Chemical Characterization of Wood Pellets - Determination of Volatile Organic Compounds Emitted from Softwood Pellets During Storage

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Fuel pellets made of different raw materials at BTC

Peat

Cotton residue

Hemp

Bark (pine)

Eucalyptus leaves

Olive seeds

Reed canary grass

Wheat straw

Wood pellets

- Made of sawdust
- Mainly of pine and spruce
- Energy resource for heating houses and some industries
- Wood pellets productions companies producing about 1600 000 tons of pellets per year in Sweden (price 188-248 Euro/ton).
- 6 or 8 mm in diameter
- 35-40 mm in length
- Calorific heat value 19-20 MJ/kg
- 1 m^3 oil = 2 tons pellets

SLU

Why using wood pellets and not sawdust directly?

- Lower moisture content (no risk for mould formation),
- **Lower transport and storage costs** (Higher density, 5-7 times),
- Higher energy content per volume and easy to feed in burners (better combustion),
- Homogeneity, i.e. less variations in moisture content.

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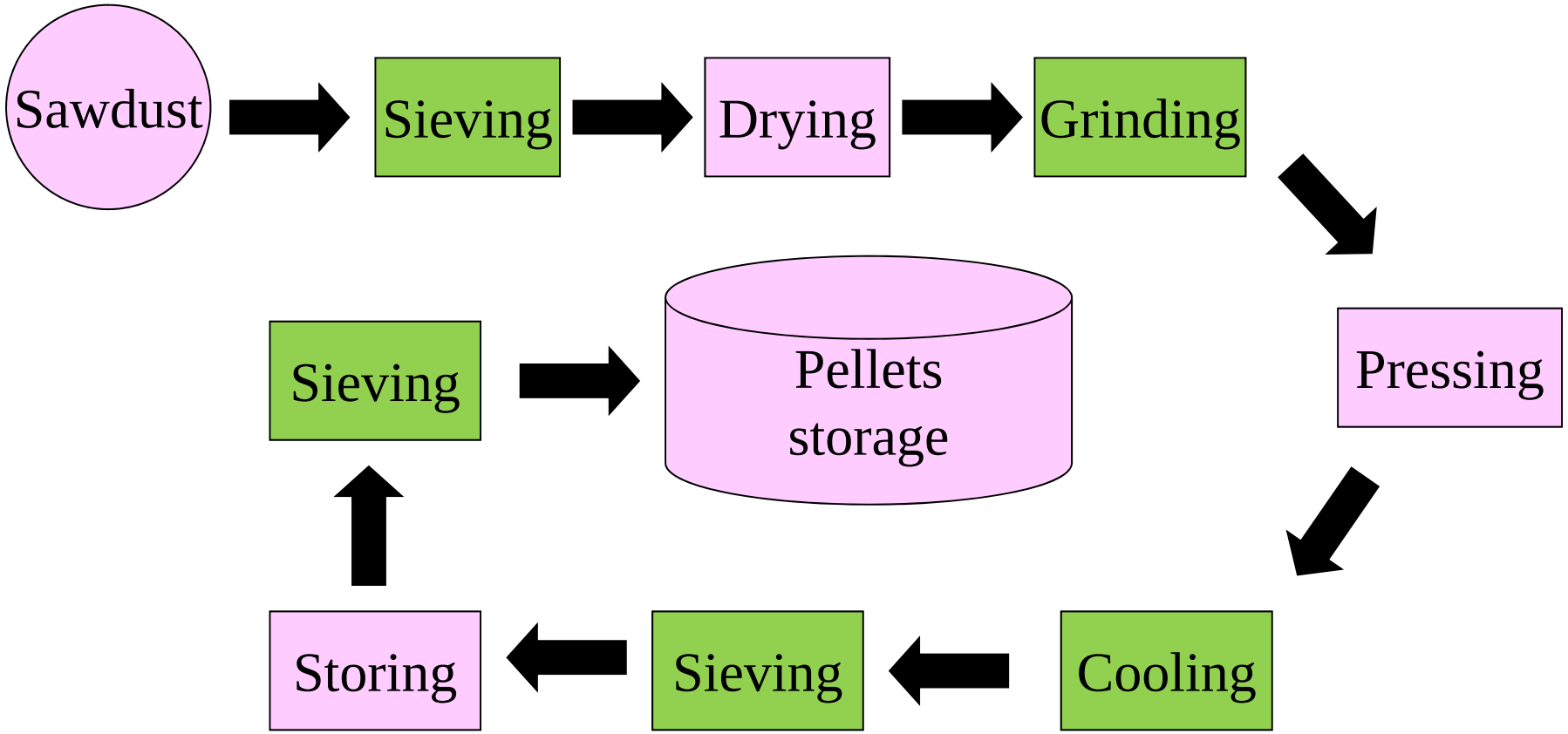
Wood pellets production process



