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Optical detection of KCl vapor and atomic K releases from biomass fuels combusted in single particle reactor

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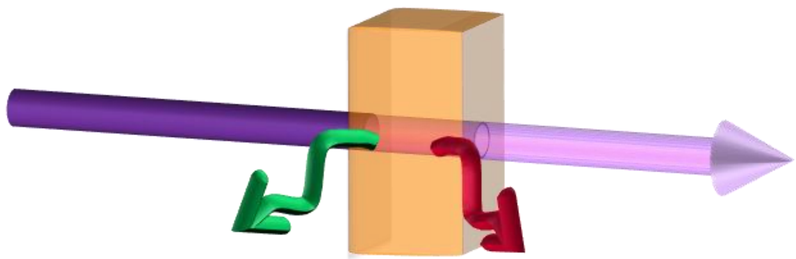
Background

- KCl accelerates high temperature corrosion and reduces the heat transfer between flue gas and superheated water vapor
- KCl reduction techniques require real-time monitoring
- The study of KCl formation kinetics needs sensitive diagnostics

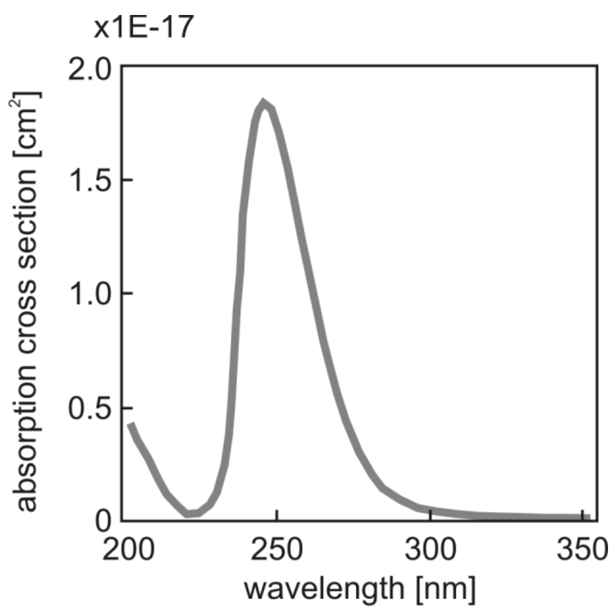
Optical Spectroscopy

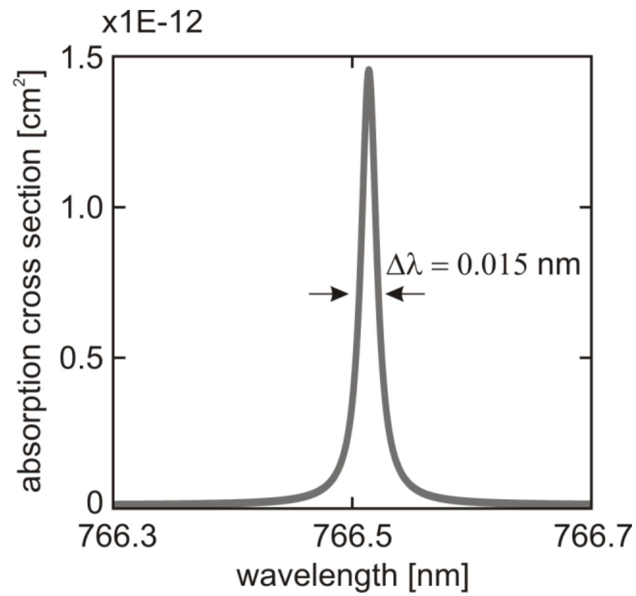
- The study of the interaction between radiation and matter as a function of wavelength.



