Author: **Martin Sabo**

Low ppb detection of Hydrogen Chloride (HCl) and Hydrogen Fluoride (HF) by Advanced Ion Mobility Spectrometer - AIMS

The ion mobility spectrometry technique offers advantages like high sensitivity (ppb range), fast response (ms range), compact design, operation in atmospheric pressure and ability to separate the isomeric compounds. In this short report we demonstrate the sensitivity and fast response of IMS Hydrogen Chloride (HCl) and Hydrogen Fluoride (HF) species.

The HCl and HF are small molecules with molar mass 36.46 g/mol (HCl) and 20 g/mol (HF). HCl and HF chemicals are important compounds in pharmaceutical, polymer and petrochemical industry. This two chemicals are also important in semiconductor industry. In many semiconductor applications need to be presence of HCl and HF monitored at low ppb level.

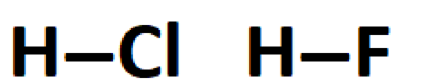

Figure1. HCl and HF

In this short Laboratory Report we demonstrate the ability of Ion Mobility Spectrometer operated in sub-atmospheric pressure for continuous monitoring of HCl and HF at low ppb level.

Experiment

The **Portable-Advanced Ion Mobility Spectrometer** (**PAIMS**) was used in this experiment. The operating parameters of **PAIMS** are listed in Table 1.

Working pressure	**900 mbar**
Working temperature	**65 ^{o}C**
Drift Gas	**Zero Air**
Drift gas flow	**1000 mL/min**
Drift field intensity	**570 V/cm**
Sample gas flow	**60 mL/min**
Polarity	**Negative**

*Table1. **PAIMS** working parameters*

The gas dilutor from *Molecular Analysis series 7800* was used in this work, for generation of low ppb concentrations of HCl and HF in zero air. The **PAIMS** operate in sub-atmospheric pressure and continuous sample sniffing was set to 60 mL/min. The sample inlet suck the atmospheric air. The air from the gas dilutor was sniffed to **PAIMS**.

Results and discussion

HCl

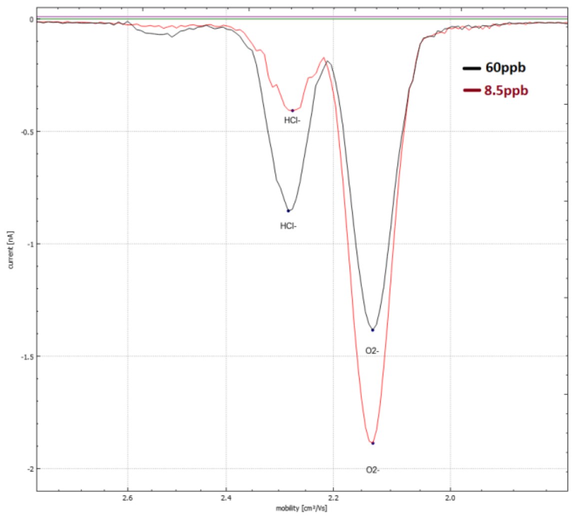

Figure 2. 8.5ppb and 60ppb HCl

The IMS response for 60 ppb of HCl is shown on figure 2 (black line). As we can see from this figure. The HCl results in formation of peak with reduced mobility *2.28* $cm^2.V^{-1}s^{-1}$. The smallest concentration that was gas dilutor able to generate was 8.5ppb. The red line on figure 2 represents IMS response for 8.5ppb of HCl. It is obvious from this figure that concentration 8.5ppb is not detection limit of **PAIMS**, but this value is our limit concentration generated gas diluter.

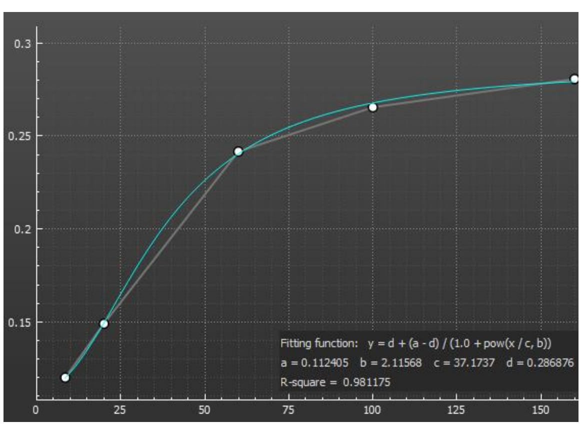

Figure 3. IMS response for different HCl concentration.

