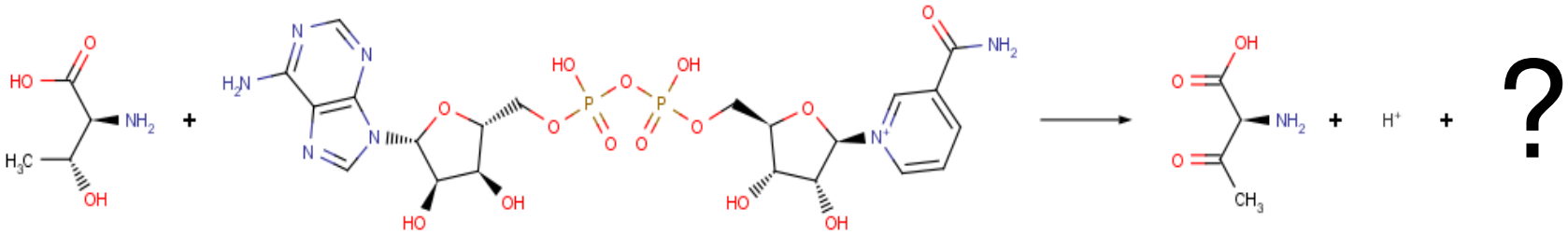
NMRShiftDB – a spectral database

EBI Bioinformatics Roadshow

Paula de Matos

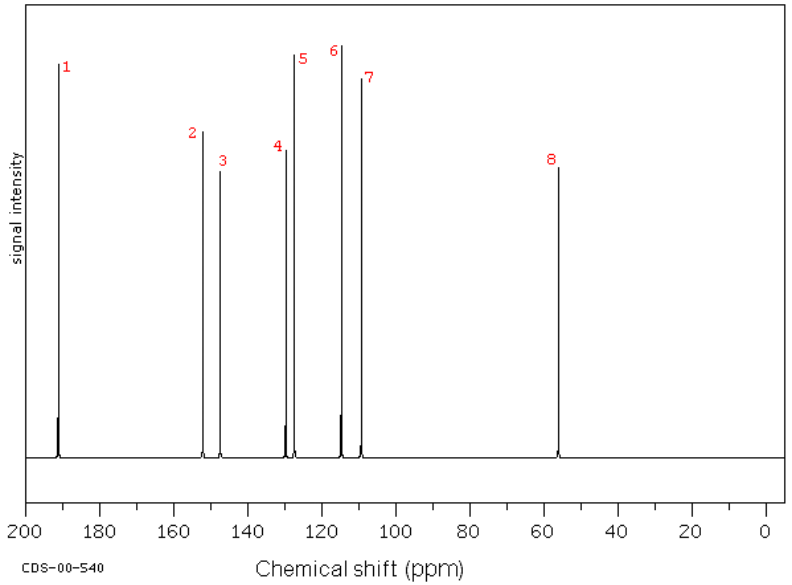
EMBL-EBI

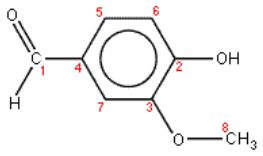
Identifying chemicals?



- Scientist needs to verify what a chemical is?
- Isolates a sample and then what?

NMR – Nuclear Magnetic Resonance





ppm	Int.	Location	
191.21	955	1	
152.18	791	2	
147.50	692	3	
129.77	746	4	
127.49	975	5	
114.75	1000	6	*
109.34	920	7	*
56.10	706	8	

Introduction

- NMR - magnetic nuclei have in a magnetic field and applied electromagnetic (EM) pulse or pulses, which cause the nuclei to absorb energy from the EM pulse and radiate this energy back out.
- The energy radiated back out is at a specific resonance frequency which depends on the strength of the magnetic field and other factors.
- This allows the observation of specific quantum mechanical magnetic properties of an atomic nucleus.

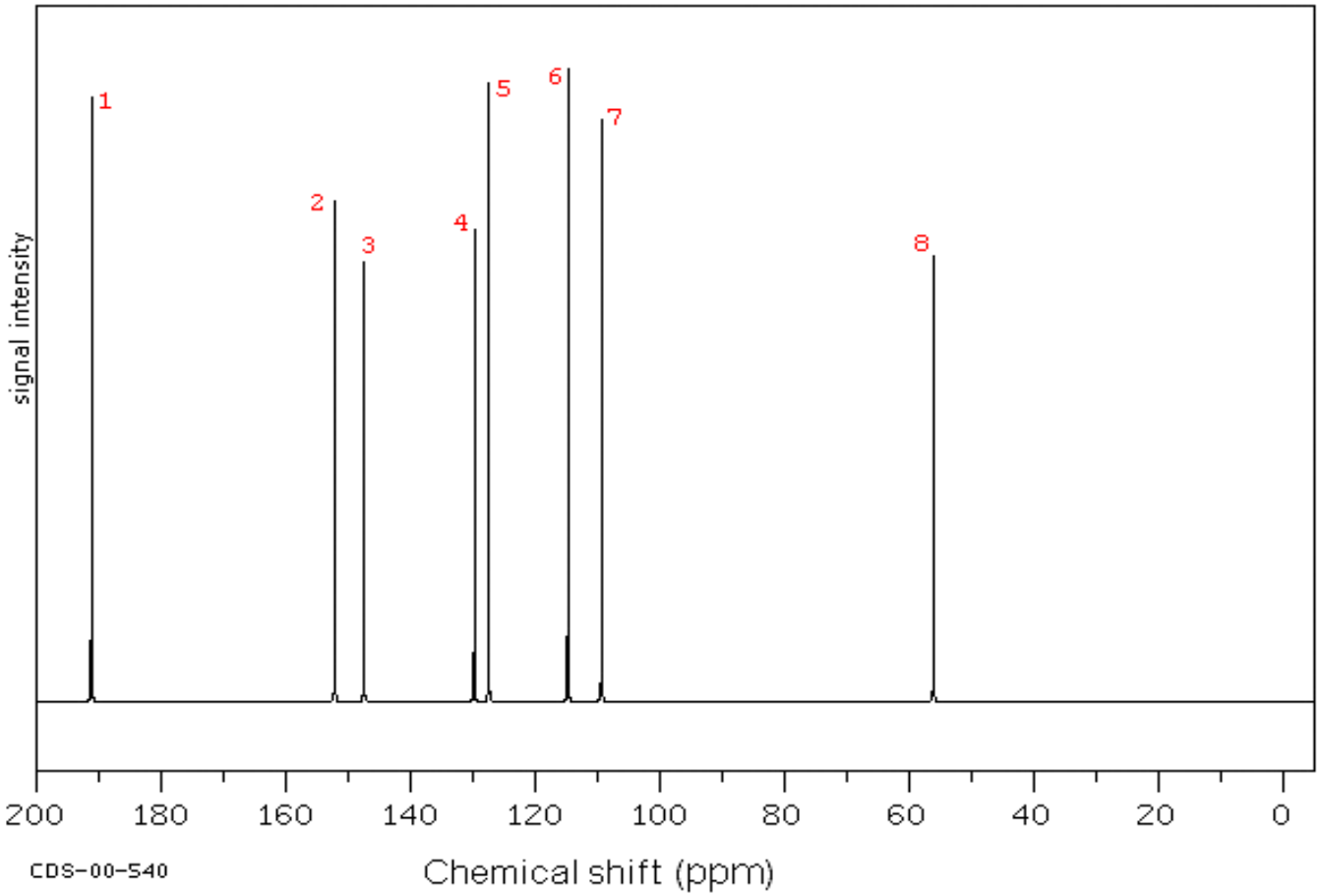
NMR vocabulary

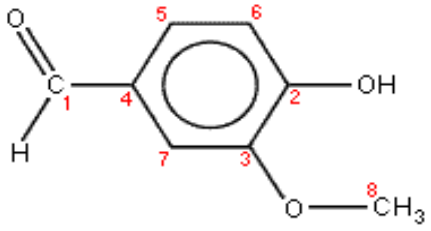
- **Chemical Shift** – measured in ppm (parts per million). Measure of frequency relative to magnetic frequency

$$\delta = \frac{\text{difference in precession frequency between two nuclei}}{\text{operating frequency of the magnet}}$$

- Although frequency depends on the applied field the chemical shift is independent of it.