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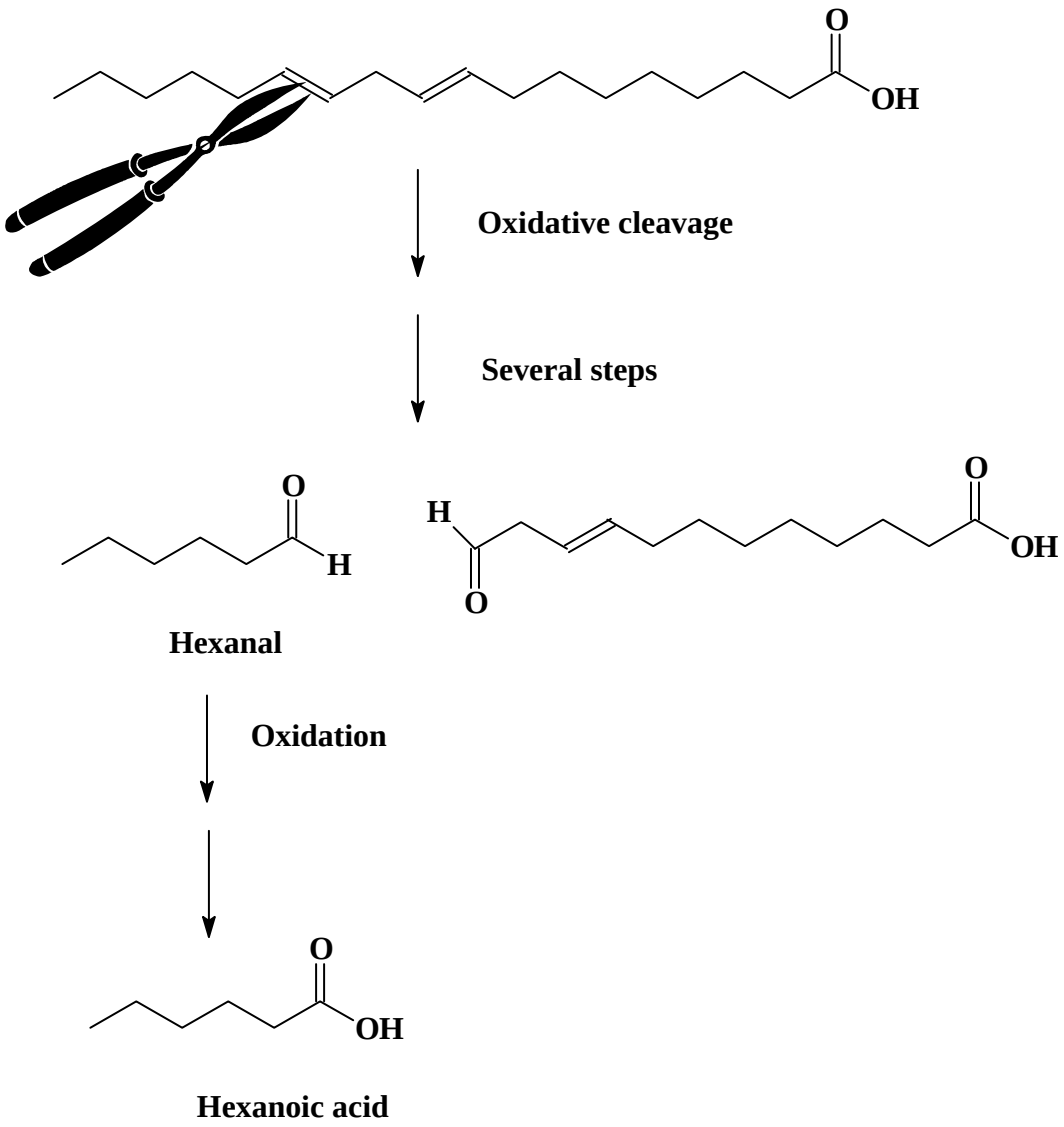
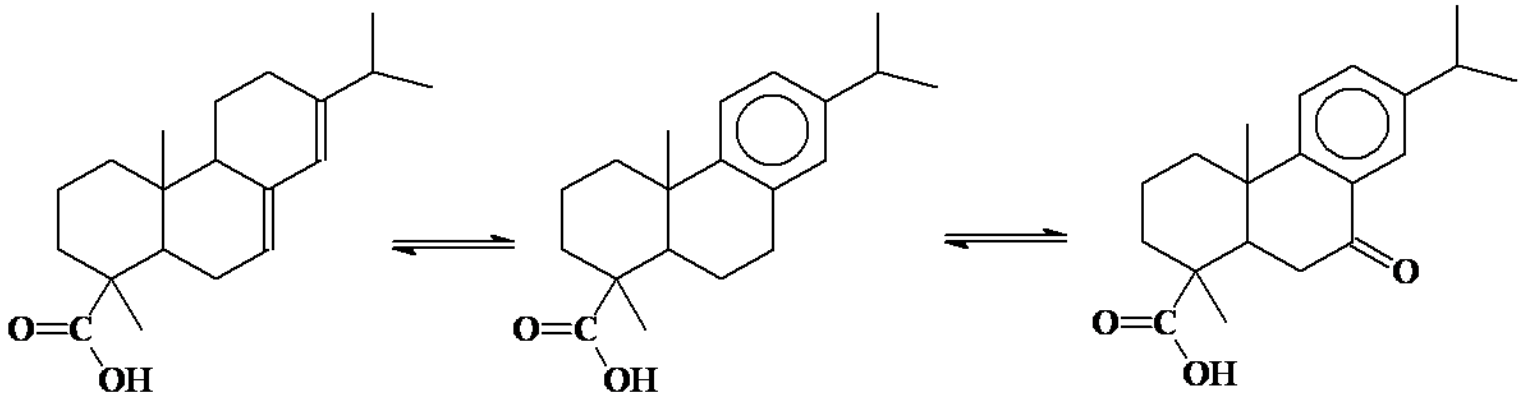
- **Oxidation of fatty/resin acids**
- Industrial experimental design
- Data analyses
- Emissions of aldehydes
- Emissions of CO, CO_2
- Conclusions

