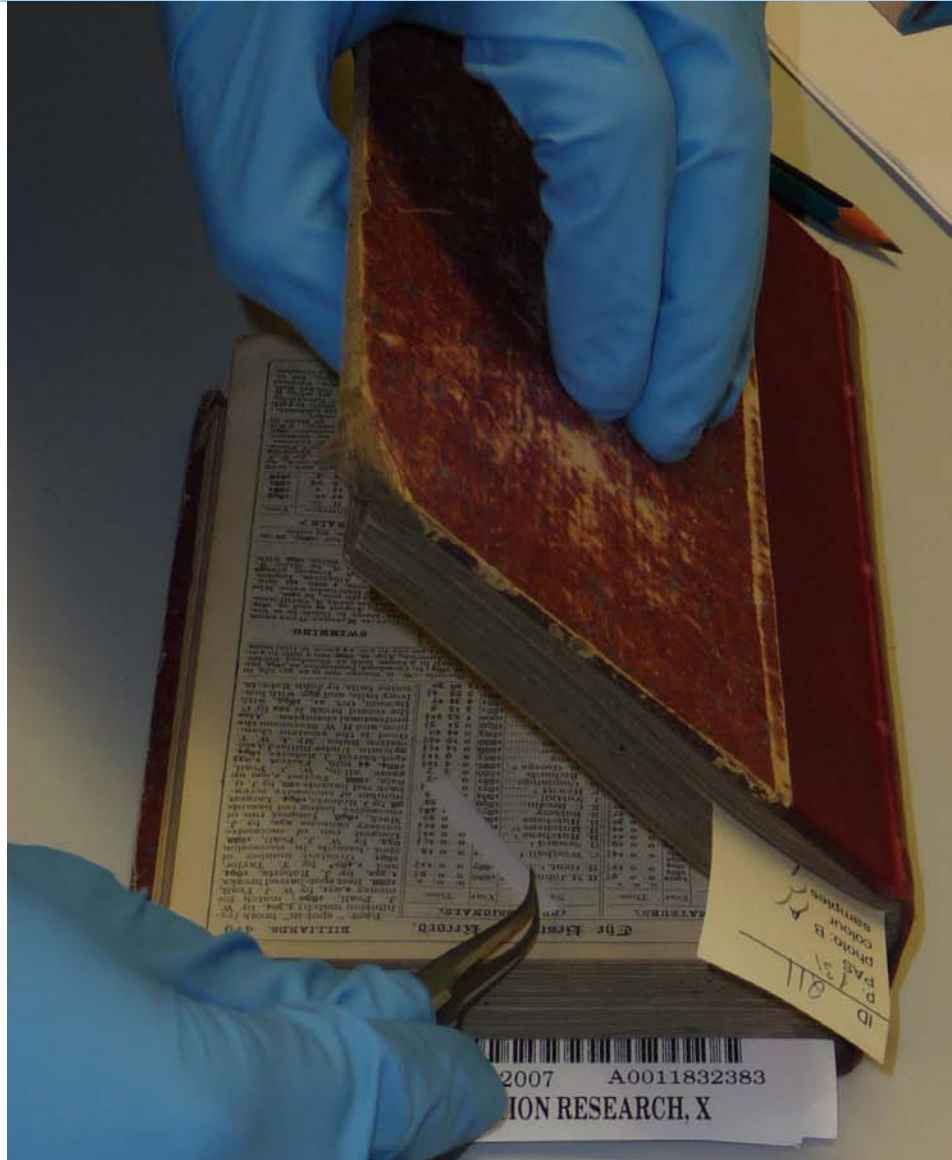
212 VOCs identified from books (so far)

