Characterization of a Portable, Light-Weight, Low-Power Chemical Ionization Time-of-Flight Mass Spectrometer

Austin D. Dobrecevich[1,2], Felipe Lopez-Hilfiker[3], Chris J. Wright[2], Urs Rohner[3], Joel A. Thornton[2]

[1]Department of Chemistry, University of Washington, Seattle, 98195, USA
[2]Department of Atmospheric and Climate Science, University of Washington, Seattle, 98195, USA
[3]Tofwerk AG, Thun, 3645, Switzerland

Correspondence to: Joel A. Thornton (joelt@uw.edu)

AC: (Black)

RC2: (Orange)

This paper developed and characterized the performance of a Portable-ToF-CIMS. This new lightweight and low-power instrument has high sensitivities and acceptable mass resolving power, allowing its great use in a range of mobile or stationary platforms for characterizing ppt level of trace gases. The authors demonstrate the performance of this instrument through short-period field measurements. This paper has important implications in atmospheric chemistry and air quality studies and therefore well within the scope of AMT. It can be recommended for publication after addressing the following comments.

Specific comments:

Lines 112-115: Can the authors provide more details on how calibration was performed, e.g., the number of data points? It looks to me that six different levels of standard gases were measured (Fig. 2a) while only four data points were used to generate the calibration curve (Fig. 2b). How would the calibration curve change if all data were included?

This calibration was performed using the four concentration steps as shown in Fig. 2b. At higher concentrations significant reagent ion titration is observed from our multi-component gas standard with nominal concentration of 1 ppbv. We have revised the figure to include the independently measured isotopes to extend the number of data points in our linearity figure and added the timeseries of the calibration experiment to the SI for clarity.

Line 133-135: How long would it take to power on the instrument and get a stable reagent ion signal?

Starting from a powered off state, the instrument takes about 15-20 minutes to acquisition startup. Establishing high vacuum in the TOF analyzer is relatively fast due to the much smaller analyzer volume. Ensuring the instrument is kept under vacuum when it is powered off, or it is filled with dry nitrogen helps ensure a fast startup time. The permeation tube also requires about 15-20 minutes to reach a stable operation temperature if starting from a typical room temperature of ~20 C. Our experience is that even in a non-ideal scenario a maximum startup time of about 30 minutes is routinely achievable. With vacuum established, voltages set and measuring is < 1 minute from off.

Line 166-167: The correlation coefficient of the fit should be given.
This addition has been made to the manuscript.

Line 201-202: The authors stated that "The dynamic range (<1 pptv to > 1 ppbv), ppt-level precision and low detection limits of the instrument are evident.". However, only normalized signals were shown in Fig. 5. The mixing ratios of these key pollutants should be provided.

Our approach has been to display ncps on the figures in the paper and then calculate expected sensitivities based on other studies and the calibrations that we did in our experiments. See below, in the paper and in the SI for more information.

Table S2: Measured and Calculated Analyte Sensitivities of the AIM reactor in $[I]^-$ mode. These sensitivities were reported in the literature for the AIM IMR operated at 50 mbar(Aggarwal et al., 2025; Riva et al., 2024; Wang et al., 2026). The AIM inlet in our experiments for the Portable-TOF-CIMS was operated at 100 mbar. A sensitivity in [I]- mode was experimentally determined for formic acid (CHOOH) and is shown in the table below as 8.4 ncps/pptv and is bolded. Using the ratio of this as the lower bound and the collision limited sensitivity as the upper bound we calculated the sensitivities of the AIM operated at 100 mbar for the other species we detected in these experiments.

Analyte	**Reported Sensitivity @50 mbar (ncps/pptv)**	**Calculated Sensitivity @100 mbar (ncps/pptv)**
HONO	6.5	22.0
HNO3	15.0	30.0
C2H4O2	1.0	3.4
HCOOH	**2.5**	**8.4**
C6H10O5	15.0	30.0
C5H10O3	15.0	30.0

Line 202-205: The morning peak of HONO started increasing at around 3 am. Is this due to automobile traffic or ground elements? Is the signal in Fig. 5b in units of ncps or pptv? If it is pptv, the HONO mixing ratio at noon time is high. Is this consistent with previous studies?