- **Intensity** – intensity of the signal at a particular frequency





ppm	Int.	Location	
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152.18	791	2	
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129.77	746	4	
127.49	975	5	
114.75	1000	6	*
109.34	920	7	*
56.10	706	8	

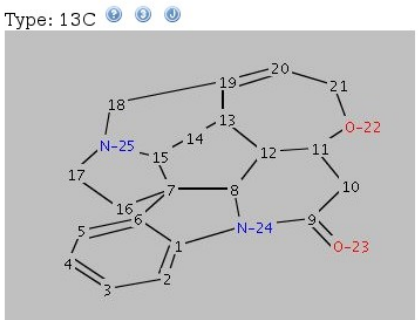
Favourite NMR Isotopes

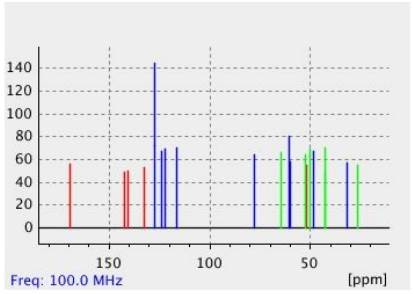
- Only some isotopes are detectable by NMR

- Hydrogen 1 (^{1}H) – natural abundance of hydrogen 1 is almost 100%
- Carbon 13 (^{13}C) - an important tool in chemical structure elucidation in organic chemistry.
- Carbon 13 has a natural abundance of 1.1% - not able to use Carbon 12 as its not detectable

NMRShiftDB – what is it about

- NMRShiftDB holds chemical structures and (assigned) NMR peak spectra.
- NMR peak spectra can be used as fingerprints of compounds.
- Therefore, they can be used for structure elucidation and verification.





Atom No.	Mult.(coupling const.)	Meas. Shift	Intensity	expt-0
1	S	140.4	0.616352	141.99
2	D	116.3	0.877358	115.96
3	D	127.4	0.902516	128.33
4	D	124.2	0.839623	123.98
5	D	122.2	0.867925	122.03
6	S	132.7	0.666667	132.39
7	S	52.0	0.691824	51.73
8	D	60.6	1.0	59.84

General properties

- Available via the web:
  http://www.ebi.ac.uk/nmrshiftdb or
  http://www.nmrshiftdb.org

- Community built

- All data are freely available under the GNU FDL and bulk downloadable for use in your own research

- This tutorial will cover the use of the web interface

NMRshiftDB home page

Current usage of NMRShiftDB is:
Registered Users: 2083
Structures which can be searched: 34824
Spectra: Measured 38747, calculated 550

Username: **Password:** Login
Logon with SSL
Use cookies for persistant login

Create New Accoun
(Only necessary for contributing data)
Forgot password?

Problems using NMRShiftdb? See our tips on browsers to use !

Home | Search | Results | Predict | Submit | Review | Wishlist-Guestbook | Help

NMRShiftDB Links

Developers' page
Sponsoring
Media coverage
Static name list
Links
FAQ
Contact

Hall of Fame

	Name	Contributions
1	E. Willighagen	1094
2	S. Dathe	505
3	P. Braeutigam	439
4	S. Kuhn	393
5	N. Prakash	350
6	B. Patel	305
7	M. Gericke	181
8	N. Kuznik	120
9	K. Bohn	111
10	R. Ellinger	76
11	A. Dransfeld	56
12	K. Bartusseck	26
13	M. Mitchell	20

About NMRShiftDB

NMRShiftDB is a NMR database (web database) for organic structures and their nuclear magnetic resonance (nmr) spectra. It allows for spectrum prediction (13C, 1H and other nuclei) as well as for searching spectra, structures and other properties. Last not least, it features peer-reviewed submission of datasets by its users. The NMRShiftDB software is open source, the data is published under an open content license. Please consult the documentation for more detailed information.

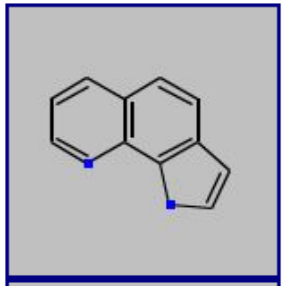
News about NMRShiftDB

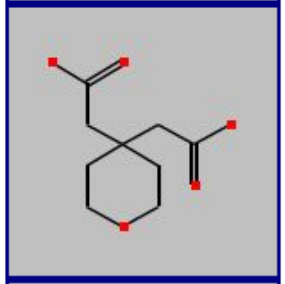
Standalone client released 2009-09-07 13:59 - NMRShiftDB
The 1.0 release of our standalone client called Speclipse is available for download from here. It offers offline editing of data and download and submit facilities. It is based on Bioclipse 2.0.
Read More »

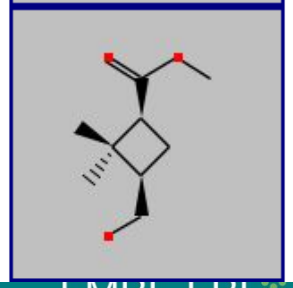
Server Consolidation 2009-07-08 11:41 - NMRShiftDB
We have consolidated the NMRShiftDB servers to run at European Bioinformatics Institute. The URL here and all existing server URLs redirect to the server, so users should not notice that except from the URL in the browser.
Read More »

Bugfix release 2009-04-07 10:42 - NMRShiftDB
Bug fix release 1.3.4 is now available. It fixes some bugs and cleans up ID handling. See here for details.
Read More »

