

Any practical solutions to the storage problematic?

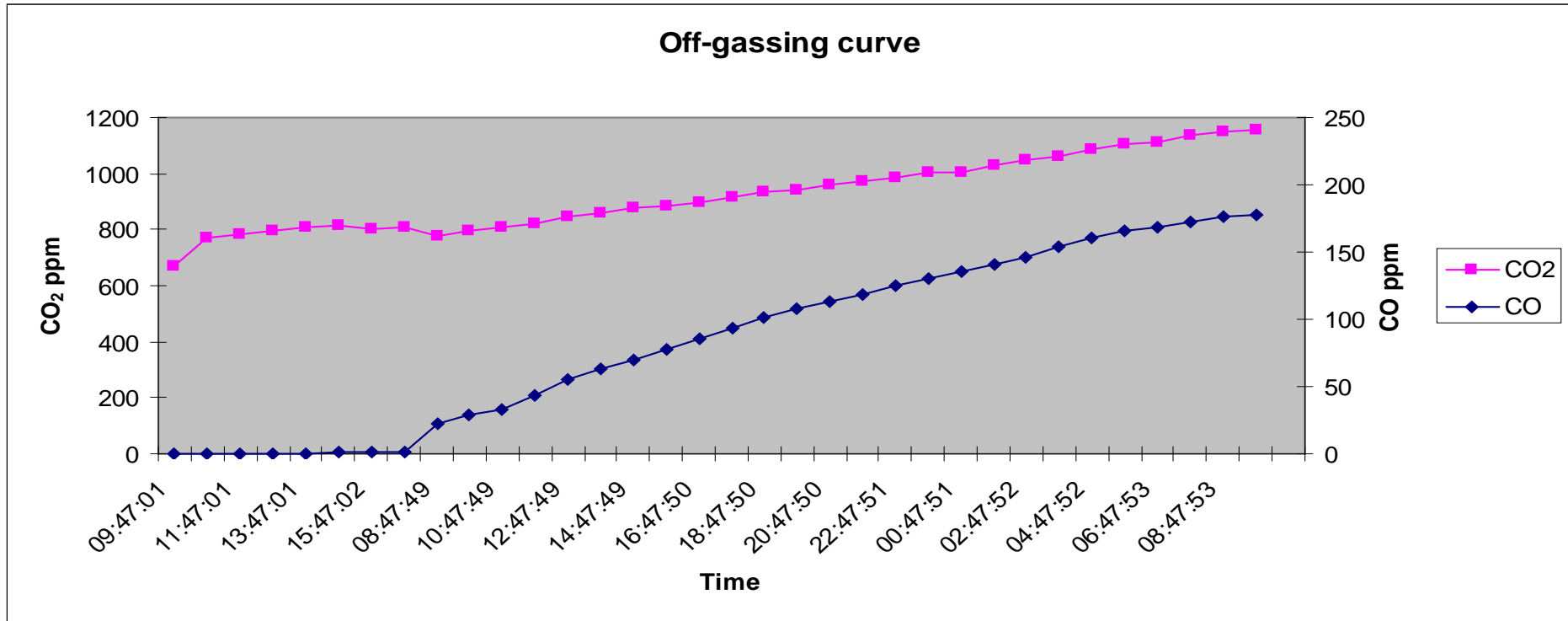
Blocking autoxidation by additives