1-hexanol	butyl alcohol	isononyl alcohol
1-octen-3-ol	butyl acetate	methyl cyclohexane
1-decanol	butyl-cyclohexane	methyl heptenol
1-dodecanol	camphene	methylisobutyl ketone
1-heptanol	cumene	naphthalene derivative
1-ethyl-2-methyl cyclohexane	cyclohexyl carbinol	nonadecane
1-methylethyl ester dodecanoic acid	d-limonene	nonanal
1,3-butylene glycol	decamethylcyclopentasiloxane	nonanoic acid
1,3-dimethyl cyclohexane	decanal	o-,m-p-xylene (isomers)
1,3,5-trimethyl benzene	decane	octadecane
1,4-dimethyl cyclohexane	decanoic acid	octanal
2-heptanol	dibutyl phthalic acid	octanoic acid
2-ethoxy ethanol	diethyl acetal	p-t-butyl cyclohexanol
2-hexenol	dimethoxy benzene	p-ethyl phenol
2-ethyl hexanol	dimethylphenyl alcohol	PAHs
2-methyl-3-methylbutyl propanoate	dipropyl acetal	pentadecane
2-ethyl hexanoic acid	docosane	pentanoic acid
2-ethyl-1-hexanol	dodecanal	pentyl alcohol
2,3-dimethyl butyl alcohol	dodecane	pentyl butyrate
2,4-dimethyl hexane	dodecanoic acid, 1-methylethyl ester	pentyl-cyclohexane
2,4-dimethyl heptane	eicosane	phenanthrene derivative
2,6-dimethyl heptanol	ethyl acrylate	phenol
3-butyl-4-hydroxy anisole	ethyl benzene	propyl-cyclohexane
3-methyl nonane	ethyl cyclohexanol	siloxane derivative
3-ethyl-2-methyl heptane	ethyl acetoacetate	styrene
3-methyl octane	fatty acids and their esters	t-butyl benzene
3-methyl pentanol	furfural	tetradecane
3-methyl heptane	heneicosane	tetradecanoic acid, 1-methylethyl ester
3-octanol	heptadecane	toluene
3,7-dimethyl octanol	heptanal	tridecane
4-isopropyl cyclohexanol	heptane	trimethyl-benzene
5-methyl-furfural	heptanoic acid	undecanal
5,9-dimethyl dec-8-en-3-ol	heptyl- cyclohexane	undecane
acetaldehyde	hexadecane	undecanol
acetic acid	hexanoic acid	vanillin
acetoin	hexyl acetate	
acetophenone	hexyl-cyclohexane	total 212
α-pinene	higher hydrocarbons	
anisole	isoamyl alcohol	Sources: Buchbauer 1995, Lattuati-Derieux 2004, Lattuati-Derieux 2006
benzaldehyde	isoborneol	
benzoic acid	isobutyl acetate	
benzyl alcohol	isobutyl cyclopentanol	
benzyl acetate	isobutylallyl carbinol	
butanoic acid		

Volatile organic chemicals (VOCs)



Using SPME fibres and elastomer strips to gather VOCs from books



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

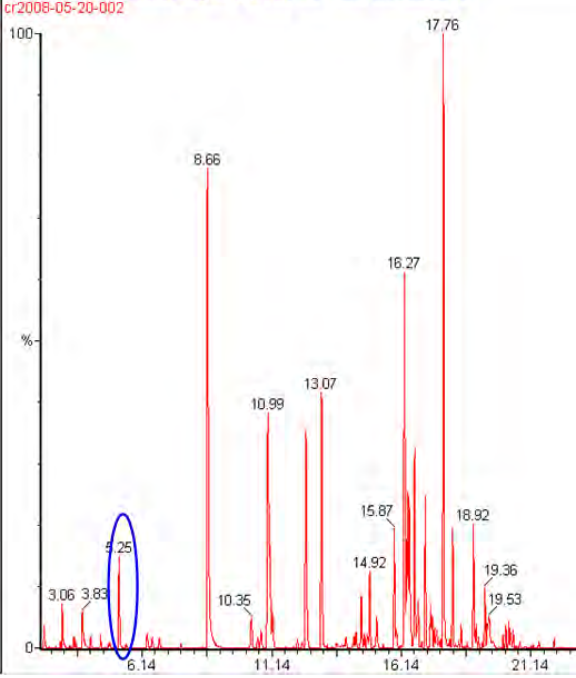
- Off-line sample preparation and analysis
- Uses thermal desorption – gas chromatography – mass spectrometry
- More complex analysis than the organic acids and aldehydes
- Each sample run is 60 minutes



GC-MS identification and quantification

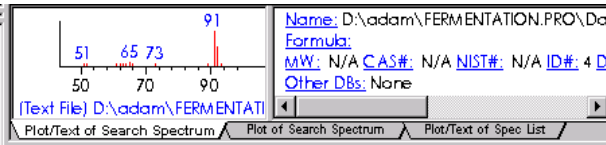
20-May-2008 11:32:12 Split approx 0.5% BL Location A

