

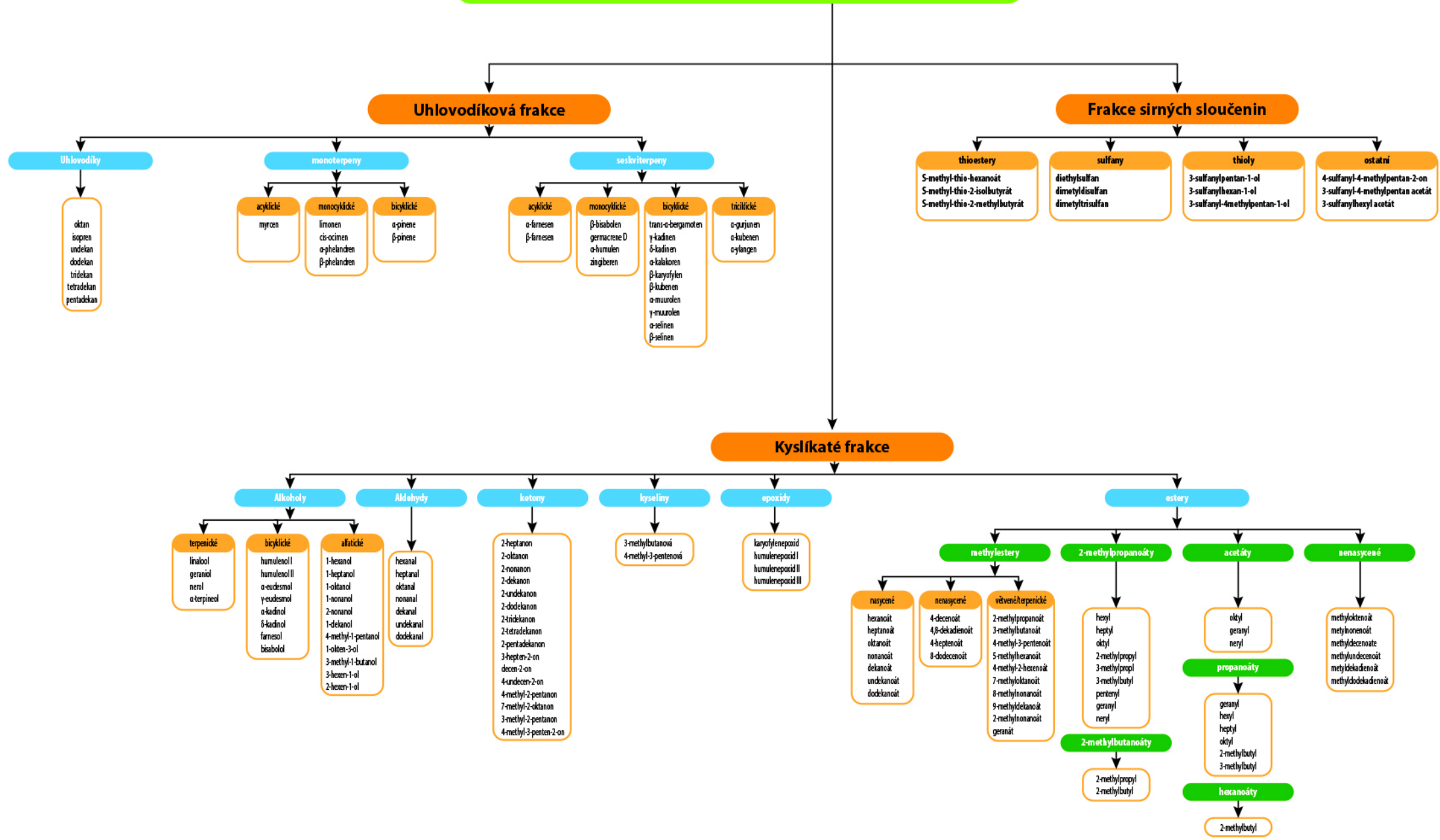
CHMELOVÉ SILICE

obsah, složení, vlastnosti



BOHEMIA HOP CUP, Žatec, 9.4.2026

Složení chmelových silic

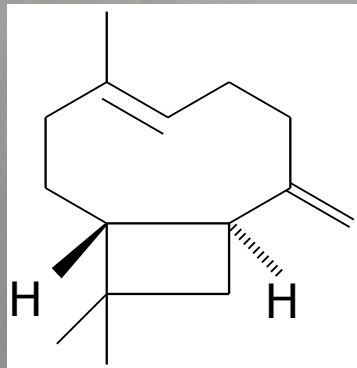


CHMELOVÉ SILICE

Terpenická frakce
75 %

Kyslíkatá frakce
24 %

- **Monoterpeny**,
myrcen, pineny, limonen
- **Sesquiterpeny**,
např. α -humulen, β -farnesen
 β -karyofylen