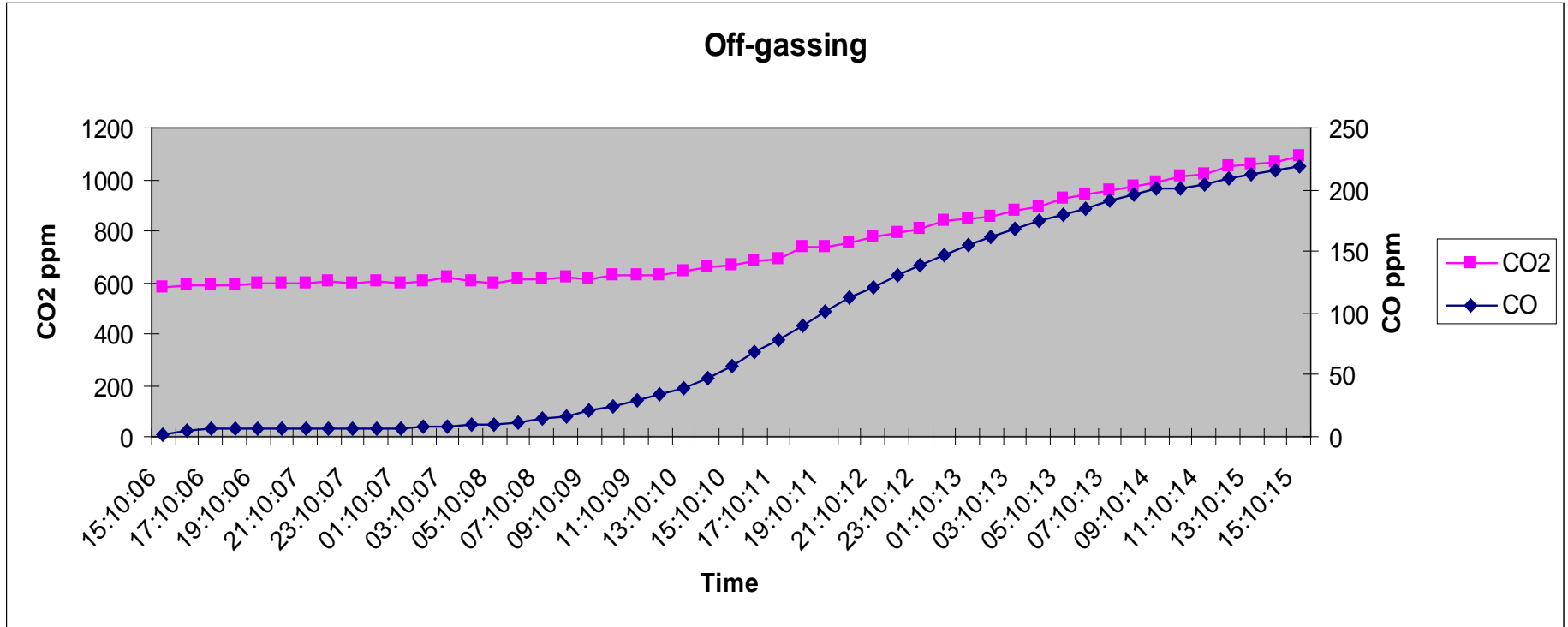
Mehrdad Arshadi
Docent

PELS Workshop
Älvdalen, 18:e – 19:e september, 2018

Pellets from Industry

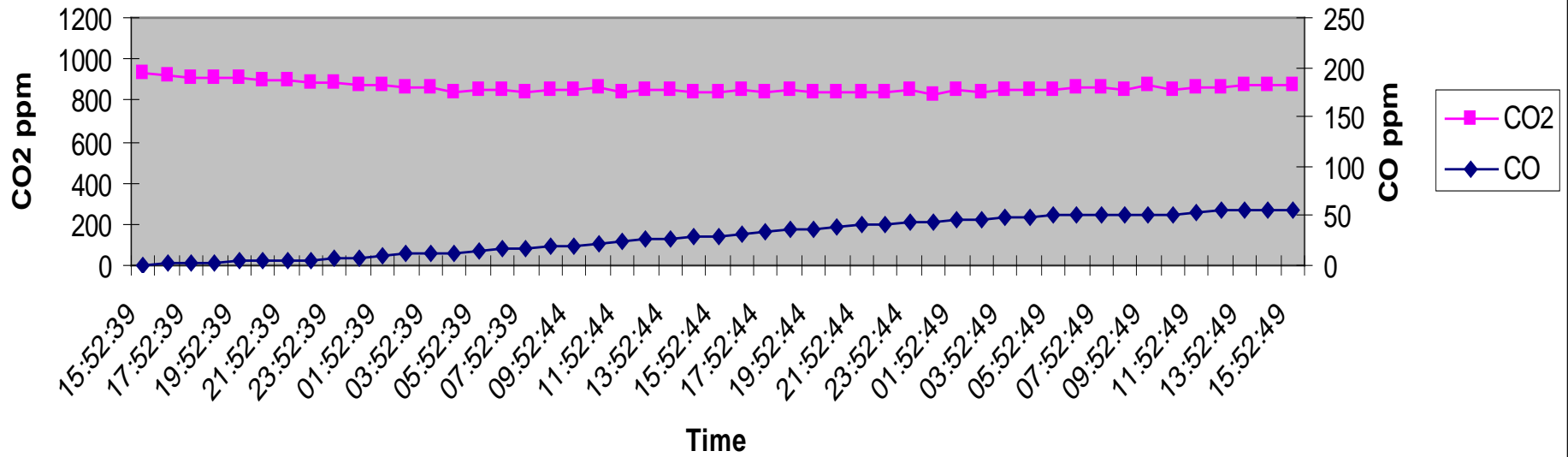


