High-Throughput Analysis of VOCs From Electronic Waste Emissions

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Electronic waste (e-waste) has received considerable attention from regulatory agencies in the last decade. E-waste contains both metallic and non-metallic elements, which may pose a threat to human health and the environment during production, usage, and recycling. The outgassing of volatile and semi-volatile organic compounds (VOCs and SVOCs) from the electronic materials can introduce impurities within a clean production facility and lead to contamination of air and water during disposal.

Directly emitted brominated flame retardants (BFRs), polychlorinated biphenyls (PCBs), silicone adhesives and dissociated by-products are the primary compounds of interest. BFRs and PCBs are persistent, bioaccumulative, and toxic to both humans and the environment. The use of certain BFRs is banned or restricted in the US and EU, however some are still used in plastic manufacturing in China. Further, new chemically similar classes of compounds have appeared on the market with limited information about their toxicity.

Most methods for measuring material outgassing involve complex and time-consuming sample preparation followed by GC-MS analysis. TOFWERK Vocus PTR-TOF can simultaneously detect a wide range of VOCs in real time. By coupling a high-throughput headspace autosampler, automated analysis of hundreds of samples within one day is achievable.

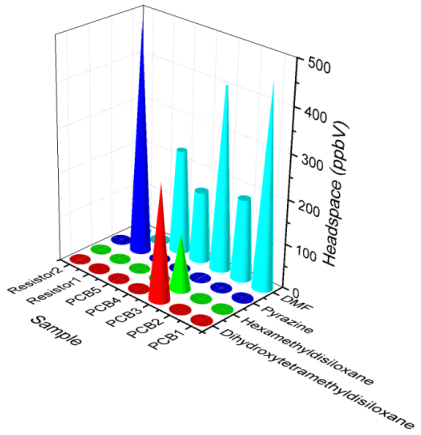

Figure 1 *Four selected substances emitted by PCBs and resistors taken from disposed electronics. Dimethylformamide is listed as the dominating specie from PCB samples. The PCB piece which was coated with silicone layer can be clearly differentiated.*

In this work, several pieces of printed circuit boards and resistors were taken from disposed electronical devices. Each sample was placed in a sealed vial and kept at 65 °C. The headspace from individual electronic pieces was measured directly via Vocus PTR-TOF.

Figure 1 shows the major emitted substances from five printed circuit boards and two resistors. High concentrations of dimethylformamide (DMF) was observed in all five samples. Being potentially teratogenic and carcinogenic, this observation is important in occupational health environments where printed circuit boards can be heated up to 40-50 °C during normal computer operations.

Sample 3, which is shown in Figure 2, is characterized by silicone signals that are attributed to the insulating silicone coating (intentionally removed from the board prior to analysis). One resistor sample emits high levels of pyrazine whose source remains unknown.

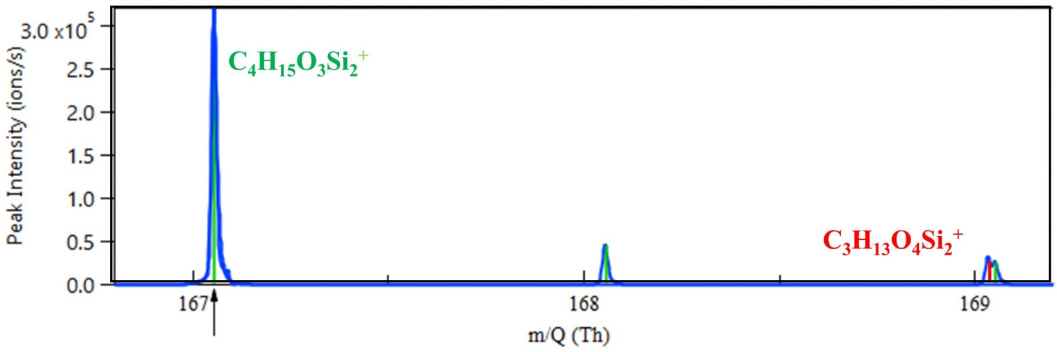

Figure 2. *Headspace mass spectra acquired from sample 3. The peak identification as Dihydroxytetramethyldisiloxane was both confirmed by exact mass and characteristic ^{29}Si and ^{30}Si isotopic pattern (illustrated as green sticks). Due to the high resolving power of Vocus PTR-TOF, another organic silicon compound was clearly identified at the m/Q 169.*

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