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# Characterization of Volatile Organic Compounds (VOCs) in the emissions of railway braking system: exploratory study at reduced scale

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## INTRODUCTION

Air quality is a major public health issue over the world. Many studies have evidenced poor air quality in confined railway stations with major concerns about particles from non-exhaust emissions. In addition to particles, **Volatile Organic Compound** (VOC) emissions are also expected to worsen air quality although much less investigations have been carried out. Methods are available for the determination of VOCs, both directly with online monitors and off-line, back to the laboratory after sample collection. However, online techniques have certain limitations as they can only analyze a limited range of compounds. Therefore, for our analysis, off-line measurements have been selected.

## METHOD

A **cast iron brake disc** was tested in a reduced scale brake dynamometer against an **organic brake pad**. Sampling of air was performed before and after the tribometer chamber as illustrated in Fig. 1. Since we focus on the presence of volatile and semi-volatile organic compound, we took special care to use a high-purity flushing gas. To collect these compounds, a sampling method was employed using **Tenax** tubes at a flow rate of 1 L/min for a duration of 80 min allowing for approximately 100 brake events to be performed. Afterwards, the collected air samples were analyzed in the lab using thermal desorption-gas chromatography/mass spectrometry/flame ionization detector (**TD-GC/MS/FID**, Fig. 2).