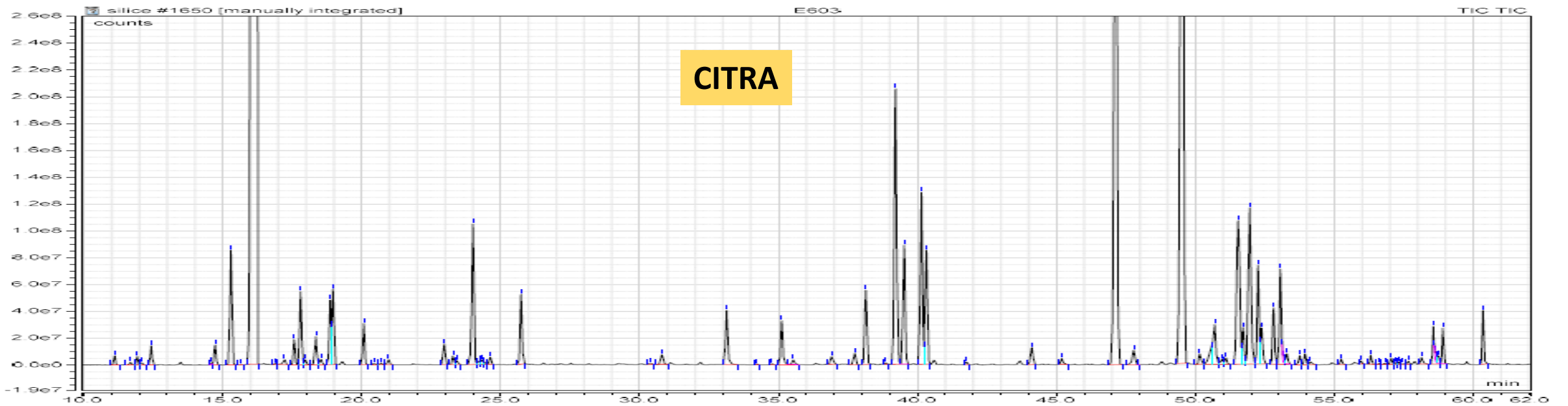
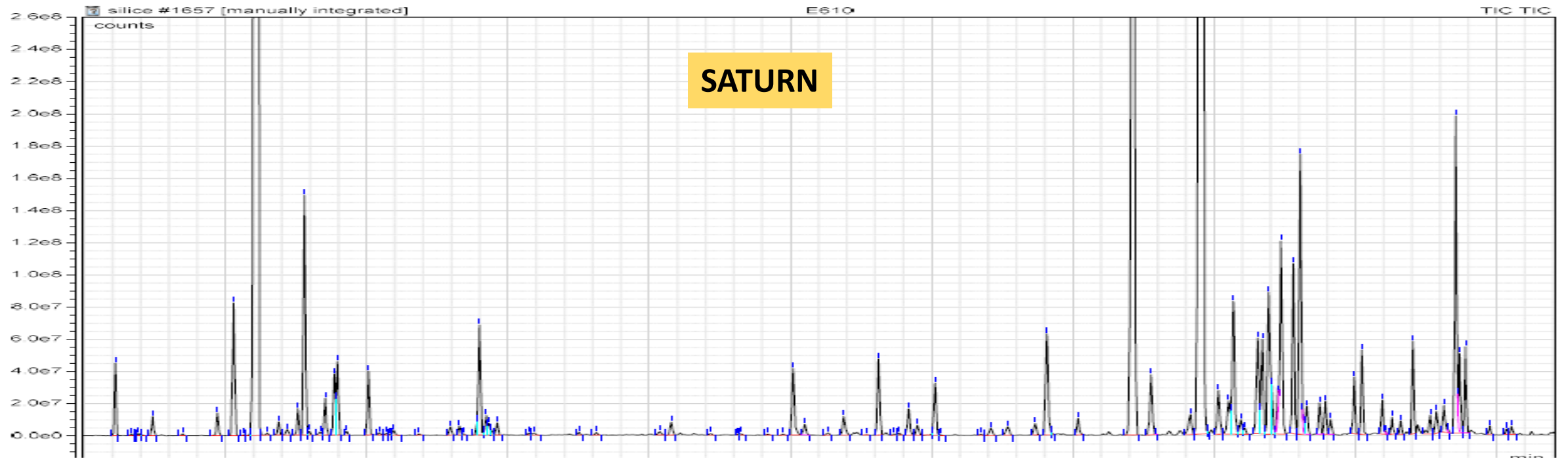
- **Epoxidy**,
humulenepoxid I, II
karyofylenepoxid
- **Alkoholy**,
např. linalool, geraniol
- **estery kyselin**
(methyl estery, isobutylestery)
vyskytují se v homologických řadách

obsah ve chmelu = 0,30–3,00 % hm.