Pellets made of fresh pine sawdust at laboratory



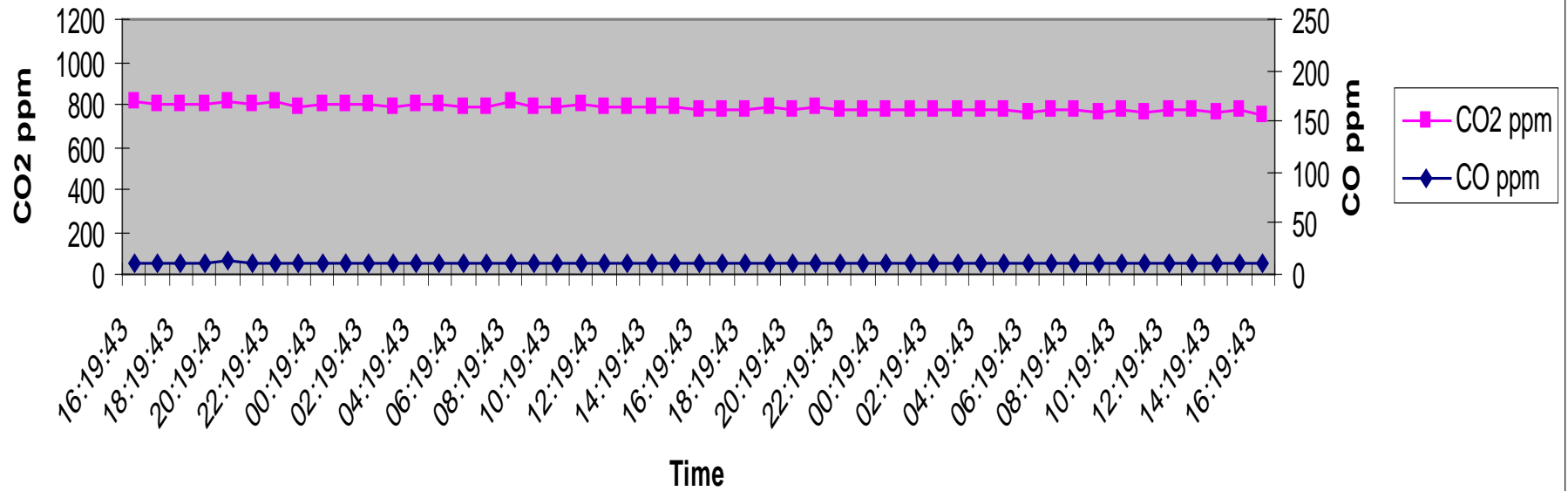
Fresh pine Sawdust + 2% "Super 1" additive

