

Artificial Intelligence applied to thermal analysis and calorimetry of food materials inclusive cellulose

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Artificial Intelligence Selected: ChatGPT , editor OpenAI, USA, the free of charge version

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- Question 1: **What are the phenomena involved in exothermic reactions and self-ignition of foods ?**

- Response:

1. Oxidation of Organic Compounds: Foods, especially those containing fats, oils, or sugars, can undergo oxidation reactions with oxygen from the air. For instance:

- 1 a. Fats and oils are highly susceptible to oxidation, especially when exposed to light, air, or moisture. When they oxidize, they produce heat.

Remark: Oxidation of fats and oils (not of sugars) is an exothermic surface phenomenon.

- 1 b. Carbohydrates ($C_6H_{12}O_6$)_n can also oxidize, releasing energy. This process is often harnessed in cooking (such as caramelization), but it can happen spontaneously under certain conditions.

Remark: We call this decomposition or pyrolysis of carbohydrates; it is a bulk phenomenon, exothermic when the sample is analysed in a sealed cell or under inert gas pressure.

2. Microbial Activity and Fermentation: Microorganisms, such as bacteria and yeast, can metabolize sugars and other nutrients in food, producing heat as a byproduct. This is particularly common in foods like silage (fermented animal feed) or composting food waste, where microbial activity generates significant heat and can lead to warming of the material.

Remark: This is also important when storing wet cereals in silos or wet hay in farms.

3. Maillard Reaction: This is a reaction between amino acids and reducing sugars that happens at elevated temperatures, often giving browned foods their flavor and color. The Maillard reaction is exothermic and contributes to heat generation in food during cooking.

Remark: This is particularly important when drying dairy products.

N. B. Other topics mentioned are Key Points in Self-Ignition (spontaneous combustion) of foods, Material Composition concerning point 1 and point 3, Storage Conditions and Moisture Contents concerning point 2.

Sources:

Chemistry books such as:

- J.M. de Man, Principals of Food Chemistry
- O. Fennema, Food Chemistry
- Gareth Price, Thermodynamics of Chemical Processes

Microbiology books such as

- M. R. Adams and M. O. Moss, Food Microbiology

Journal of Food Chemistry

Journal of Food Engineering

Remark: No mention of publications or book chapters published by Alois Raemy using thermal analysis and calorimetry.

- Question 2: **What did Alois Raemy perform in the context of exothermic reactions and self-ignition of foods with thermal analysis and calorimetry studies ?**

- Response:

Alois Raemy, using DSC and TGA, has conducted influential research in food science, specifically in the thermal analysis and calorimetry of foods, focusing on exothermic reactions and the self-ignition of food products. His studies often involved investigating how thermal properties of foods influence safety and stability, particularly under conditions where they could potentially self-heat and ignite.

- Use of Thermal analysis of Food and Food Components
- Isothermal Calorimetry for Oxidative Stability
- Self-Ignition Risk Assessment in Food Products
- Modeling Thermal Decomposition

- **Remarks:**

1.- Use of Heat flow calorimetry from SETARAM (F), DSC, High pressure differential thermal analysis (HPDTA) from Netzsch (GE) but not Thermo-Gravimetry analysis (TGA) which is however mentioned (this is called «Hallucination») in the response¹⁾

2.-Adiabatic calorimetry (ARC, Columbia Scientific Industry, Milton Keynes, UK) is not mentioned²⁾

3.- Our modeling is very simple, see references in Journal of Food Technology or Thermochimica Acta (for obtaining more kinetic information use software of AKTS Thermokinetics, or of Netzsch or contact ICTAC Kinetics Committee)

4.- Google Scholar indicates some more references

5.- An exhaustive list of references is indicated in [Google](#) [alois raemy](#)

- Question 3: **What did Alois Raemy perform in the context of exothermic reactions and self-ignition of cellulose with thermal analysis and calorimetry studies ?**
- **Response: Alois Raemy** with collaborators, has conducted significant research on the thermal behavior of cellulose, particularly focusing on its exothermic reactions and self-ignition characteristics. In the next slide a summary of his contributions based on known studies.

Remark: Cellulose is a carbohydrate which can be found in food products but cellulose is also an important part (about 50%) of wood as well as the main component (about 100%) of cotton.

- Additional Question: Could you site specific results ?

- Responses:

Alois Raemy has contributed to the understanding of cellulose's thermal behavior, particularly its exothermic decomposition and self-ignition processes. Key findings :

- 1. Onset of Decomposition: Cellulose begins exothermic decomposition at around 200°C, with specific temperatures depending on measurement methods, such as calorimetry or differential thermal analysis (DTA).

Remark: Onset of Decomposition was also obtained with the adiabatic calorimeter ARC²⁾ .

- 2. Self-Ignition: The lowest observed self-ignition temperature under controlled oxygen pressure was approximately 240°C. Oxygen availability and pressure significantly impact these reactions.

- 3. Calorimetry Findings: The heat of cellulose decomposition (pyrolysis) was measured as 650 J/g, while the combustion heat was significantly higher, approximately 17 kJ/g.

- **General remarks:**

ChatGPT mentions (at question 2) a technique, TGA, we have never used !

ChatGPT does not mention adiabatic calorimetry !

ChatGPT does not present or interpret DTA curves or calorimetric curves !

ChatGPT seems not to mention or interpret tables, formulas and equations !

In a European context, Le Chat (editor Mistral, F) seems to be more efficient.

References:

- 1) A.Raemy, Differential Thermal Analysis and Heat Flow Calorimetry of coffee and chicory products, *Thermochimica Acta*, 43 (1981) 229-236.**
- 2) A. Raemy and M. Ottaway, The Use of High Pressure DTA, Heat Flow and Adiabatic Calorimetry to Study Exothermic Reactions, *J. of Thermal Analysis*, 37 (1991) 1965-1971.**