SELF-IGNITION HAZARDS OF BIOMASS, RECYCLING MATERIALS AND MUNICIPIAL SOLID WASTES

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introduction

Self ignition incidents occur e.g. at

- storage facilities (silos)
- waste deposits
- landfill sites
- heaps of solid fuels (coal, biomass)

extended use of biomass for heat and power generation → strong increase in number of large-scale storage sites (up to 50 000 tons)

→ emerging risk of large fires caused by self ignition

landfill site fire in Germany (dez. 2005)

introduction

Example: intermediate storage of recycling materials

experiments

- Isothermal hot storage tests of wood chips, briquettes, pellets and waste wood
- Isothermal hot storage tests of model substances (cellulose and diatomite) mixed at different ratios
- Isothermal hot storage tests of 9 fractions of waste materials
- Continuous temperature measurement and periodic gas extraction
- Analysis of the gaseous products via FT-IR
- Continuous measurement of mass loss
- Qualitative and quantitative determination of the gases

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experimental set-up

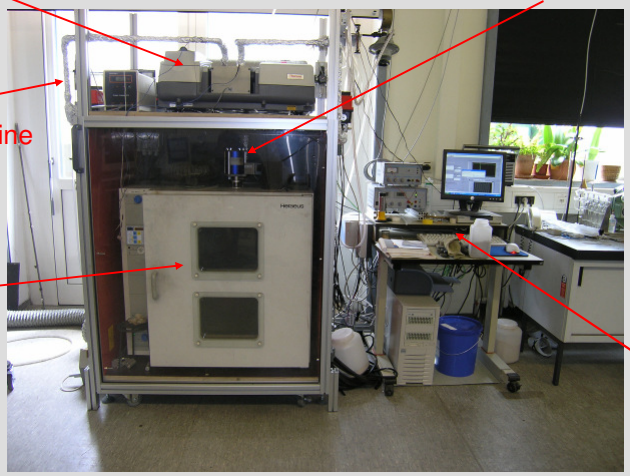
FTIR-spectrometer

macro-balance (electronics)

gas-transfer-line

oven

daq-system



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experimental set-up

hood

inner chamber

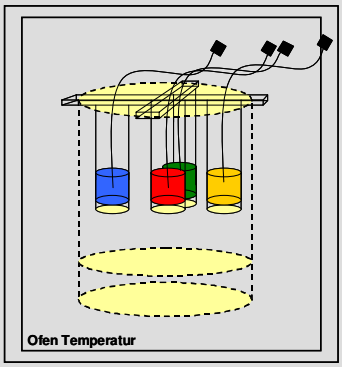
wire mesh basket attached to the scale

experimental set-up…

for a second series of experiments:
pockets of combustibles embedded in inert material

volume of pockets: 100 mL,

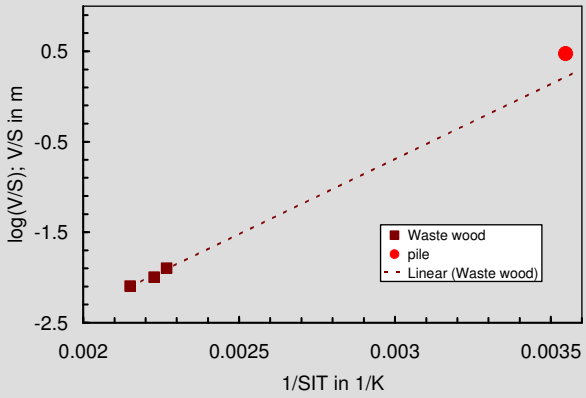
volume of embedding cylinder: 12.8 L



self-ignition temperatures

Sample	Volume in cm³	V/S in m	SIT in °C
Wood chips	100	0.005	210
Wood chips	200	0.006	204
Wood chips	400	0.008	196
Wood chips	800	0.010	188
Wood pellets	100	0.005	184
Wood pellets	200	0.006	180
Wood pellets	400	0.008	172
Wood pellets	800	0.010	168
Wood briquettes	200	0.006	180
Wood briquettes	400	0.008	176
Waste wood	400	0.008	188
Waste wood	800	0.010	176
Waste wood	1600	0.013	176