Figure 3 shows calibration plot of IMS response for 8.5, 20, 60, 100 and 160ppb of HCl. The MaSa**TECH** software allow calculation of peak **volume**, peak **area,** averaged peak **area** along the monitoring time as well like peak **intensity** and averaged peak **intensity** along the monitoring time. The averaged **HCl** peak **area** along the monitoring time was used in calculation. The *Logistic Fitting* with $R^2=0.981$ was chosen as an optimal for calculation. Considering 3x noise level we calculate **limit of detection for HCl** at value **1.5 ppb.**

HF

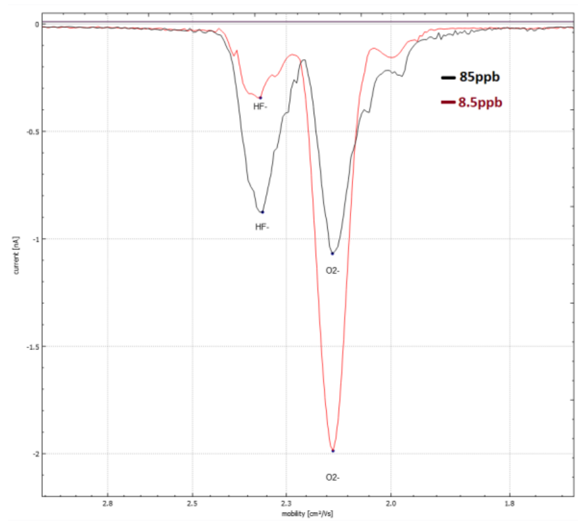

Figure 4. 8.5 ppb and 85 ppb of HF

The IMS response for 85 ppb of HF is shown on figure 4 (black line). As we can see from this figure The HF results in formation of peak with reduced mobility *2.32* $cm^2.V^{-1}s^{-1}$. The smallest concentration that was gas dilutor able to generate was 8.5ppb. The red line on figure 2 represents IMS response for 8.5ppb of HF. Like in the previous case it is obvious from this figure that concentration 8.5ppb is not detection limit of **PAIMS**, but this value is our limit concentration generated gas diluter.

Figure 5 shows calibration plot of IMS response for 8.5, 17, 85 and 120ppb of HF.

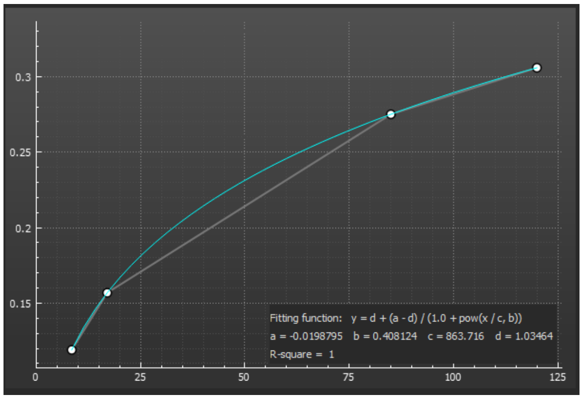

Figure 5. IMS response for different HF concentration.

The averaged **HF** peak **area** along the monitoring time was used in calculation. The *Logistic Fitting* with $R^2=1$ was chosen as an optimal for calculation. Considering 3x noise level we calculate **limit of detection for HF** at value **2 ppb.**

HCl & HF

The ability of **PAIMS** to distinguish between HCl & HF is shown on figure 6.

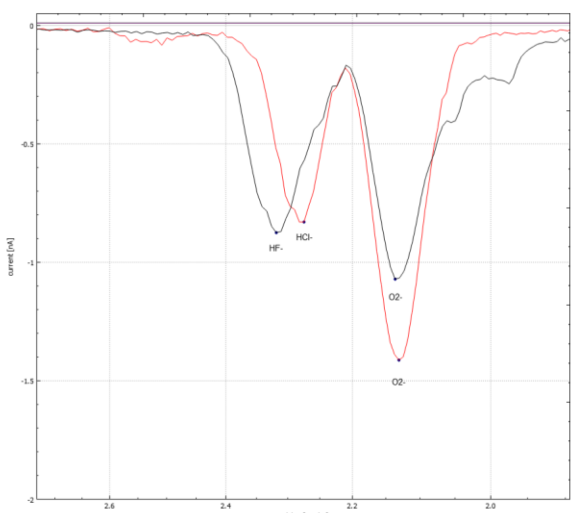

Figure 6. IMS response for HCl and HF

The HCl of 60 ppb was compared with 85ppb of HF. It is evident that this two compounds can be easily distinguished by **PAIMS**. We have to point out that separation power of our IMS can be improved by decreasing the length of shutter grid pulse. This can be easily made in our software. However the improvements of separation will results in decrease of sensitivity. On other hand it is possible to increase the sensitivity at the expense of resolving power of IMS. All this modifications can be easily made in MaSa**TECH** software and user can comfortably set optimal parameters for HCl and HF detection.

Conclusion

In this short laboratory report we demonstrate the ability of **PAIMS** to detect HCl and HF at low ppb concentration. The **LOD** for **HCl** was **1.5ppb** while the **LOD** of **HF** was **2ppb.** We also demonstrate easy recognition of this two compounds by out IMS. The Resolving power/sensitivity was also discussed. The decrease of resolving power will improve IMS sensitivity for this compounds so the LOD 1.5ppb do not have to be final.