Split approx 0.5%, 20-May-2008 + 11:32:12

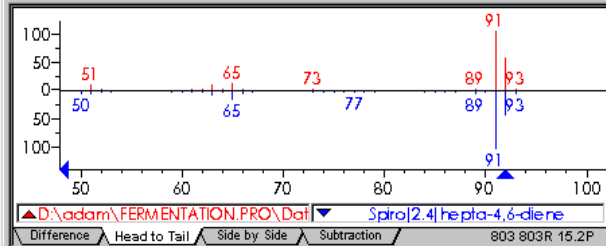


1: Scan E+
TIC
9.98e7

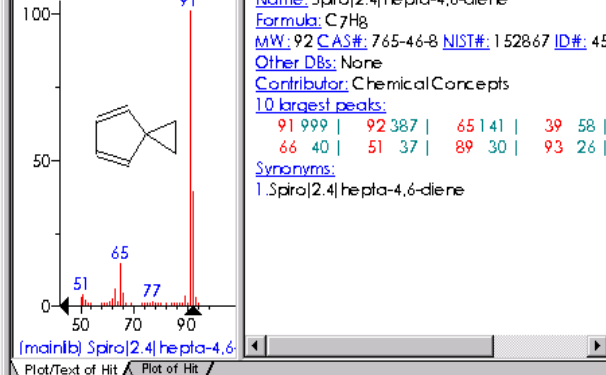
#	Lib.	Match	R.Match	Prob.	Name
1	M	803	803	15.2	Spiro[2.4]hepta-4,6-diene
2	M	802	828	14.6	Bicyclo[3.2.0]hepta-2,6-diene
3	M	801	801	14.0	1,3,5-Cycloheptatriene
4	M	786	788	8.50	Cyclobutene, 2-propenylidene-
5	R	785	785	8.17	Toluene
6	M	782	838	7.22	Benzene, (propoxymethyl)-
7	M	775	775	8.17	Toluene
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-chloroethylsulfone
17	R	738	741	1.77	Benzyl 2-chloroethylsulfone
18	M	738	741	1.57	Benzene, 1-nitro-4-(phenylmethoxy)-
19	M	736	738	1.45	Benzeneethanol, alpha-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)imidazo[1,2-a]pyridine
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-chloroethylsulfone
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[2.2.2]oct-7-en-2-one, 5-methyl-