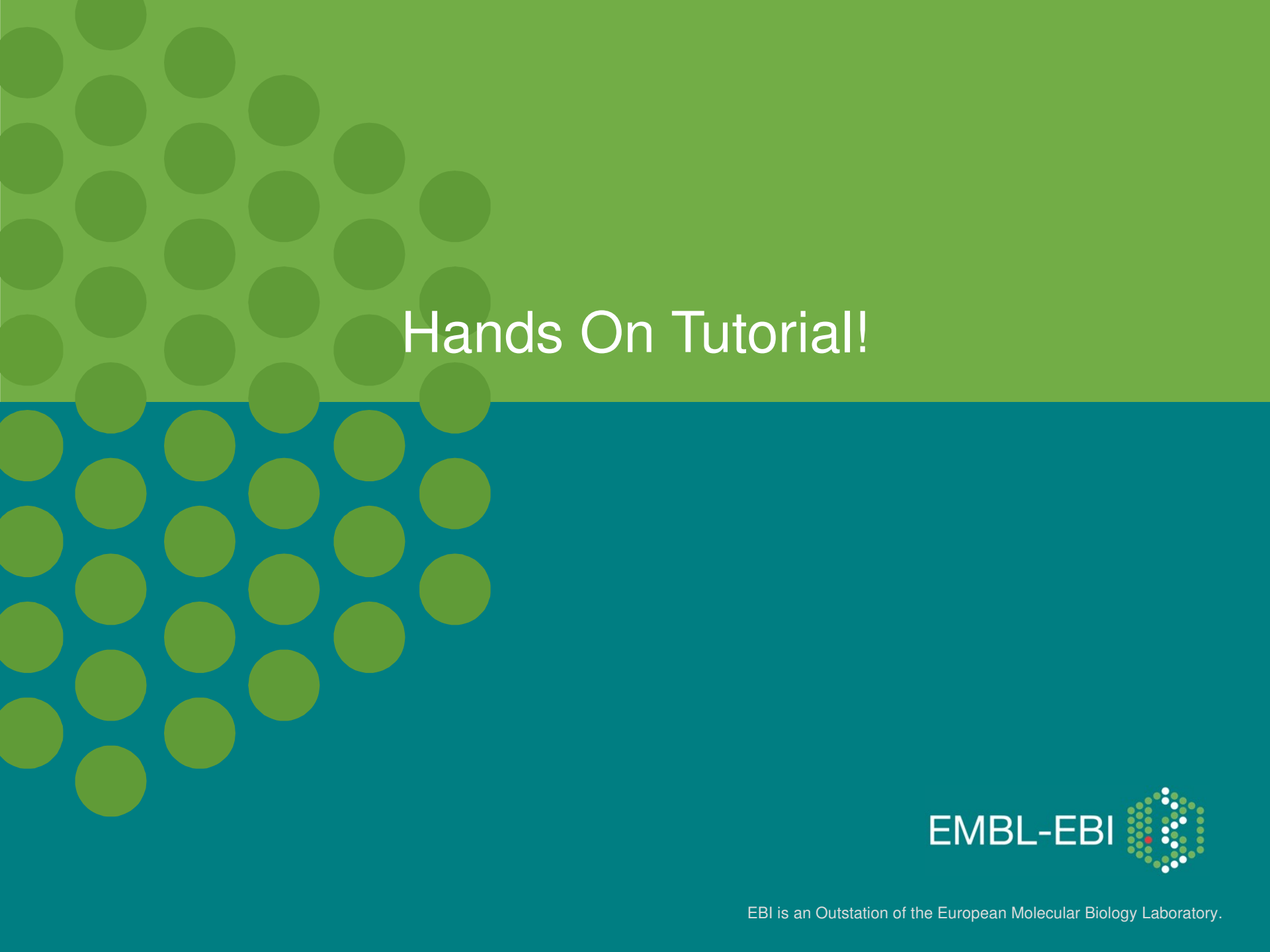
Latest Additions



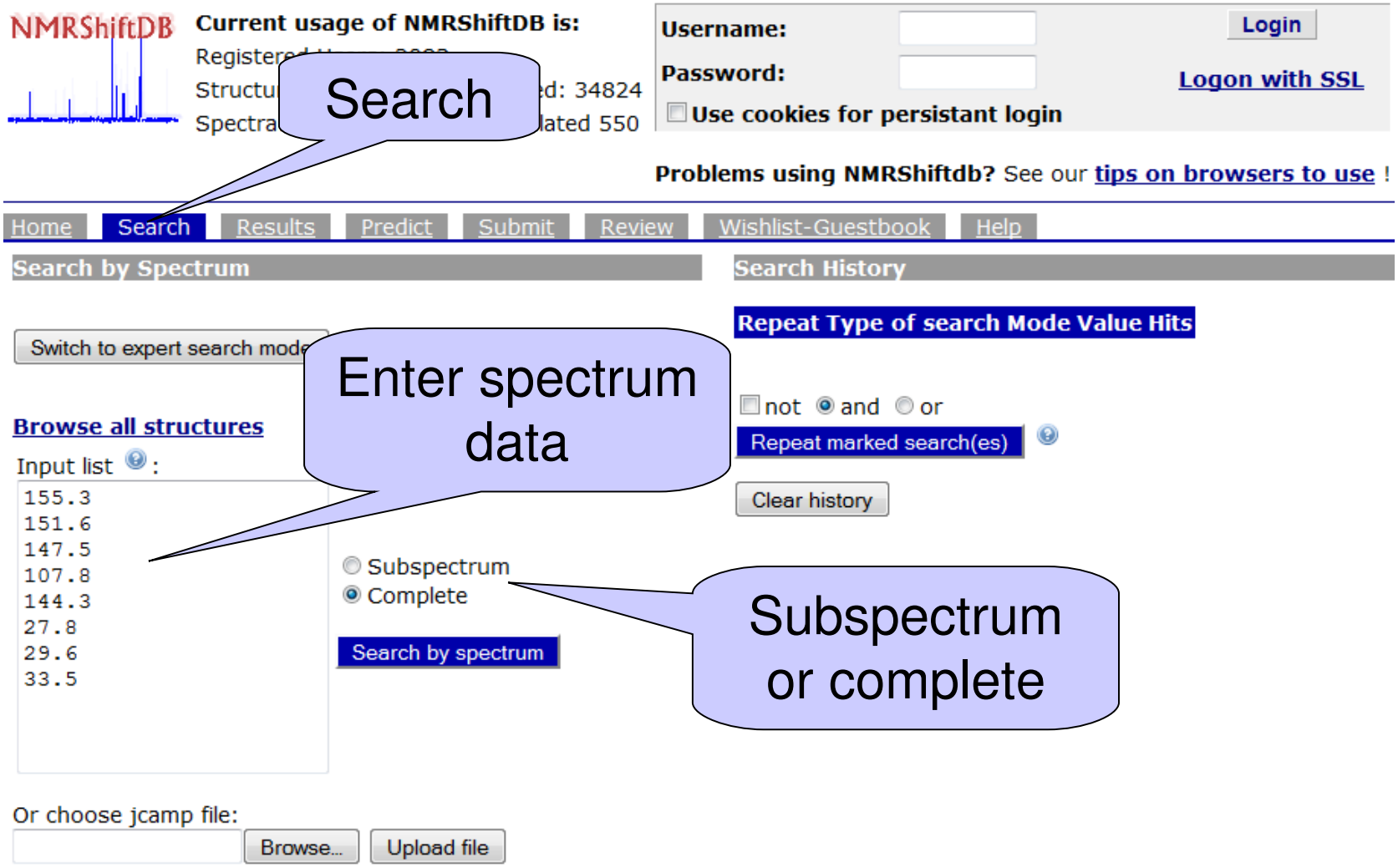




Hands On Tutorial!



Example 1: Searching by spectrum



Search Results

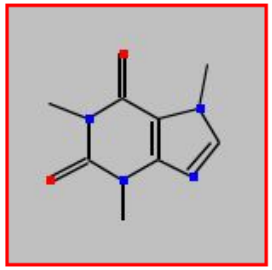
There were more than 300 results. The rest was cut off !

Type of search	Mode	Value
total similarity spectrum search	--	27.8|29.6|33.5|107.8...

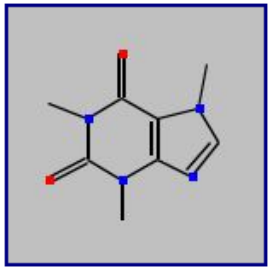
Results: 300

Browse: 1 2 3 4 5 6 7 8 9 10 >>

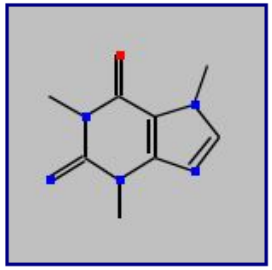
Next structure



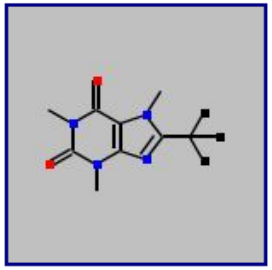
Similarity: 100.00 %



Similarity: 95.48 %



Similarity: 85.80 %



Similarity: 82.49 %

Bookmarks

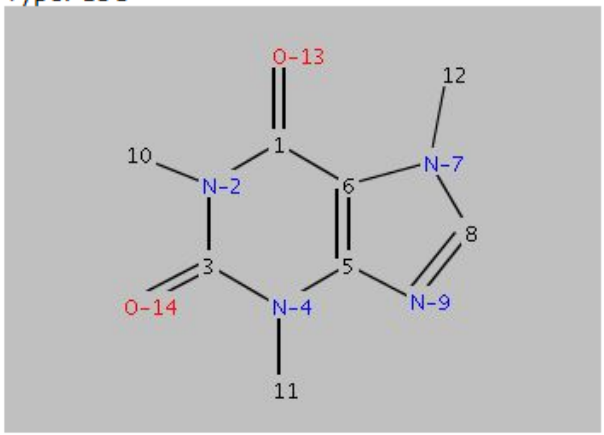
You could bookmark structures if you were logged in!

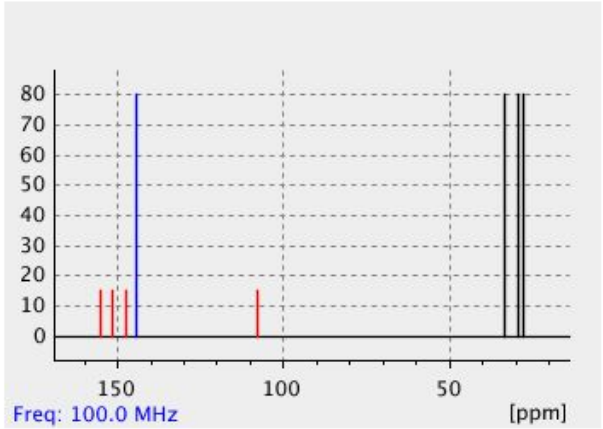
Details

Spectral Data | Additional Data

Search for complete spectrum: Similarity measure for the complete spectrum in this record is 100.0.

