Approaches to reduce the cross-sensitivity in photoacoustic soot measuring

Alexander Bergmann[1], Tristan Reinisch[1,2], Robert Diewald[1], Michael Arndt[1], Bernhard Gaulhofer[1], Roland Resel[2], [1]AVL List GmbH, Graz, Austria, [2]TU Graz, Austria

The Photoacoustic phenomenon is based on light induced heat expansion of to be examined material. It has been shown that this effect occurs in solids and gases as well. At the detection of the soot mass, by this principle, the sp2-bindings of Carbon are excited which is possible over a very broad wavelength range (UV to NIR). For the detection of the pure acoustic signal of the soot, a wavelength has to be chosen which doesn't excite any other components in the matrix. In the following there will be on the one hand typical absorption spectra of selected components of the emission matrix discussed. On the other hand selected examples will be evaluated in photoacoustic experiments.

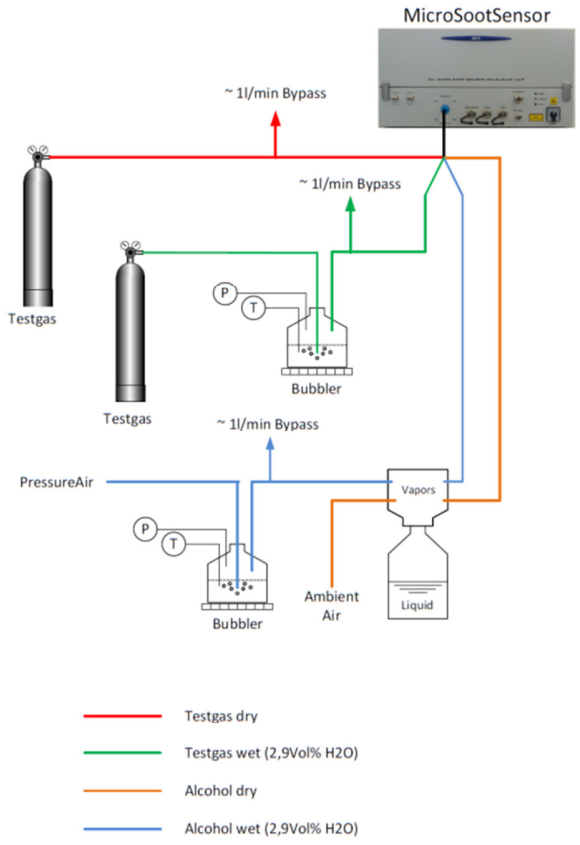


Figure 1: Measuring setup to sample components of the emission matrix

Experimental Setup

Figure 1 is a schematic of the experimental setup. All measurements have been taken with one Micro Soot Sensor. The wavelength of the laser diode was set by adjusting the temperature of the diode by a Peltier cooler. The impact of other constituents was analyzed in the range of interest for the detection of the soot-mass concentration.