Oxidation of fatty acids



Oxidation of resin acids in pine and spruce



Abietic acid

Dehydroabietic acid

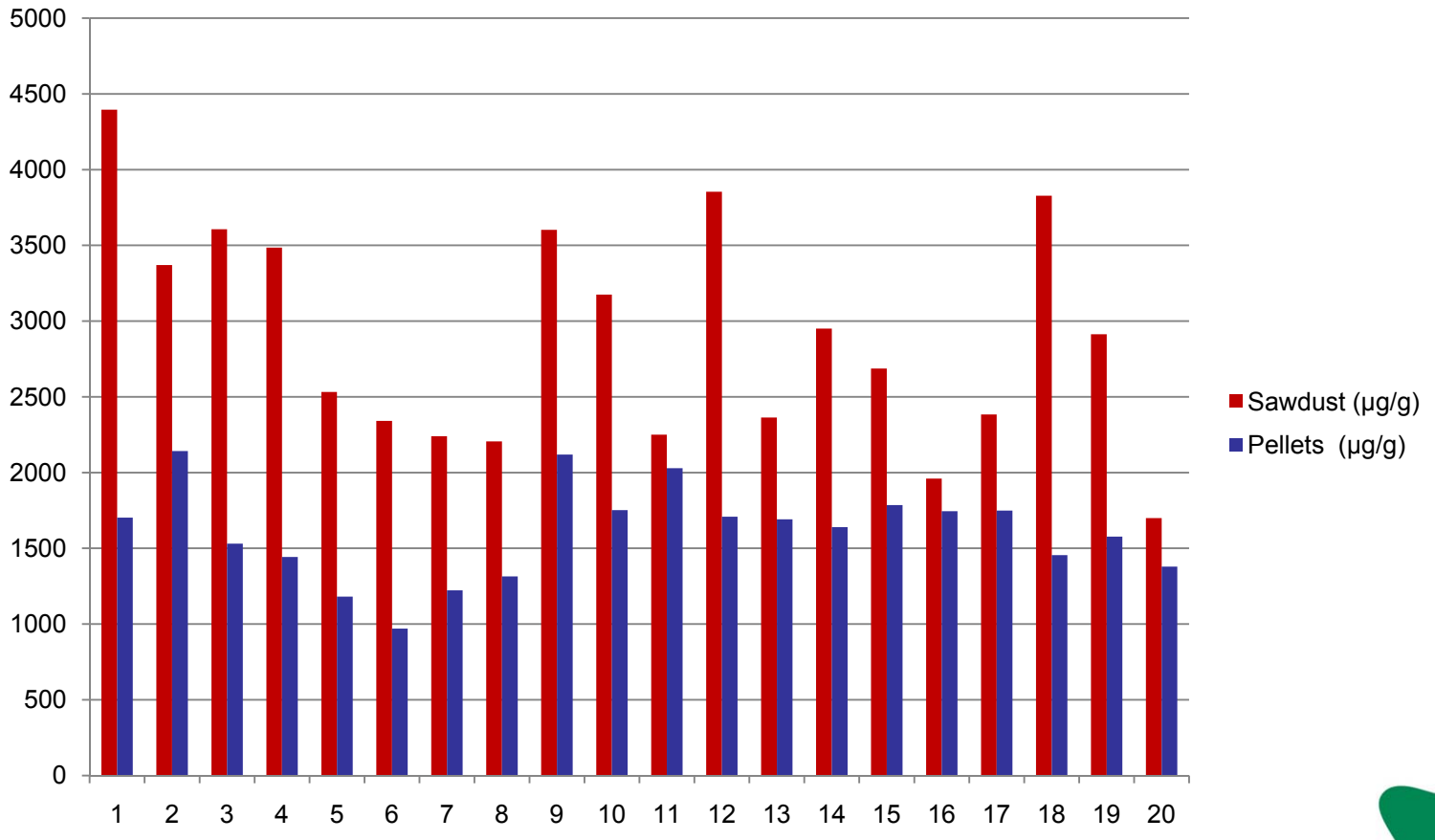
7-Oxodehydroabietic acid

Fatty/resin acids analyses

- Extraction by petroleum ether/acetone
- Gas chromatography separation and mass spectrometry detection

Total fatty/resin acids in sawdust and pellets

µg/g



Sample number

Results

- Wood pellets with low moisture content are hygroscopic,
- Water absorption is an exothermic reaction,
- During heat development volatile organic compounds (VOC) are released from wood pellets,
- Bad smell (health effects) in pellets storage space.

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Experiment with industrial pellets production

- Industrial pellets production and storage in companies.
- Analyses of fatty- and resins and theirs oxidation products (aldehydes).
- Multivariate data analyses.

Method

- Pellets from all of 11 experiment analyzed directly.
- Pellets stored at the factory as 11 different piles indoor.
- Pellets samples collected every week during 4 weeks and analyzed.

11 samples every week	33 fatty/resin acids per sample	17 aldehydes/ketones per sample

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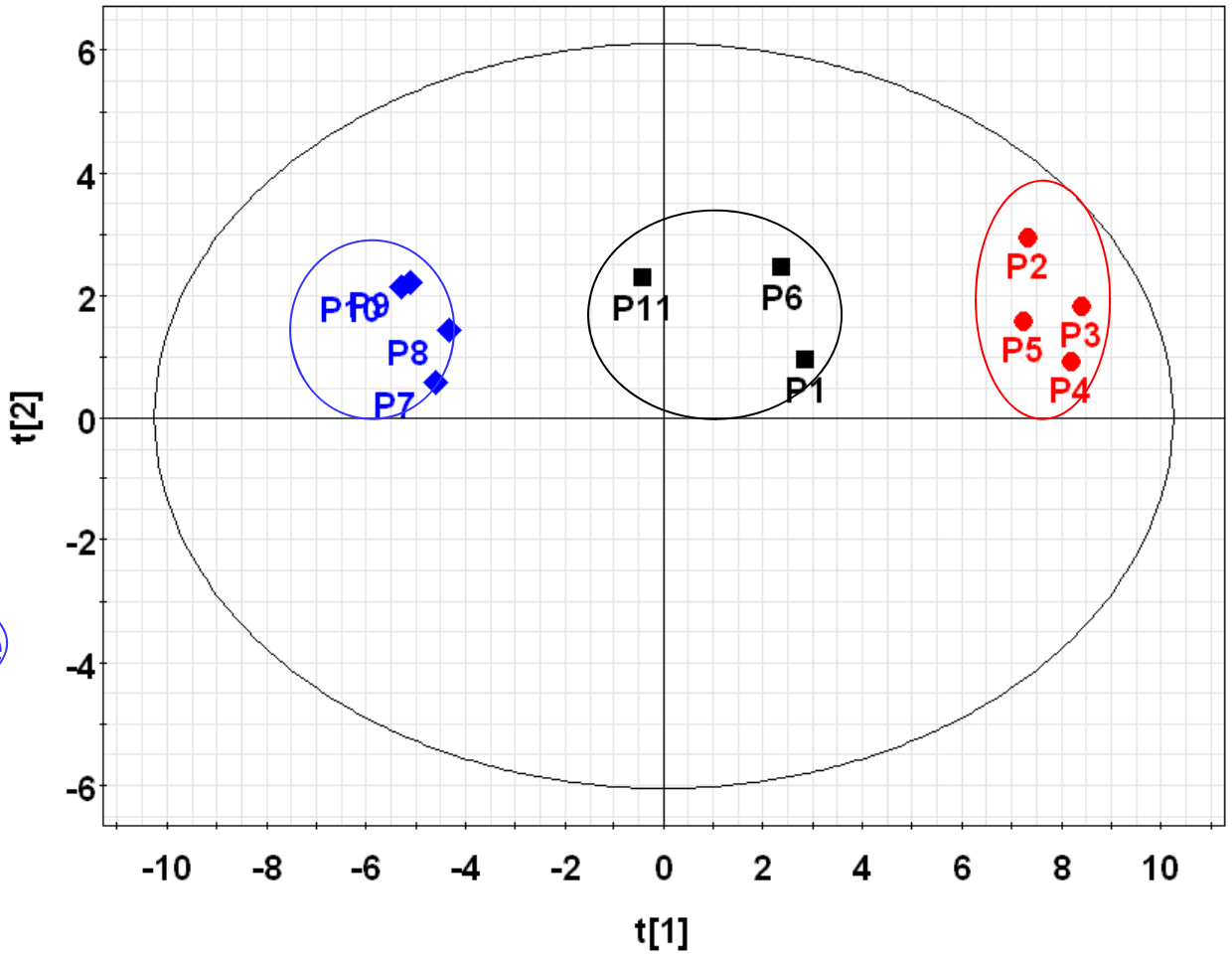
Fatty- & resin acids in newly produced pellets