Type: 13C





Atom No.	Mult.(coupling const.)	Meas. Shift	Input Shift	Diff. M-I	expt-0 sdbs
1	S	155.3	155.3	0.00	155.32
3	S	151.6	151.6	0.00	148.67
5	S	147.5	147.5	0.00	151.66
6	S	107.8	107.8	0.00	107.51
8	D	144.3	144.3	0.00	141.57
10	Q	27.8	27.8	0.00	29.7
11	Q	29.6	29.6	0.00	27.88
12	Q	33.5	33.5	0.00	33.57

Threshold is 12.50

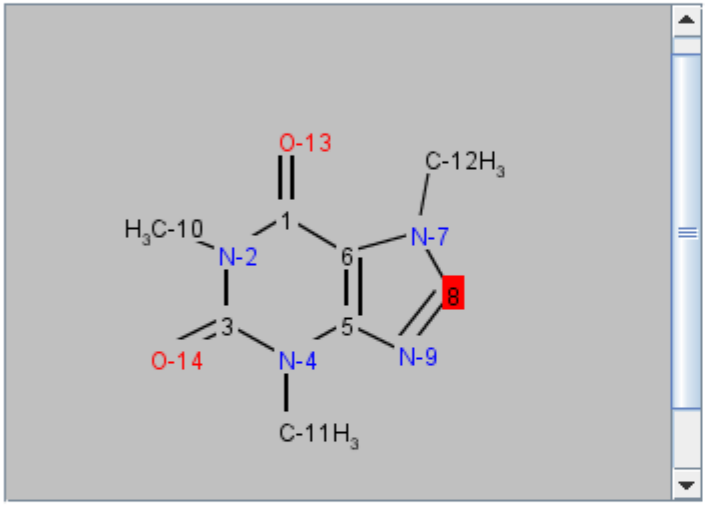
Details

User input (2D) | Show with this coordinate set

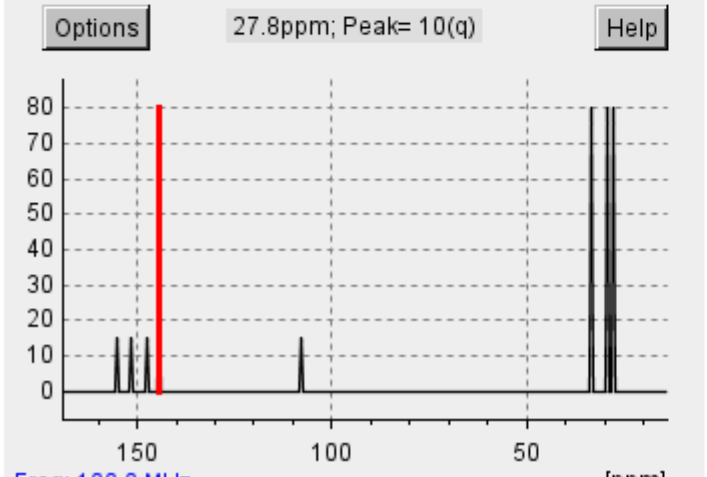
Spectral Data | Additional Data

Search for complete spectrum: Similarity measure for the complete spectrum in this record is 100.0.

Type: 13C Double click to get resizeable window!



Double click upper part to get resizeable window!



Atom No.	Mult.(coupling const.)	Meas. Shift	Input Shift	Diff. M-I	expt-0 sdbs
1	S	155.3	155.3	0.00	155.32
3	S	151.6	151.6	0.00	148.67
5	S	147.5	147.5	0.00	151.66
6	S	107.8	107.8	0.00	107.51
8	D	144.3	144.3	0.00	141.57
10	Q	27.8	27.8	0.00	29.7
11	Q	29.6	29.6	0.00	27.88
12	Q	33.5	33.5	0.00	33.57

Threshold is 12.50

Details

Spectral Data | Additional Data

Additional molecule data

Molecule	10016316
Chemical name(s)	Coffein
Chemical formula	$C_8H_{10}N_4O_2$
Molecular weight	194.191
Number of double bond equivalents (DBEs)	6.0
Number of all rings, size of smallest set of smallest rings	3, 2
Canonical name(s)	• O=C2c1c(ncn1C)N(C(=O)N2C)C (SMILES) • 1,3,7-trimethyl-3,7-dihydro-1H... (truncated) (IUPAC from ACD/Name) • 1H-purine-2,6-dione, 3,7-dihyd... (truncated) (Index from ACD/Name) • InChI=1/C8H10N4O2/c1-10-4-9-6-... (truncated) (INChI) • RYYVLZVUVIJVGH-UHFFFAOYAW (InChI Key)
CAS-Number	58-08-2
Additional information	Deposition in PubChem; Compound in PubChem; ChEBI;
Molecule keywords	

Spectrum	30127729 Rating: 10
Type	13C
Measurement conditions	
Assignment Method	Unreported
Field Strength [MHz]	Unreported
Temperature [K]	Unreported
Solvent	Unreported
Literature	S. Berger;S. Braun;H.-O. Kalinowski: 13-C-NMR-Spektroskopie, New York: Thieme Verlag 1984.
Additional comments	624.MOL; / * changed /
Additional information	
Spectrum categories	

Example 2: Search by JCAMP file

Current usage of NMRShiftDB is:
Registered Users: 2083
Structures which can be searched: 34824
Spectra: Measured 38747, calculated 550

Username: **Password:** Login
Logon with SSL
Use cookies for persistant login

Problems using NMRShiftdb? See our tips on browsers to use !

Home | Search | Results | Predict | Submit | Review | Wishlist-Guestbook | Help

Search by Spectrum

Switch to expert search mode

Browse all structures

Input list :

```
133.28;0.14
123.85;0.12
115.17;0.13
113.56;0.16
70.45;0.13
46.55;0.16
40.15;0.15
39.93;0.44
39.73;0.94
39.51;1.0
39.31;0.94
```

Subspectrum
Complete

Search by spectrum

Search History

Repeat	Type of search	Mode
	total similarity spectrum search --	26.8|3
	total similarity spectrum search --	27.8|2

not and or
Repeat marked search(es)

Clear history

Upload JCAMP file

Or choose jcamp file:
C:\Users\Paula\Docum Browse... Upload file

Search Results

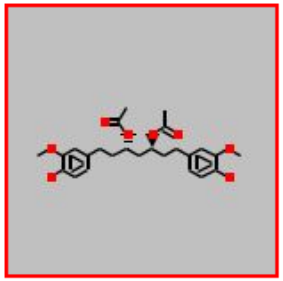
There were more than 300 results. The rest was cut off !

Type of search	Mode	Value
total similarity spectrum search	--	21.26;0.14|30.58;0.1...

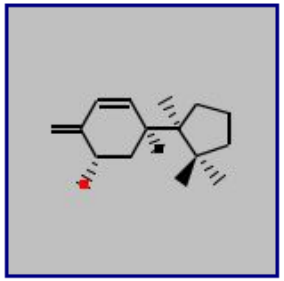
Results: 300

Browse: 1 2 3 4 5 6 7 8 9 10 >>

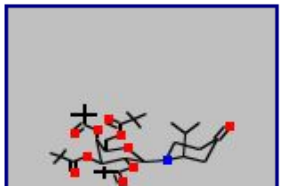
Next structure

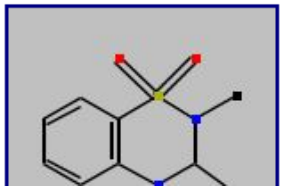


Similarity: 49.01 %



Similarity: 44.82 %





Bookmarks

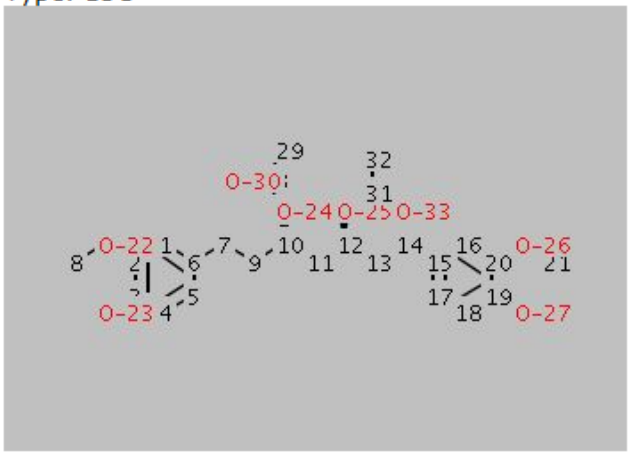
You could bookmark structures if you were logged in!