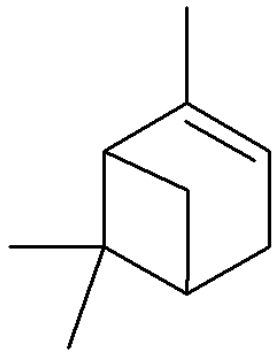
hustota = 0,85 g/ml

obsah složek = stopová množství až 10 %

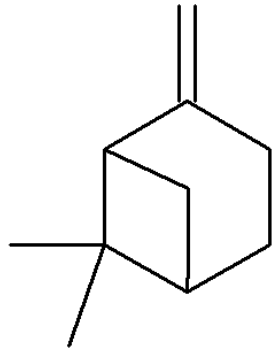
Frakce sirných sloučenin 1 %



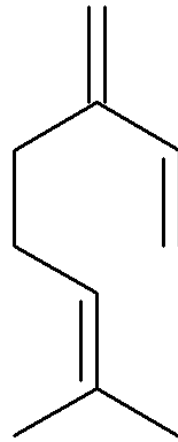
Monoterpeny chmelových silic



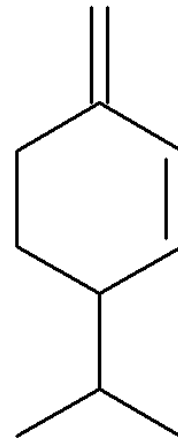
α -pinen



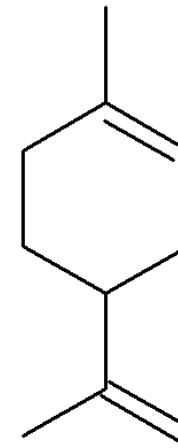
β -pinen



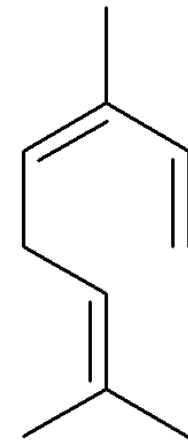
myrcen



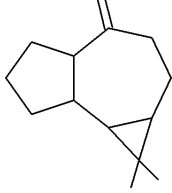
β -phellandren



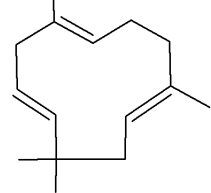
limonen



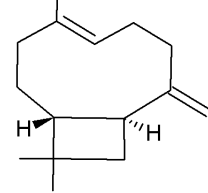
cis-ocimen



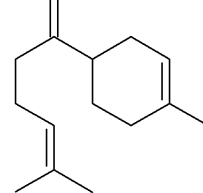
aromadendren



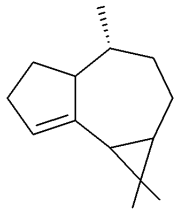
α -humulen



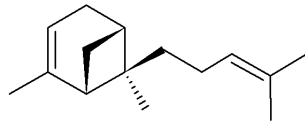
β -karyofylen



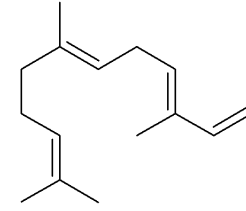
β -bisabolen



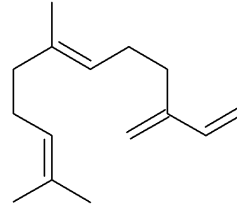
α -gurjunen



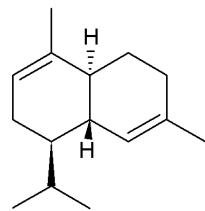
trans- α -begramoten



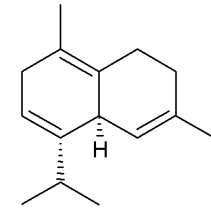
α -farnesen



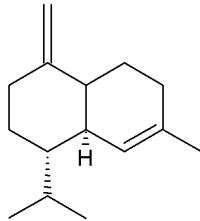
β -farnesen



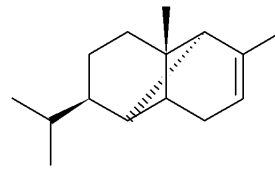
α -kadinen



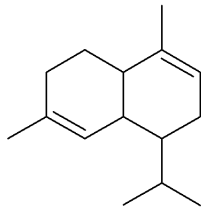
δ -kadinen



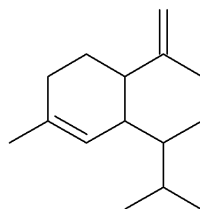
γ -kadinen



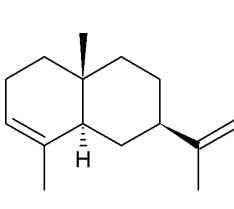
α -ylangen



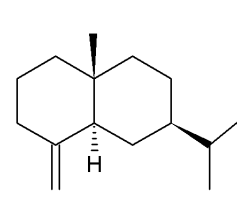
α -muurolen



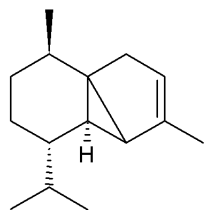
γ -muurolen



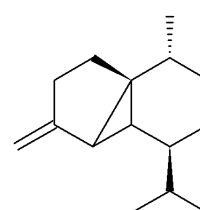
α -selinen



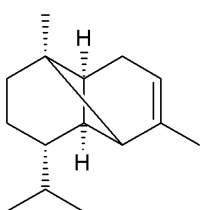
β -selinen



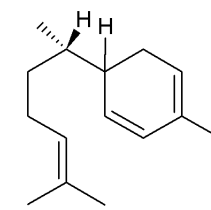
α -kubenen



β -kubenen

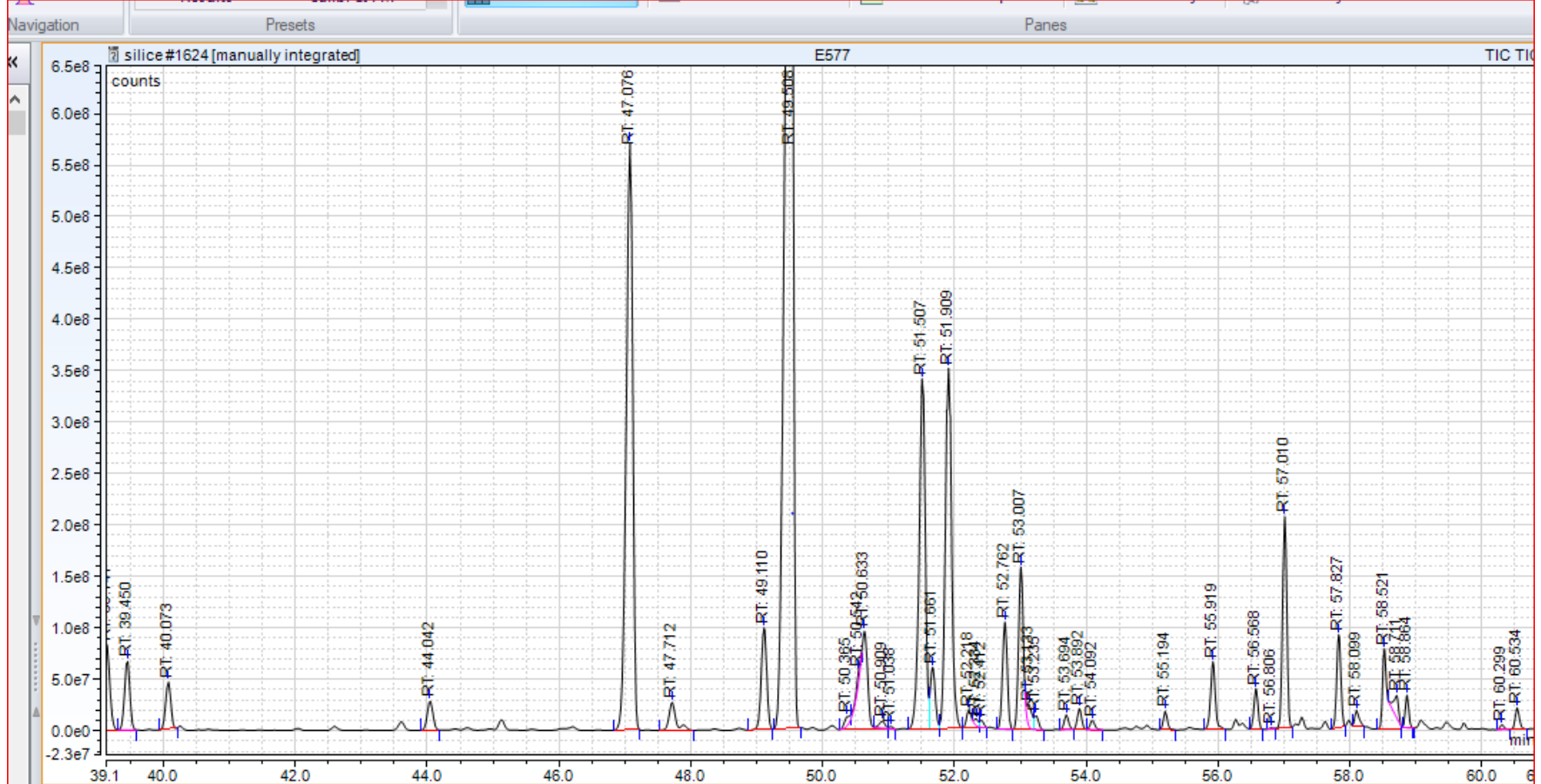


α -kopaen



α -zinaiberen

Seskviterpeny chmelových silic



	A	B	C	D	E	F	G	H	I	J
1	Peak Name	Ret. Time	Area	Rel Area	Amount	Overall Ion Ratio	Quant. Ion	Conf. Ion #1	Ion Ratio #1	Ion Ratio
2		min	counts*min	%	n.a.	Confirmation	m/z	m/z	(Expected)	(Observed)
4		12.45	1129562	0.17	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
5		14.73	515326	0.08	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
6		15.30	6033406	0.91	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
7		15.85	966379	0.15	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
8		16.12	191376466	28.82	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
9		17.79	1200335	0.18	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
10		18.85	2931809	0.44	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
11		22.93	1223781	0.18	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
12		23.24	2045213	0.31	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
13		23.96	4336533	0.65	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
14		24.30	1582391	0.24	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
15		25.69	1765844	0.27	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
16		30.74	2111841	0.32	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
17		33.06	1331197	0.20	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
18		35.04	1646647	0.25	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.
19		36.84	2260529	0.34	n.a.	Not confirmed	n.a.	n.a.	n.a.	n.a.