practical storage

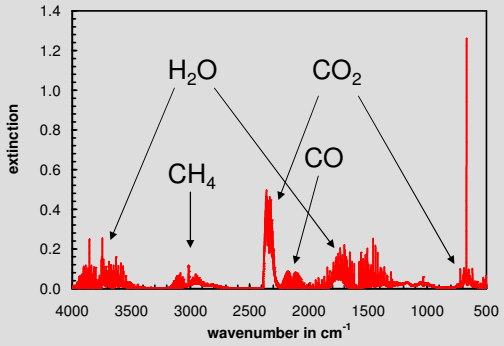


Conditions:
- 7500 t waste wood
- bulk density 0.3 t/m³

- V = 25000 m³ V/S = 3m
- Average annual temperature in Berlin 8.9 °C

results

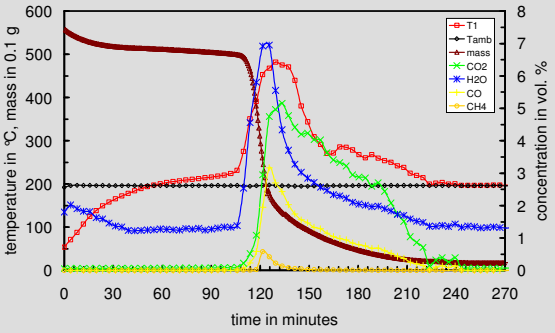
Typical FTIR spectrum of 400 cm³ wood chips at 200 °C



- Standard hot storage set-up
- Most important gas products can be detected
- gas analysis is possible for the whole process

results

400 cm³ wood chips at 200 °C

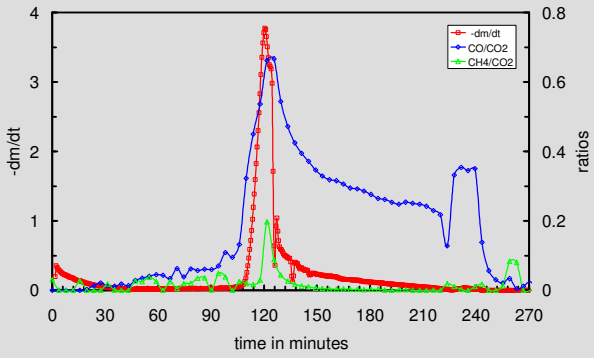


<u>information from a single experiment</u>
in general:
- temp-time evolution
- gas concentrations
- mass loss

specific:
- main products CO_2 and H_2O
- max. mass loss coincides with increase of gaseous products
- H_2O is detected before the other gas products
- CO and CH_4 indicate incomplete oxidation

results

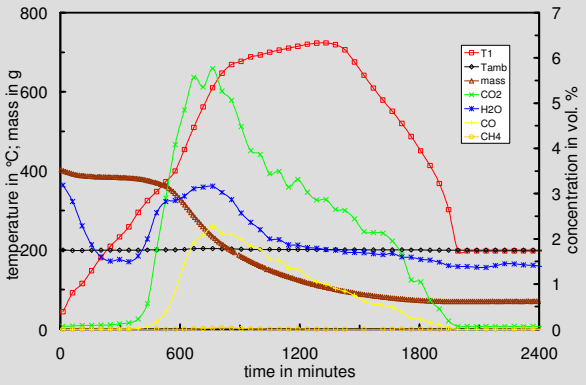
400 cm³ wood dust at 200 °C



- High mass loss rate coincides with high $CO(CH_4)/CO_2$ ratios
- reaction limited by the diffusion rate of O_2 to active sites?

results

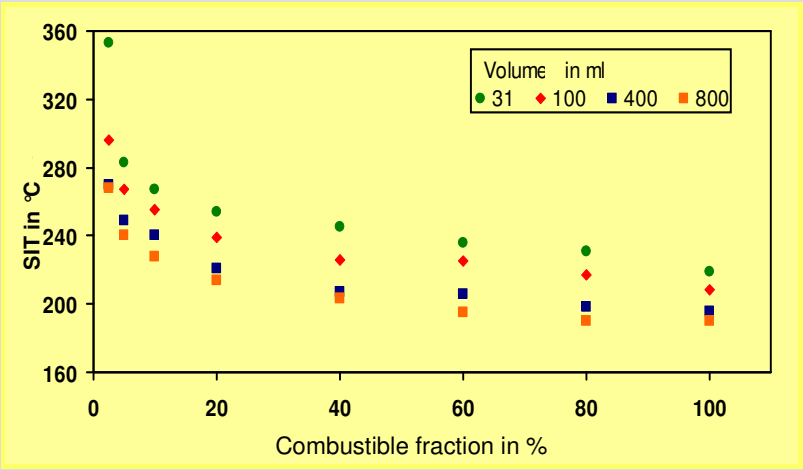
400 cm³ black coal < 10 mm at 202 °C



- Combustion process significantly longer for coal
- Continuous increase of temperature
- H_2O increase before the other gases