10% Spruce

55% Spruce

100% Spruce



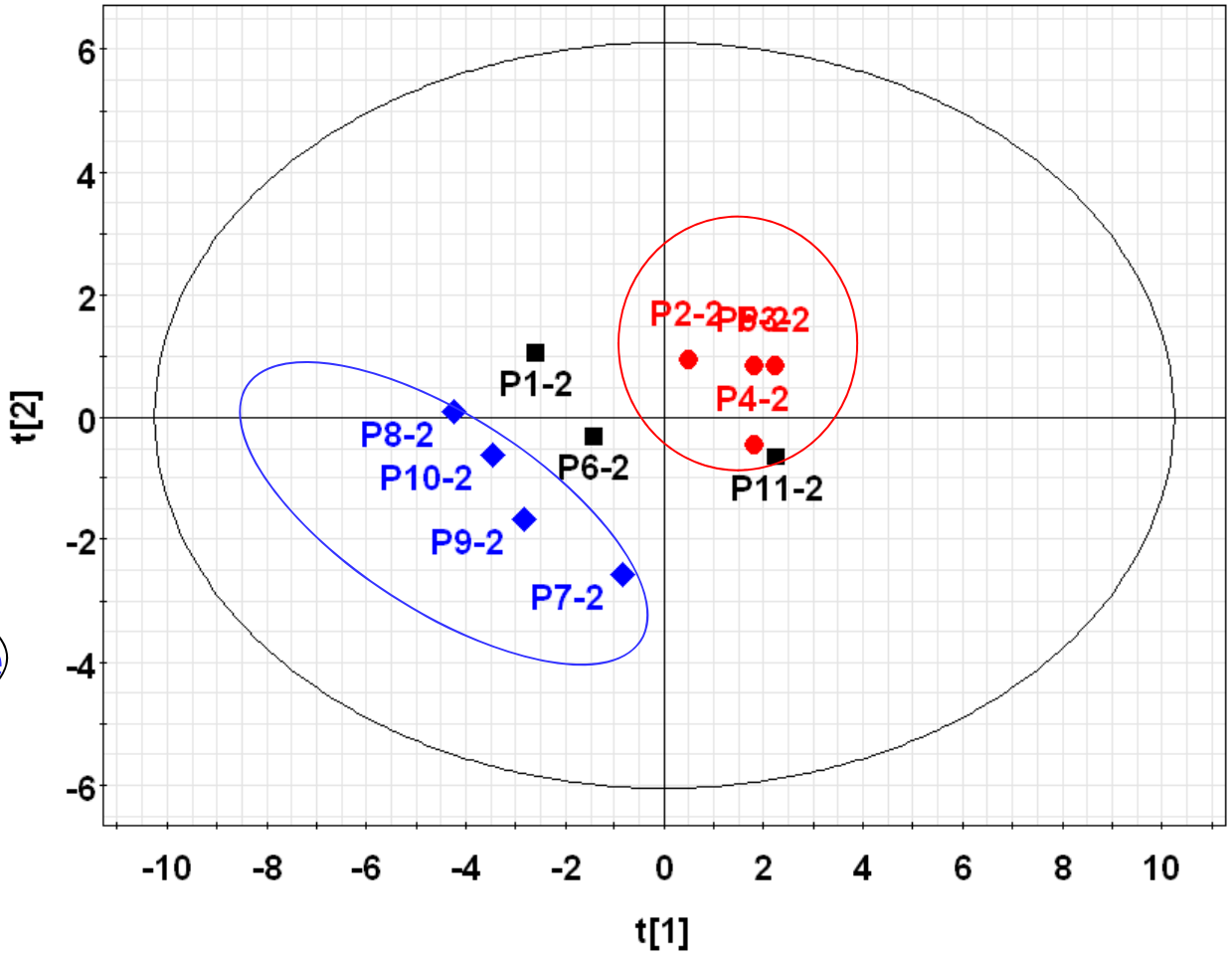
T1= 64%
T2= 14%

Fatty- & resin acids in 2 weeks stored pellets

10% Spruce

55% Spruce

100% Spruce



T1= 45 %
T2 = 19 %

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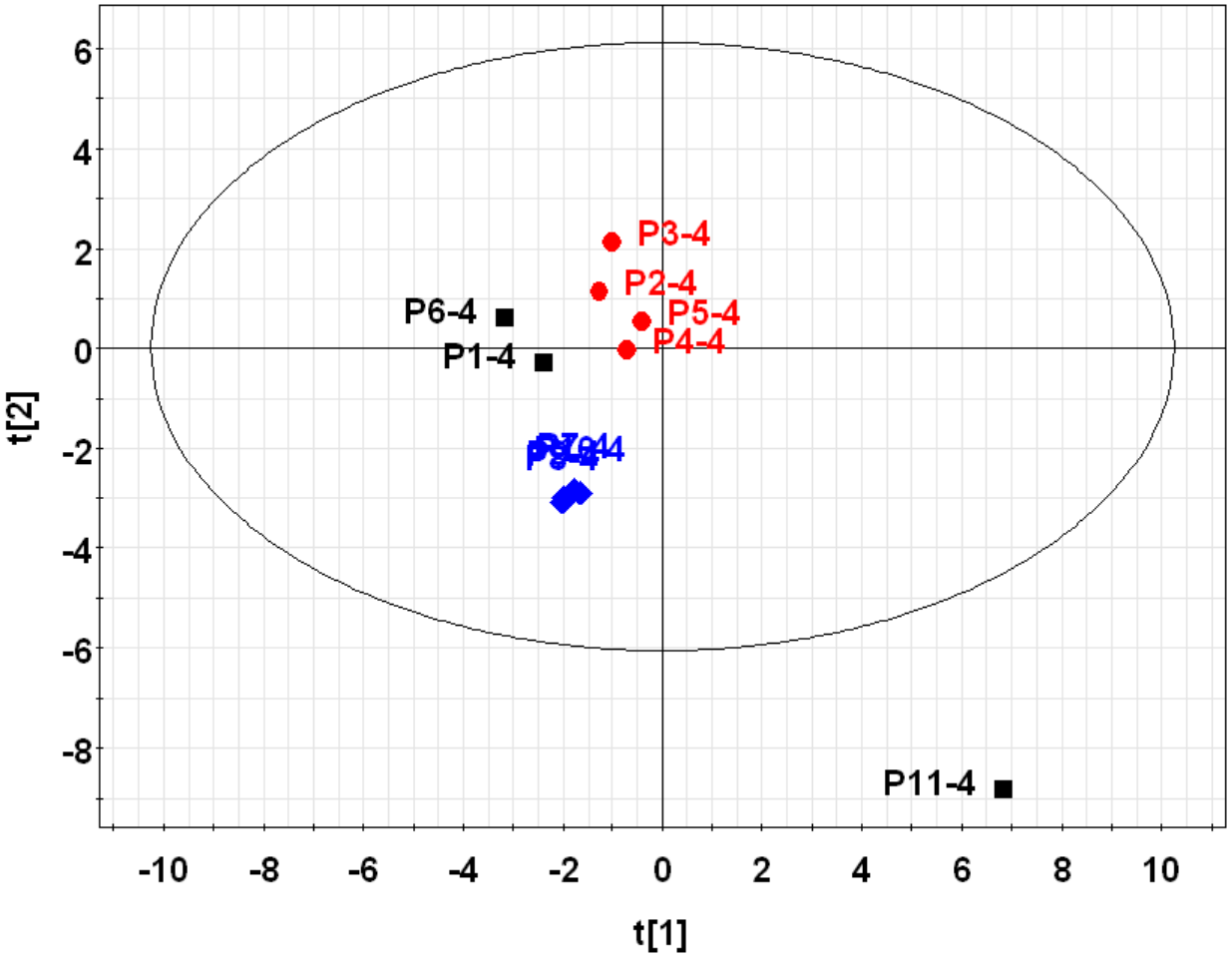
Fatty- & resin acids in 4 weeks stored pellets