Details

Spectral Data | Additional Data

Search for complete spectrum: Similarity measure for the complete spectrum in this record is 49.01.

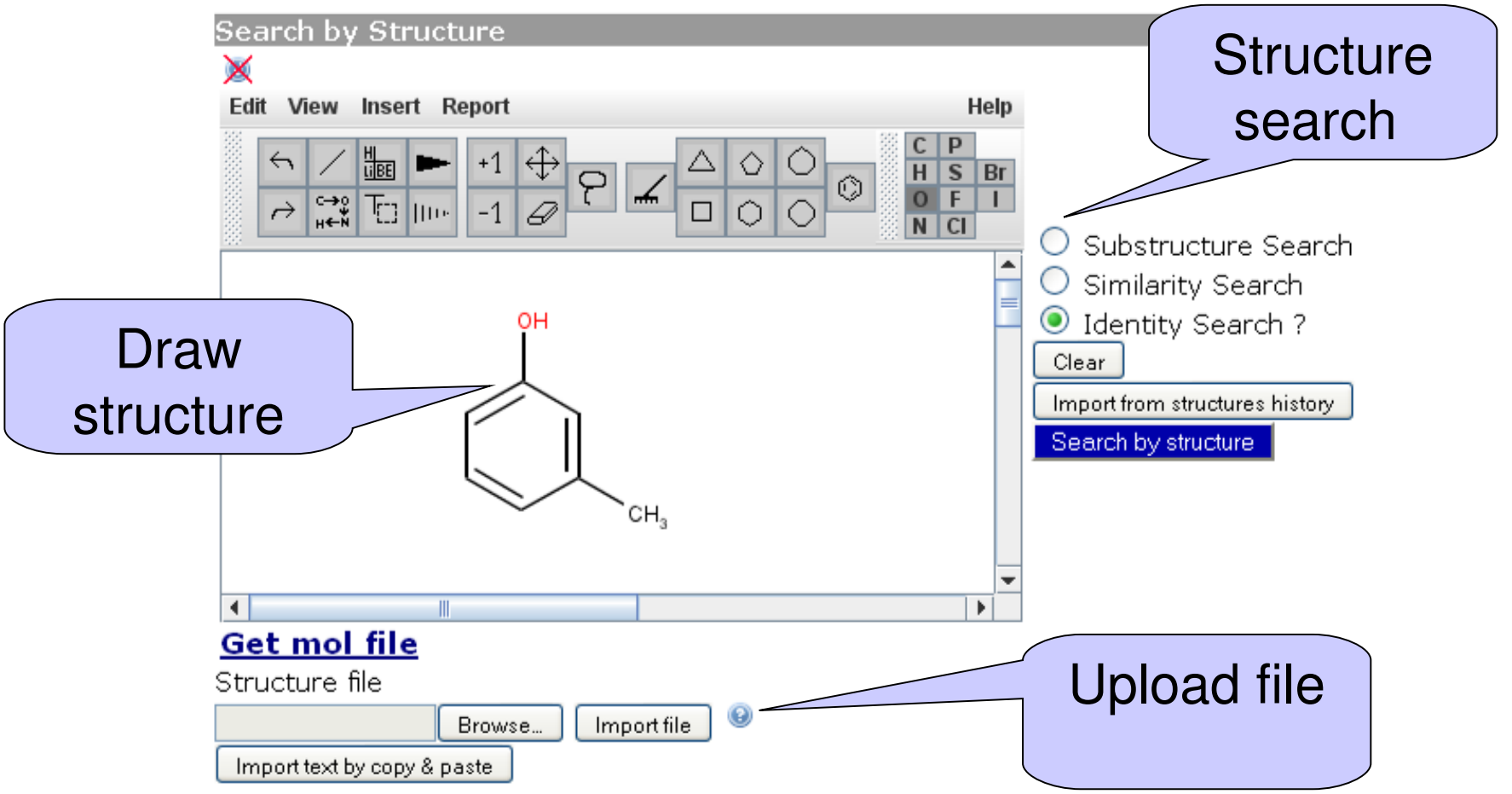
Type: 13C



Atom No.	Mult.(coupling const.)	Meas. Shift	Input Shift	D M
1	D	110.9	113.56	2
2	S	146.3		0
3	S	143.7		0
4	D	114.2	115.17	0
5	D	120.8	123.85	3
6	S	133.2	133.28	0
7	T	31.2	30.58	0
8	Q	55.8		0
9	T	36.7	38.89	2
10	D	69.7	70.45	0
11	T	38.6	39.11	0
12	D	69.7	70.45	0
13	T	36.7	38.89	2
14	T	31.2	30.58	0
15	S	133.2	133.28	0
16	D	110.9	113.56	2
17	D	120.8	123.85	3
18	D	114.2	115.17	0
19	S	143.7		0

Example 3: Structure search

- Given a chemical structure, search for similar structures



Identity search results

NMRShiftDB

Current usage of NMRShiftDB is:
Registered Users: 2083
Structures which can be searched: 34824
Spectra: Measured 38747, calculated 550

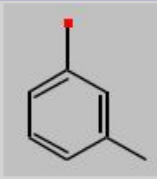
Username: **Password:** **Login** **Logon with SSL**
Use cookies for persistant login

Create New Account (Only necessary for contributing data)
Forgot password?

Problems using NMRShiftdb? See our **tips on browsers to use** !

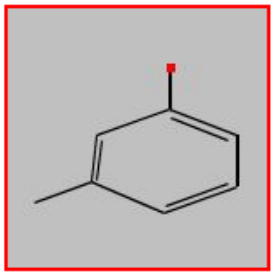
Home | Search | Results | Predict | Submit | Review | Wishlist-Guestbook | Help

Search Results

Type of search	Mode	Value
identity search	--	

Results: 1

Browse: **1**



TOLUENE,3-HYDROXY (META-...

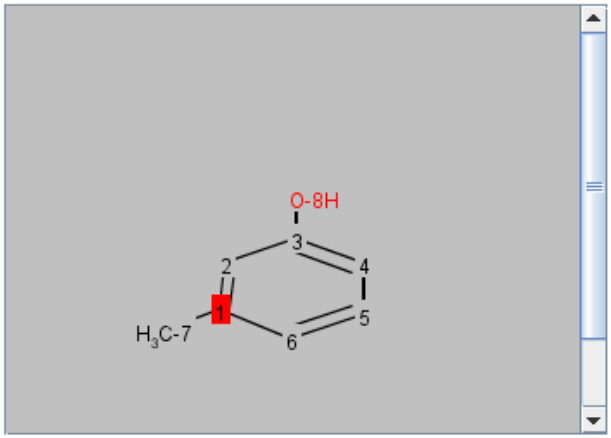
Bookmarks
You could bookmark structures if you were logged in!

Details

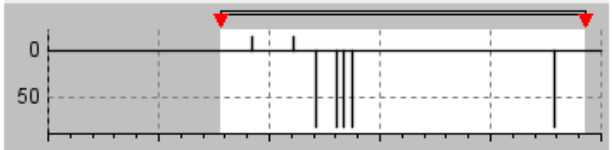
User input (2D) | Show with this coordinate set

Spectral Data | Additional Data

Type: 13C Double click to get resizeable window!



