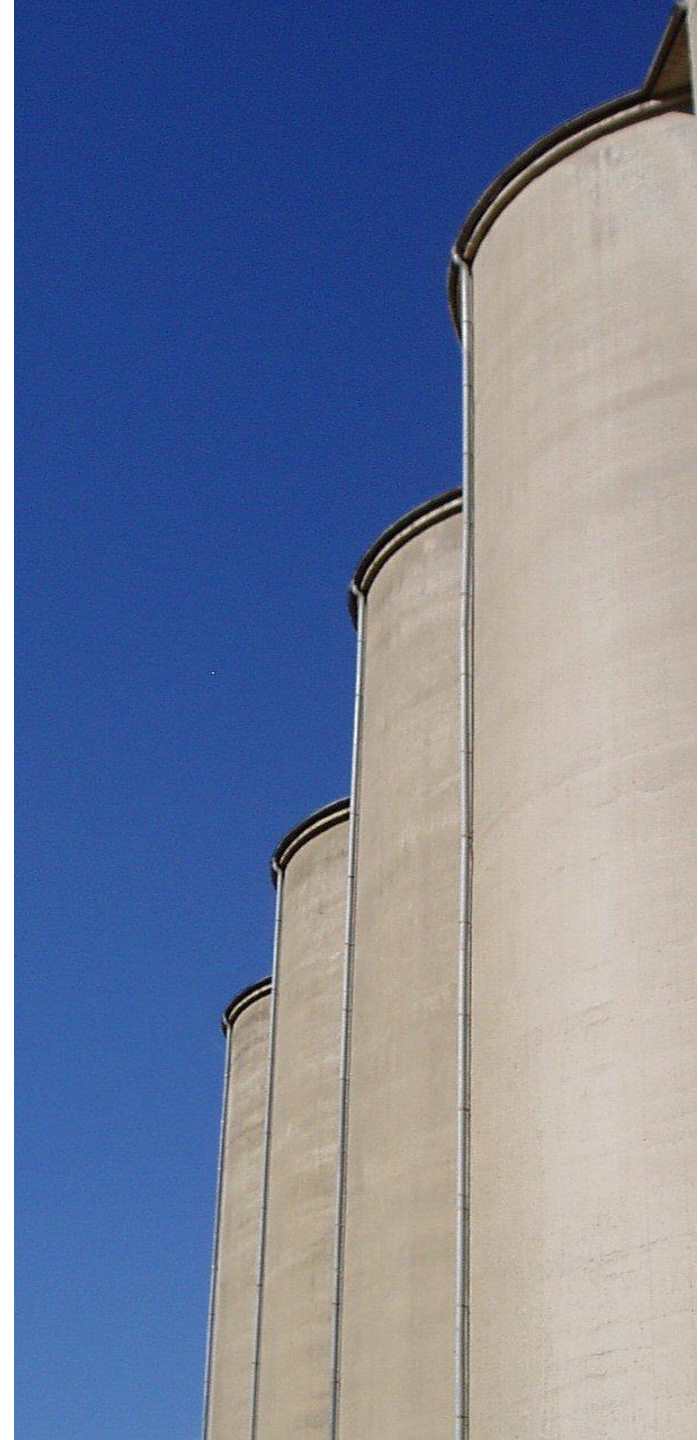


Factors Affecting Self-heating in Biomass During Storage and Transportation

Date: 4 February 2026

Presenter

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The Wolfson Centre for Bulk Solids Handling Technologies,
University of Greenwich



The Wolfson Centre for Bulk Solids Handling Technology

**51
Years**

Providing cost effective solutions to industrial problems.



Activities

Consultancy Projects

- Range of projects: from one-day visits to in-depth work for a few months

Industries

- Minerals
- Petrochemicals
- Metals
- Chemicals
- Polymers
- Blends
- Quarrying
- Cement
- Plastics
- Beverages
- Agriculture
- Recycling
- Power
- Pharmaceuticals
- Energy
- Ceramics

200 mg 80,000 tonnes



Prototype 1 Prototype 2 Final Product

Research

- Aimed at addressing real problems within industry
- Collaboration and partnerships
- Contract Research, Research Supervision, KTPs