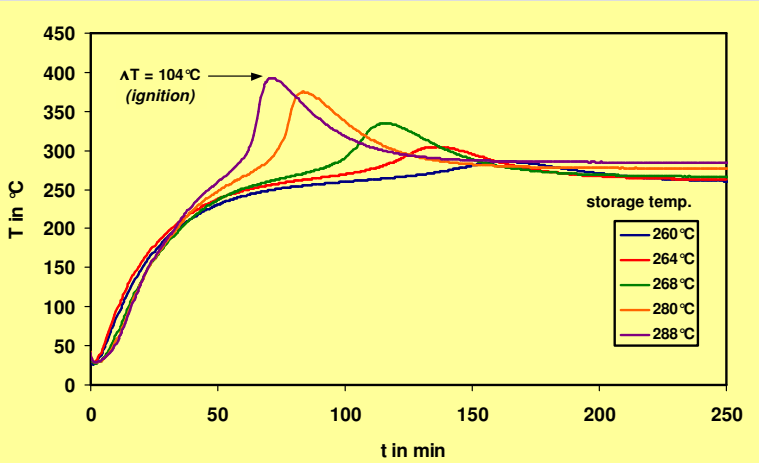
results

Mixtures of cellulose and diatomite



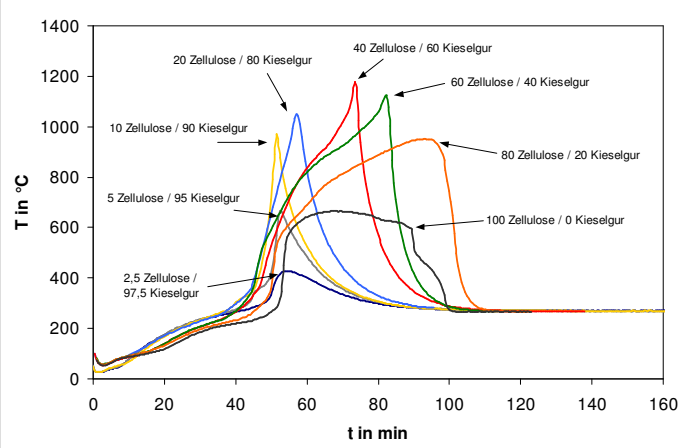
results

temperature-time curves for a mixture of 2.5 % combustible and 97.5 % of inert material at different storage temperatures



results

temperature-time curves for different mixtures of cellulose/diatomite (sample volume = 400 mL, storage temp. = 272 °)