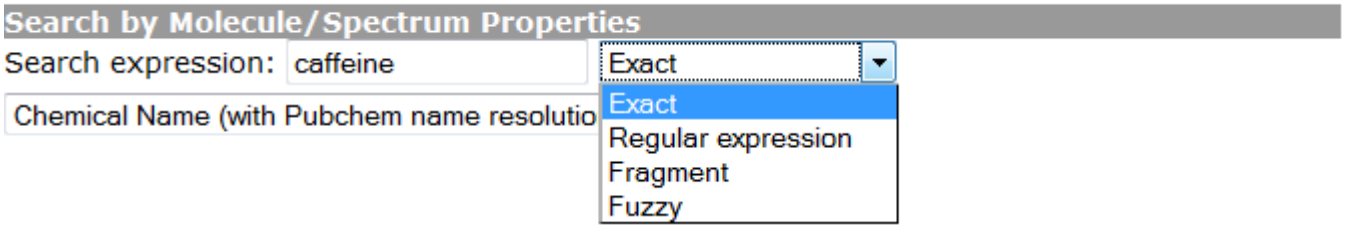
Double click upper part to get resizeable window!

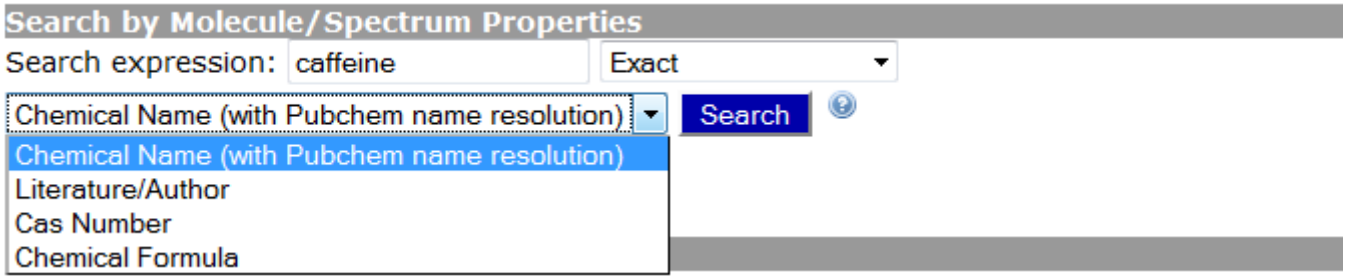


Atom No.	Mult.(coupling const.)	Meas. Shift	expt-0 ocmainz inhouse-2	expt-1
1	S	138.9	139.8	139.3
2	D	116.1	116.2	116.1
3	S	157.7	155.0	154.9
4	D	112.6	112.5	112.7
5	D	129.3	129.4	130.3
6	D	119.8	121.8	122.2
7	Q	21.0	21.1	

Example 3: Search by name

- Search by name, literature, CAS Number or formula





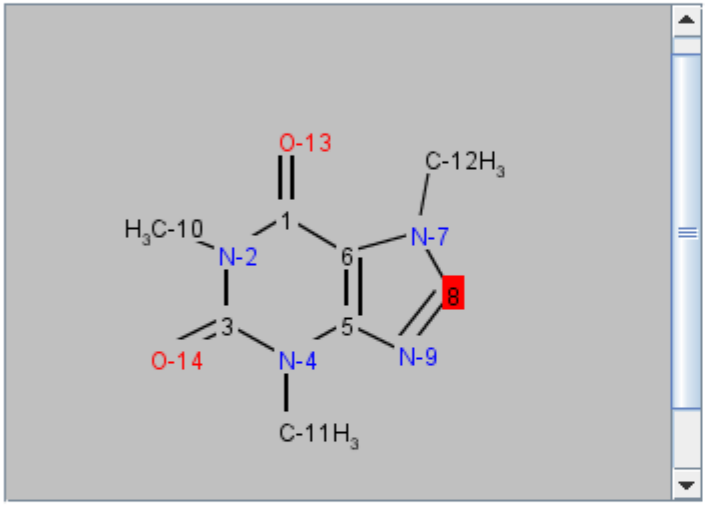
Details

User input (2D) | Show with this coordinate set

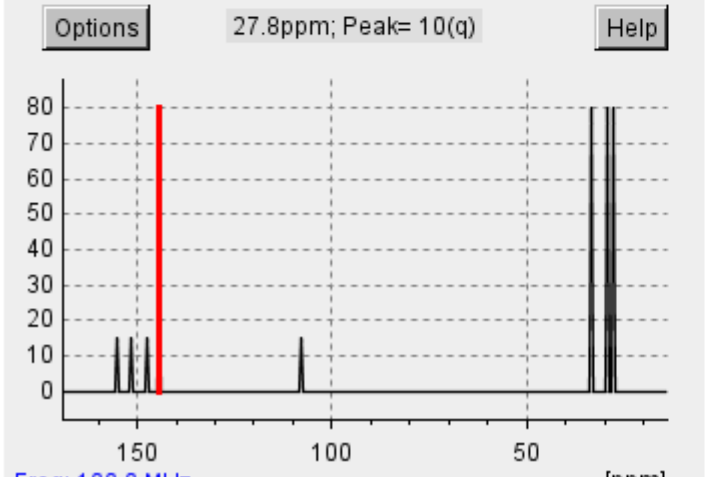
Spectral Data | Additional Data

Search for complete spectrum: Similarity measure for the complete spectrum in this record is 100.0.

Type: 13C Double click to get resizeable window!



Double click upper part to get resizeable window!

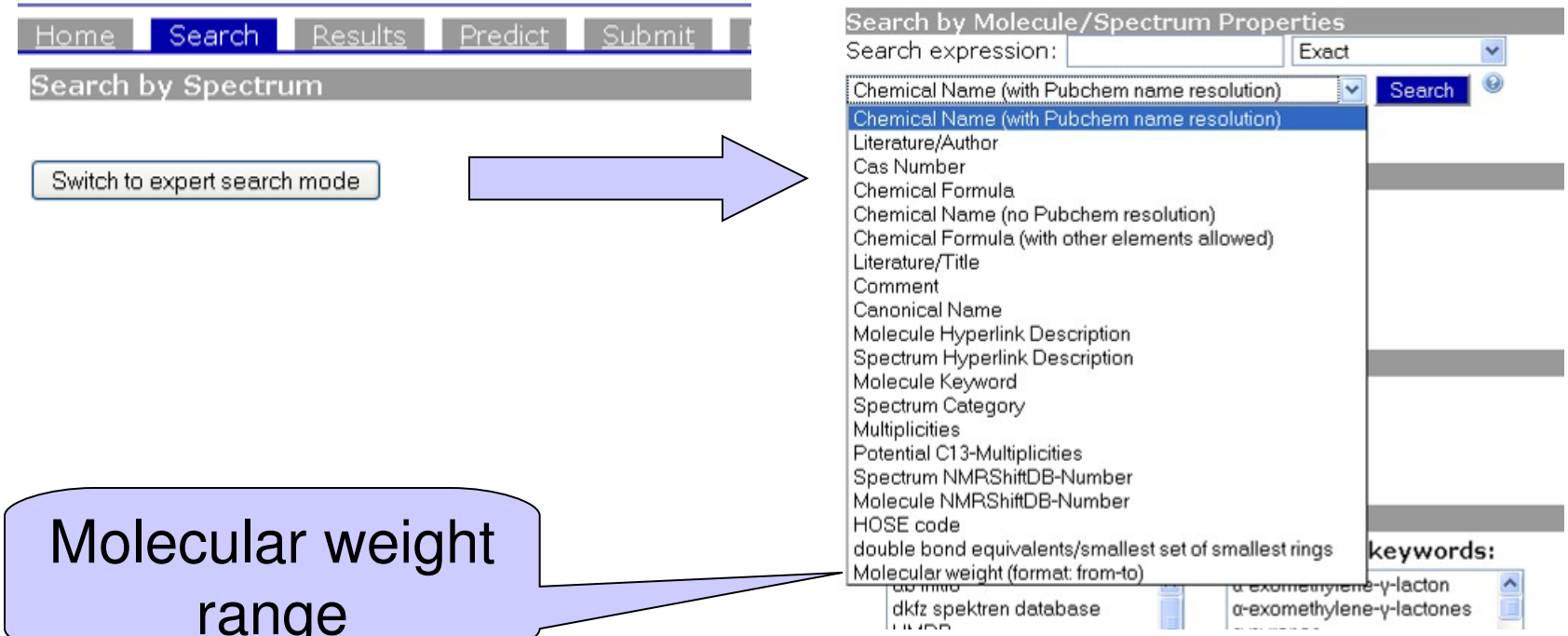


Atom No.	Mult.(coupling const.)	Meas. Shift	Input Shift	Diff. M-I	expt-0 sdbs
1	S	155.3	155.3	0.00	155.32
3	S	151.6	151.6	0.00	148.67
5	S	147.5	147.5	0.00	151.66
6	S	107.8	107.8	0.00	107.51
8	D	144.3	144.3	0.00	141.57
10	Q	27.8	27.8	0.00	29.7
11	Q	29.6	29.6	0.00	27.88
12	Q	33.5	33.5	0.00	33.57

