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Storage of Wood Pellets (self-heating)

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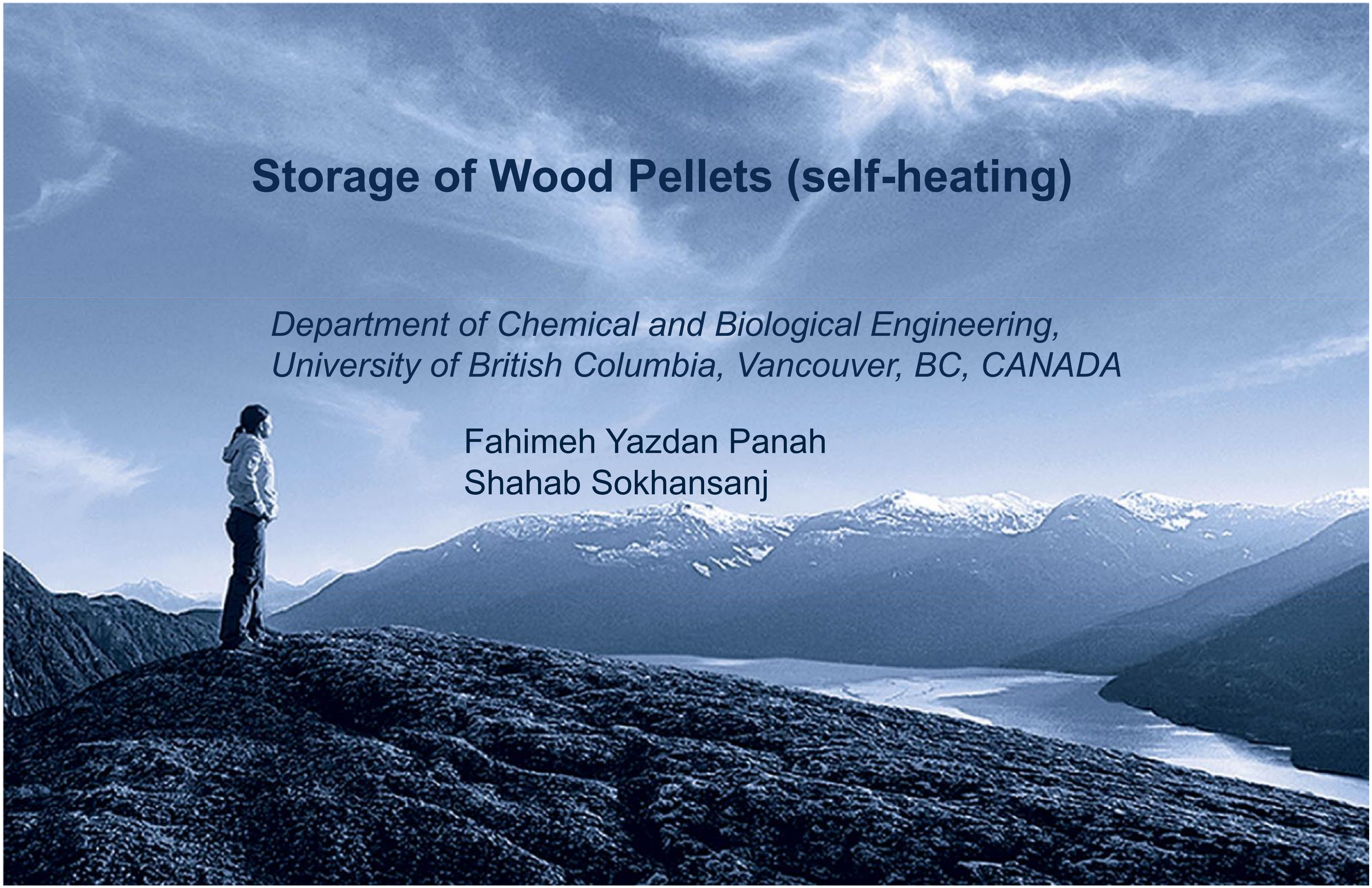


Self-heating and thermal runaway

Thermal runaway

Smoldering combustion

Chemical degradation

Chemical oxidation

Pyrolysis

Hydrolysis

Biological degradation

Metabolism and biological oxidation

Factors that influence self-heat are:

- Oxygen concentration in the bulk
- Moistening of bulk
- Relative humidity

Aggravating factors are:

- Pellet temperature and moisture content.
- Conduction and convection of heat and moisture in the pile.
- Physical properties (broken pellets and dust).