Aktuální atlas českých odrůd chmele

Mimosa	Pluto	Premiant	Rubín	Saaz Brilliant	Saaz Comfort	Saaz Late	Saaz Shine	Saaz Special	Saturn	Sládek	Vital	Žatecký poloraný červeňák
--------	-------	----------	-------	----------------	--------------	-----------	------------	--------------	--------	--------	-------	---------------------------

CHMELOVÉ SILICE

Obsah silic (g/100 g)	0,4–1,0	1,0–2,0	0,7–1,2	0,9–1,8	0,3–0,6	0,5–1,2	0,4–0,8	0,45–1,0	0,8–1,5	1,5–2,5	0,9–2,0	1,5–3,0	0,2–0,8
Myrcen*	15–35	20–40	15–35	15–35	15–30	15–35	15–40	10–30	20–35	30–45	15–35	25–50	10–35
Linaool*	0,4–1,1	0,4–0,8	0,45–1,50	0,3–0,7	0,15–0,45	0,4–1,0	0,4–1,0	0,5–1,2	0,5–1,2	0,4–0,7	0,15–0,60	0,7–1,5	0,15–0,70
Geraniol*	<0,2	0,3–0,6	<0,25	0,3–0,7	0,25–0,60	0,40–0,60	0,15–0,45	<0,2	0,1–0,3	<0,1	0,1–0,6	0,2–0,6	0,05–0,50
Karyofylen*	5–8	8–12	9–15	7–13	9–15	6–12	6–10	7–15	5–12	8–14	9–20	7–12	6–9
Farnesen*	<1,0	<1,0	1,5–5,5	<1,0	10–20	15–25	10–20	10–20	10–20	<1,0	<1,0	1,5–3,5	10–25
Humulen*	1–4	20–30	20–40	20–30	15–35	1–4	15–25	20–40	15–25	20–35	20–40	1,5–4,0	15–30
Selineny*	25–45	1–4	1–4	15–25	1–3	15–25	3–7	1–4	1–2	1–3	0,6–3,5	15–25	<3,0