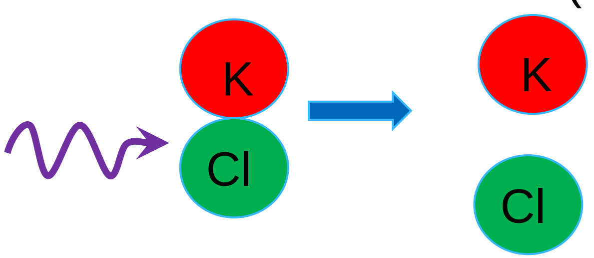
- Benefits in metrology:
  - Sensitivity
  - Wide dynamic range
  - Molecule specific
  - Possibility of remote and *in-situ* sensing

Absorption of KCl and K

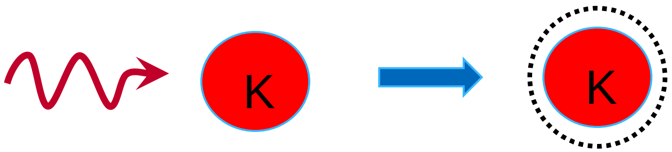




Potassium chloride (KCl)



Potassium (K)

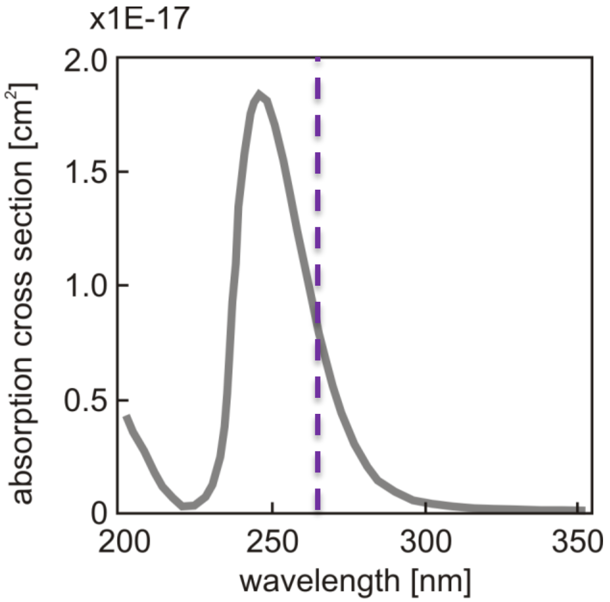


CPFAAS technique

(Collinear Photofragmentation and Atomic Absorption Spectroscopy)