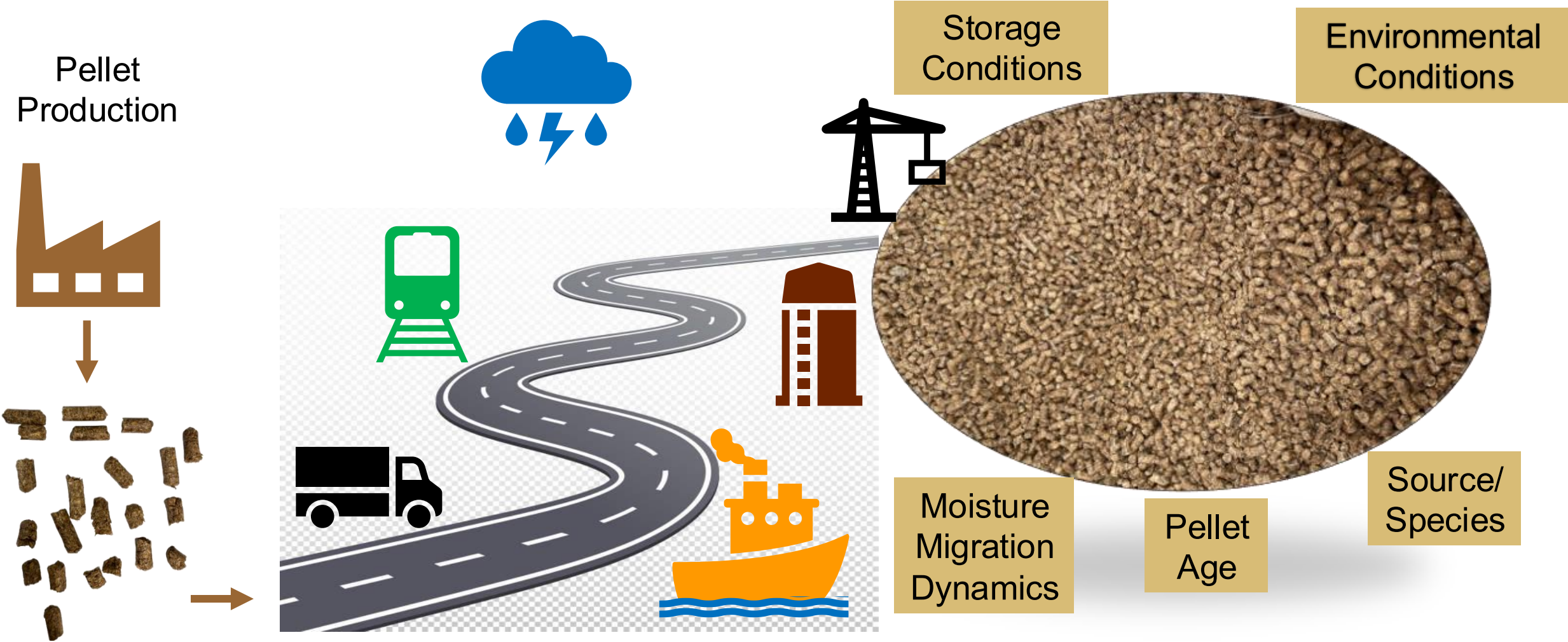


Short Courses and Training

-  In-company and university-based courses
-  Showcasing laboratory facilities
-  Creating opportunities for further collaboration
-  Free webinars to engage wider audience

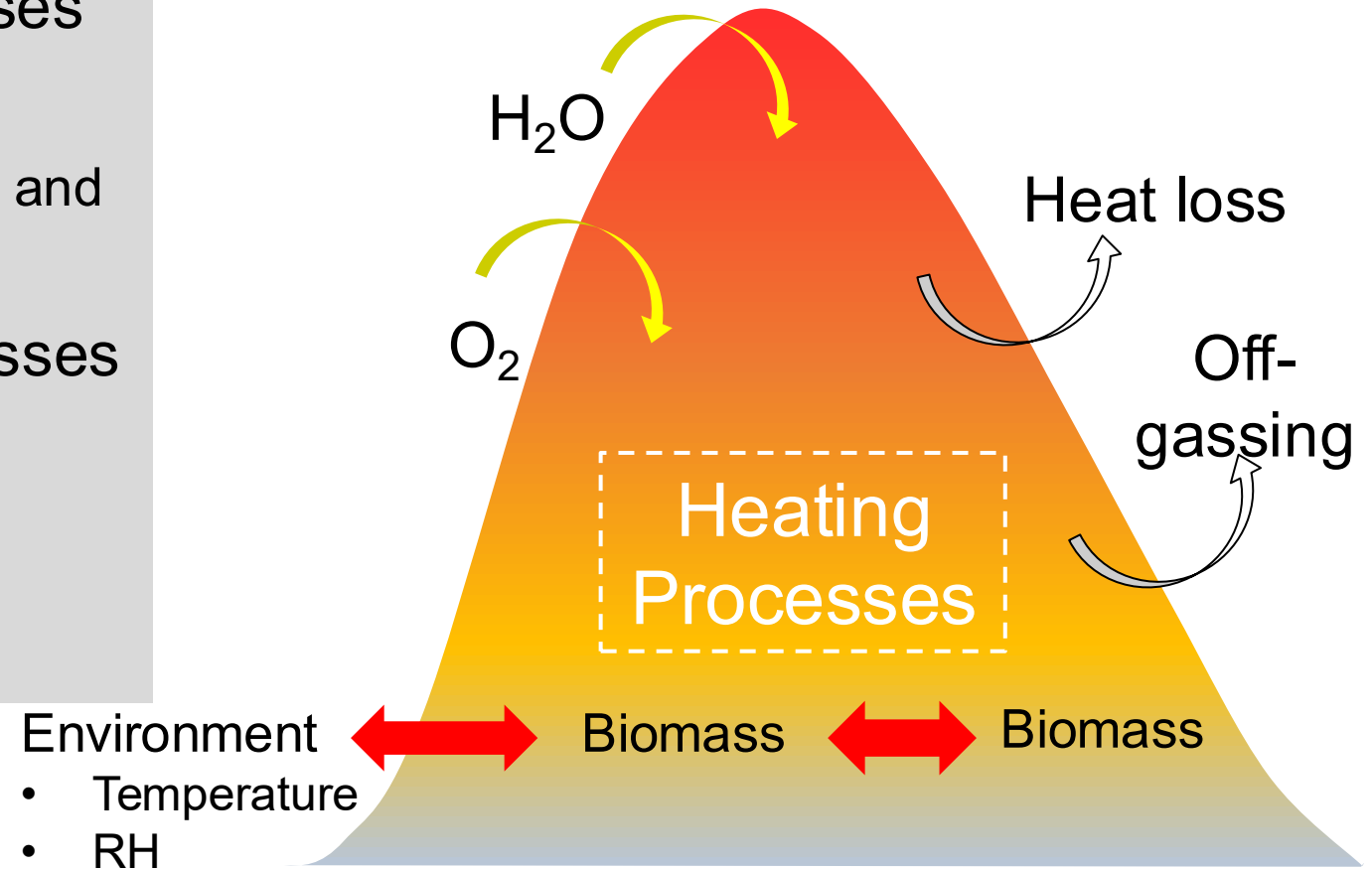


Pellets to Stockpiles: How to Decode Self-Heating?