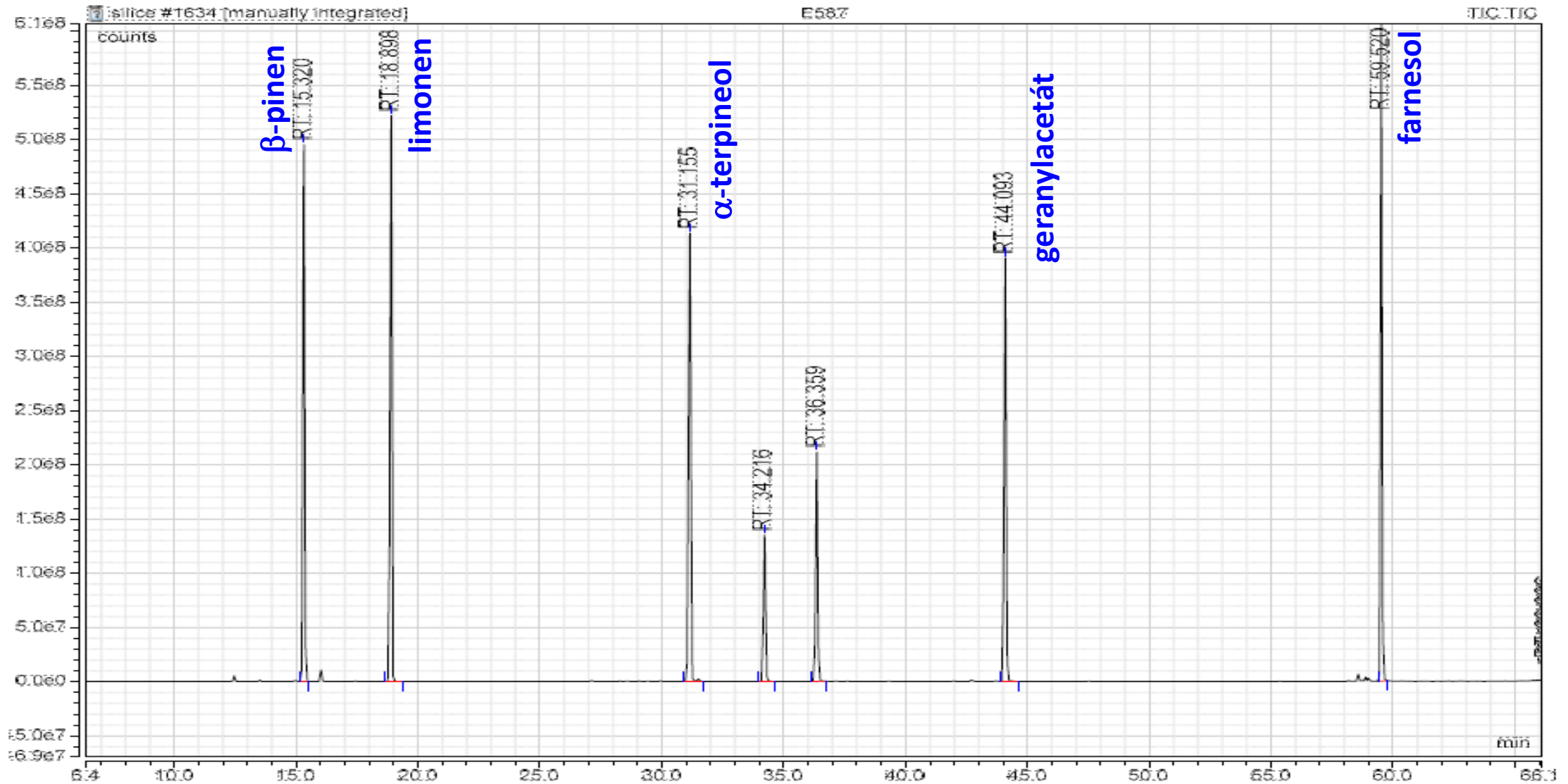
* % rel. celkových silic

VÝNOS

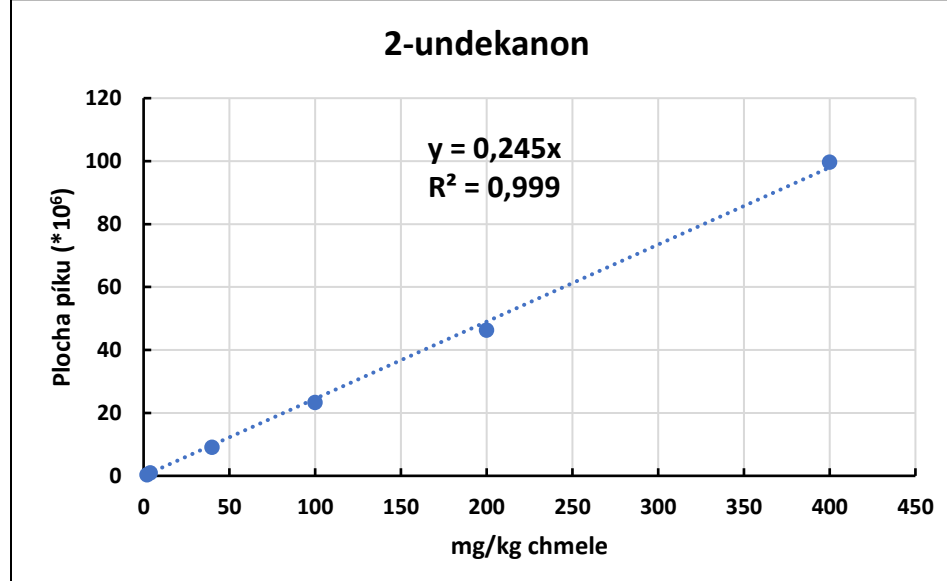
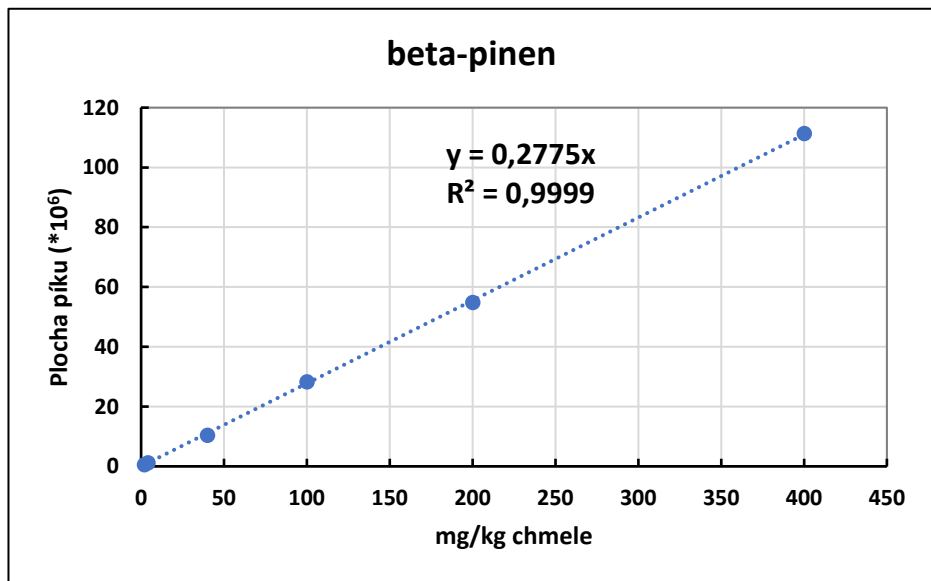
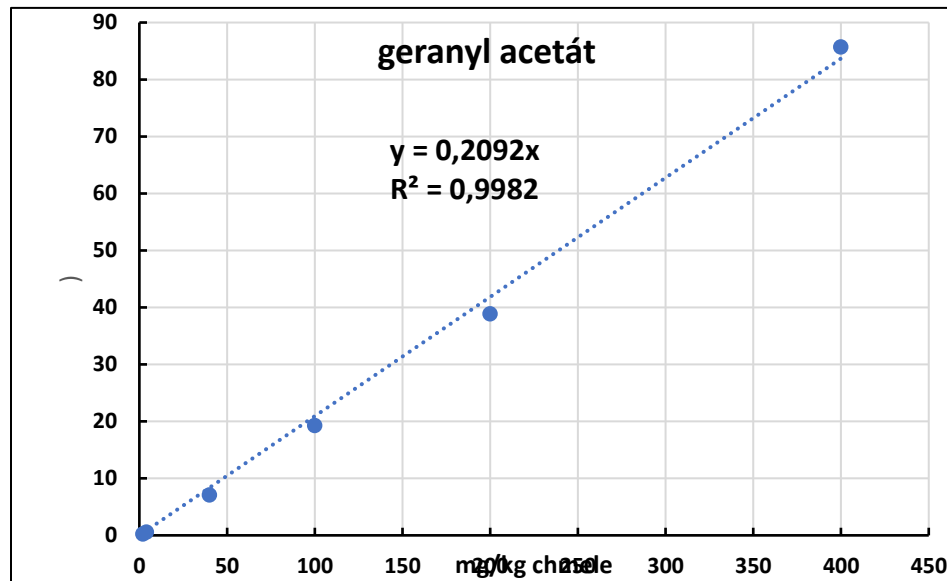
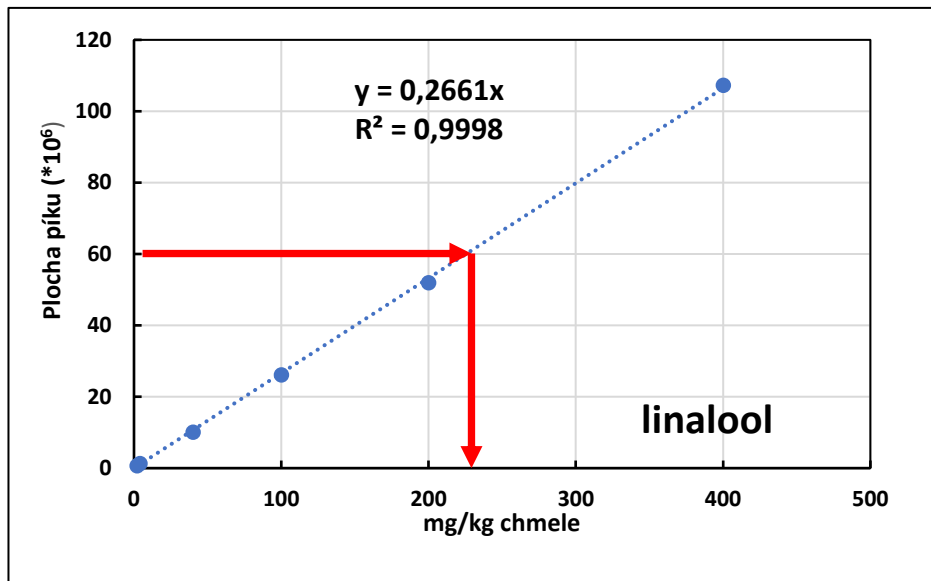
Odezvy detektoru na vybrané složky chmelových silic při stejné koncentraci