Thank you for pointing this out; the HONO is in ncps, and is now in a much more reasonable range in terms of mixing ratio.

Line 211-213: The maximum mixing ratio of HONO can reach 10 ppbv. It seems like a high value. What is the typical concentration of NOx in this area?

I believe this is addressed above by fixing the label for the HONO diurnal plot. Using transferred sensitivity for HONO, we found the mixing ratio maxima reaches a more reasonable value.

Line 224-227: Did C6H10O5 correlate with acetonitrile, another typical tracer of biomass burning? Mixing ratios should be given in Fig. 6, just like what the authors did for Fig. S1.

Acetonitrile can form a weak adduct with iodide but is typically better measured in positive ion mode. We used the collision limited rate for the quantification of Levoglucosan following Lopez-Hilfiker et al. (2016).

Line 236-238: Are there any other VOCs emitted from grilling detected, e.g., alkanals (Klein et al., 2016)?

We did not analyze these as the main goal of this paper was to simply assess portability and stability of the instrument.

Technical comments:

Line 16: Iodide and Benzene should be in lowercase.

These corrections have been addressed in the manuscript.

Line 41: Spell out the full term of VOC and VCP. Check out the whole manuscript for similar issues.

These changes have been addressed in the manuscript.

RC2 References:

Klein, F., Platt, S.M., Farren, N.J., Detournay, A., Bruns, E.A., Bozzetti, C., Daellenbach, K.R., Kilic, D., Kumar, N.K., Pieber, S.M., Slowik, J.G., Temime-Roussel, B., Marchand, N., Hamilton, J.F., Baltensperger, U., Prévôt, A.S.H., El Haddad, I., 2016. Characterization of Gas-Phase Organics Using Proton Transfer Reaction Time-of-Flight Mass Spectrometry: Cooking Emissions. Environ. Sci. Technol. 50, 1243-1250.

Author References:

Aggarwal, S., Bansal, P., Wang, Y., Jorga, S., Macgregor, G., Rohner, U., Bannan, T., Salter, M., Zieger, P., Mohr, C., and Lopez-Hilfiker, F.: Identifying key parameters that affect sensitivity of flow tube chemical ionization mass spectrometers, https://doi.org/10.5194/egusphere-2025-696, 6 March 2025.

Lopez-Hilfiker, F. D., Iyer, S., Mohr, C., Lee, B. H., D'Ambro, E. L., Kurtén, T., and Thornton, J. A.: Constraining the sensitivity of iodide adduct chemical ionization mass spectrometry to multifunctional organic molecules using the collision limit and thermodynamic stability of iodide ion adducts, Atmospheric Meas. Tech., 9, 1505–1512, https://doi.org/10.5194/amt-9-1505-2016, 2016.

Riva, M., Pospisilova, V., Frege, C., Perrier, S., Bansal, P., Jorga, S., Sturm, P., Thornton, J. A., Rohner, U., and Lopez-Hilfiker, F.: Evaluation of a reduced-pressure chemical ion reactor utilizing adduct ionization for the detection of gaseous organic and inorganic species, Atmospheric Meas. Tech., 17, 5887–5901, https://doi.org/10.5194/amt-17-5887-2024, 2024.

Wang, Y., Voliotis, A., Matthews, E., Wu, R., Roska, M., Adam, M. G., Dubus, R., Kesper, L., Rohrer, F., Wegener, R., Winter, B., Bates, K. H., He, Q., Hohaus, T., Grasse, A., Tillmann, R., Wahner, A., Wang, H., Wesolek, C., Wedel, S., Wu, Y., Zorn, S. R., Canagaratna, M., Worsnop, D., Lopez-Hilfiker, F., Gkatzelis, G. I., Coe, H., and Bannan, T. J.: Voltage Scanning to Calibrate Multi-Reagent Chemical Ionization Mass Spectrometers (MR-CIMS): From Signal to Sensitivity, https://doi.org/10.5194/egusphere-2025-6102, 19 January 2026.