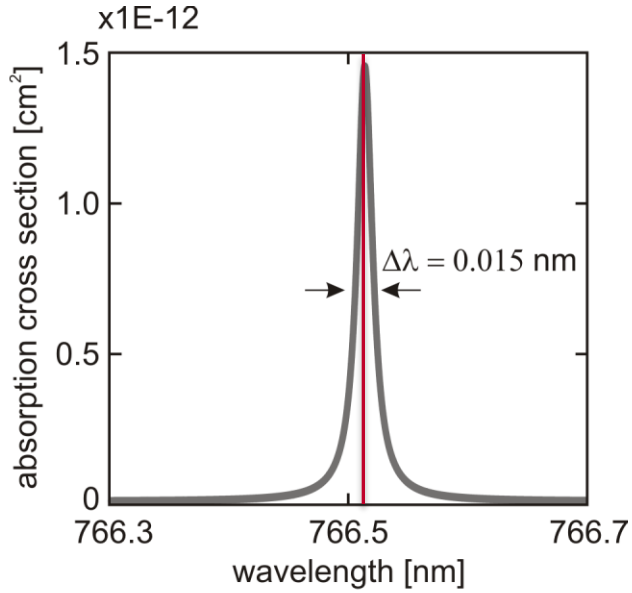
Two lasers

UV laser emitting 1 ns pulses



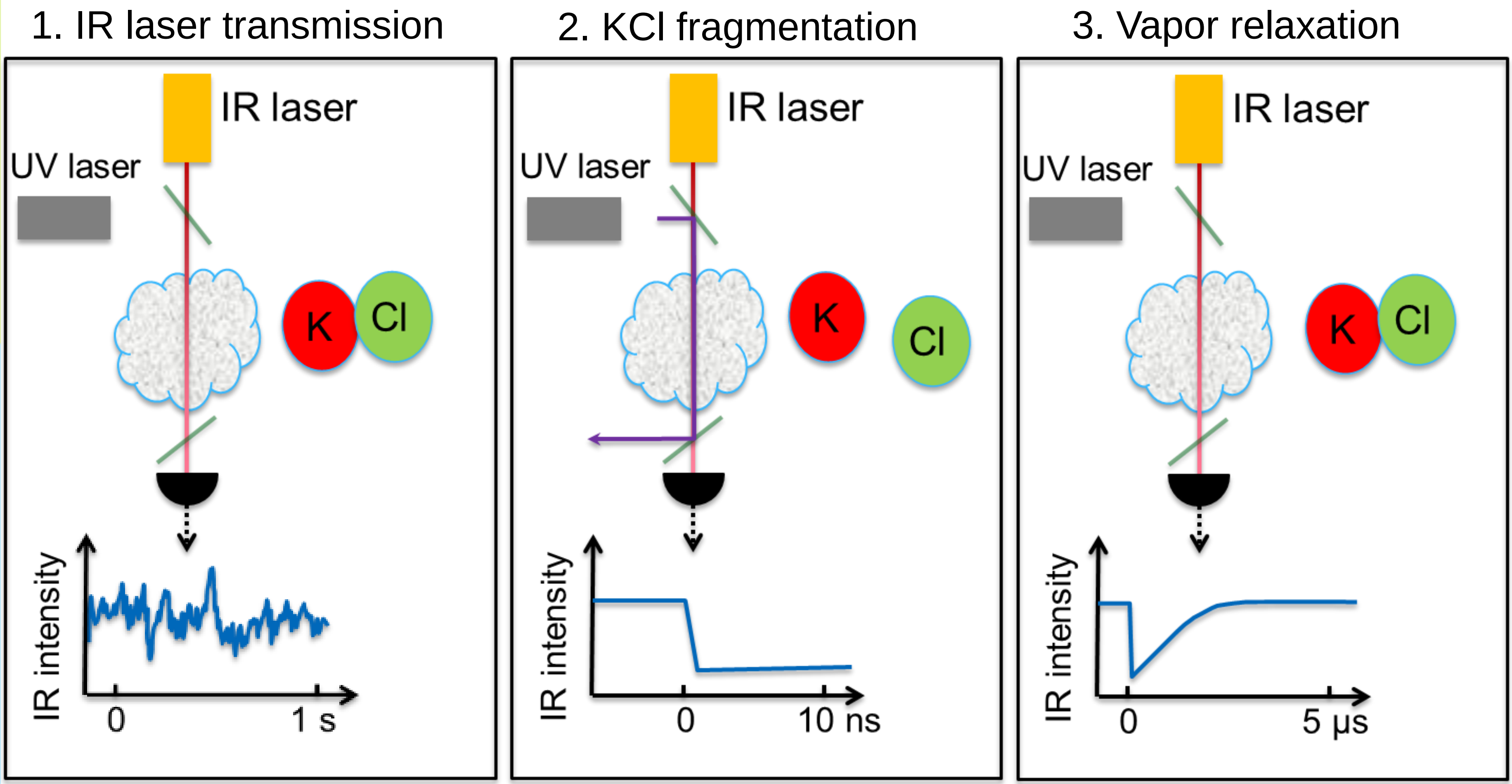
Potassium chloride (KCl)

IR laser emitting cw-light

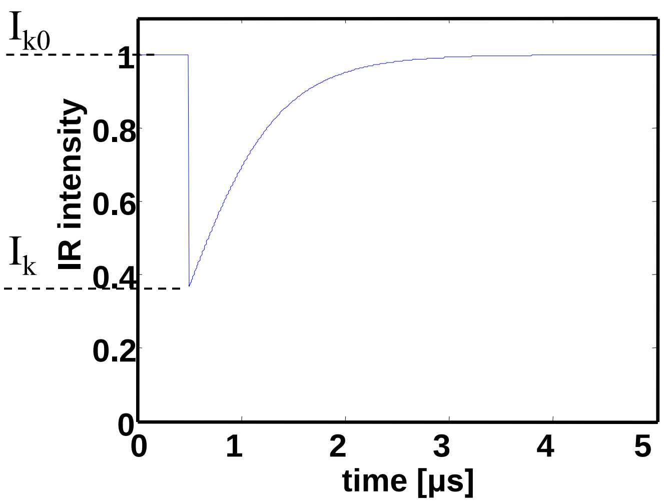


Potassium (K)

