Photoacoustic analysis of alkali chloride vapors

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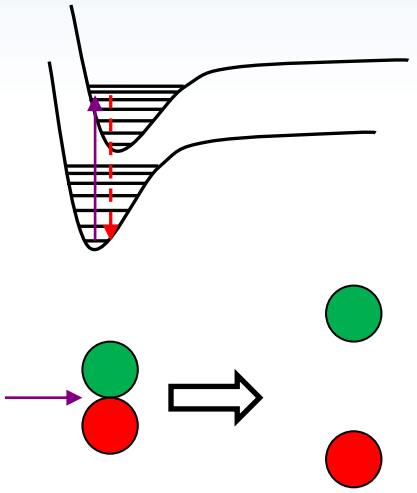
Motivation

- Potassium is abundant in biomass
- Alkali chlorides adhere on surfaces
  $\Rightarrow$ Heat transfer is reduced & corrosion of superheaters is increased
- KCl & NaCl are difficult to identify with In-situ methods

Photoacoustic effect in gases

- Photoacoustic effect may occur when light is absorbed in a medium
- Absorbed light increase the temperature and/or the number of particles in a medium
- According to ideal gas law change in temperature or in number of molecules induce a change in pressure



$$pV = NkT$$

Photoacoustic vs. Direct absorption