Sequence: silic
Injection #1634

rogram



Kalibrační přímky vybraných složek chmelových silic



Testované odrůdy (pelety T90), sklizeň 2025

České chmele

Ceres (2025)

Eris (2025)

Juno (2025)

Jupiter (2025)

Pluto (2025)

Saturn (2025)

Zahraniční odrůdy

Citra (USA, 2025)

Mosaic (USA, 2025)

Simcoe (USA, 2025)

Nectaron (NZ, 2025)

Citra (USA, 2024)

Cascade (USA, 2024)

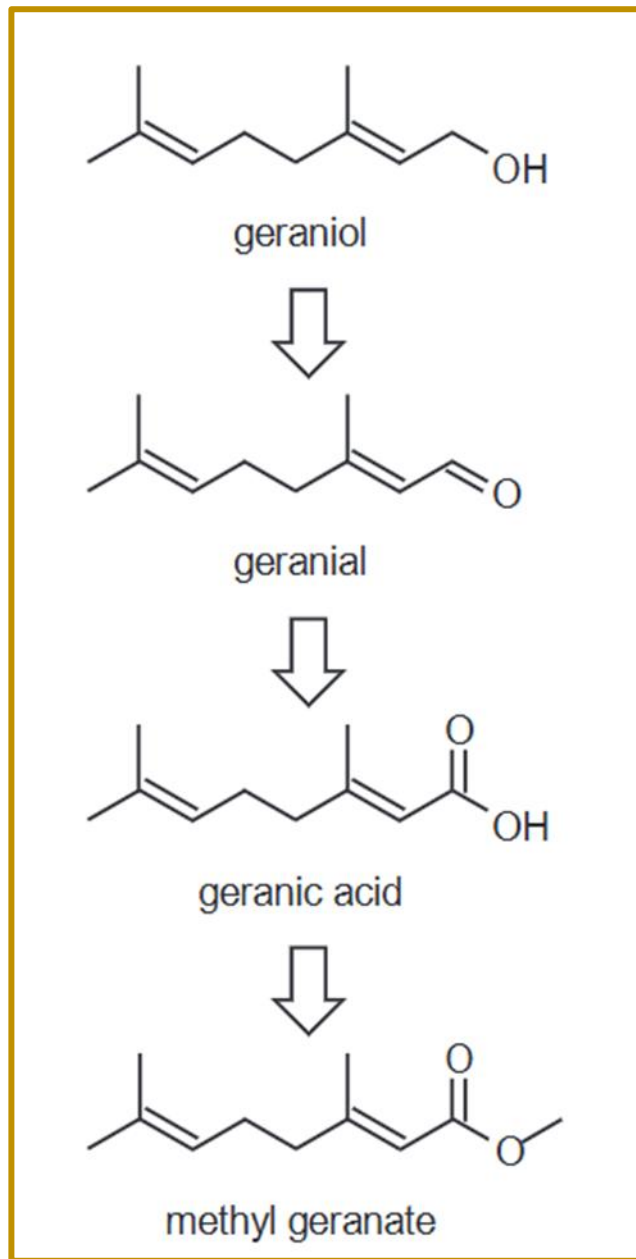
Porovnání složení silic českých a zahraničních „flavour“ odrůd chmele - I

Granule T90

Složka	mg/kg						mg/kg					
	CERES	PLUTO	ERIS	JUPITER	SATURN	JUNO	MOSAIC 2025	NECTARON 2025	SIMCOE 2025	CITRA 2025	CITRA 2024	CASCADE 2024
Total oil (% w.)	1.05	0.83	0.83	0.84	1.16	0.84	1.57	1.85	1.42	2.10	1.40	0.88
Isobutylisobutyrate	21.1	72.7	69.5	22.6	45.8	34.3	14.0	11.3	6.9	7.7	11.3	8.0
β-Pinene	66.1	69.1	54.2	73.3	66.3	78.1	77.1	55.8	53.4	68.5	663	781
myrcene	3145	1799	2670	3557	3123	3555	3330	3096	2746	3694	3118	2747
limonene	30.7	27.2	23.6	34.9	30.9	36.7	40.8	29.6	31.9	50.1	48.9	60.5
cis -ocimene	68.6	10.2	158	131	37.7	136	17.7	30.1	2.30	29.3	20.0	25.6
linalool	47.2	48.4	47.2	67.9	58.1	92.9	63.2	69.4	47.6	93.7	100.9	66.5
geraniol	47.4	66.4	44.7	60.1	55.1	98.7	69.8	85.8	52.2	68.0	115.6	25.5
2-undecanone	33.2	36.6	38.3	33.6	45.5	39.3	122.6	22.6	90.0	53.3	90.7	20.0
methylgeranate	38.5	25.8	23.8	56.2	31.1	46.1	161	93.3	118	123	137	56.8
geranylacetate	74.6	261	87.5	111.2	69.1	96.6	9.2	14.4	15.4	12.8	13.3	133.3
α-humulene	1117	979	1018	870	1178	370	591	953	852	476	691	965
geranyl propionate	24.8	101.8	28.7	46.1	29.2	34.2	48	27.7	14.2	24.0	10.2	67.8
geranyl isobutyrate	90.8	293	123	101	114	200	48.0	82.7	37.2	24.0	35.2	151.8
caryophyllenoxide	9.6	93.5	25.4	11.4	12.4	22.1	1.01	3.05	4.44	1.02	1.38	9.53
humulenepoxide II	23.9	247	58.2	25.2	30.5	15.0	4.29	12.7	9.16	2.54	1.45	38.6
trans-farnesol	6.7	13.9	7.7	21.3	2.2	42.1	0.25	11.8	1.50	23.1	28.2	6.75