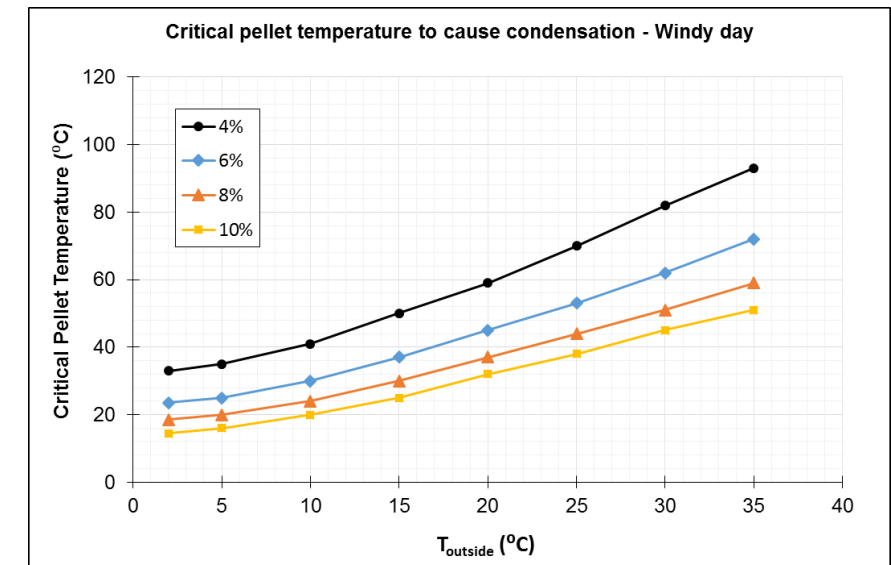
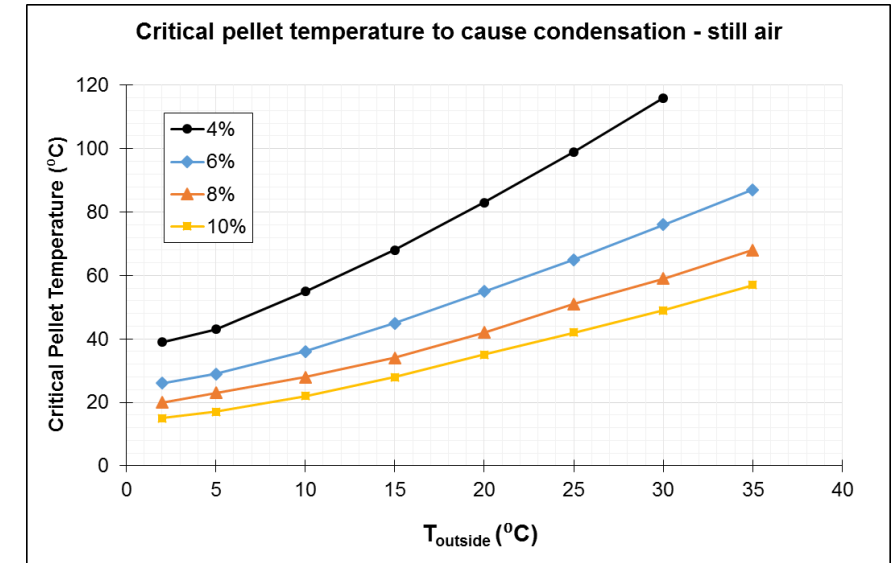
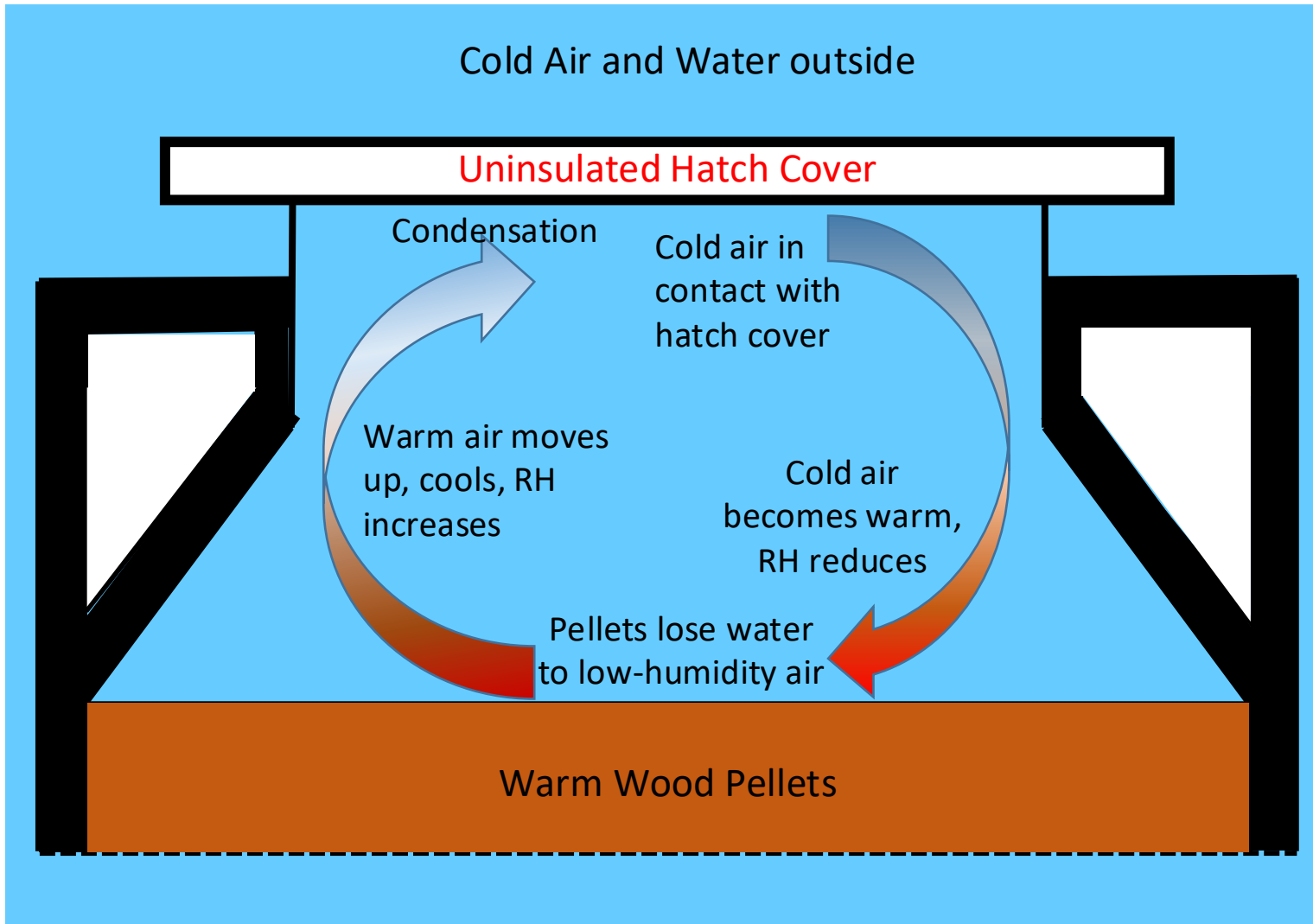