Photoacoustic signal and reference spectra

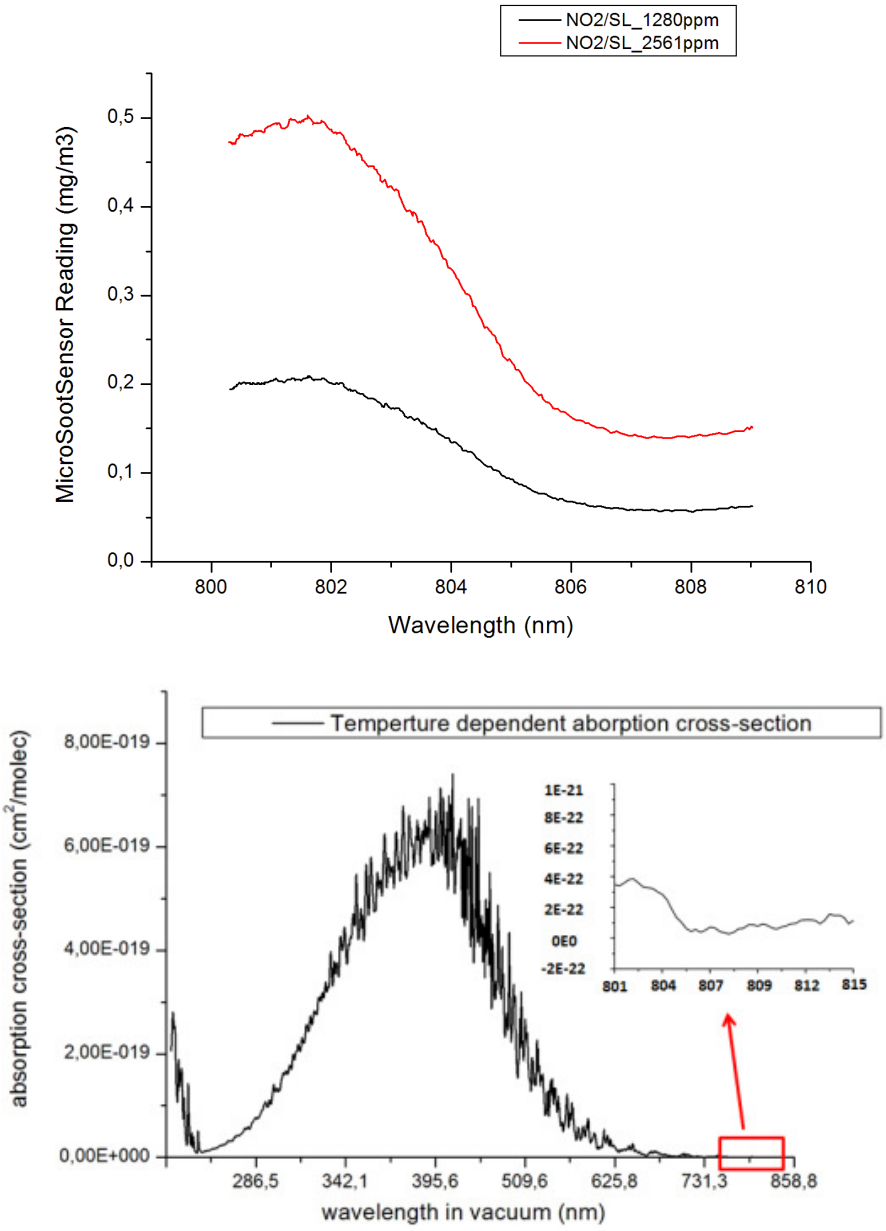


Figure 2: Photoacoustic Signal and reference spectrum of NO2 (Bogumil et al. 2000, Proc. ERS-Envisat Symposium)

At the reference spectrum a local maximum of the absorption cross-section of NO_2 can be seen at ~802nm (Figure 2). H_2O has a local maximum at this wavelength as well (Figure 3). Both would contribute substantially to the photoacoustic signal at this particular wavelength. The absorption of other tested constituents was found to be well below the intensity of NO_2 (Figure 4). Thus, for measurements of soot

concentrations in exhaust gases the wave length is typically chosen around 807nm, where nitrogen dioxide has a minimum of its absorption cross-section. The water influence could be mitigated by a heated measuring system.