Off gassing curve



Fresh Sawdust + 20% "super 2" additive

Off-gassing curve

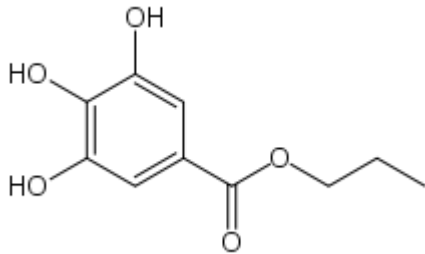


Pellet made from sawdust and three additives



Pilot study at BTC

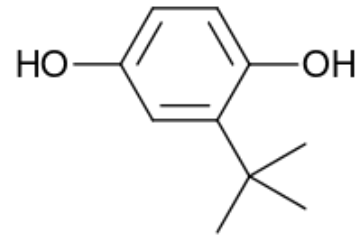
Antioxidants



Propyl gallate (PG, E310)

1% based on weight of wet sawdust

Melting point 146–150 °C



Tert-butylhydroquinone (TBHQ, E319)

0.5% addition

Melting point 126.5–128.5 °C

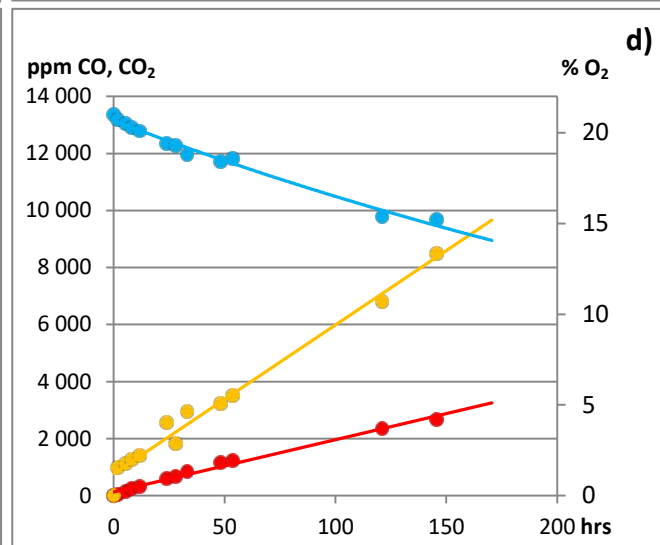
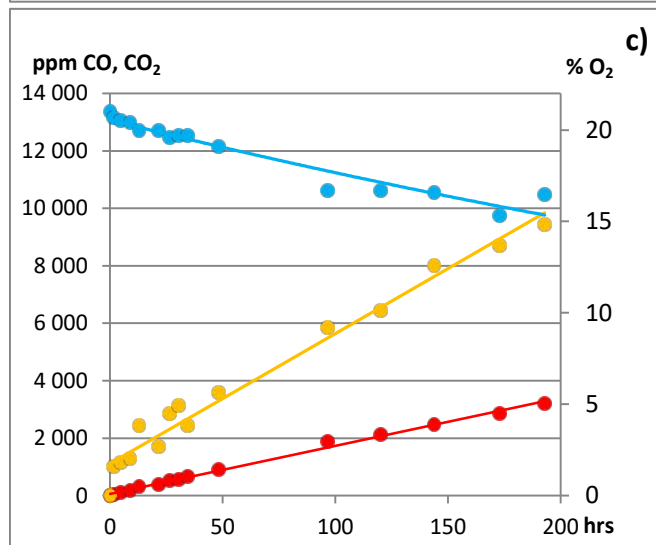
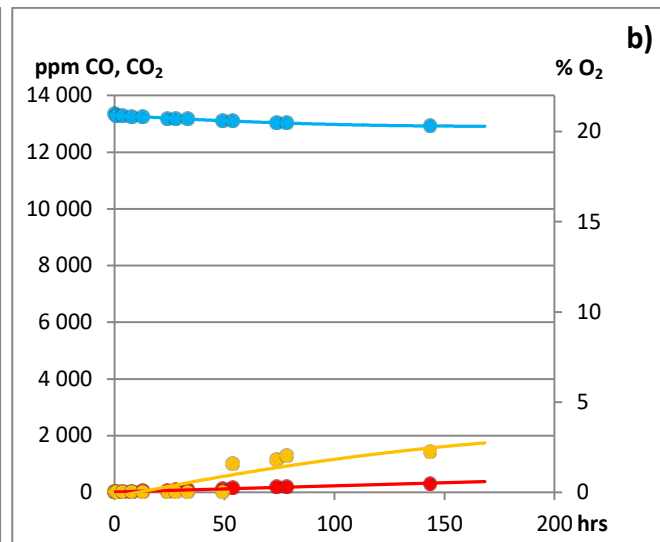
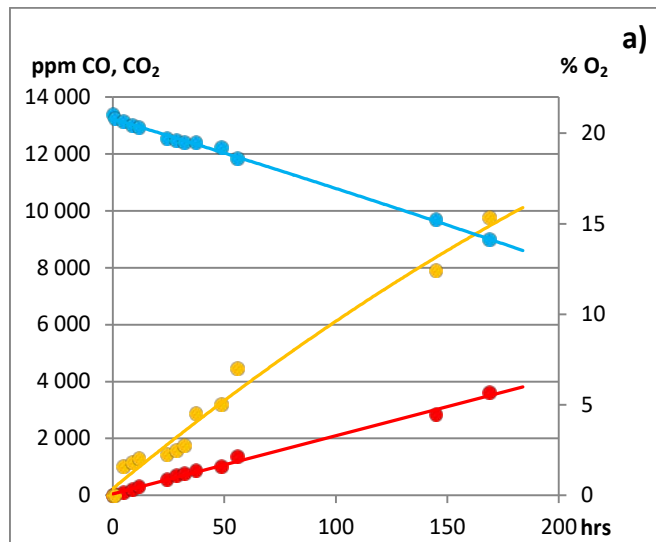