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



Name: Spiro[2.4]hepta-4,6-diene



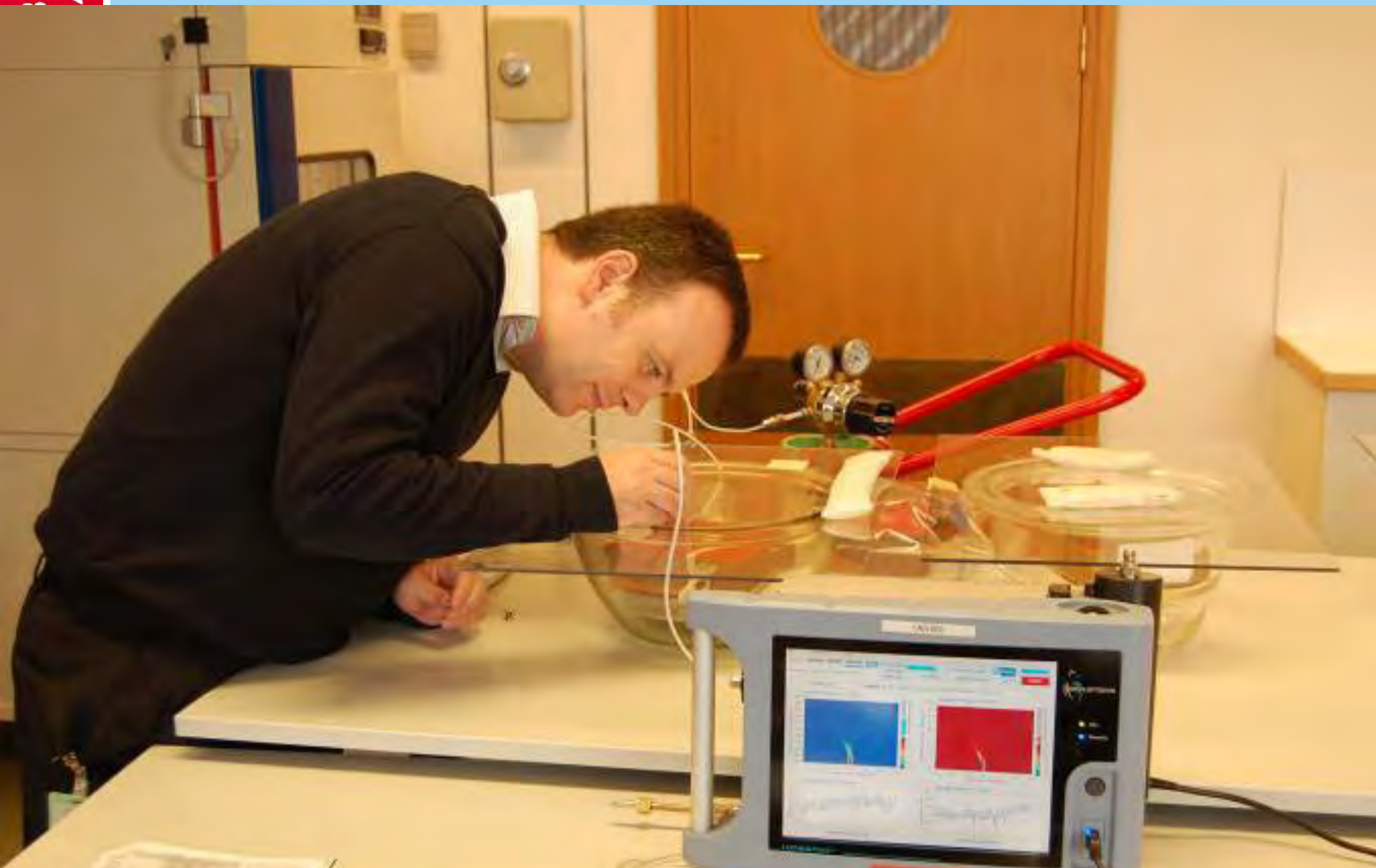
Name: Spiro[2.4]hepta-4,6-diene
Formula: C₇H₈
MW: 92 CAS#: 765-46-8 NIST#: 152867 ID#: 45
Other DBs: None
Contributor: Chemical Concepts
10 largest peaks:
91 999 | 92 387 | 65 141 | 39 58
66 40 | 51 37 | 89 30 | 93 26
Synonyms:
1. Spiro[2.4]hepta-4,6-diene