10% Spruce

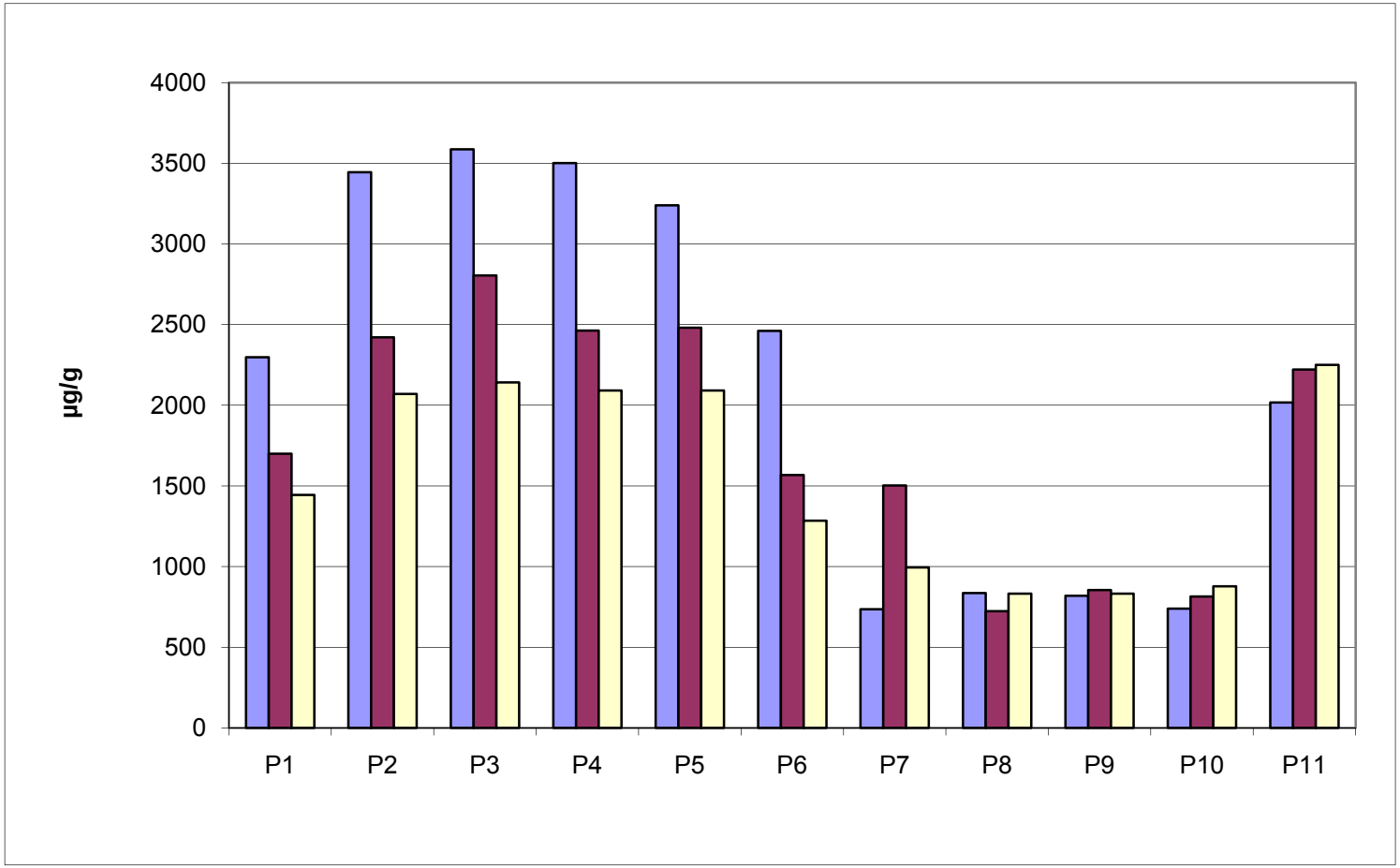
55% Spruce

100% Spruce



T1=49 %
T2= 29 %

Fatty- & resin acids degradation during storage of pellets



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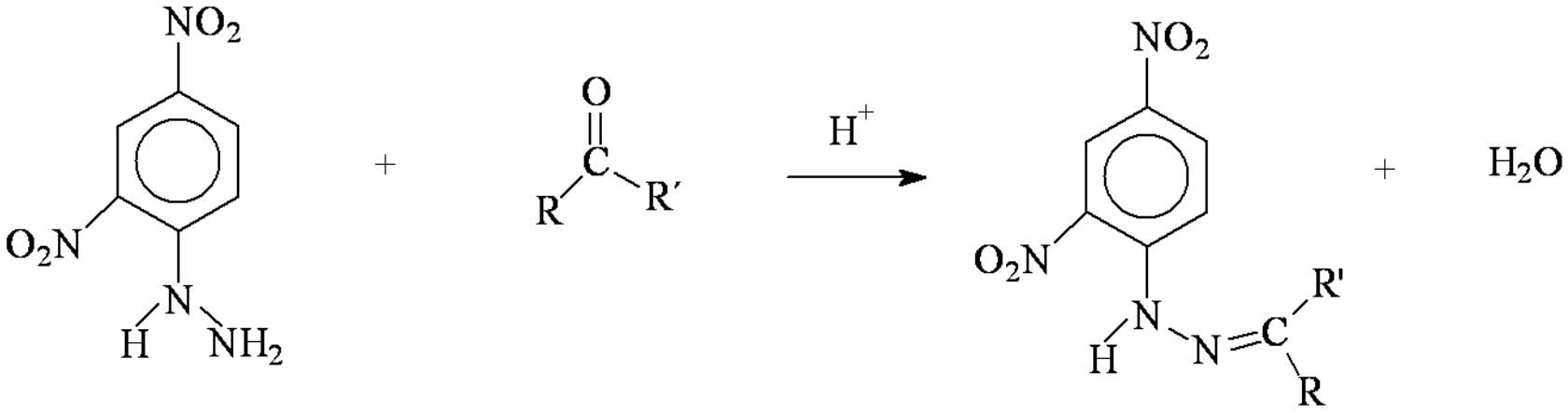
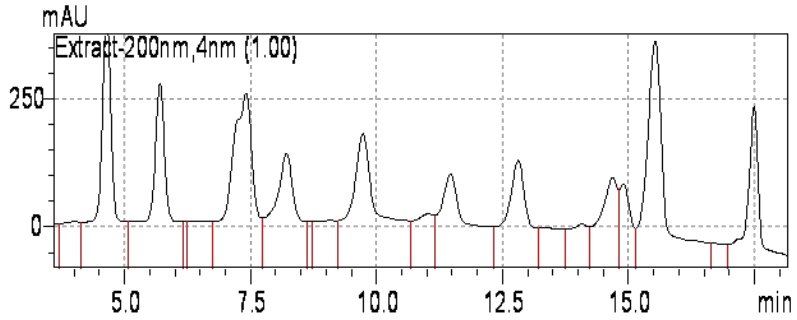
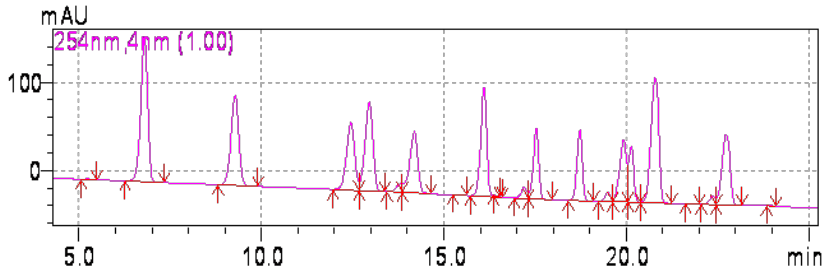
DNPH sampler (absorbing unit)