Threshold is 12.50

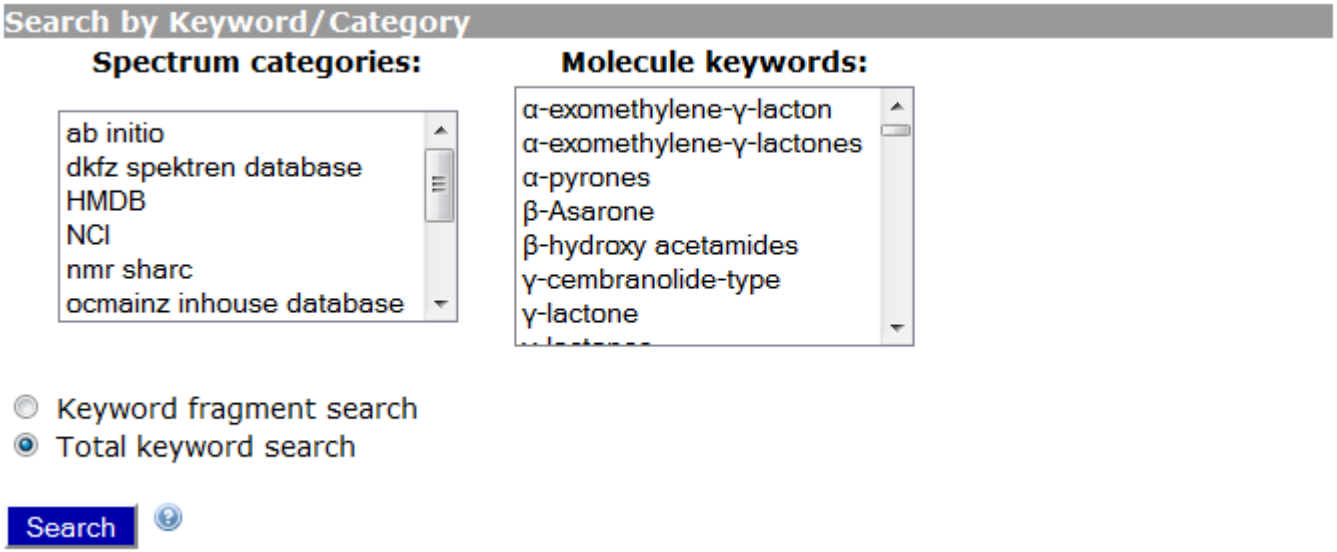
Search in “Expert Mode”

- Switch to “expert” search mode for additional search options



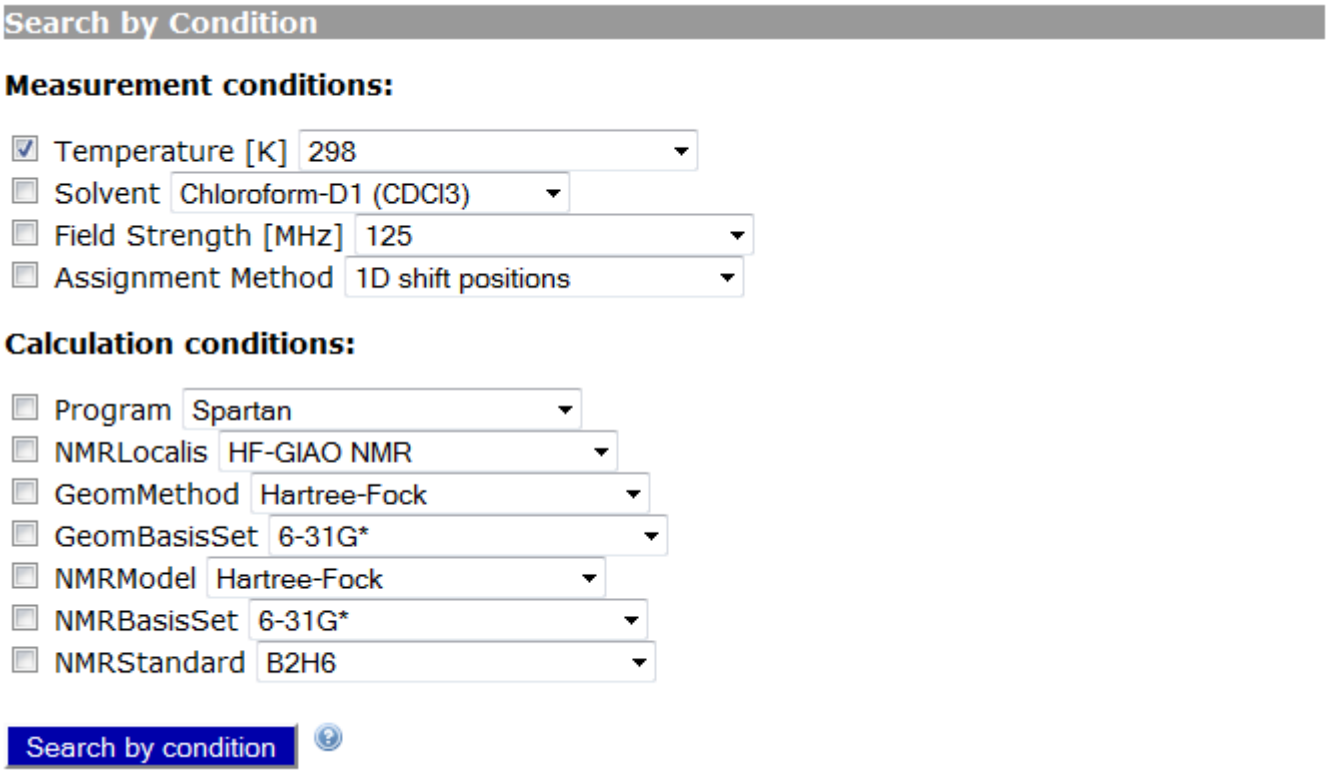
Search by Keyword/Category

- Can search by defined categories
- Can select multiple keywords by holding ctrl key