Bark spruce 5% addition

Emissions during simulated storage at room temperature (22 °C) for 1 week.

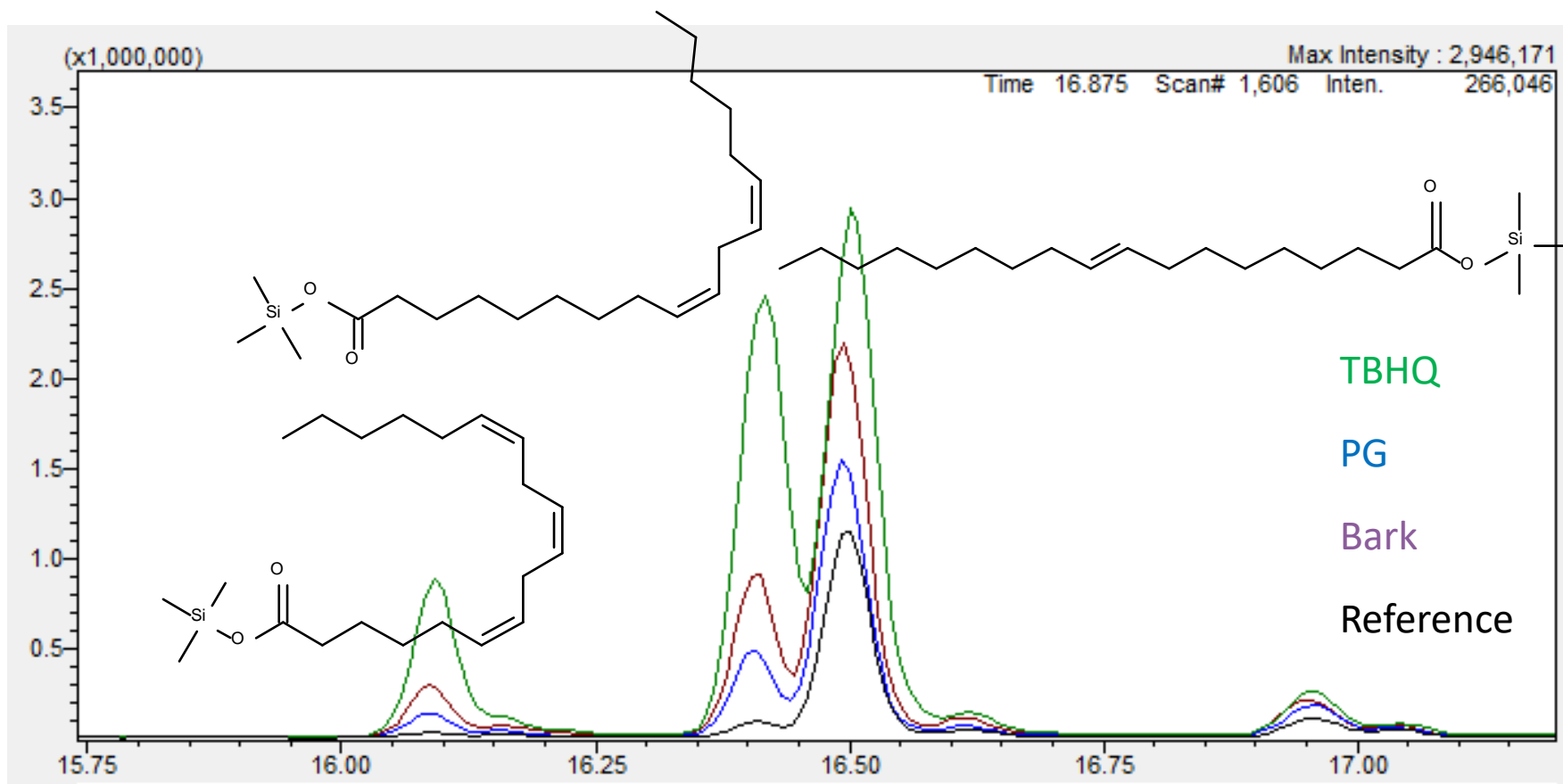
Carbon monoxide (●),
carbon dioxide (●) and
oxygen depletion (●).