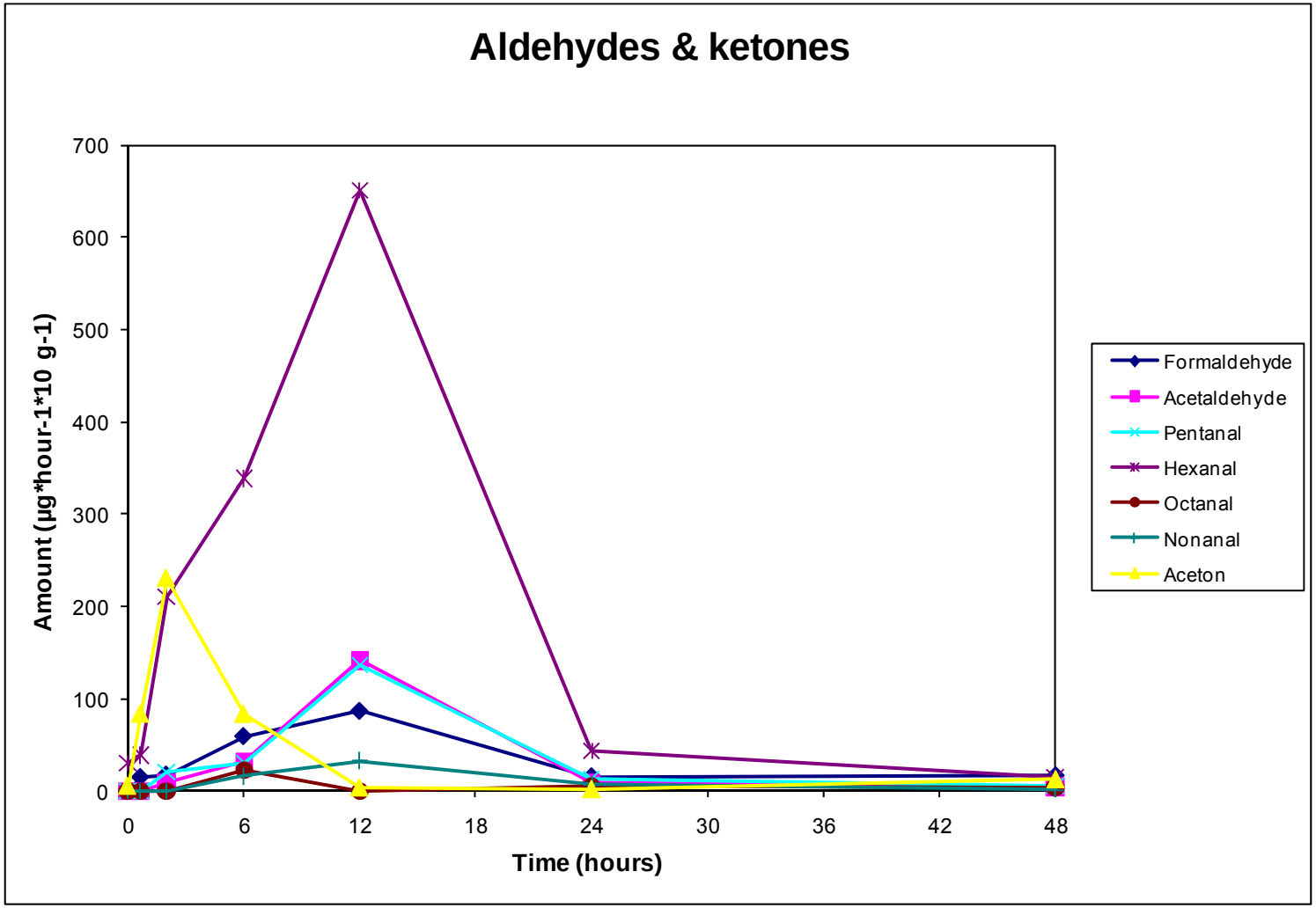


Analyzed by HPLC

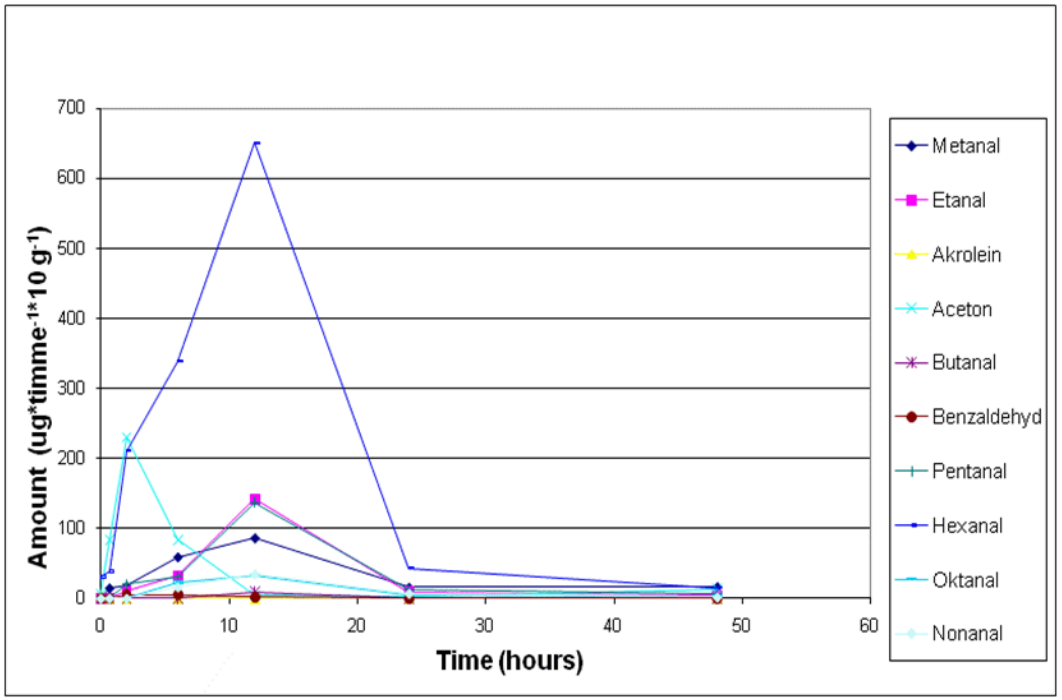


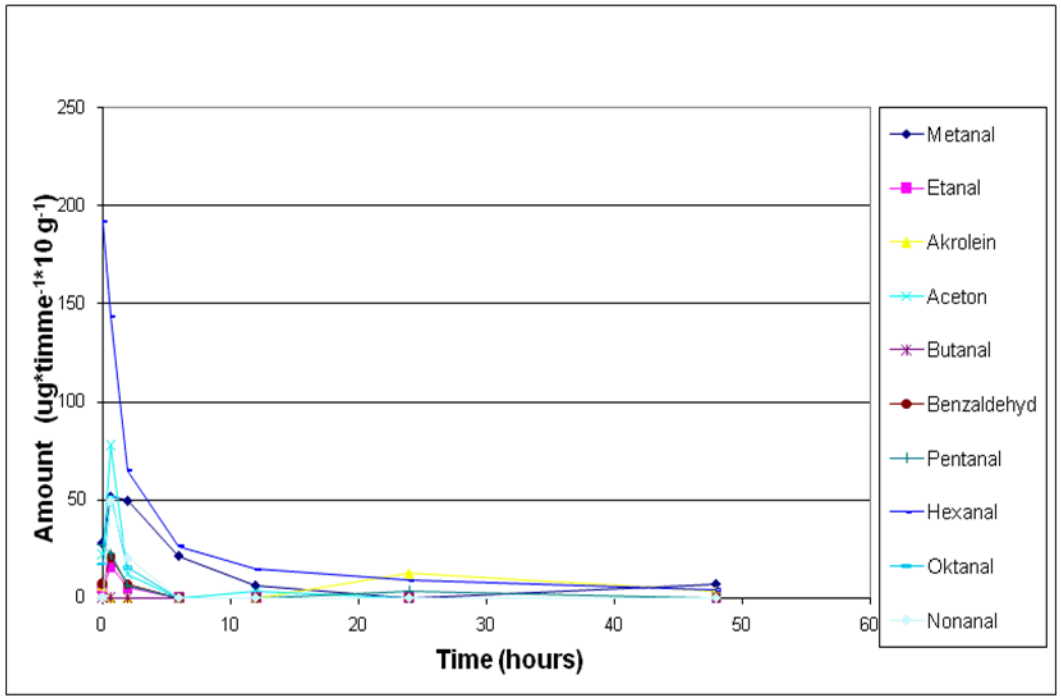


Newly produced pellets



Aldehyde emissions from newly produced and stored pellets (from the same stack)