Self-heating studies and approaches

To quantify and predict self-heating process, runaway condition and spontaneous combustion of wood pellet during storage.

Previous Studies

Measurement of thermal properties.

- Thermal conductivity
- Specific heat capacity

Investigation of the thermal runaway .

- Self-heating kinetics
- Thermal runaway critical condition

Theoretical model

- 2 Phase heat /mass transfer
- 2D axis symmetric model

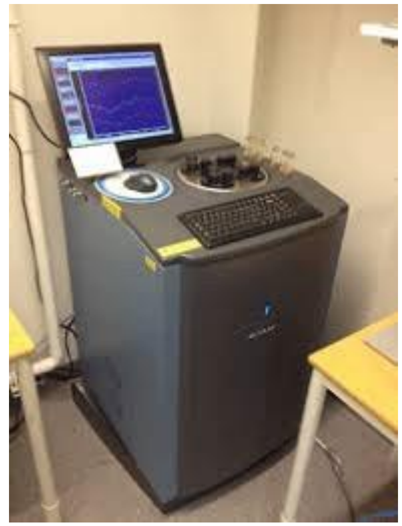
Current Studies

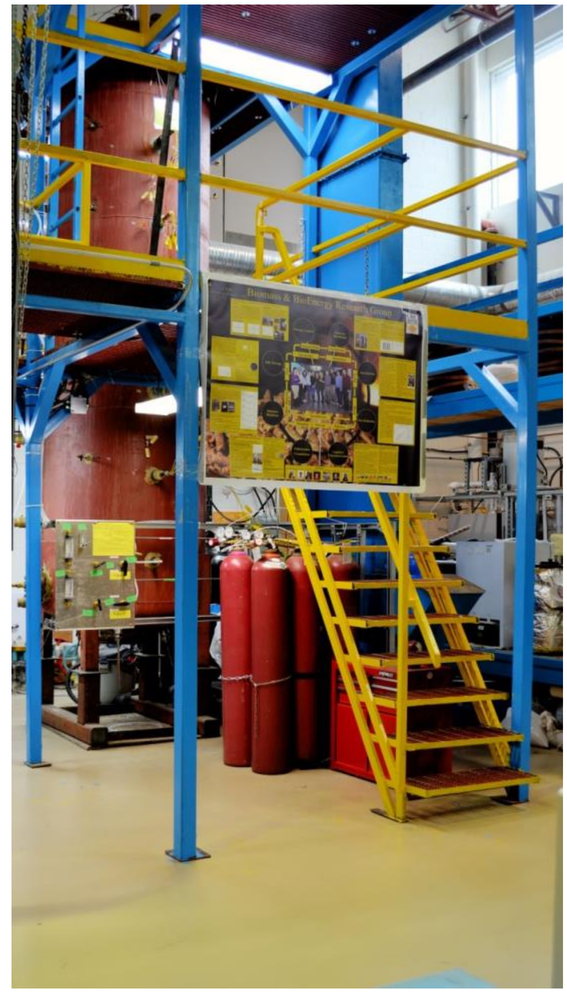
Measurement of self-heating using Calorimetry.

- Moisture content effect
- Age effect
- Feedstock effect
- Humidity, temperature