- a) Batch 1, reference material with no antioxidant added,
- b) Batch 2, 0.5 % TBHQ added
- c) Batch 3, 1% PG added,
- d) Batch 4, 5% bark added



Ca 90 % lower CO emissions in TBHQ cf. reference pellets

Unsaturated Fatty acids



The individual fatty/resin acids ($\mu\text{g/g}$) after the off-gassing experiment at 23 °C

Name	Type of substances	Reference	TBHQ	PG	Bark
Octanoic acid	C8:0	30	11	18	17
Nonanoic acid	C9:0	14	14	18	18
Dodecanoic acid	C12:0	3	3	2	2
Tetradecanoic acid	C14:0	7	9	7	7
Pentadecanoic acid	C15:0	13	15	14	15
cis-9-Hexadecenoic acid	C16:1	5	10	9	10
Hexadecanoic acid	C16:0	126	147	129	119
Heptadecanoic acid	C17:0	50	66	47	63
6,9,12-octadecatrienoic acid (Z,Z,Z)-	C18:3	5	146	28	46
9,12-Octadecadienoic acid (Z,Z)-	C18:2	21	561	56	156
trans-9-Octadecenoic acid,	C18:1	328	853	336	504
Pimaric, (1R,4aR,4bS,7S,10aR)-1,4a,7-Trimethyl-7-vinyl-3,4,4b,5,6,9,10,10a-octahydro-2H-phenanthrene-1-carboxylic acid	RA	289	483	365	434
Isopimaric, 1R,4aR,4bS,7R,10aR)-7-Ethenyl-1,4a,7-trimethyl-3,4,4b,5,6,9,10, 10a-octa-hydro-2H-phenanthrene-1-carboxylic acid	RA	84	227	104	135
Abietic, Abieta-7,13-dien-18-oic acid	RA	13	399	42	150
Dehydroabietic, Abieta-8,11,13-trien-18-oic acid	RA	3206	3144	3529	3816
Abietic, Abieta-7,13-dien-18-oic acid	RA	175	1322	407	516
Trimethylsilyl 7-oxoabieta-9(11),8(14),12-trien-18-oate	RA	350	161	249	246
Total Fatty acids		602	1835	664	957
Total saturated fatty acids		243	265	235	241
Total unsaturated fatty acids		359	1570	429	716