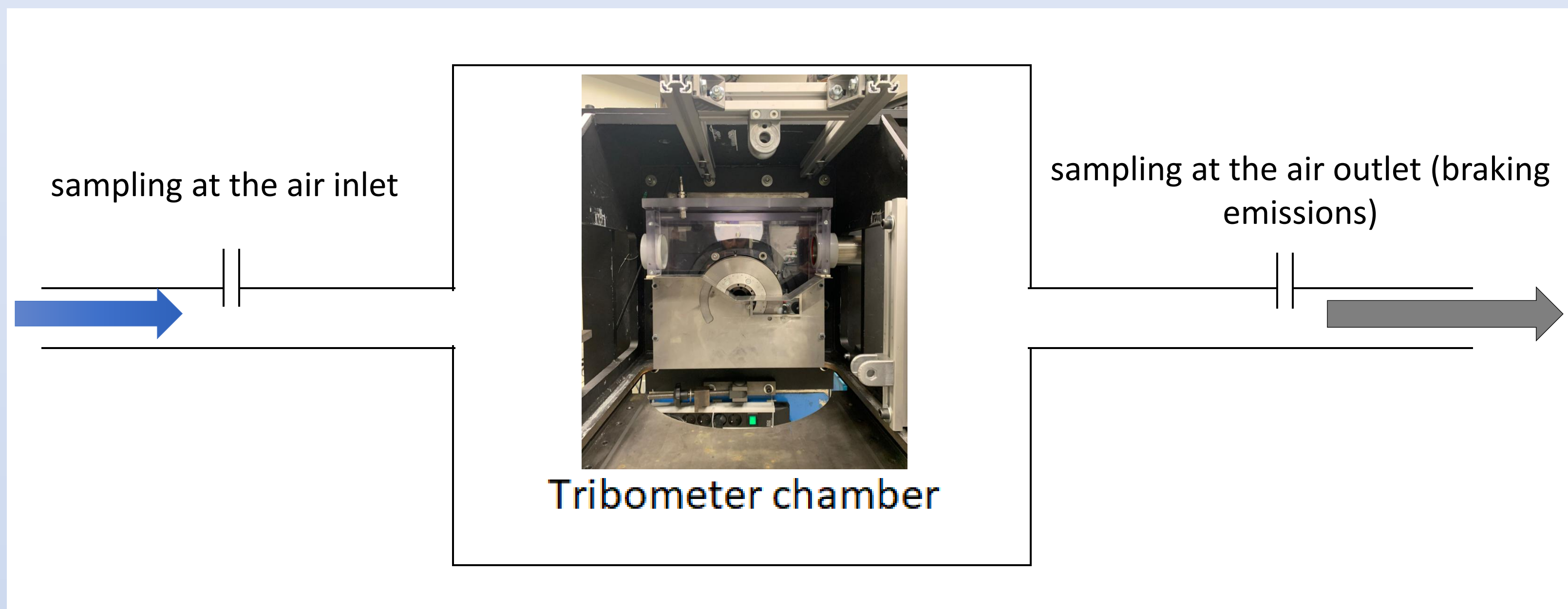


Fig.1: Scheme of the experimental setup with the positions of the VOC samplings

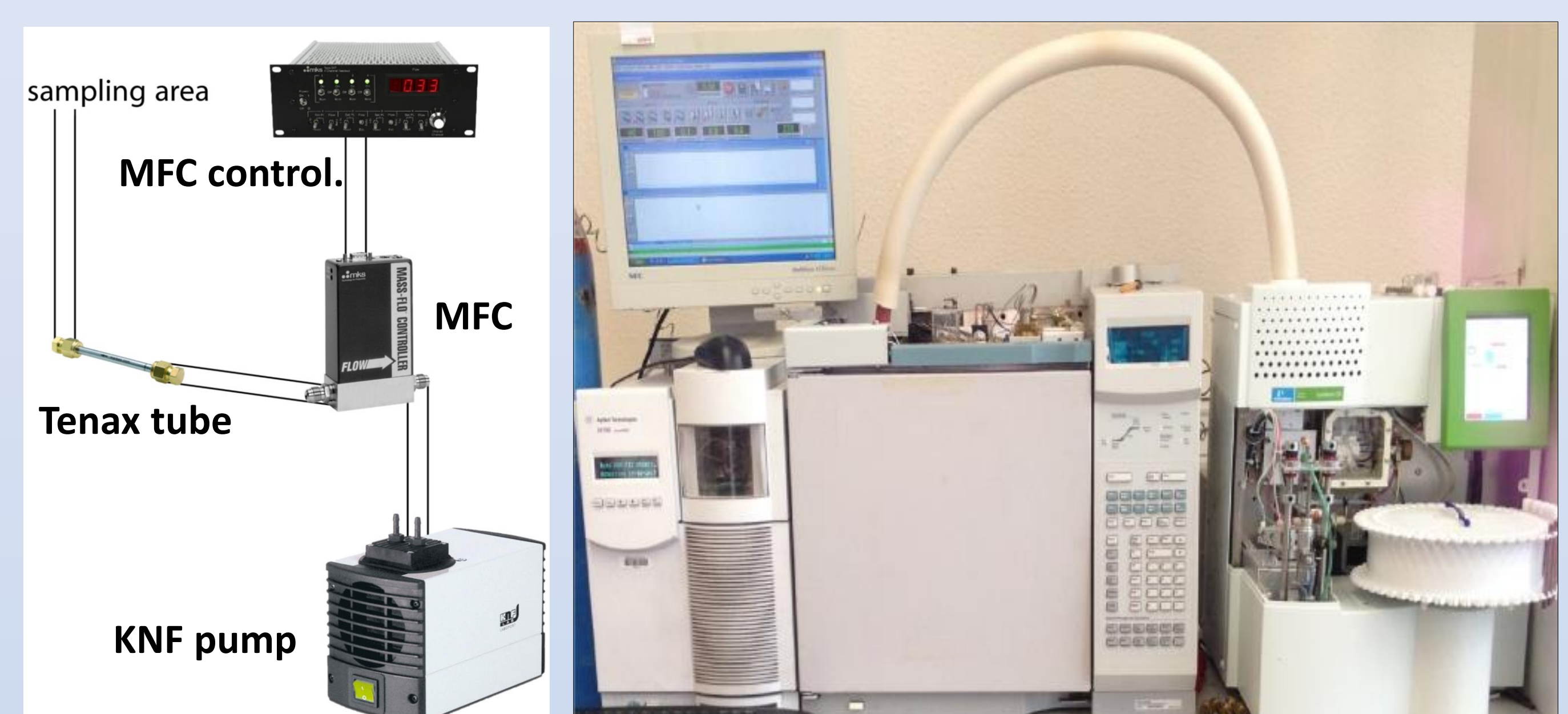


Fig. 2: Setup for VOC sampling using a Tenax cartridge for adsorption, flow controller with an MFC and pump, and analysis by TD-GC/MS/FID