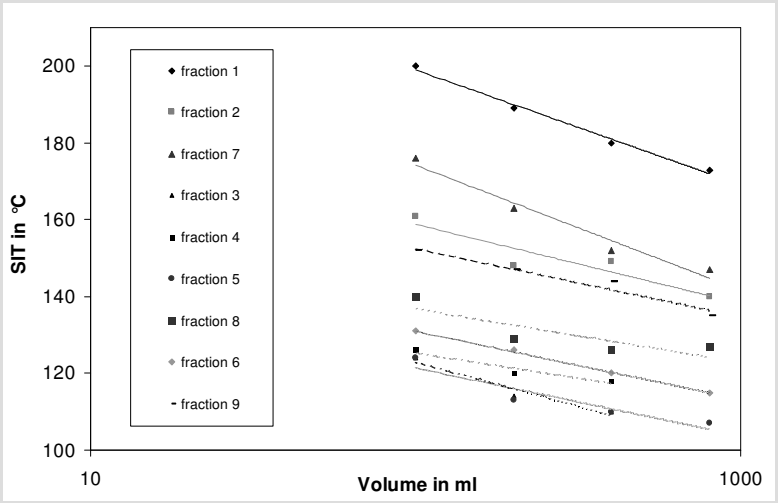


results

Self-ignition tests of recycling materials:
description of fractions tested

Fraction 1	Paper and paperboard with a particle size of 1mm
Fraction 2	Textiles with a particle size of 1mm
Fraction 3	Cleaned plastic with a particle size of 1mm mixed with diatomite (4:1)
Fraction 4	Cleaned Plastic with about 50% tin foils with a particle size of 1mm mixed with diatomite (4:1)
Fraction 5	Dirty plastic with a particle size of 1mm mixed with diatomite (4:1)
Fraction 6	Wastes of the mechanical biological waste treatment with a particle size of 1mm mixed with diatomite (4:1)
Fraction 7	Textiles with a particle size of 5-10mm
Fraction 8	Dirty plastic with a particle size of 5-10mm mixed with diatomite (4:1)
Fraction 9	Wastes of the mechanical biological waste treatment with a particle size of 5-10mm mixed with diatomite (4:1)

results



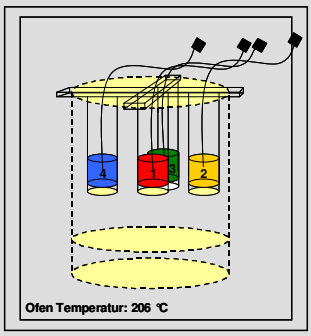
results

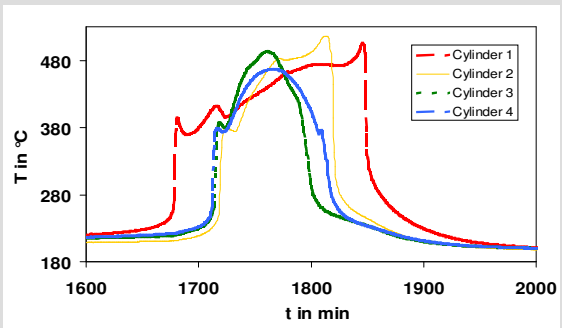
Overview of the apparent activation energies, the pre-exponential factors and the SIT's

	E_A in kJ/mol	k_o in s^{-1}	SIT in °C (V = 400ml)
Fraction 1	97	1,094 E+5	180
Fraction 2	102	1,991 E+6	149
Fraction 3	78	9,853 E+3	110
Fraction 4	115	3,722 E+8	118
Fraction 5	105	3,226 E+7	110
Fraction 6	118	8,556 E+8	120
Fraction 7	79	3,970 E+3	152
Fraction 8	114	2,023 E+8	126
Fraction 9	124	1,132 E+9	144

results

Primary and secondary self-ignition of combustible pockets embedded in inert matter at storage temperature 206 °C





conclusions

- biomass, here mainly consisting of wood, undergoes self-ignition if stored in heaps of sufficient size (and sufficiently long time)
- the preparation of the biomass is of secondary importance
- rapid temperature rise accompanied by H_2O production prior to other gases
- in practice → wetted zones in stockpiles around hot spots
- organic wastes, though mixed with inert matter are self-ignitable too
- mixing plastic wastes with inert granules increases the hazard of self-ignition
- heat transmission through inert matter may cause secondary ignitions in embedded pockets of combustibles

Outlook

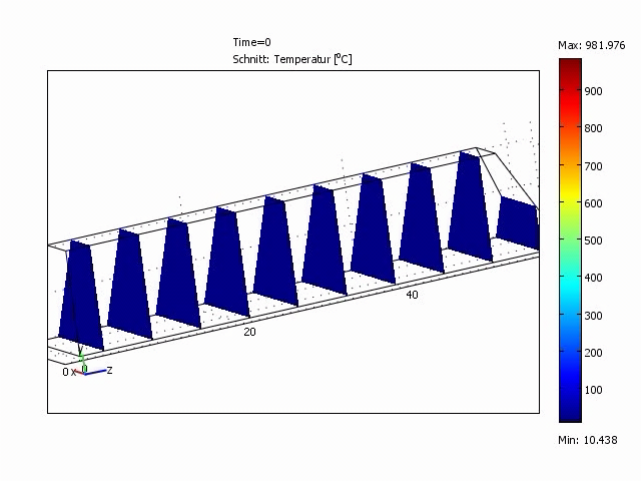
field investigations (since mid november 2006)

portable FTIR-analyzer for onsite investigations

temperature measurement

Outlook

Numerical simulation of temperature evolution in the deposit



Thank you for your attention!

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