Pellet made from sawdust and TBHQ



Pilot study at BTC



The Pellets press and the transport system



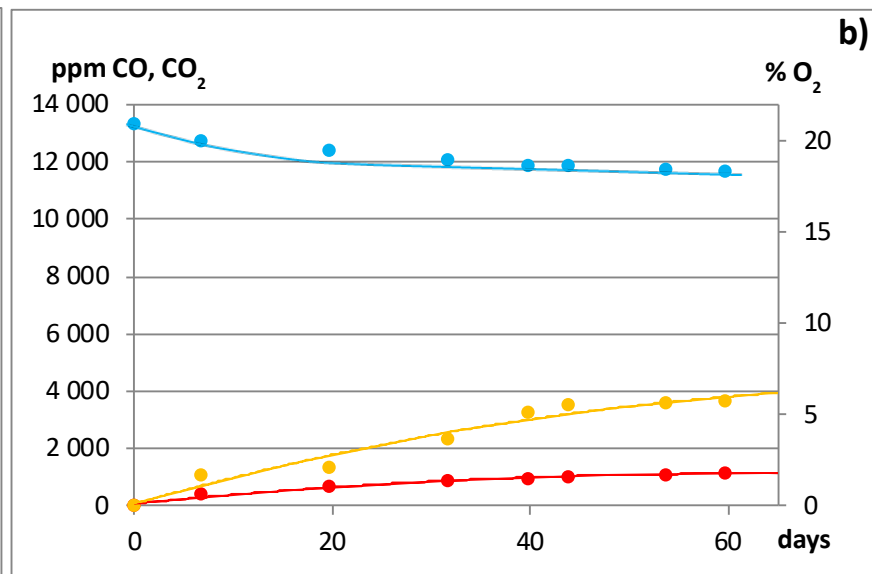
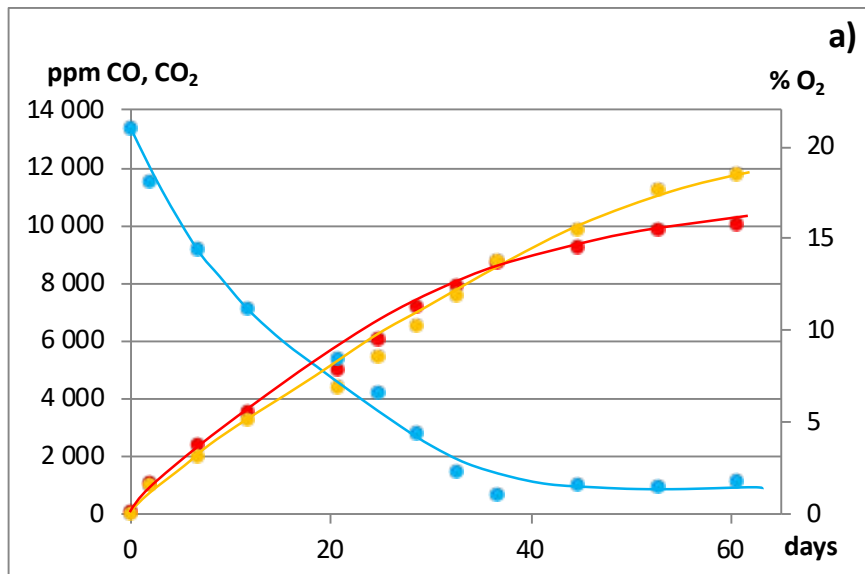
Cooling the produced pellets during 30 minutes before collection



Off-gassing measurements in two 1 m³ (500.0kg) and two 19 litre (8.0 kg) storage facilities



Lagring (under 60 dagar) av 500 kg pellets med TBHQ (0.5 %) och pellets gjord av samma sågspån utan TBHQ