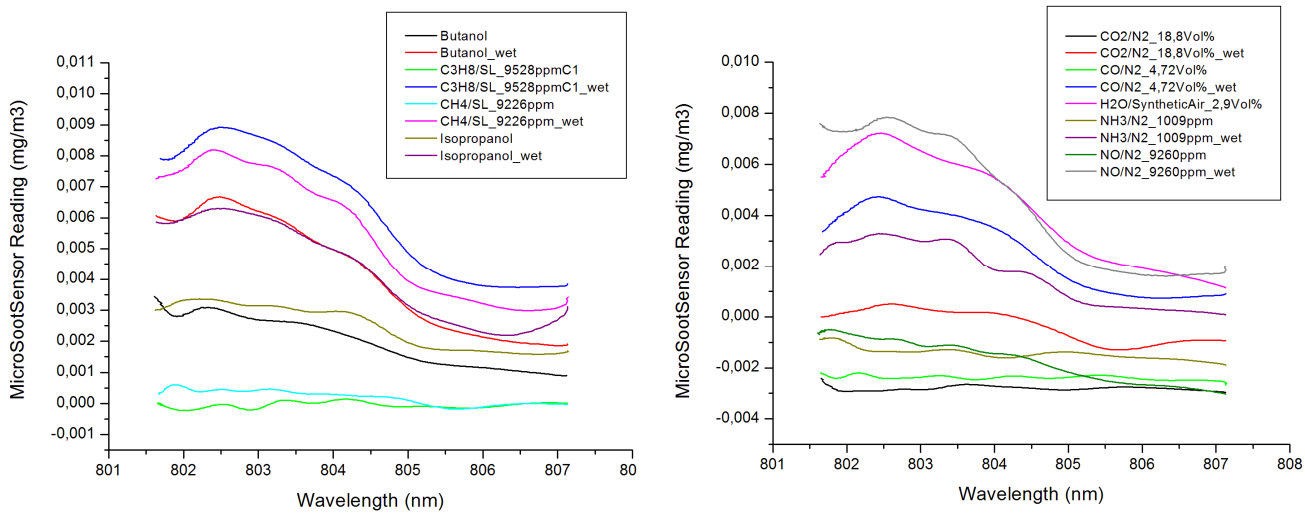


Figure 3: Photoacoustic Signal of different components of the emission matrix at different wavelengths

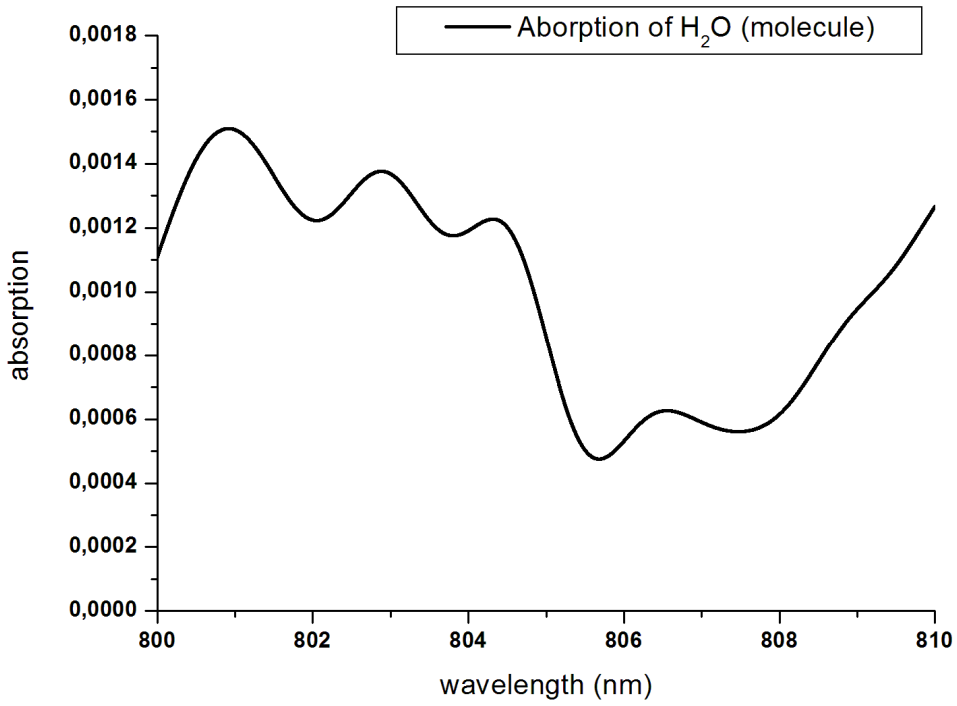


Figure 4: Absorption of molecular H2O (SPECTRA Information System based on HITRAN)

Conclusion

To reduce falsifying acoustic signals from other constituents in the exhaust, the irradiated wave length has to be selected carefully. Otherwise signal corrections have to be applied to take cross sensitivities of other contributors into account.

Approaches to reduce the cross-sensitivity in photoacoustic soot measuring

Alexander Bergmann[1], Tristan Reinisch[1,2], Robert Diewald[1], Michael Arndt[1], Bernhard Gaulhofer[1], Roland Resel[2]
[1]AVL List GmbH, Graz, Austria, [2]TU Graz, Austria

The photoacoustic phenomenon is based on periodic heat expansion induced by light absorption. It can be used to determine gas concentrations and soot concentrations of aerosols as well.
The sp2-bindings of the graphite-like soot structure absorb light over a very broad wavelength range (UV to NIR). For the detection of soot concentrations, the wavelength has to be chosen carefully to minimize cross-sensitivities to other constituents.