CPFAAS technique



CPFAAS technique



$$\frac{I_k}{I_{k0}} = \exp\left[-\left(1-\exp\left(-x_{KCl}\frac{p}{k_b T}\sigma_{KCl}L\right)\right)\frac{E_p\sigma_K}{hc/\lambda_p \, A_p}\right]$$

$$x'_{KCl} = -\ln\left[1+\ln\left(\frac{I_k}{I_{k0}}\right)\frac{A_p}{E_0}\frac{hc/\lambda_p}{\sigma_K}\right]\frac{M_{KCl}}{N_a\sigma_{KCl}}\frac{1}{L} \qquad [x'_{KCl}] = g/m^3$$

Tunable parameters: (green)

Physical constants: (blue)

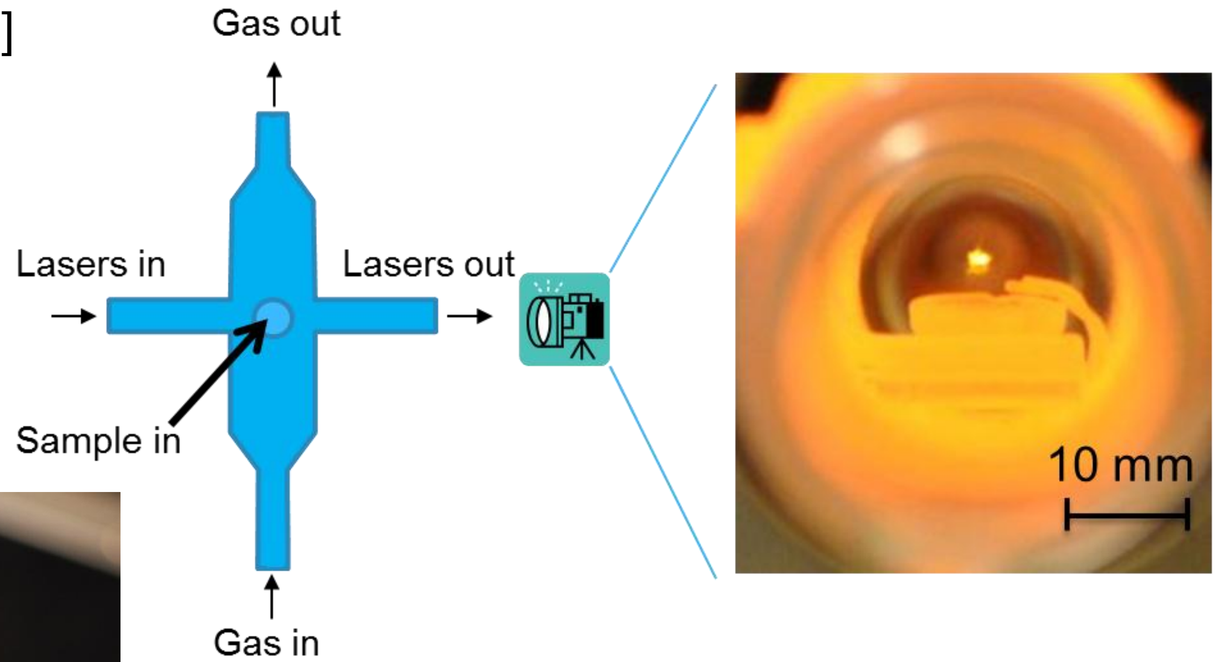
Sample specific quantity: (red)

Applications

- Determination of vapor pressures in thermodynamic equilibrium
- Real-time analysis of KCl release from combustion gas and flame
- Monitoring of KCl concentration in flue gases