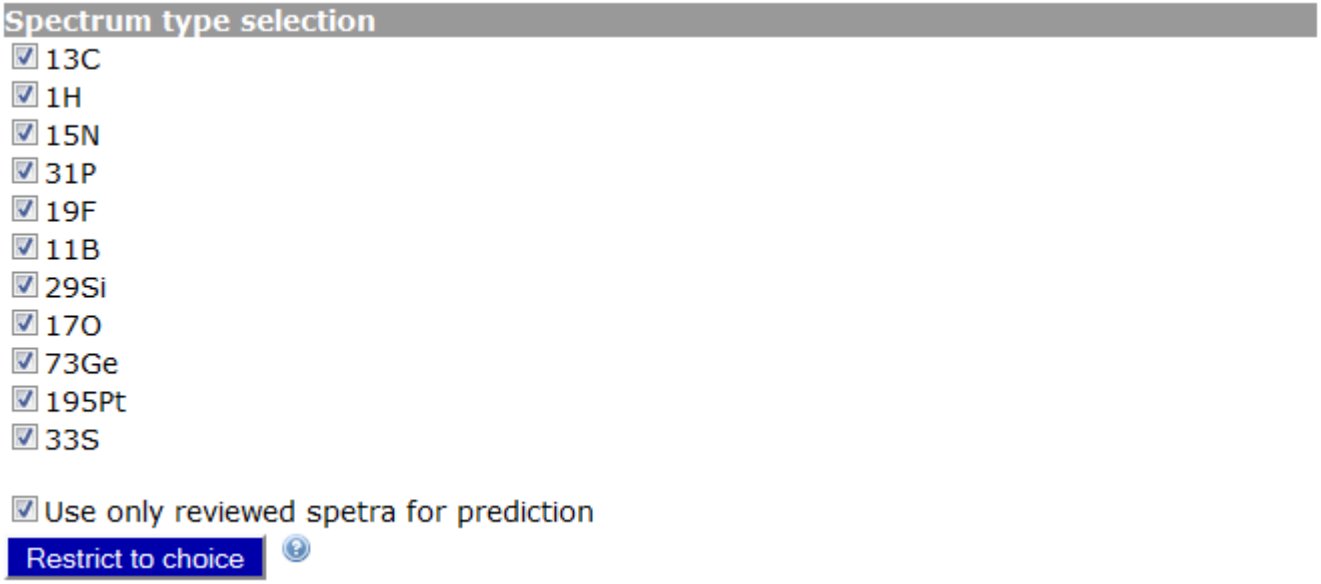
Search by Condition

- Search by certain measurement condition or calculated condition



Search by selection of isotopes

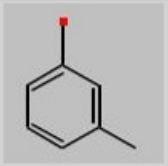
- Can restrict your search to only certain isotopes



Example 4: Combining searches

- Search history allows you to repeat and combine previous searches
- For example, combining a substructure with a spectrum search

Search History

Repeat	Type of search	Mode	Value	Hits
☐	subspectrum search	--	11.345651|128.42825|...	300
☐	chemical name using Pubchem	fragment	InChI=1/C21H22N2O2 /c24-18-10-16-19-13-9-17-21(6-7-22(17)11-12(13)5-8-25-16)14-3-1-2-4-15(14)23(18)20(19)21 /h1-5,13,16-17,19-20H,6-11H	2
☑	substructure search	--		300
☑	total similarity spectrum search	--	11.345651|26.956678|...	300

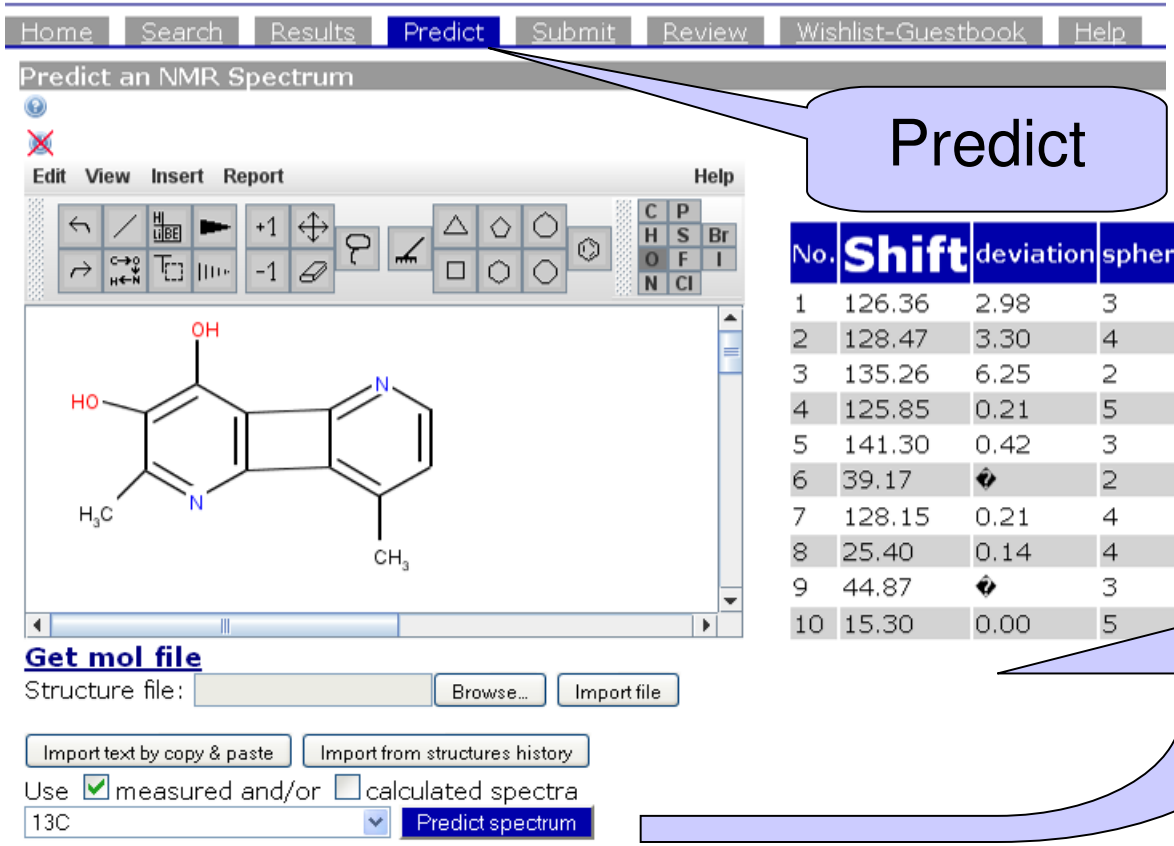
☐not ◉and ○or

Repeat marked search(es)

Combined search mode

Example 5: Prediction

- Structure search can find a spectrum only for those compounds in the database
- For any structure, you can *predict* the spectrum



Predict

No.	Shift	deviation	spheres	min	max	mean	median	values
1	126.36	2.98	3	117.40	134.30	126.36	126.85	172
2	128.47	3.30	4	123.30	135.90	128.47	127.05	134
3	135.26	6.25	2	121.80	154.80	135.26	135.90	302
4	125.85	0.21	5	125.70	126.00	125.85	125.85	2
5	141.30	0.42	3	141.00	141.60	141.30	141.30	2
6	39.17	[illegible]	2	39.17	39.17	39.17	39.17	1
7	128.15	0.21	4	128.00	128.30	128.15	128.15	2
8	25.40	0.14	4	25.30	25.50	25.40	25.40	2
9	44.87	[illegible]	3	44.87	44.87	44.87	44.87	1
10	15.30	0.00	5	[illegible]	15.30	15.30	15.30	2

Time for exercises

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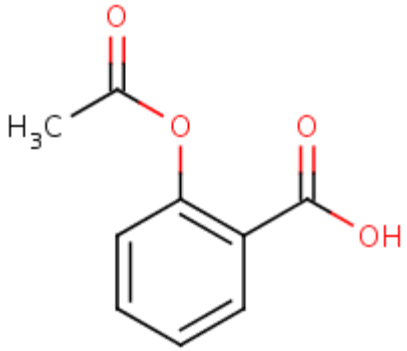
Exercise 1

- Given the following chemical structure can you **identify** whether its spectrum is in the database? (Hint use the chemical structure search, use ChEBI to find and import the structure)



- Using the same chemical structure can you **predict** the spectrum?

Exercise 2

1. Search for the term ‘aspirin’ using NMRShiftDB? Do you find any spectrum?

3. Using the answer in 2.1 can you name any synonyms of aspirin?

Exercise 2

- Given the following spectrum data, can you find **subspectrums** which match it?

122
132
126
135
124
151
170

To summarise

- NMRShiftDB to supports structure identification.
- NMRShiftDB ca be used to identify chemicals by searching using spectrum data which you have measured
- NMRShiftDB can be used to search by chemical structure, names and additional properties
- NMRShiftDB can be used to predict spectrum for a specific chemical structure if its not found in the database.

Conclusions

- You can use the data for your research.
- Since NMRShiftDB is a community effort, you can contribute yourself using the “Submit” function.
- The Speclipse application available at http://sourceforge.net/projects/nmrshiftdb/ offers a user-friendly client for the database.

Thank you

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