CO-ADSORPTION OF WATER AND AMMONIA ON STAINLESS STEEL

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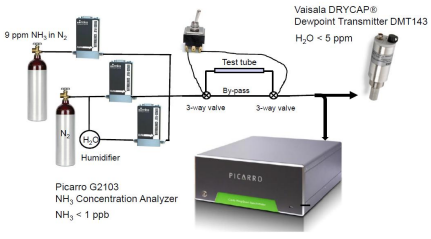
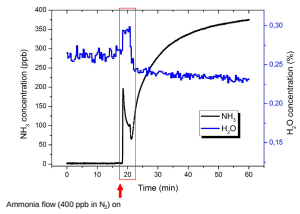
Ammonia (NH_3) is an important air constituent present at variable trace concentrations in the environment. Accurate quantification of the ammonia concentration is challenging due to the molecule's adsorption and desorption on the sampling and detection instrumentation. This induces a strong time-dependent bias on the measurement result The adsorption process depends heavily on the surface material and prevailing humidity level. Understanding these effects helps to improve the time-resolution and accuracy of the trace ammonia quantification.

In this study, cavity ring-down spectroscopy (CRDS) has been used to investigate the adsorption of dynamically diluted ammonia (concentration 400 part-per-billion) on coated and non-coated stainless steel surfaces in the presence of water from low part-per-million to percent levels. A commercial Picarro G2103 Ammonia Analyzer has been used to monitor the adsorption process in continuous-flow conditions in real time. So-called test tubes coated with different surface materials were used to quantify the adsorption.

Measurement

Measurement set-up

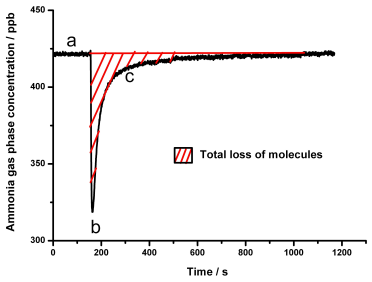




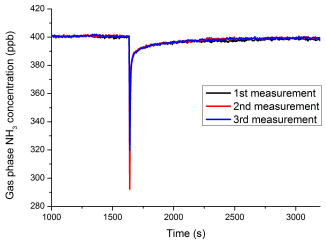
Interaction between NH_3 and H_2O during the exposure phase of the measurement protocol.

Measurement protocol

1) Test tube flushed with N_2 (containing H_2O)
2) Vacuum line and analyzer exposed to NH_3 via by-pass line
3) Time-resolved NH_3 adsorption quantified in 3 steps (a-c, see figure below):
   a) Gas flow via by-pass line
   b) Gas flow switched to pass via test tube
   c) Recovery of NH_3 signal



Measurement reproducibility

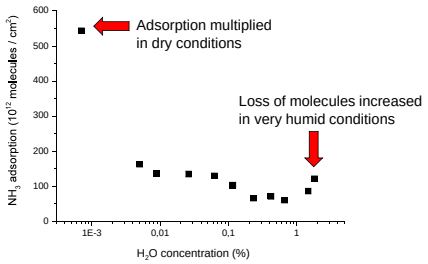


Measurement conditions

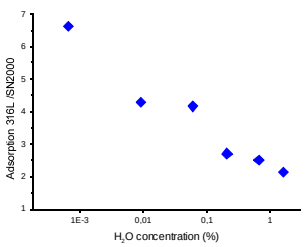
Variable	Value
Tube length (cm)	30-1000
Tube i.d. (mm)	4
Tube area (cm²)	38-1300
Pressure (mbar)	1015
Temperature (K)	295
Flow rate (ml/min)	1265
NH_3 concentration (ppb)	400
NH_3 concentration (ng/m³)	285
H_2O concentration (ppm)	4-18000
Coefficient of variation (%, N=36)	11

Results

Effect of water concentration

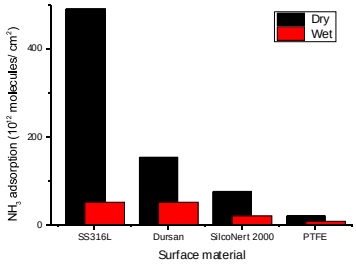


NH_3 adsorption on stainless steel 316L surface as a function H_2O concentration.

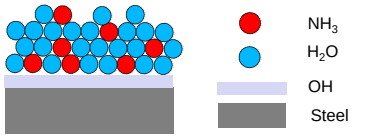


The ratio of NH_3 adsorption stainless steel 316L vs. SilcoNert 2000 as a function H_2O concentration.

Effect of surface material



NH_3 adsorption on different surface materials in dry and wet conditions.



NH_3 adsorption on different materials

Surface material	Adsorption dry* (10^{12}molec/cm²)	Adsorption wet** (10^{12}molec/cm²)
SS316L	492	52
Dursan (SilcoTek)	153	52
SilcoNert 2000 (SilcoTek)	78	22
Halocarbon wax	48	9
Teflon PTFE	21	8
PVDF	5	7

*Dry condition: H_2O concentration = 6 ppm

**Wet condition: H_2O concentration = 6400 ppm

Acknowledgements

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