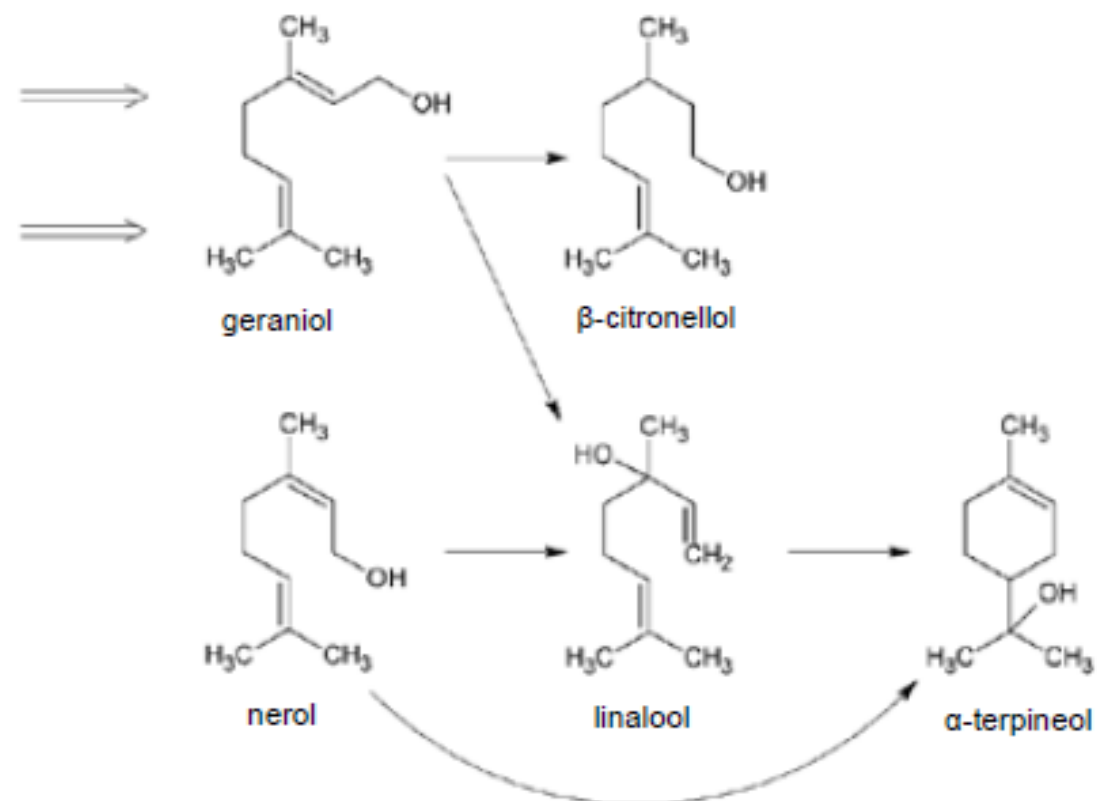
Porovnání složení silic českých a zahraničních „flavour“ odrůd chmele - II

- Americké chmele obsahují větší množství volného linaloolu a geraniolu (100-200 mg/kg) v porovnání s českými flavour odrůdami (do 120 mg/kg, výjimka Juno),
- Charakteristickým rysem českých „flavour odrůd“ je vysoký obsah esterů geraniolu 150-300 mg/kg (geranylacetát, propionát, isobutyryl)
- Americké odrůdy obsahují velká množství 100-160 mg/kg methylgeranátu, české flavour chmele 25-50 mg/kg
- Americké odrůdy obsahují podstatně méně oxidačních produktů karyofylenu a humulenu (epoxydy) (*Chenot a Shellhammer: Food Chemistry, 2026, 503, 147870*)
- Novozélandská odrůda Nectaron je ve sledovaných parametrech podobná americkým odrůdám Mosaic, Simcoe, Citra



Glykosidicky vázané
prekurzory geraniolu

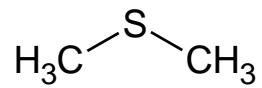
Estery geraniolu



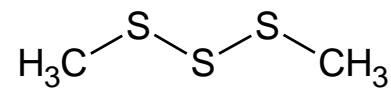
Obrázek 10.9.6.2 Metabolické transformace monoterpenických alkoholů pivovarskými kvasinkami
[King a Dickinson, 2003]