Experimental Setup

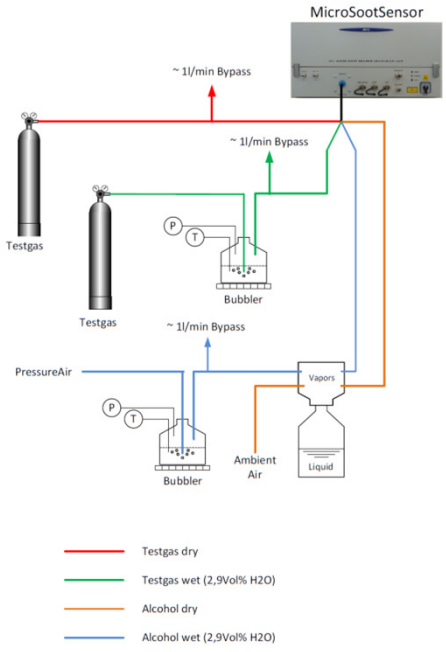
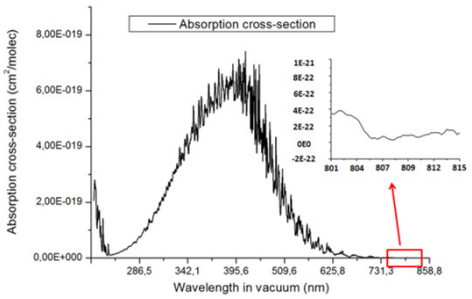


Figure 1: Measuring setup to sample components of the emission matrix

Figure 1 is a schematic of the experimental setup. All measurements have been taken with one Micro Soot Sensor. The wavelength of the laser diode was set by adjusting the temperature of the diode. The impact of other constituents was analyzed in the range of interest for the detection of the soot-mass concentration.

Photoacoustic signal and reference spectra



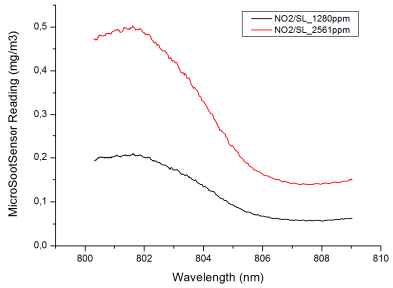


Figure 2: Absorption cross-section of NO_2 (Bogumil et al. 2000, Proc. ERS-Envisat Symposium)

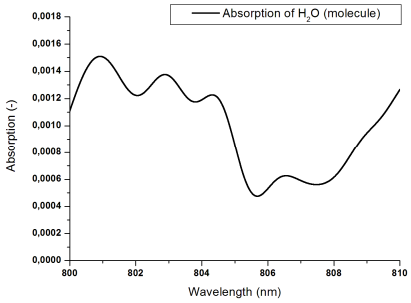
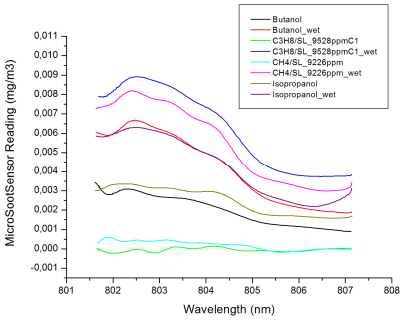


Figure 3: Absorption of molecular H_2O (SPECTRA Information System based on HITRAN)

At the reference spectrum a local maximum of the absorption cross-section of NO_2 can be seen at ~802nm (Figure 2). H_2O has a local maximum at this wavelength as well (Figure 3). Both would contribute substantially to the photoacoustic signal at this particular wavelength. The absorption of other tested constituents was found to be well below the intensity of NO_2 (Figure 4). Thus, for measurements of soot concentrations in exhaust gases the wave length is typically chosen around 807nm, where nitrogen dioxide has a minimum of its absorption cross-section. The water influence could be mitigated by a heated measuring system.



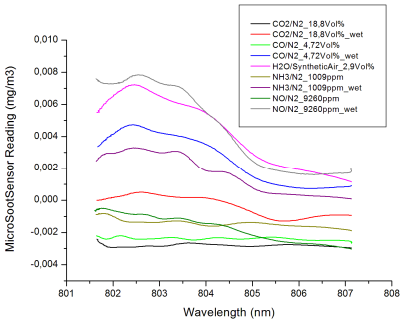


Figure 4: Photoacoustic Signal of different components of the emission matrix at different wavelengths

Conclusion

To reduce falsifying acoustic signals from other constituents in the exhaust, the irradiated wave length has to be selected carefully. Otherwise signal corrections have to be applied to take cross sensitivities of other contributors into account.