Sampling lines for HCl

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In gas analysis often much effort and money are spent on the analytical instrument and the calibration gas mixtures. In contrast, sampling lines are often taken for granted while they can directly impact the time needed for analysis or even the analytical result, in particular when measuring at trace levels.

The MetAMC II project focusses on measurements methods and reference materials for hydrogen chloride (HCl). As HCl strongly interacts with many materials, a proper choice of all materials in contact with HCl is required. For this purpose, VSL conducted a short study on a selection of materials for their suitability for HCl analysis at low concentrations and under dry conditions. The tested tubing materials can be divided in 3 groups:

1) Polymer
2) Metal
3) Coated metal

HCl at an amount fraction of about 1 µmol/mol (i.e., 1 ppm) was dynamically prepared using mass flow controllers by diluting a HCl gas mixture in a cylinder with nitrogen at a total flow rate of 0.3 L/min. The mixture was directed to the analyzer (see Figure 1, panel A). For the HCl analysis a spectrometer based on optical feedback cavity enhanced absorption spectroscopy (OF-CEAS) from AP2E was used. After the measured concentration stabilized, the gas mixture was switched to the test tube (panel B). Due to adsorption of HCl on the test tubing the analyzed concentration will decrease temporarily. From this, the number of adsorbed HCl molecules can be determined. This number is normalized to the inner surface area so that tubings of different dimensions can be compared (more information on this method can be found in Vaittinen et al., 2018).

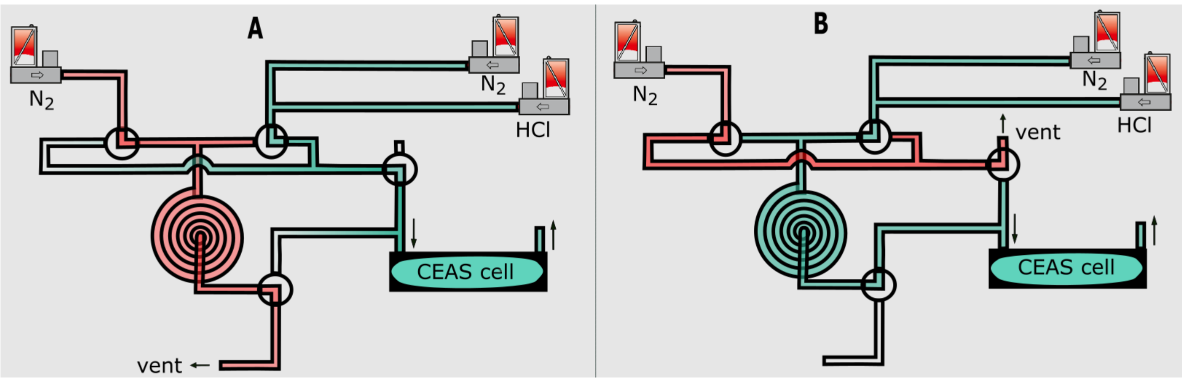

Figure 1 *Experimental set-up for testing the adsorption of HCl in sampling lines.* ***Panel A****: Initially, the mixture of HCl (—) is directly sent to the CEAS measurement cell. The sampling line under test is flushed with nitrogen (—).* ***Panel B****: After switching the electronic valves, the mixture of HCl is directed to the sampling line after which it is analysed in the CEAS measurement cell.*

An example of a typical experiment is shown in Figure 2. Here a stainless steel tubing (SS304) coated with Dursan (SilcoTek) was tested. From the analysed concentration, the adsorption profile can be determined (=input concentration minus analysed concentration). Integrating the latter curve yields the total loss in the tubing due to adsorption and reactions after applying a small correction needed for gas exchange as the tube was previously filled with nitrogen.

Uncoated metals (stainless steel and copper) turned out to show by far the highest losses. Coated stainless steel with various coatings from SilcoTek showed lower losses. Polymer tubings also exhibited low losses and in particular the polymers PVDF and TFE look promising for analyzing HCl under dry conditions.

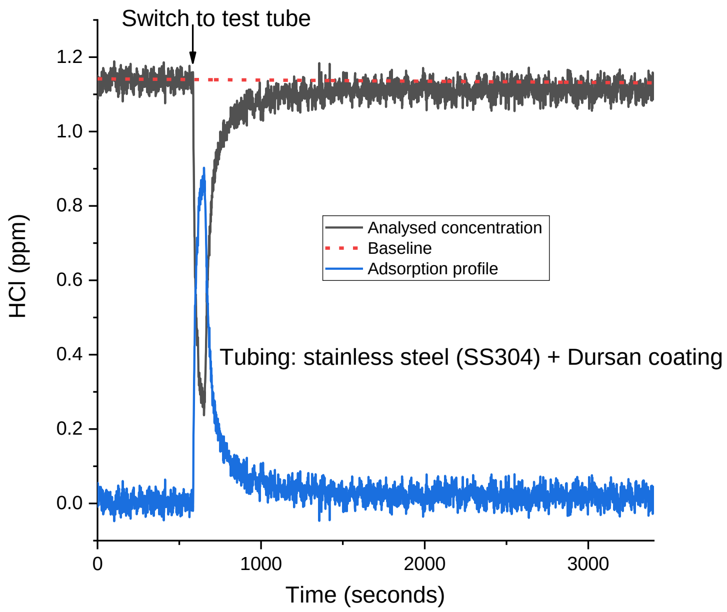

Figure 2 *Typical test result for a stainless steel tubing (SS304) coated with Dursan (SilcoTek) with a length of 15.24 m and an inner diameter of 0.21 cm. From the analysed concentration (—) the adsorption profile can be determined (—). Integrating the latter curve yields the total loss in the tubing due to adsorption and reactions.*

Another factor which can influence the adsorption of the analyte is the humidity level. Prior exposure of the tubing to humid air led typically to somewhat higher losses as compared to a tubing previously exposed to dry nitrogen.

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Reference

Vaittinen, O., Metsälä, M., Halonen, L., Persijn, S., Leuenberger, D., & Niederhauser, B. (2018). Effect of moisture on the adsorption of ammonia. *Applied Physics B*, *124*(9), 189.