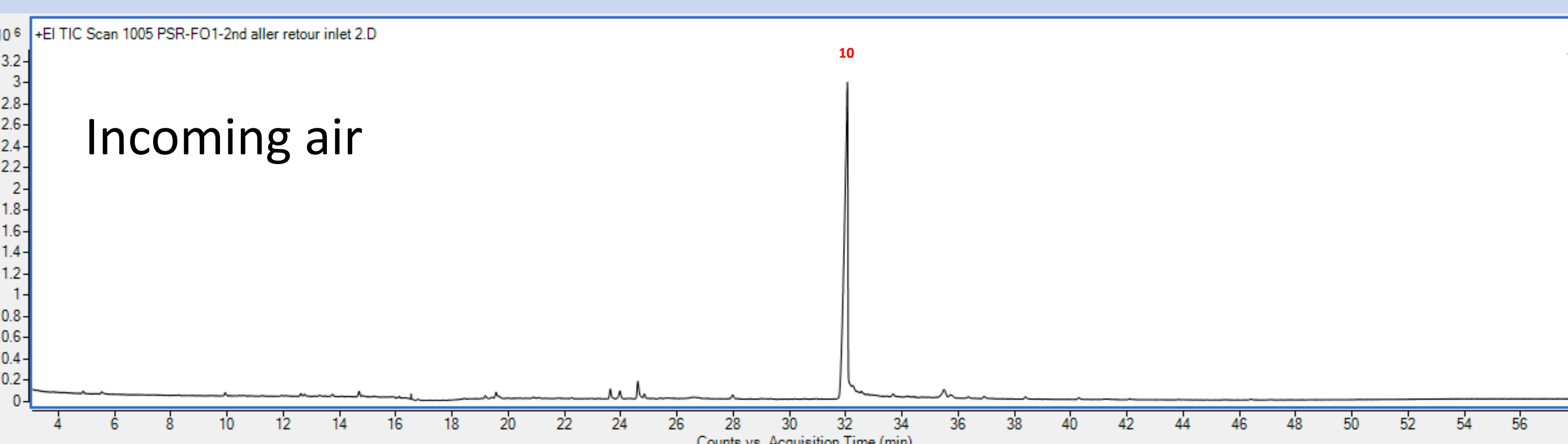


Fig.3: Typical chromatogram of the air entering the tribometer chamber

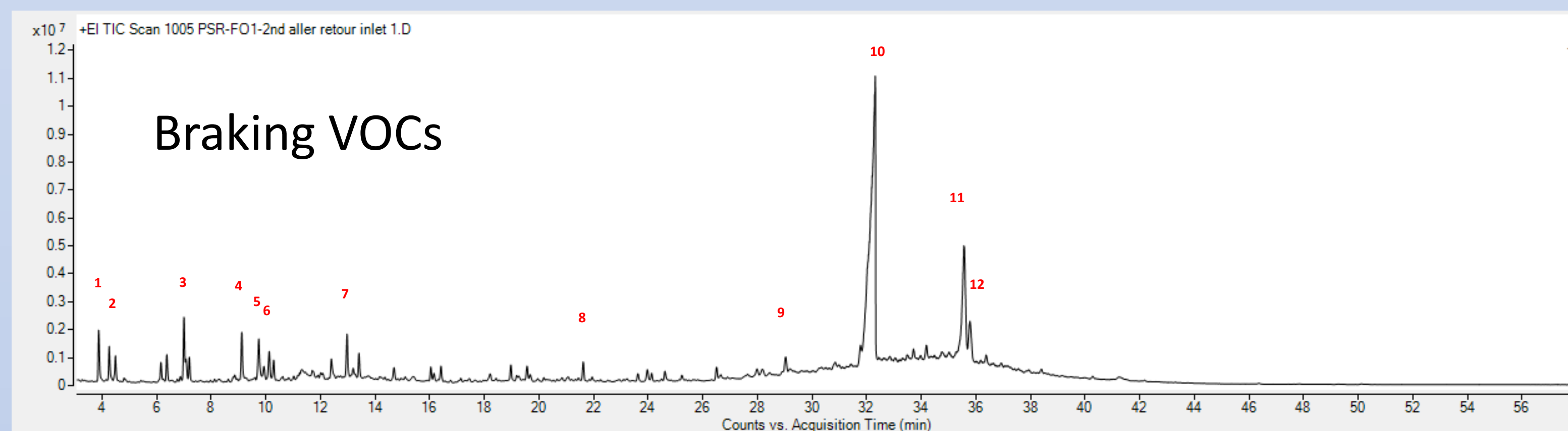


Fig.4: Typical chromatogram of the air exiting the tribometer chamber (~100 brake events)

Table 1: Volatile Organic Compounds identified in the braking emissions

	Retention time (min)	Name (probability %)	Structure	Area (x10 <sup>6</sup> )	
				Inlet	Outlet
1	3.90	Toluene (100%)	<chem>Cc1ccccc1</chem>	-	4.48
2	4.29	1-Octene (27 %)	<chem>CCCCCCCC=C</chem>	-	3.41
3	7.02	Bicyclo[4.2.0]octa-1,3,5-triene (35 %)	<chem>C1=CC2=CC1C=C2</chem>	-	7.0
4	9.14	Benzaldehyde (100%)	<chem>O=Cc1ccccc1</chem>	-	6.24
5	9.76	Phenol (100%)	<chem>Oc1ccccc1</chem>	-	6.9
6	10.14	Decane (32 %)	<chem>CCCCCCCCCC</chem>	-	3.36
7	12.99	Benzenemethanol, α,α-dimethyl- (54 %)	<chem>Cc1ccc(CO)cc1</chem>	-	5.98
8	21.63	Tetradecane (30 %)	<chem>CCCCCCCCCCCC</chem>	-	3.38
9	29.04	Heptadecane (14 %)	<chem>CCCCCCCCCCCCC</chem>	-	3.62