effect ○ Particle size effect ○
Storage time effect

Storage Studies Facilities at UBC



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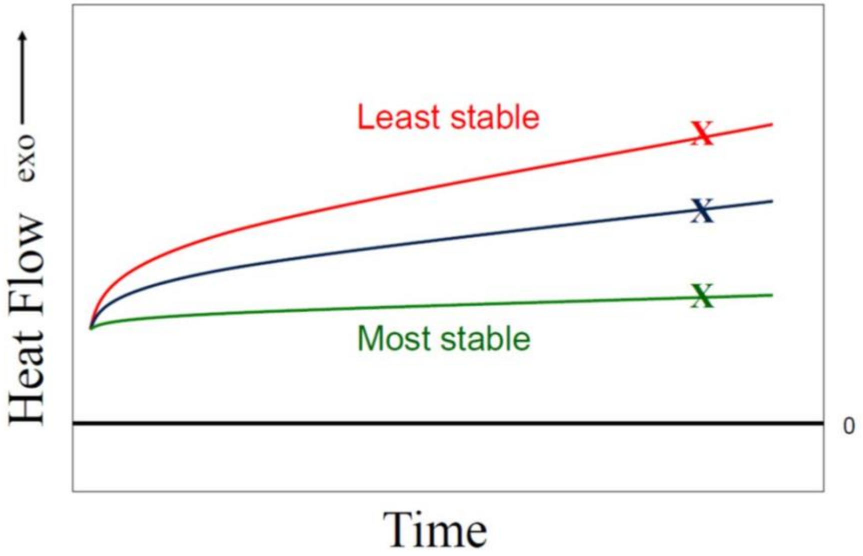
Measurement of self-heating using Isothermal Calorimetry

- Self heating tests at 25/40/60°C

Pellets + $O_2 \rightarrow CO_2 + CO + CH_4$ + q mW



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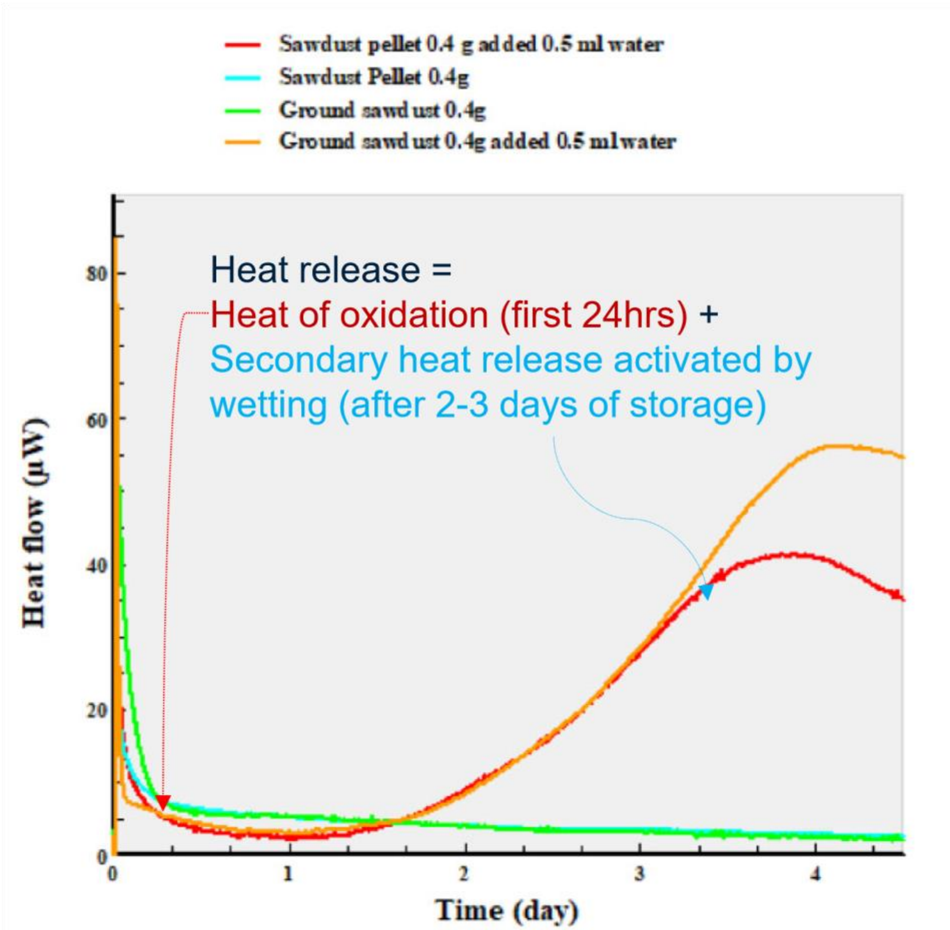
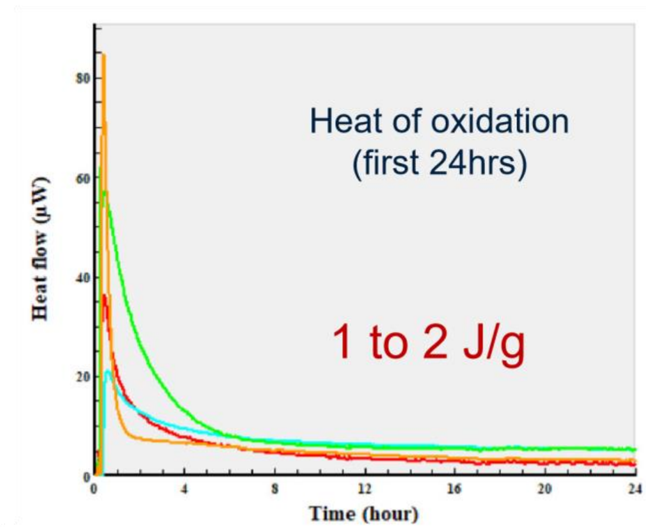
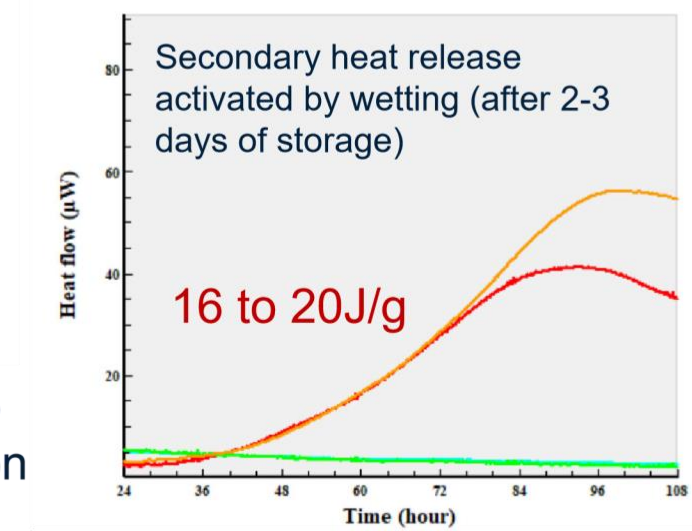
Calorimetry is sensitive to all physical and chemical processes associated with a heat flow. Thus, the monitored heat flow may contain contributions from several processes.