Experiments - Single particle reactor

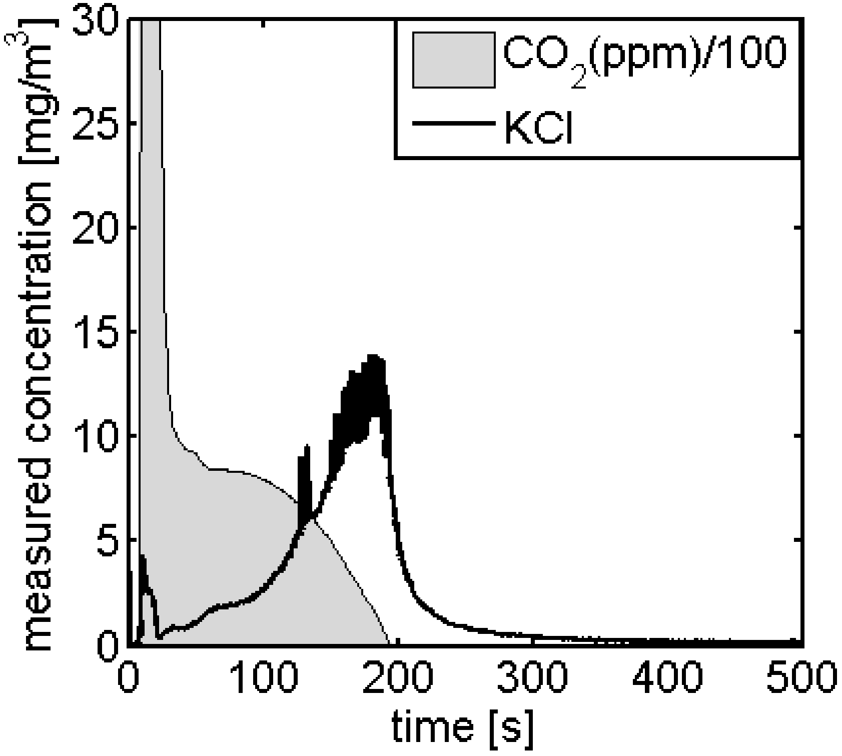
[4]