Dynamics in Stored Biomass

- Water associated physical processes
 - Water catalyses chemical reactions
 - Thermophysical properties of material and gases
- Microbiological degradation processes
- Chemical oxidative processes
 - Reaction between O_2 and Terpenes



Condensation Mechanism During Storage & Transport ("Hold sweat" or "silo sweat")



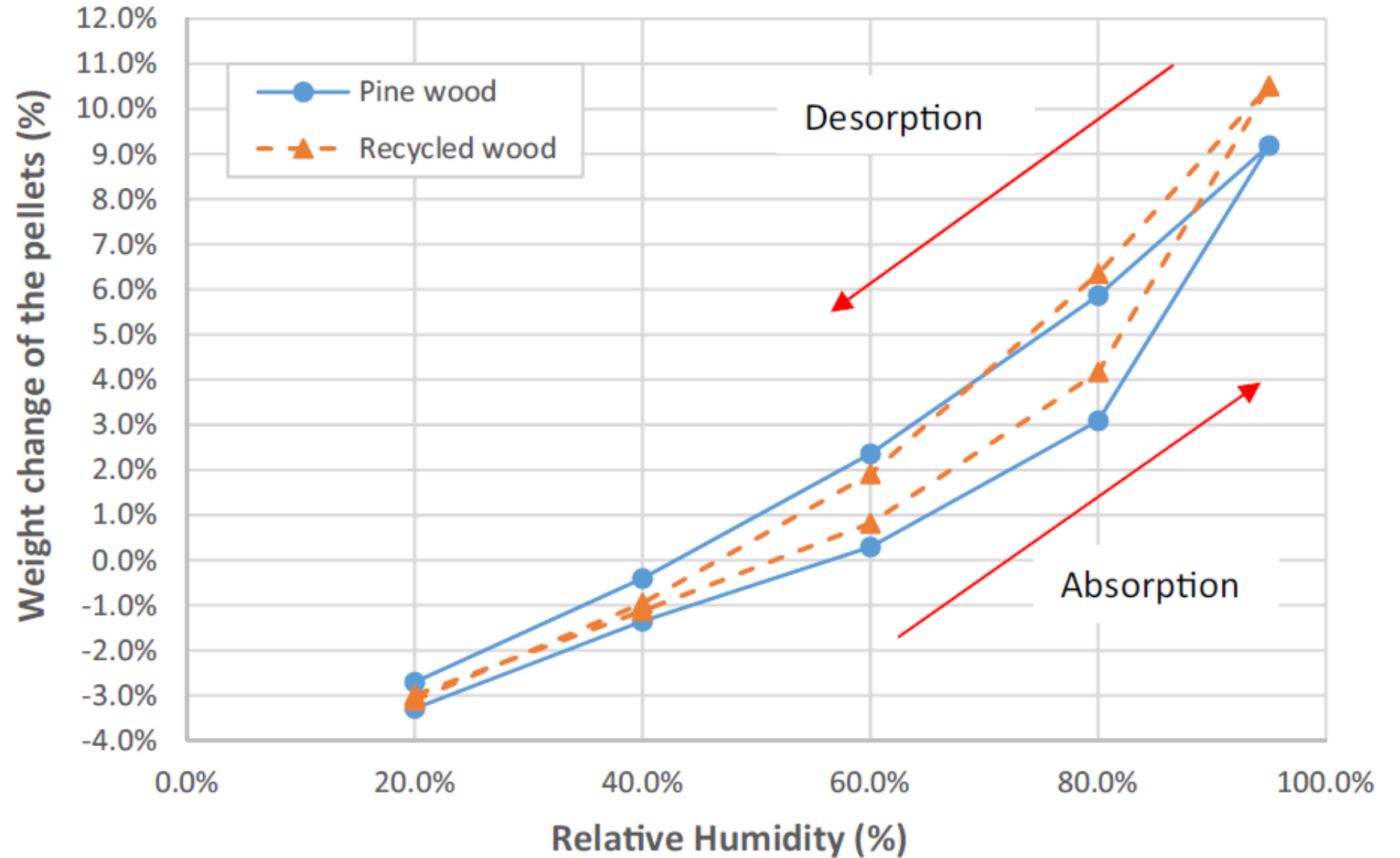