Isothermal Calorimetry- Effect of Moisture

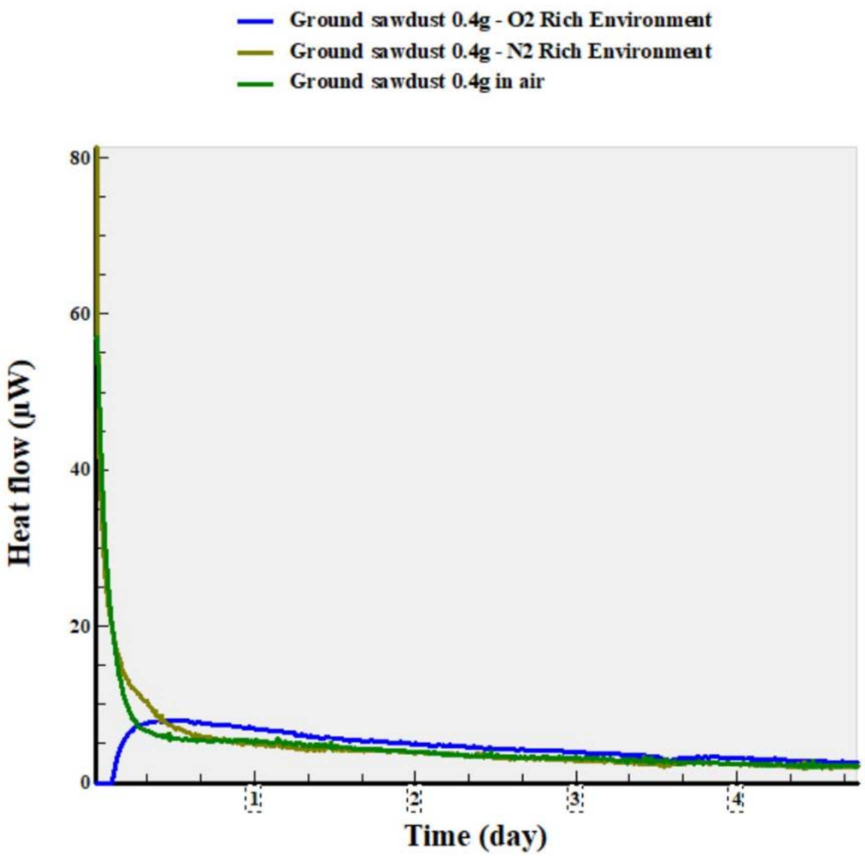


Heat released from ground sawdust over 5 day of storage in air with and without addition of moisture