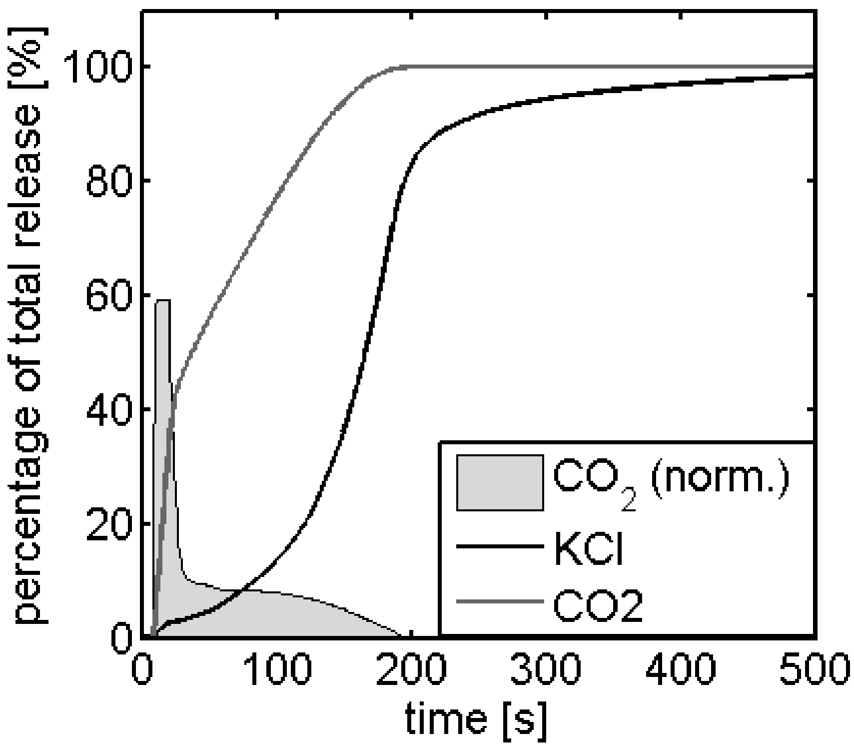


Results

20 mg of bagasse

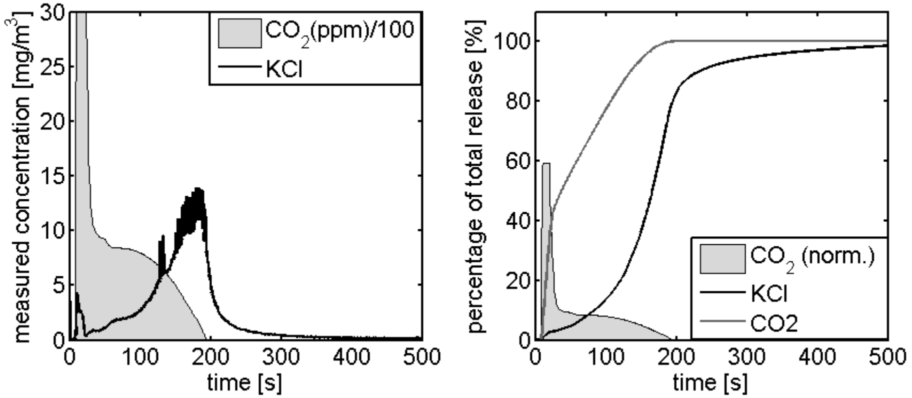
950 C 3 % O_2



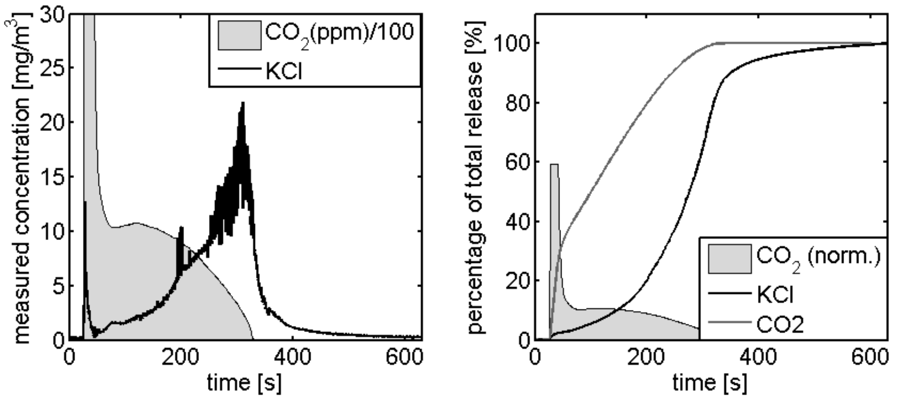


Results - Bagasse

950 C 20 mg



950 C 45 mg

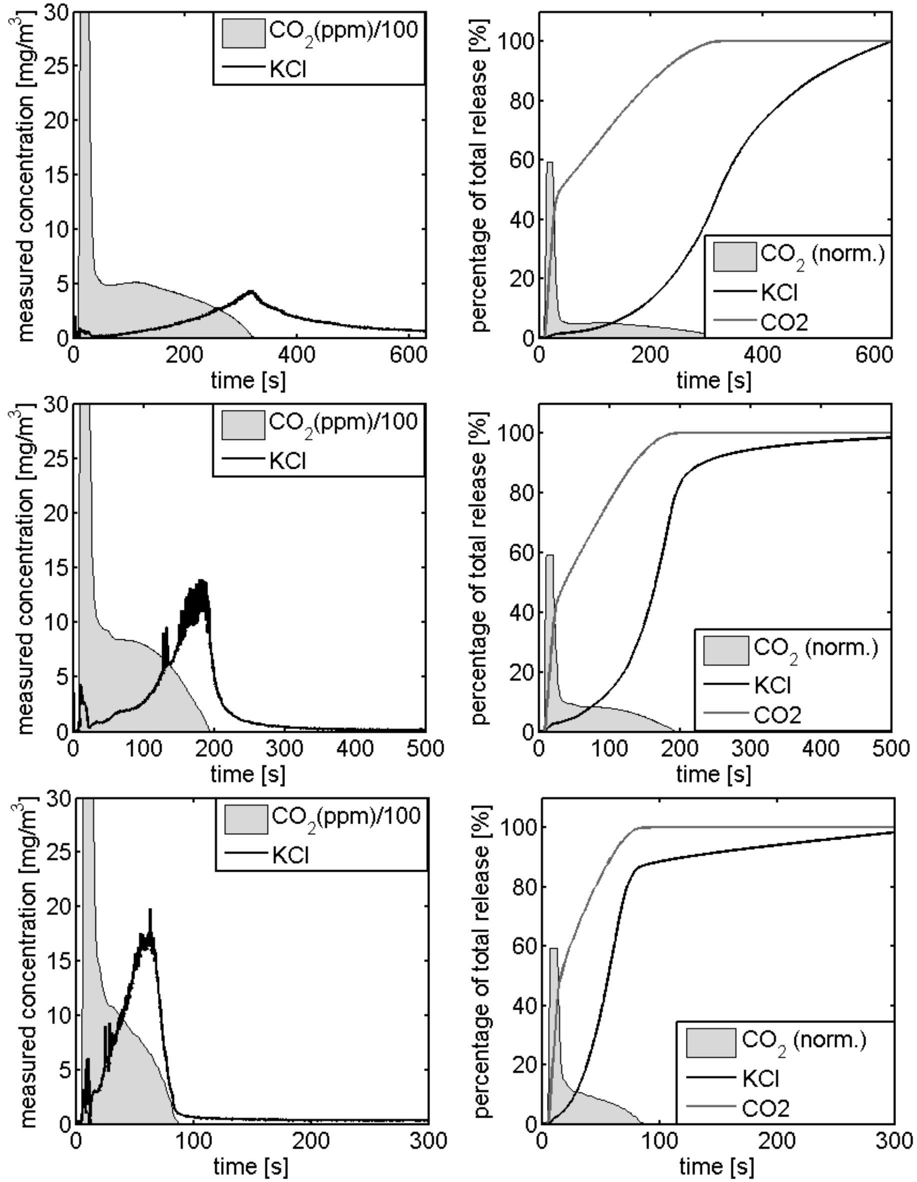