Moisture Migration Dynamics



Fresh wood pellets



Humidity conditioned wood pellets



Pellet Degradation Index

Rotary Impact Tester



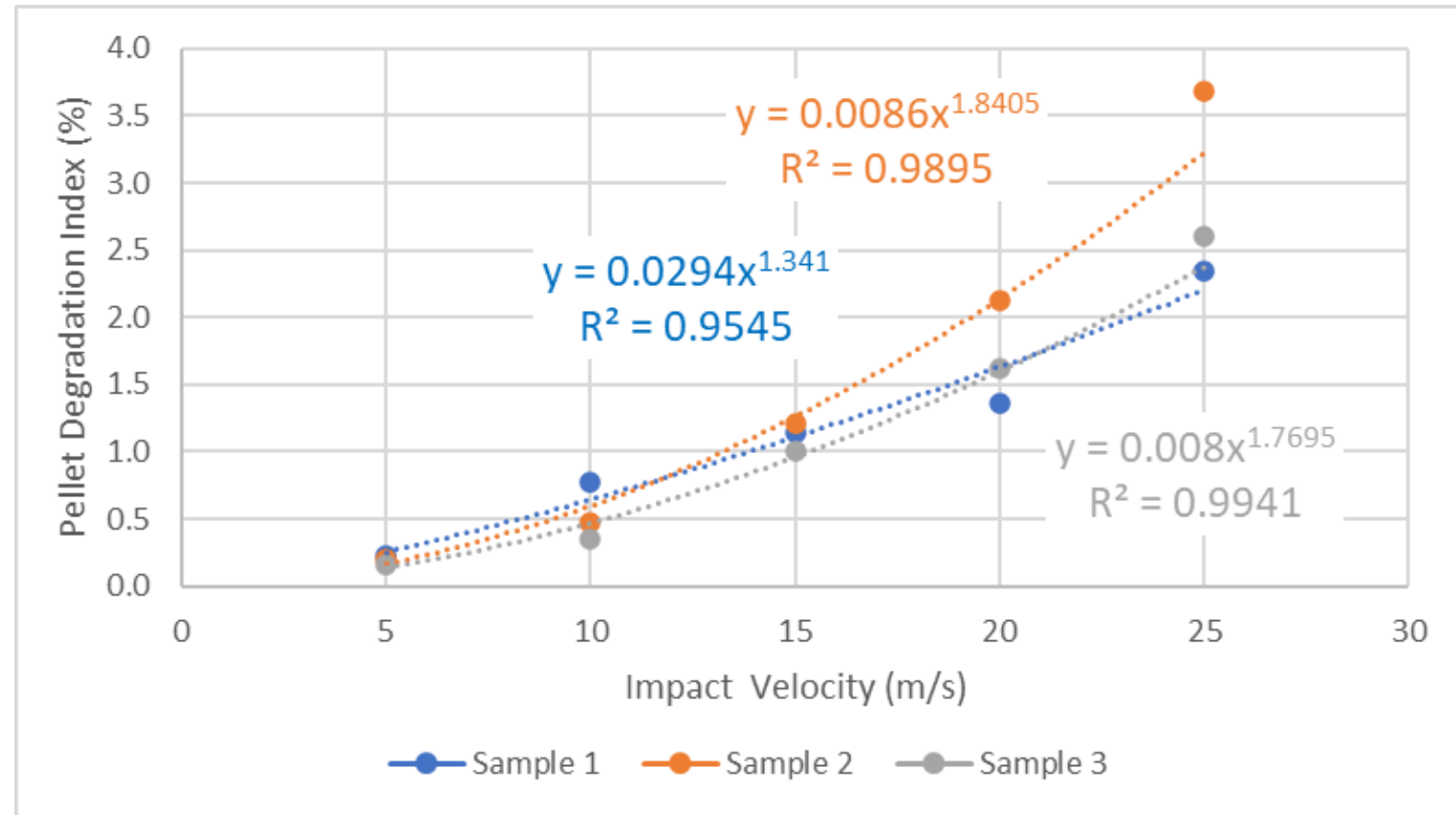
Sample 1



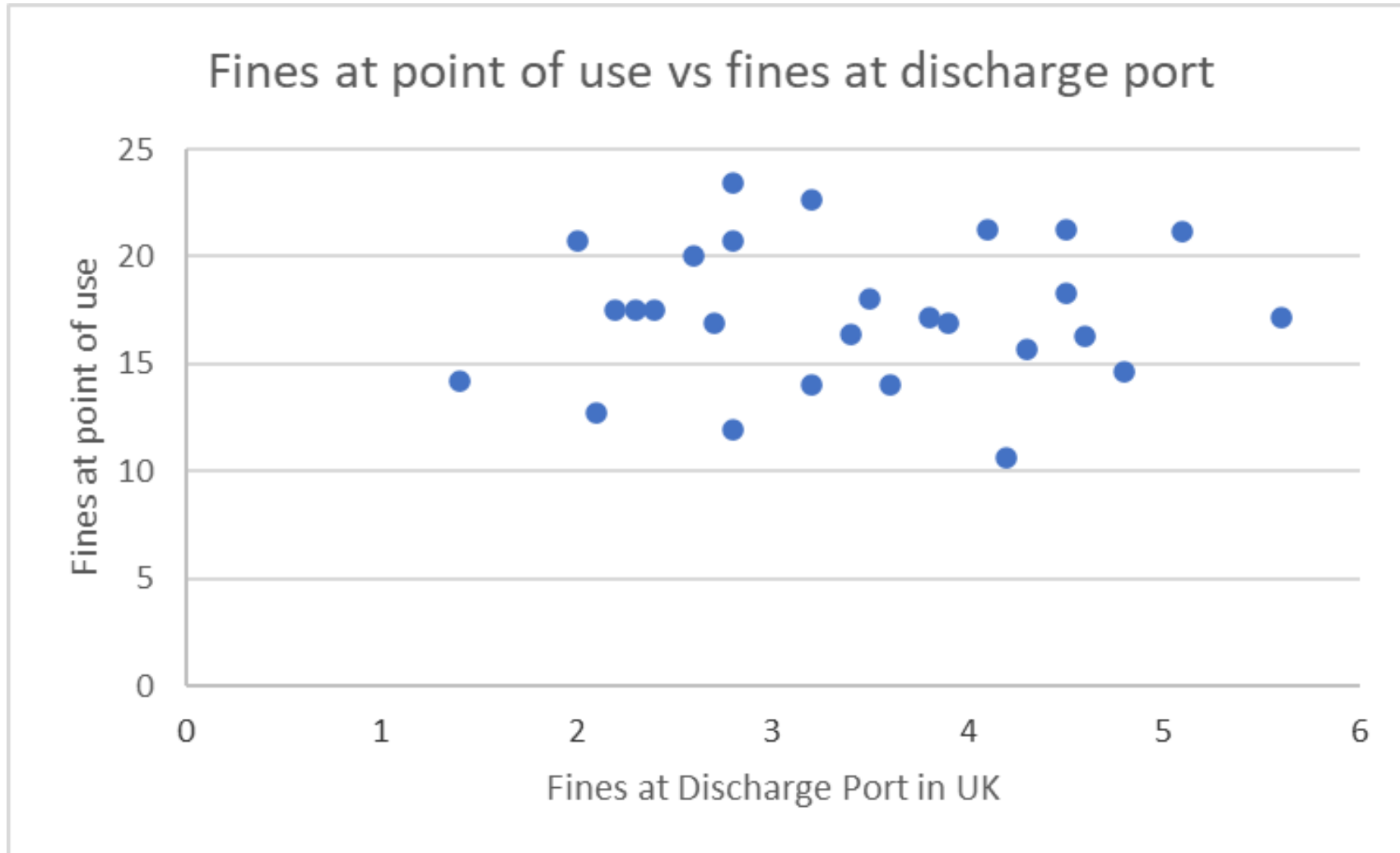
Sample 2



Sample 3



Degradation of Pellets



Segregation

Bench scale
segregation
demonstration



Fines accumulation
in discharge