(main) Spiro[2.4]hepta-4,6-
Plot/Text of Hit Plot of Hit

VOCs from individual books on-line assessment from headspace



Field Asymmetric Ion Mobility Spectrometer (FAIMS) Owlstone www.owlstone.co.uk

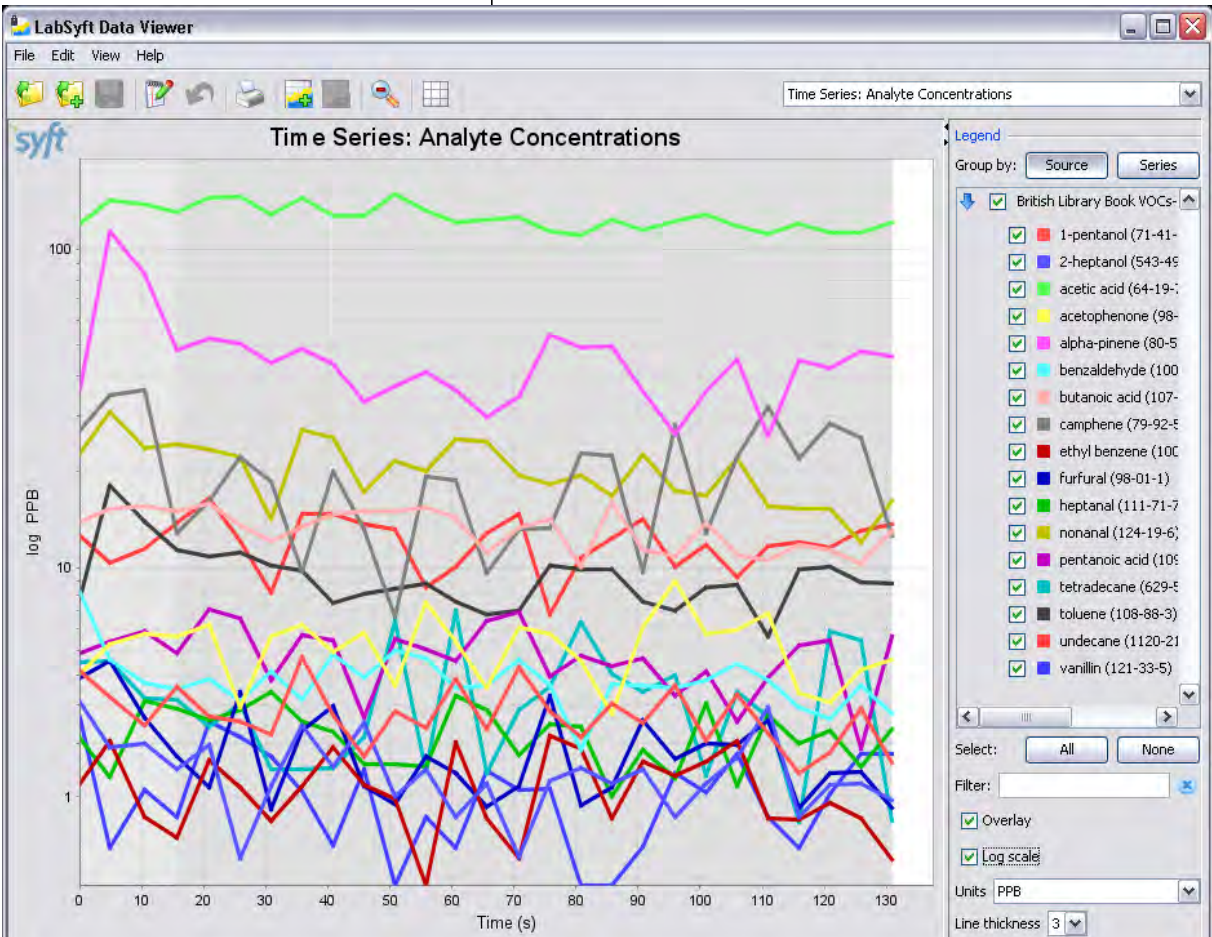
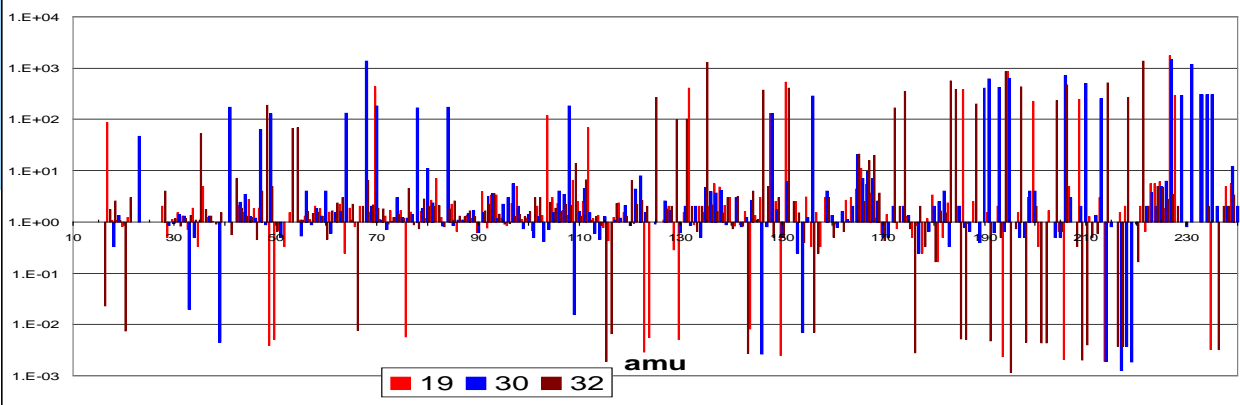


Selected Ion Flow Tube Mass Spectrometry (SIFT-MS) SYFT Technologies (UK) Limited www.syft.com



Deconvoluting the data

Syft -MS measurements for Whitaker's Almanac, 1903 data divided by 1965 data



Acknowledgements

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Prof. G Banik

National Library of Scotland



MORAN RTD d.o.o.



The NATIONAL ARCHIVES of SCOTLAND



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