Results - Bagasse

800 C 20 mg

950 C 20 mg

1100 C 10 mg



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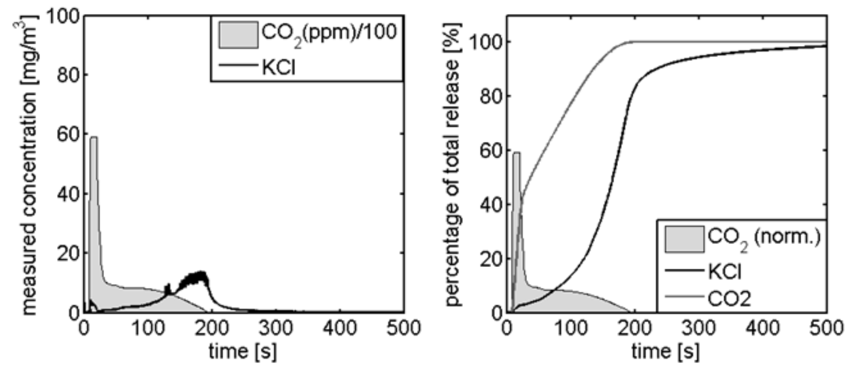
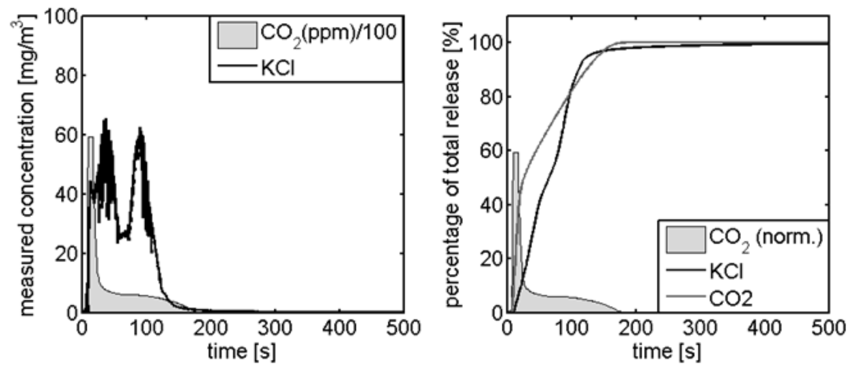
Results – Different Fuels