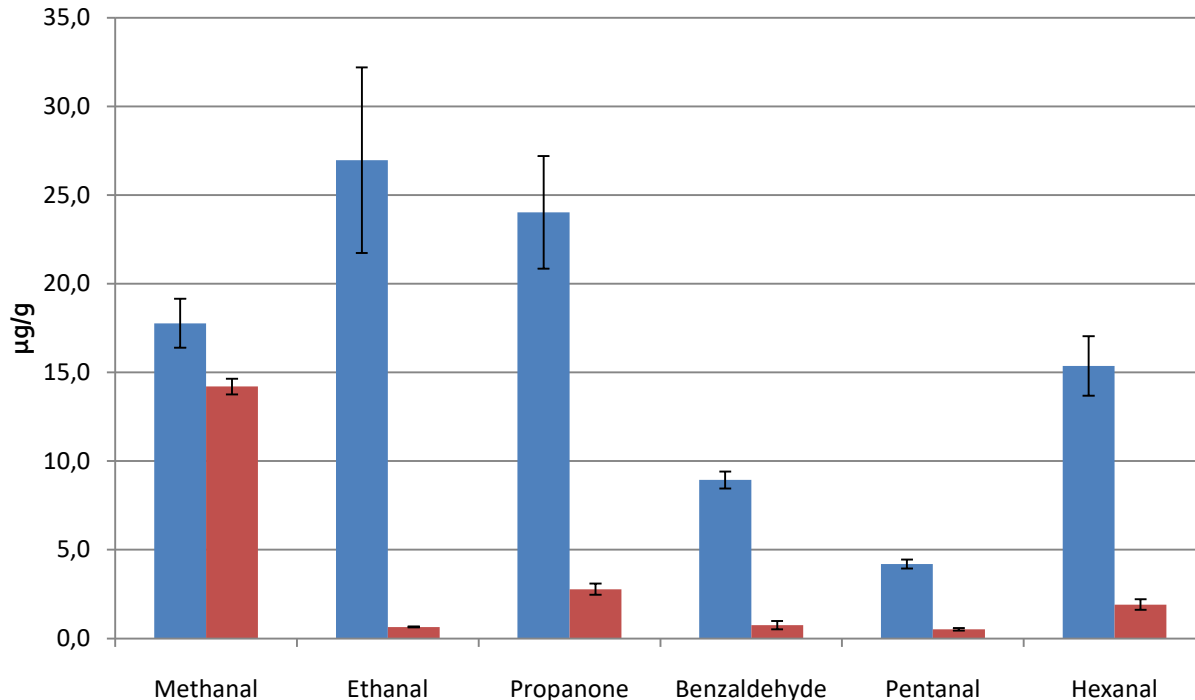


Pilot plant scale storage at room temperature (23 °C) for 2 months. Emissions of carbon monoxide (●), carbon dioxide (●) and oxygen depletion (●).

- a) Reference material with no antioxidant added,
- b) 0.5 % TBHQ added.

- 89 % lägre CO avgasning från pellets med 0.5% TBHQ
- 69 % lägre CO₂ avgasning från pellets med 0.5% TBHQ
- Syrehalten 18.4 % jmf. 1.6% i referenspellets

The concentration of major aldehydes and ketones ($\mu\text{g/g}$ pellet) in reference and pellets with TBHQ



The concentration of major aldehydes and ketones ($\mu\text{g/g}$ pellet) in **reference** and **pellets with TBHQ**.

Sampling time from start of experiment in 19-L cylinders was 1 day after production.

77 % lägre aldehyder i TBHQ pellets

- ❑ The amount of fatty/resin acids is almost intact and high (**no autoxidation**)
- ❑ Minimize oxidation and thereby less off-gassing **lower CO, CO₂ and CH₄**
- ❑ Reducing smell much lower aldehydes/ketones
- ❑ Less self-heating tendency

Arshadi, M., Tengel, T. and Nilsson, C. (2018) Antioxidants as additives in wood pellets as a mean to reduce off-gassing and risk for self-heating during storage. *Fuel Processing Technology*, **179**, 351-358.