Automated mobile indoor measurements using the Vocus CI-TOF

Adrian Müller, Simon Werren, Carla Frege, Felipe Lopez

The emergence and utilization of autonomous mobile robots has brought about a profound transformation across diverse industries. These robots, equipped with cutting-edge technologies and intelligent capabilities, autonomously navigate indoor environments, collect data, and execute monitoring tasks. Whether deployed in warehouses, hospitals, office buildings, cleanrooms, or other indoor spaces, these self-governing mobile robots provide an efficient and effective solution for surveillance and monitoring applications. In scenarios where extensive monitoring coverage is required, manifold systems are often employed, involving lengthy lines that can result in data losses or misinterpretation due to the interactions between the compounds being monitored and the sampling line, particularly in the case of inorganic acids such as HF, HCl, HNO3, and larger functionalized organic molecules. Hence, employing mobile measurements frequently leads to more precise temporal and spatial data collection.

In this proof-of-concept, a Vocus airborne molecular contamination (AMC) monitor was combined with a commercially available automated mobile robot (MiR 250). As shown in Figure 1, the entire setup was relatively compact (680 x 850 x 1550 mm), enabling easy navigation in commercial building corridors. The system included a powerful battery and a small gas cylinder which made it possible to run the system autonomously for more than one hour on a standard UPS before recharging. Furthermore, the system also included a catalyst and VOC trap system to capture any residual exhaust from the monitor.
Figure 1. (Left) CAD model of the system with dimensions. (Right) Photo of the proof-of-concept setup.

After mapping the building, the robot was programmed with a predefined track allowing a high repeatability for monitoring tasks. While looping this preset lap, trace contamination sources were introduced at specific locations. Figure 2 shows an example where a closed bottle of methyl ethyl ketone (MEK) was placed on the floor in [spot 1]. The concentration peak is clearly visible whenever the AMR approaches area. Later [in lap 5] a closed bottle of propylene glycol methyl ether acetate (PGMEA) was placed next to the MEK bottle. These two molecules are often difficult to distinguish with other analytical methods due to fragmentation but are clearly distinct with Vocus AMC monitor due to ultra-soft ionization. Furthermore, the presence of people walking next to the monitor is clearly traced with the signal of lactic acid.

Figure 2a. Map of the building and the monitored concentrations of MEK as the automated mobile monitor moved along the corridor.
Figure 2b. Map of the building and the monitored concentrations of Nitric acid as the automated mobile monitor moved along the corridor.

Figure 2c. Time series of selected molecules; lactic acid (marker for human presence), MEK, nitric acid and PGMEA.

Autonomous sampling with the Vocus AMC monitor offers a significant advantage when the monitor traverses the space: it enables easy and precise measurement of sticky compounds that are notoriously challenging to assess using lengthy inlet lines. Nitric acid, for instance, poses a substantial measurement difficulty when quantitatively assessed through long inlets. However, by employing a mobile monitor, nitric acid measurements become effortlessly achievable. Figure 2b illustrates a time series of nitric acid diffusing from a diluted diffusion source, displaying exceptional time response as the robot navigates across various regions.

This proof-of-concept demonstrates the application of autonomous mobile measurements using the Vocus AMC monitor. The concept can be further
developed into a fully integrated solution providing increased battery capacity, autonomous gas management, and a cleanroom rated system fulfilling the needs of unique industrial applications. The Vocus instrument platform can be easily adapted to a variety of mobile robots.

Automated monitoring robots have proven to be extremely useful tools. Their integration with indoor air quality monitoring is particularly promising in numerous applications. By leveraging autonomous indoor navigation and ultra-sensitive monitoring instruments, AMC measurements can be performed over larger areas and identify the exact location of contamination sources.

Contact
vocus.info@tofwerk.com
©2023 TOFWERK