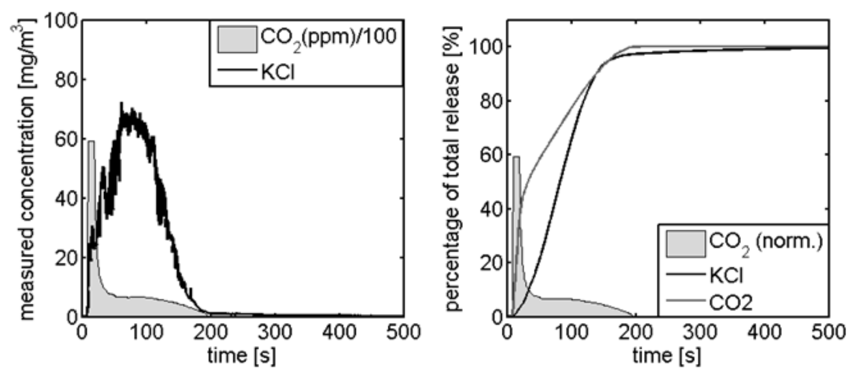
Bagasse 950 C 20 mg



Reed 950 C 22 mg

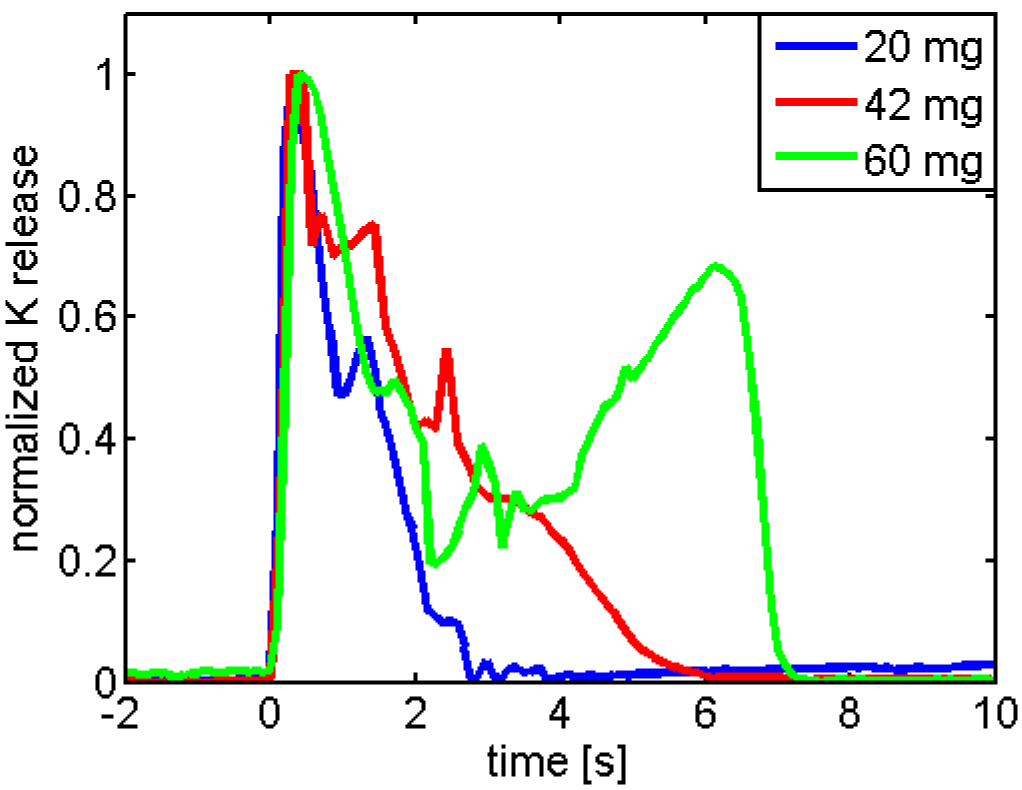


Straw 950 C 22 mg



Results – K release

Reed 950 C & 3 % O_2



Conclusions

- CPFAAS technique was applied to measure KCl and K releases from combusted biomass fuels
- KCl release was different from different fuels
- KCl release respect to CO_2 was found to depend on the combustion temperature
- K release profile changed as the mass of the sample increased.

Acknowledgements

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