Actual pellets handling system



Measuring Self-heating Tendency

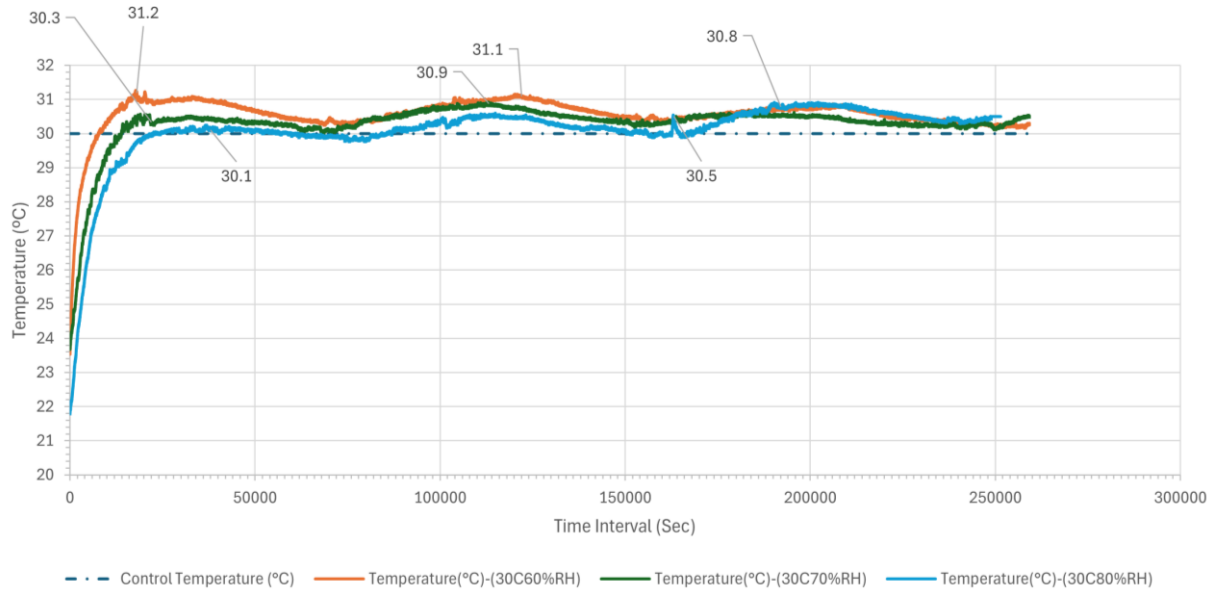
- Moisture Content Analysis
 - Water absorption and condensation due to sudden increase in humidity does cause a sharp rise of pile temperature → Self-ignition
- “Basket Test” for Thermal Stability
 - Established Standard: **BS EN 15188**
- Off-gassing Analysis