Isothermal Calorimetry- Effect of Oxygen

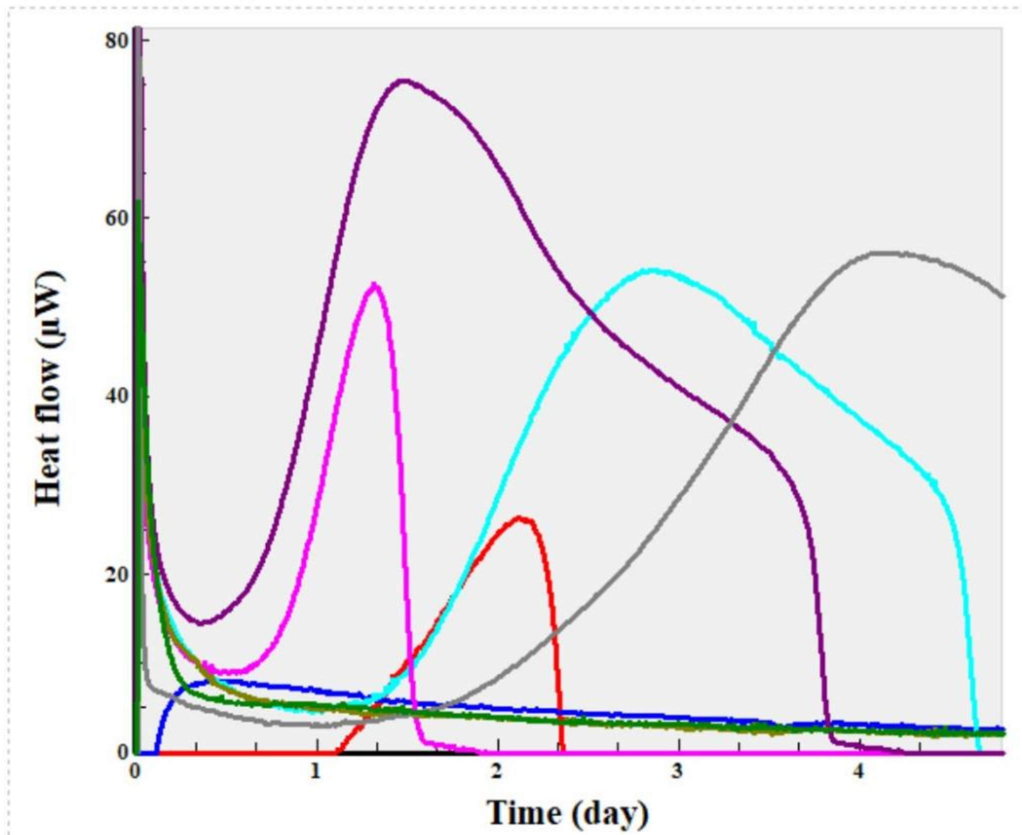


Effect of O_2 on heat release is minimal if not accompanied by wetting (moisture/humidity)

Heat released from ground sawdust over 5 day of storage in air, oxygen rich and nitrogen rich environment

Isothermal Calorimetry- Effect of Oxygen accompanied by wetting

- Ground sawdust 0.4g purged with N2 added 0.5 ml water
- Ground sawdust 0.4g purged with O2
- Ground sawdust 0.4g purged with O2 added 1 ml water
- Ground sawdust 0.4g purged with N2 added 1 ml water
- Ground sawdust 0.4g Purged with N2
- Ground sawdust 0.4g purged with O2 added 0.5 ml water
- Ground sawdust 0.4g added 0.5 ml water
- Ground sawdust 0.4g