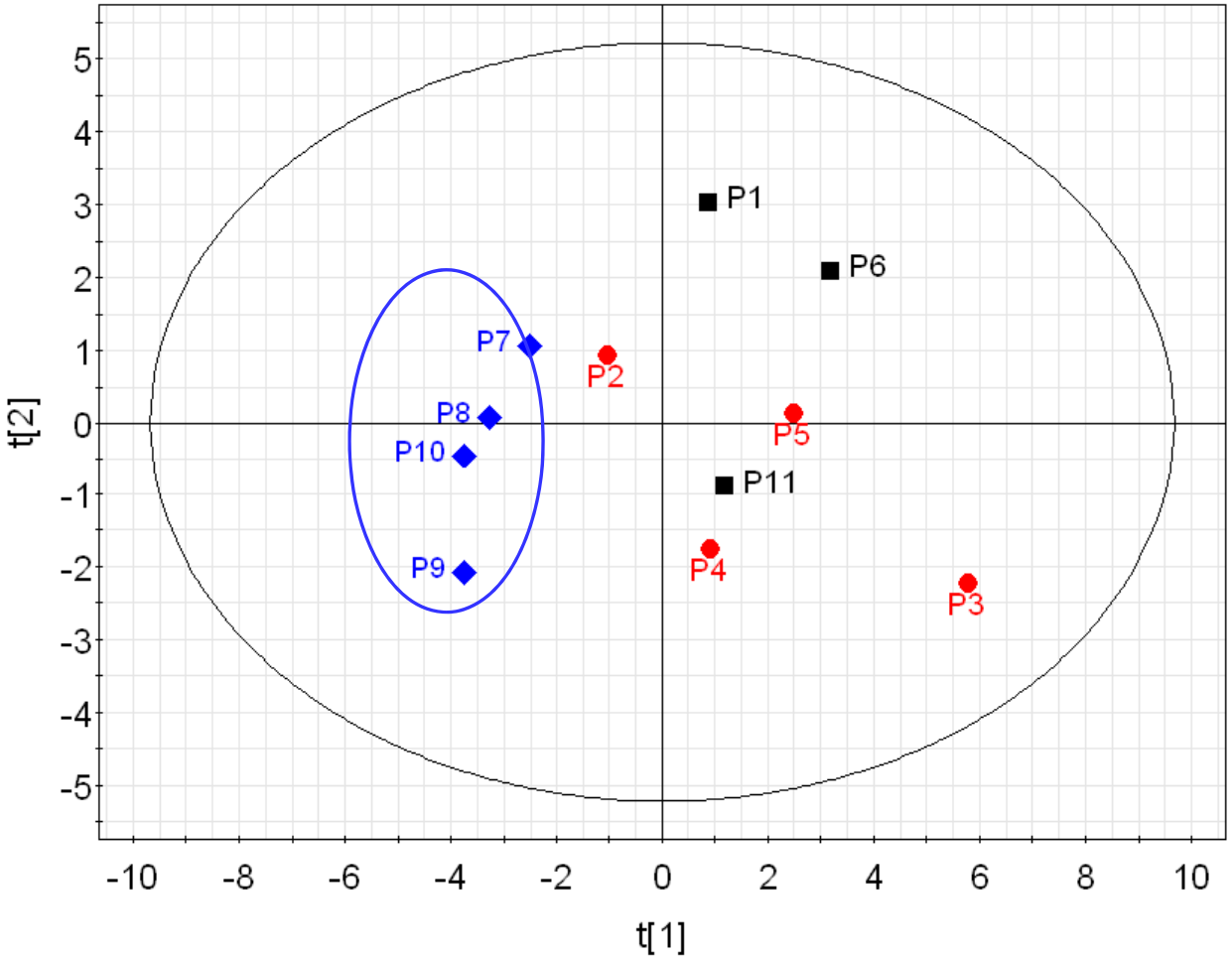


Aldehydes in newly produced pellets

10% Spruce

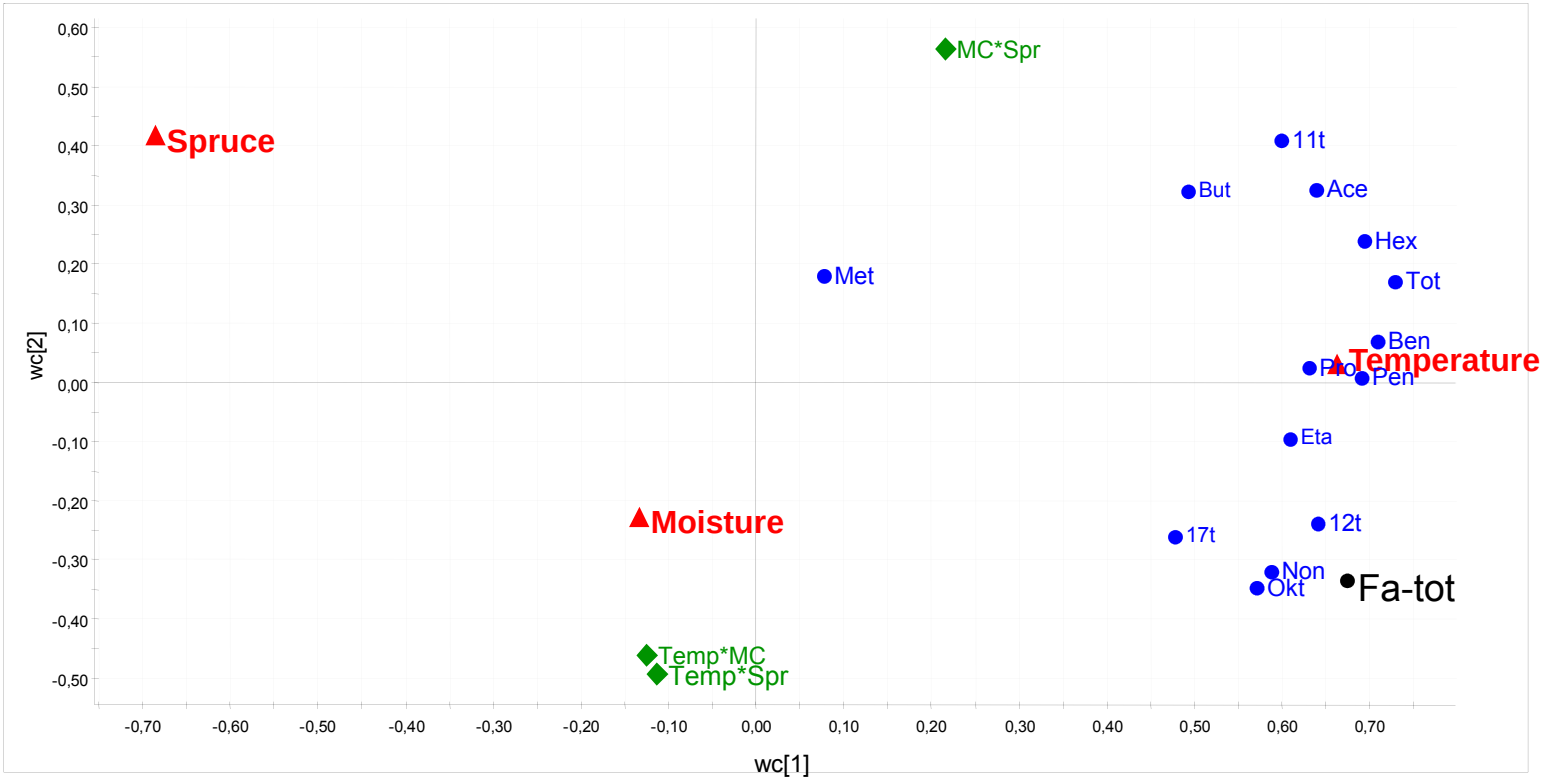
55% Spruce

100% Spruce



t1= 58 %
t2= 17 %

Correlation between process parameters and aldehydes, fatty acids & resins



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Conclusion 1

- Pine contains higher concentration of fatty- and resin acids than spruce.

- Fatty acids can oxidize to aldehydes and carboxylic acids.

- Emission of aldehydes such as formaldehyde and acetaldehyde occur in the pellets stock.

Conclusion 2

- **The amount of fatty and resin acids diminished during storage of pellets.**
- A reduction of concentration of dehydroabietic acid leads to an increase of 7-oxo-dehydroabietic acid.
- **These findings have been used to determine the degree of maturity of pellets and sawdust.**

Practical benefit of the research

The main results from my research (the industrial experimental designs) show that:

It is possible to design the pelletizing process to produce pellets with low emissions of volatile organic compounds.

The results are published in:

- Mehrdad Arshadi, Paul Geladi, Rolf Gref and Pär Fjällström. Emission of volatile aldehydes and ketones from wood pellets. Industrial experimental design for controlling emissions from softwood pellets during storage. *The Annals of Occupational Hygiene*, 2009, 53, 797-805.

- Mehrdad Arshadi, David Nilsson, Paul Geladi, Monitoring chemical changes for stored sawdust from pine and spruce using gas chromatography - mass spectrometry and Visible-NIR- spectroscopy. *Journal of Near Infrared Spectroscopy,2007, 15, 379-386.*

- Mehrdad Arshadi, Rolf Gref, Emission of Volatile Organic Compounds from Softwood Pellets during Storage, *Journal of Forest Products*, 2005, 55, 132-135.

Acknowledgements

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Thank you for your attention !