Self-Heating Experimental Setup

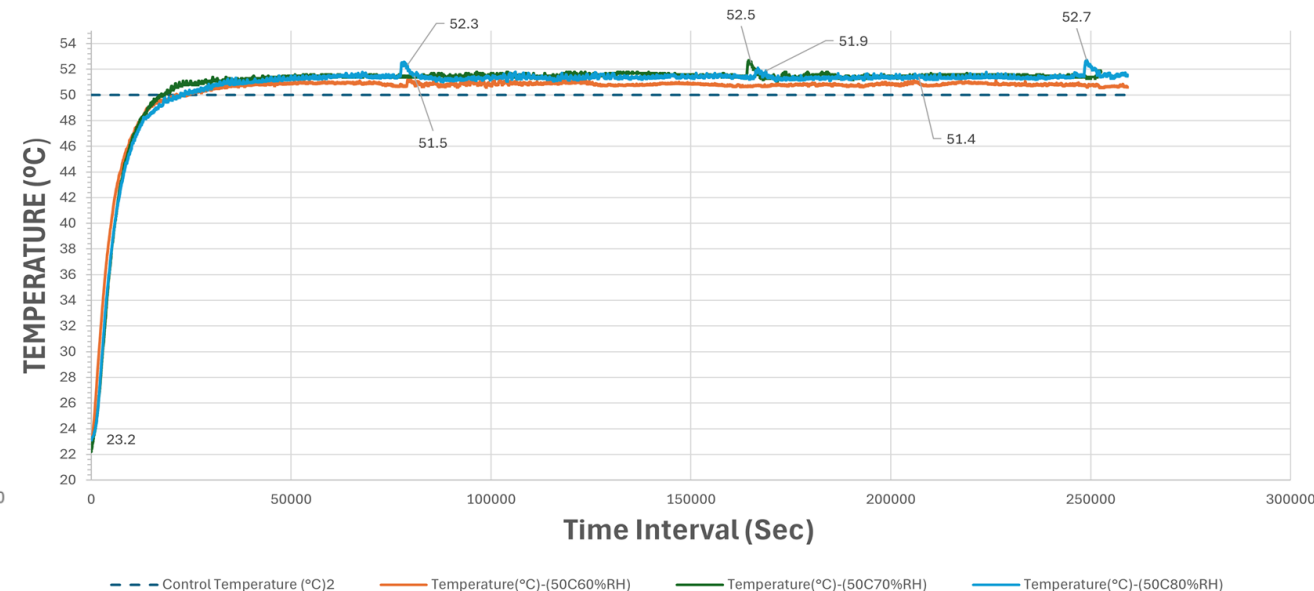
- Environmental Chamber
 - Temperature range -40°C to $+180^{\circ}\text{C}$
 - RH range 5% to 95%
- Pressure Vessel –
 - to contain the gasses & pressure within the vessel
- K-type Thermocouple
 - -75°C to $+250^{\circ}\text{C}$
- Pressure Sensor
- Pump to circulate air
- Gas analyser: O_2 , VOC and CO
- National Instruments CDAQ-9171