SIRNÉ LÁTKY I

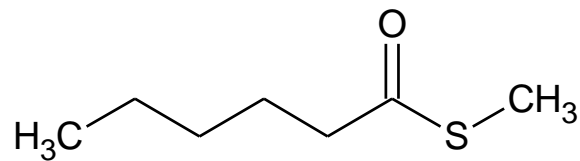
sulfidy
thioestery



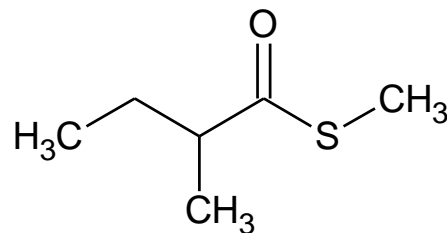
dimethylsulfid



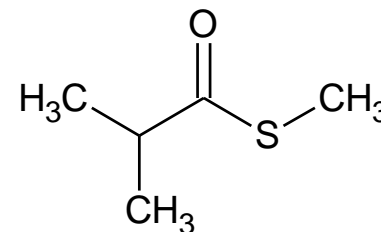
dimethyltrisulfid



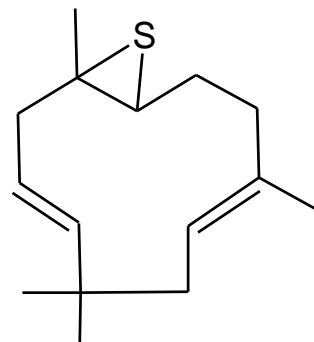
S-methyl-sulfanyl hexanoate



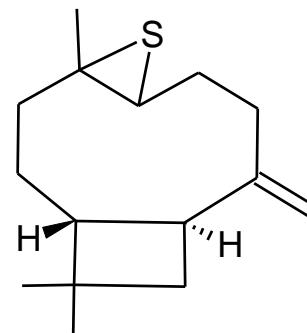
S-methyl-sulfanyl-2-methylbutyrate



S-methyl-sulfanyl-isobutyrate



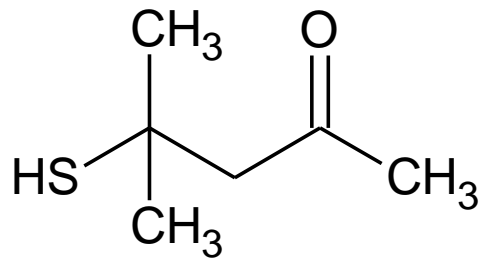
1,2-epithiohumulen



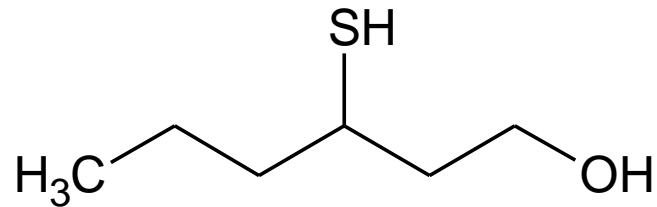
4,5-epithiokaryofylen

SIRNÉ LÁTKY II

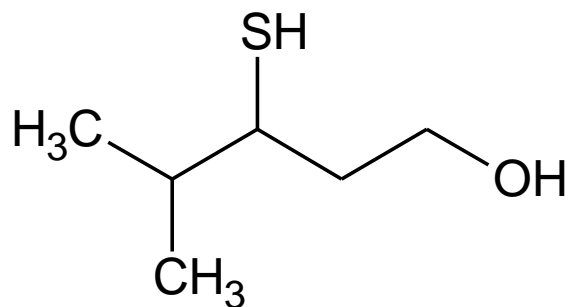
thioly



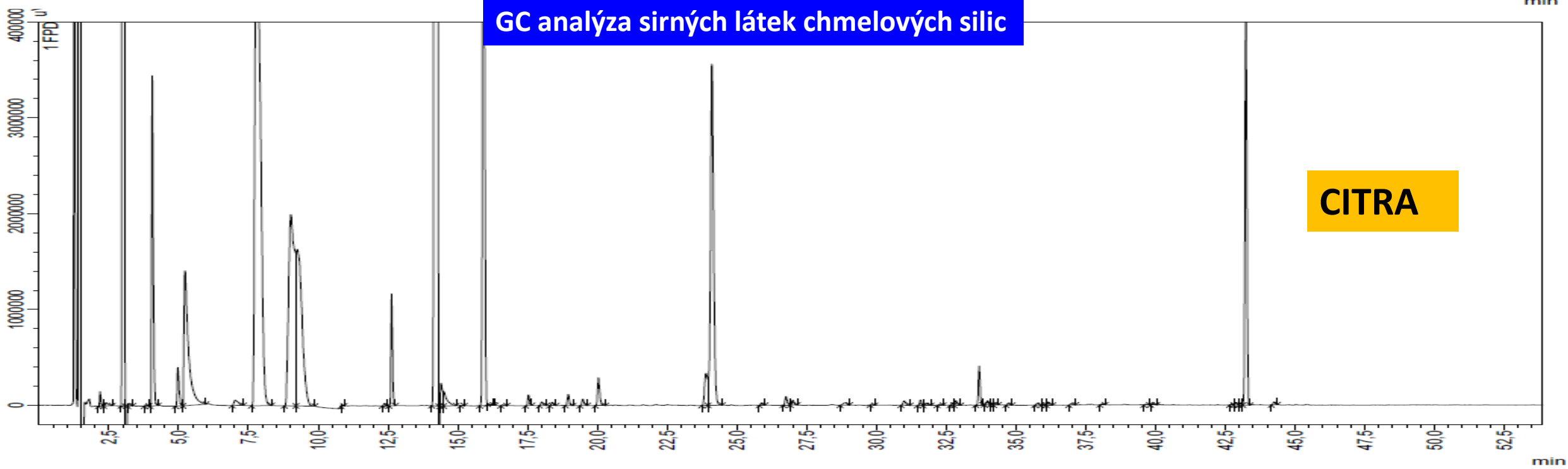
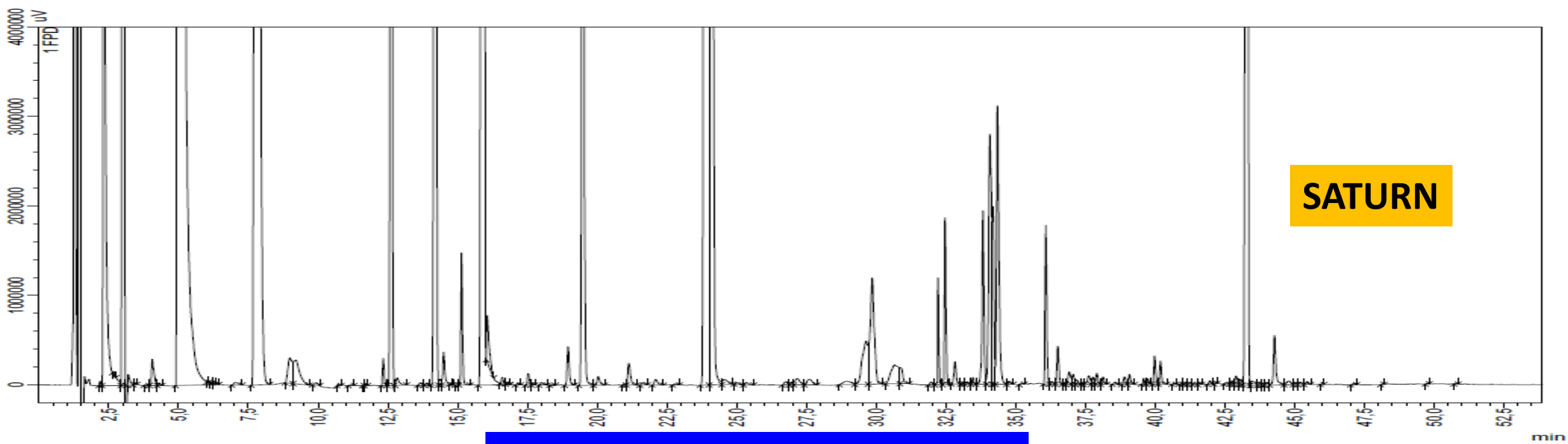
4-merkapto-4-methylpentan-2-on (4MMP)



3-merkaptohexan-1-ol (3MH)



3-merkapto-4-methylpentan-1-ol (3M4MP)



GC analýza sirných látek chmelových silic

Děkuji za pozornost