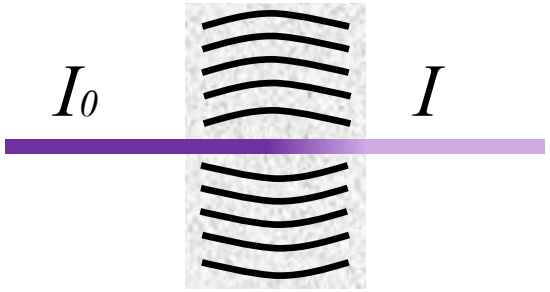
Direct absorption

- Simple technique
- Beer-Lambert Law

$$\frac{I_0 - I}{I_0} \approx \alpha L = x_i \, n\sigma_\lambda L$$

- Detection limit

$$\alpha L_{\min} \sim 10^{-4} - 10^{-5}$$



Photoacoustic

•Quite simple

•Signal is proportional to difference of input and output intensities

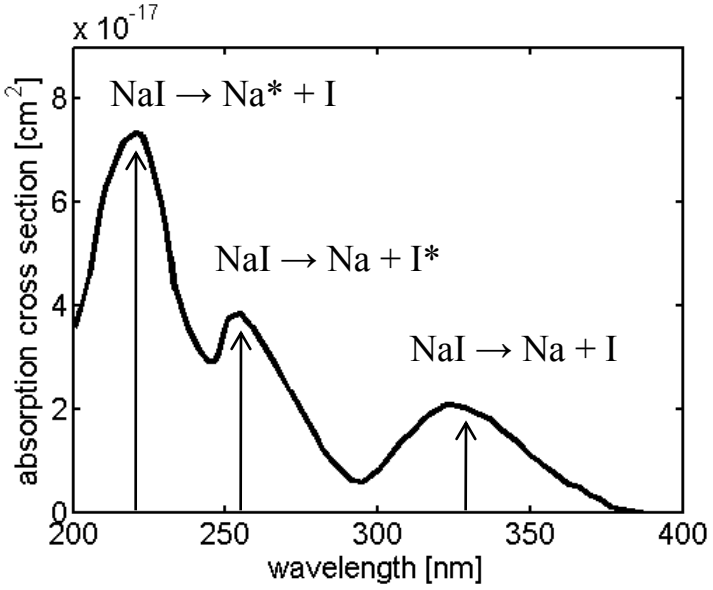
$$PA_{signal} \propto I_0 - I$$

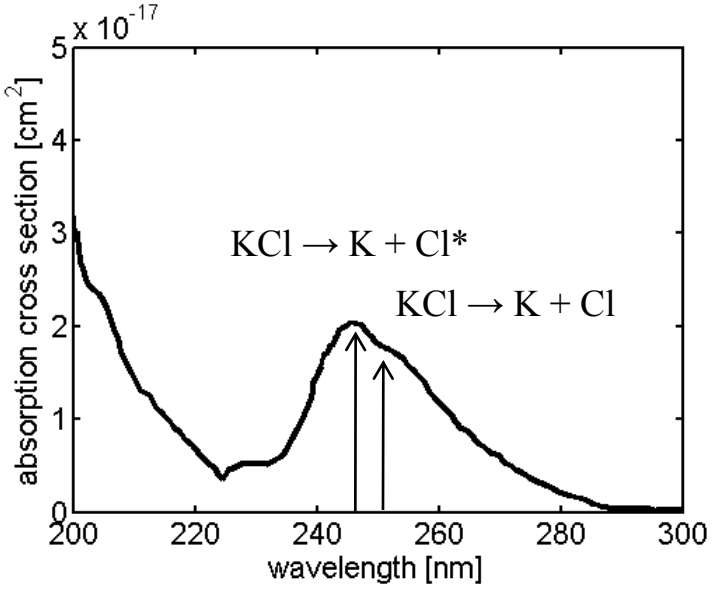
•Detection limit

$$\alpha L_{\min} \sim 10^{-7} - 10^{-9}$$

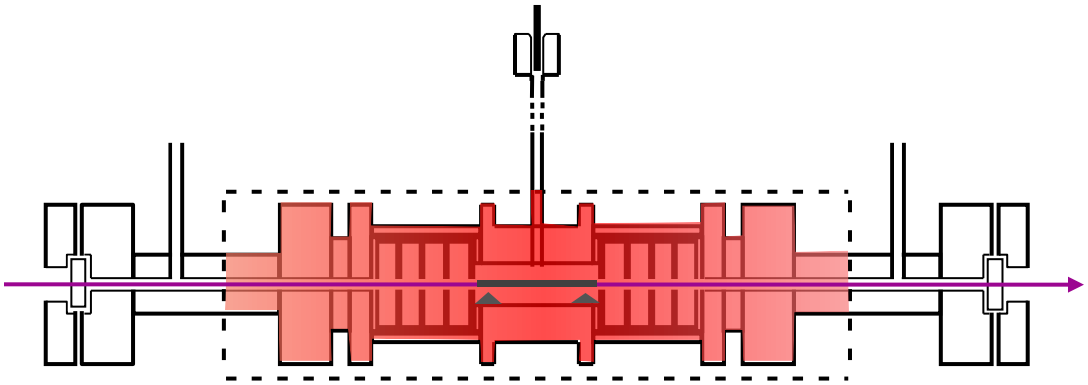
Optical properties of alkali halides

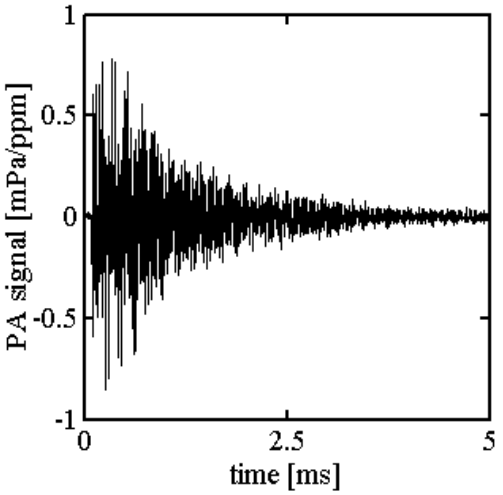
- Vibration absorptions locate at far infrared region (> 30 µm)
- Alkali halides are dissociated when exposed to UV light