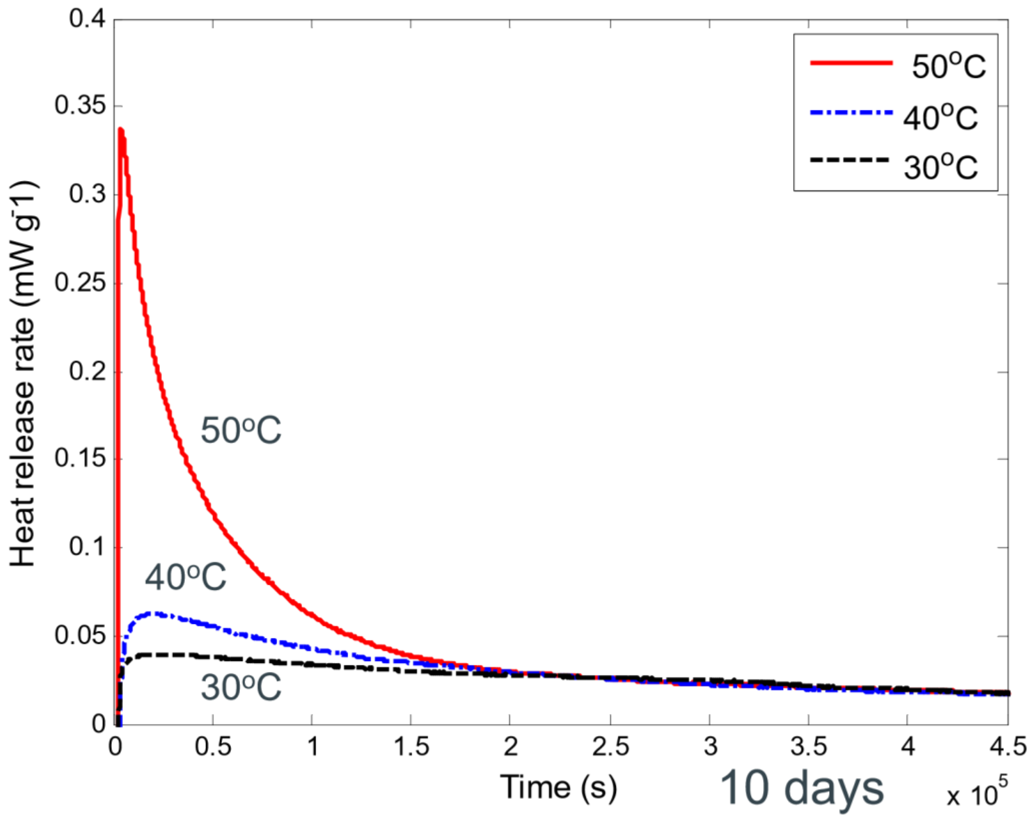


- Significant effect of O_2 when accompanied by moisture is shown→ auto-oxidation and thus significant heat release

- In oxygen poor environment the reaction is not self-sustained → no auto oxidation
- The effect of wetting in heat release is significantly higher than oxygen. e.g. the heat release in air & moist environment is as big as oxygen rich moist environment.

Heat released from ground sawdust over 5 day of storage in air, oxygen rich and nitrogen rich environment accompanied by wetting