Trials with Wood Pellets

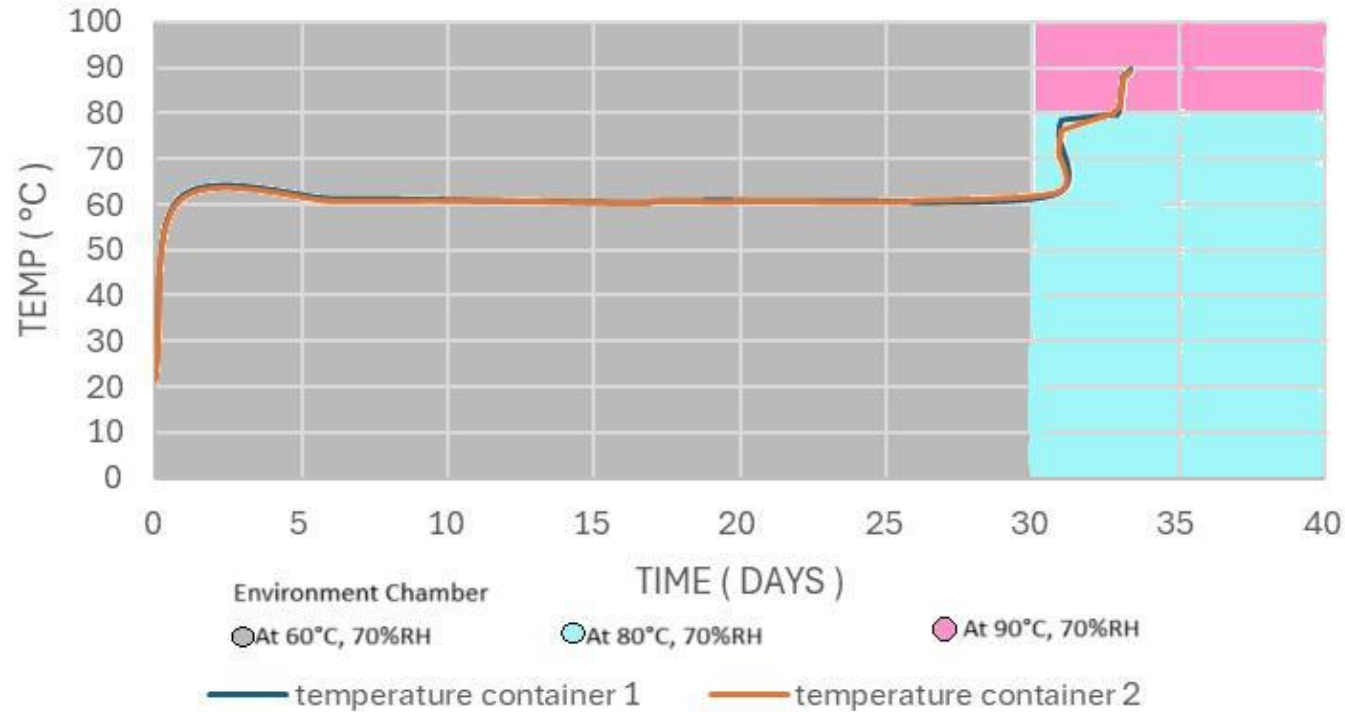


Temperature profile at 30°C and varying RH



Temperature profile at 50°C and varying RH

Trial with Miscanthus Grass



Container 1

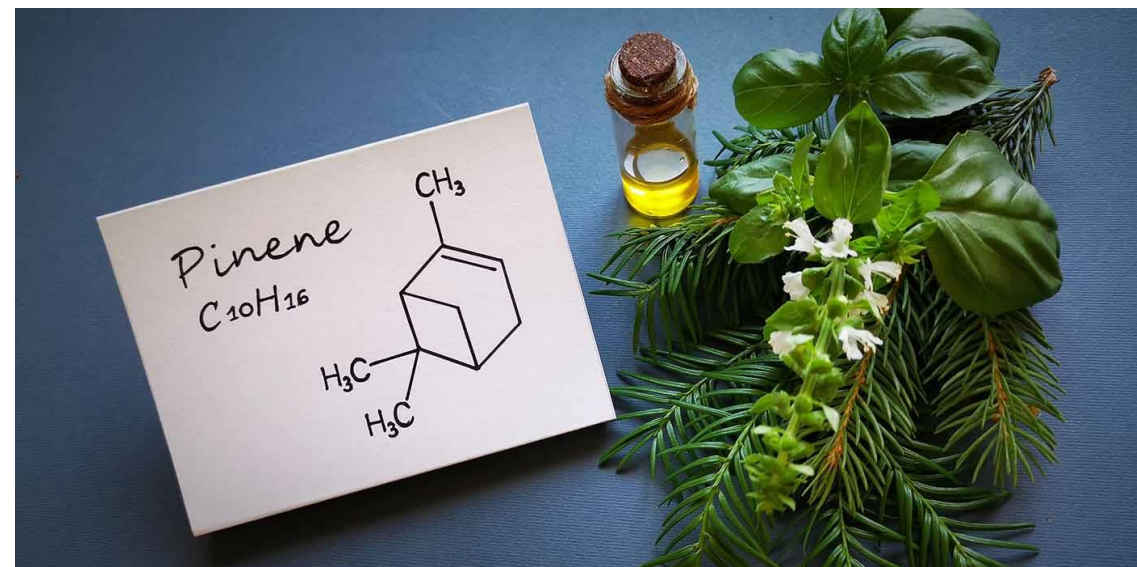
- Moisture Content = 6.15%
- MC-final = 11.38%

Container 2

- Moisture Content = 15%
- MC_final = 17.26%
- Day 34 = smoke

Mechanism of self heating

- Wood pellets have too little moisture to support biogenic heating
- Noted that wood chips do not suffer thermal runaway!
- Suspected mechanism is direct oxidation of terpene, found in conifers
 - Released from cell walls during grinding & pressing
 - Terpenes are known to oxidise in air – exothermically
- Yellow pine has higher content
 - Correlates with stronger self-heating
 - Monoterpenes (C₁₀H₁₆)
 - Sesquiterpenes (C₁₅H₂₄)
 - Diterpenes (C₂₀H₃₂)



Ventilation of wood pellets in store

- Freshly made wood pellets are stored for a number of days after manufacture
- Air is blown upwards through the pellets prior to shipping by rail to the port
- The ventilation significantly reduces self-heating during the rail journey of several days
- But no self-heating in the store



How does ventilation reduce subsequent self-heating?

Our current hypothesis:

Without ventilation

- Terpene on surface of pellets evaporates into fresh interstitial air
- Equilibrium partial pressure of terpene reached in interstitial air
- No more evaporation
- Terpene stays on pellet surface and oxidises, creating heat
- Reservoir of terpene remains inside pellets
- Increasing temperature increases rate of reaction

With ventilation

- Terpene on surface of pellets evaporates into interstitial air
- Refresh of interstitial air keeps partial pressure of terpene low
- Evaporation from surface continues, keeping surface concentration low
- Concentration difference in pellet drives terpene to surface, where it evaporates
- Low surface concentration gives low rate of oxidation – minimising heating
- This process removes terpene from the pellets
- So self-heating in subsequent (non-ventilated) storage is reduced

Should ventilation be used in long term storage of pellets?

- Question to be explored

Mathematical Modelling and Predictions

- Multi-Physics model to consider the interaction
 - Heat transfer
 - Mass transfer
 - Reactions
- “What-if” scenarios to test the effect of different parameters
- “Digital Twin” approach based on real-time monitoring of data:
 - Manage wood pellet handling
 - Predict likely problems
 - Advise on avoiding developing risks from escalating.

What Next?

- Explore the combined effect of temperature and RH on self-heating tendencies for variety of bulk materials
- Establish a set procedure for experimental measurements
 - Suitable for on-site implementation
 - Using a simplified tools
 - Quick and easy
- Develop a mathematical approach to compliment the experimental measurements.

Summary

- Factors affecting Self-heating:
 - Storage conditions
 - Wood species
 - Environmental conditions – temperature and relative humidity cycling
 - Fines generation (pellet degradation during transport and handling)
 - Segregation
 - Moisture
- Pellet degradation
 - Impact velocity
 - Pellet properties
 - Impact conditions
- Segregation of fines during handling and transportation may lead to concentrated pockets of dust → increases self-heating tendencies in wood pellets!

Acknowledgements

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THANKS

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