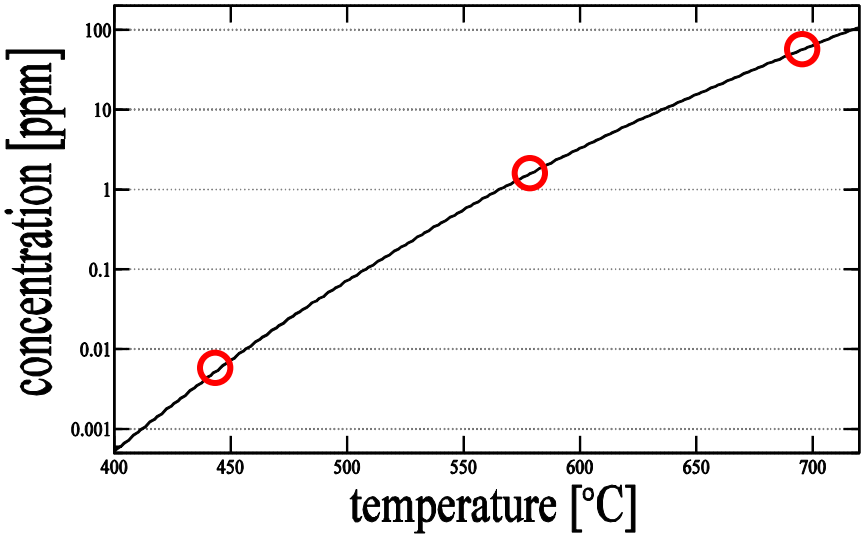


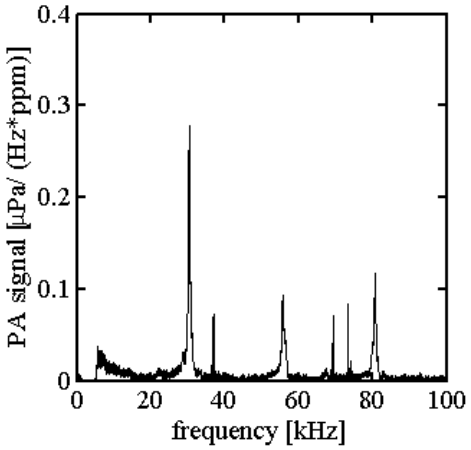


Photoacoustic resonance cell



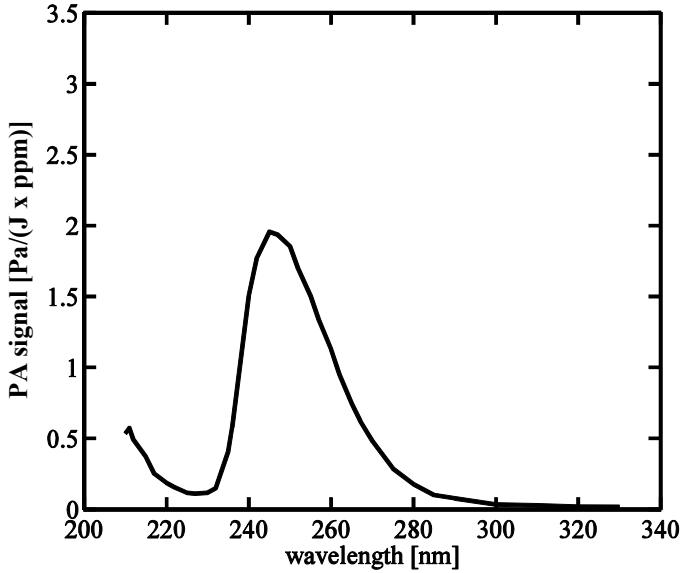




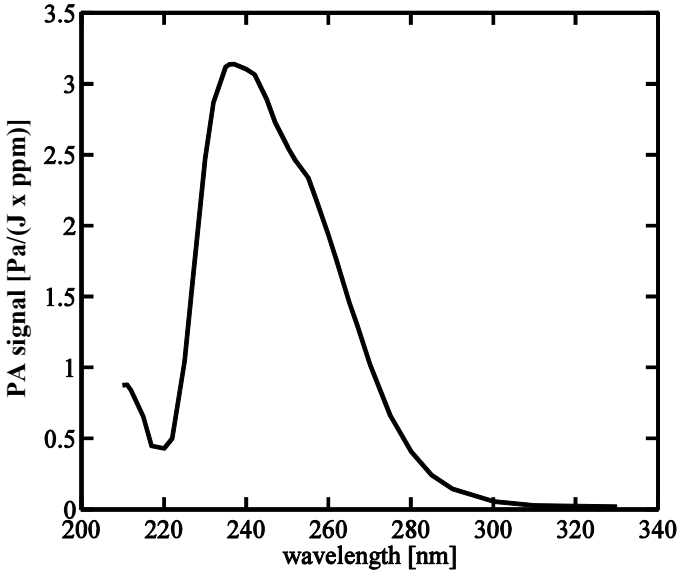


Results – PA spectra of KCl and NaCl

The PA spectrum of the KCl

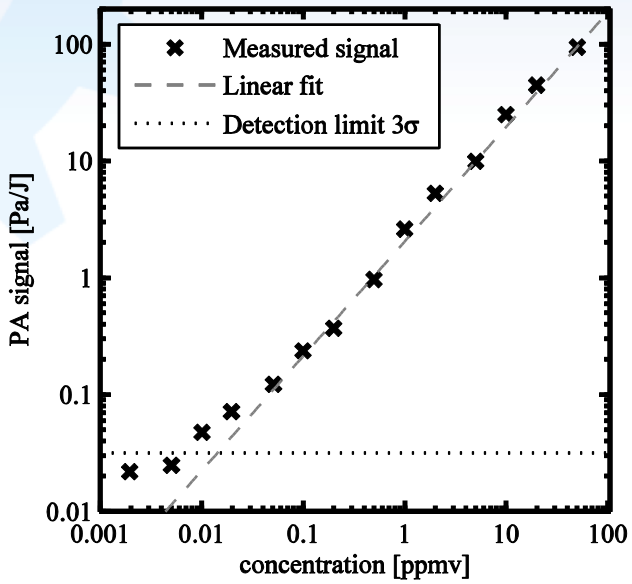


The PA spectrum of the NaCl



Results – Detection limit

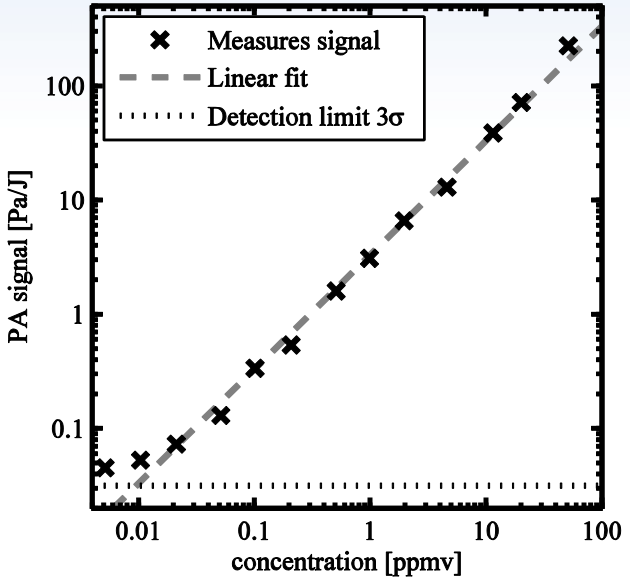
KCl 245 nm



slope is 2 Pa/(J*ppm)

detection limit 15 ppbv

NaCl 235 nm



slope is 3.3 Pa/(J*ppm)

detection limit 10 ppbv

Applications

- Fundamental work in laboratory
  - Spectral information at low temperatures
  - Development of high temperature photoacoustic resonator
- Field measurements with current photoacoustic cell (require sampling)
- In-situ measurements using probe design
- Applicable to other metal salts as well

Conclusions

- Photoacoustic spectroscopy is quite simple technique for sensitive diagnostics
- Alkali chlorides induce photoacoustic signal when exposed to UV light
- Method is demonstrated by measuring photoacoustic responses of KCl and NaCl

Sorvajärvi T. et al. "*Reosonant photoacoustic cell for pulsed laser analysis of gases at high temperature*" ,Rev. Sci Instrum. **80** 123103 (2009)

Acknowledge

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