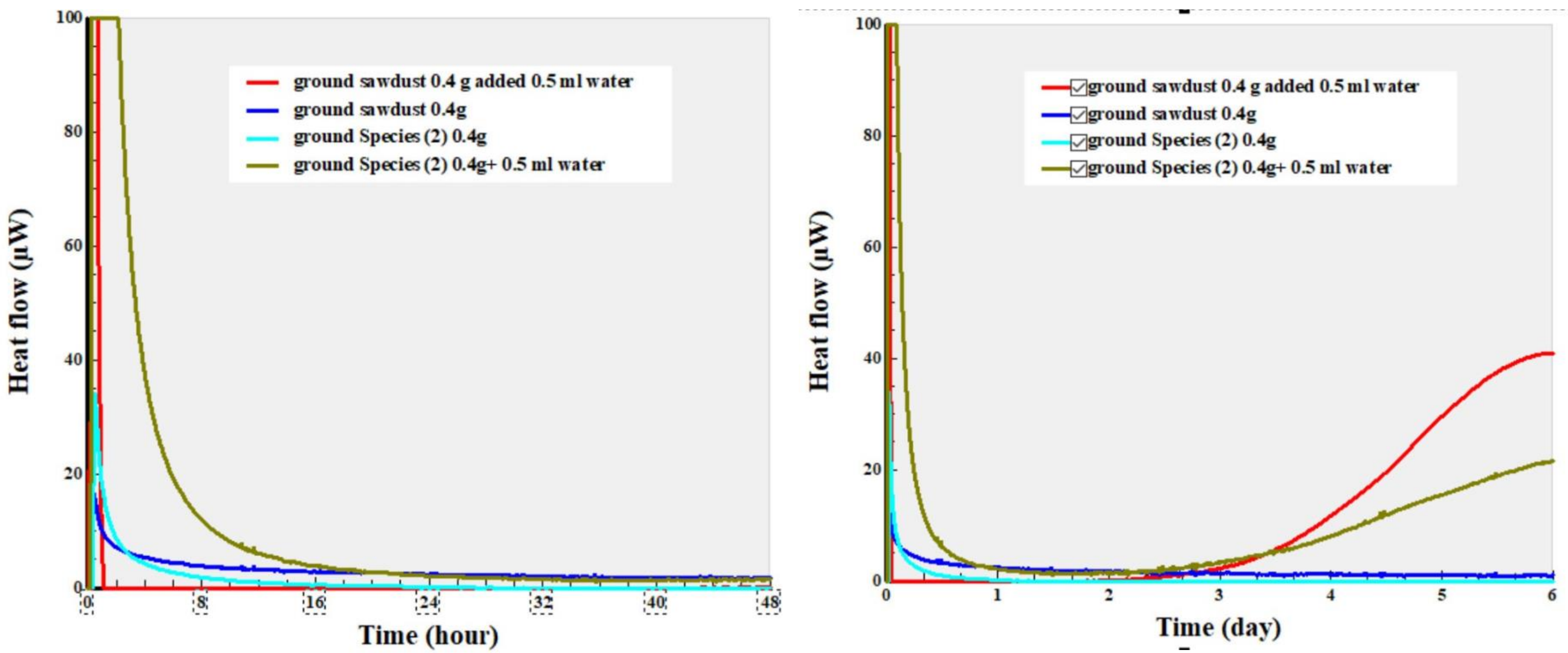
Effect of Storage Temperature



Temperature significantly effects the heat release rate

Heat released from sawdust over 10 days of storage in air stored at 30, 40 and 50C

Isothermal Calorimetry- Effect of species



Heat released from ground sawdust and another species over 6 days of storage in air (with and without moisture)

Lessons Learned

- The lower the storage temperature , the lower the risk of self-heating. Higher temperature increases both the initial heat release due to oxidation as well as the secondary auto –oxidation activated by wetting (humidity/moisture/rain)
- Amongst the species tested so far, sawdust has shown higher heat release when exposed to moist environment. Keep a balanced species mix.
- The effect of oxygen is minimal if not accompanied by moisture. The primary heat due to oxidation is slightly higher when pellets are stored in oxygen-rich environment. However this slight increase is insignificant when compared to heat release when the two parameters are of moisture and oxygen are present. Keep the material in low humidity away from rain and moisture.
- The secondary heat release of auto-oxidation that is activated by wetting (humidity, rain etc) is significantly higher (15-18 times more) compared to the primary heat release during storage.

Lessons Learned

- Rank and change in moisture are judged to be the most important factors affecting the spontaneous heating of the pile

- The two processes, **<u>oxidation and wetting</u>** contribute to spontaneous heating. The amount of energy released by oxidation and /or wetting determines the spontaneous heat hazard.

- A more general trigger of sustained, self-accelerating oxidation is seen **<u>in heat releases that accompany wetting of partly dry material.</u>** When the pellet is drier, more heat can be released from water adsorption (less heat is needed for desorption0

- The rate of heat generation is finely balanced with the rate of heat loss. **The humidity of the air is an important factor in deciding whether a heating will progress rapidly or not**

Acknowledgements

- Wood Pellets Association Canada (WPAC)
- Natural Sciences and Engineering Research council of Canada (NSERC)
- Biomass and Bioenergy Research Group

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