10	32.06	Benzenesulfonamide, N-butyl- (86 %)	<chem>CCCCNS(=O)(=O)c1ccccc1</chem>	26.8	97.3
11	35.58	Butane, 1,2,3,4-tetrachloro-1,1,2,3,4,4-hexafluoro- (32%)	<chem>ClC(Cl)(F)C(Cl)(F)C(Cl)(F)C(Cl)(F)C</chem>	-	10.1
12	35.79	Butane, 1,1,3,4-tetrachloro-1,2,2,3,4,4-hexafluoro- (61%)	<chem>ClC(F)(Cl)C(F)(Cl)C(F)(Cl)C</chem>	-	3.94

## CONCLUSIONS AND PERSPECTIVES

- The experimental set-up has yielded satisfactory results. Upon analyzing the chromatograms obtained before and after the tribometer chamber, it has been observed that the number of VOCs increases following braking events. The post-braking chromatograms predominantly show the presence of **aliphatic hydrocarbons** (ranging from C6 to C17), mono cyclic **aromatics** with various substituents including oxygen, nitrogen, and sulfur. **Aldehydes** and **alcohols** have also been detected.
- The presence of **benzaldehyde** can potentially originate from the resins present in the brake pad binders. **Phenol**, on the other hand, may originate from the organic pad used in braking systems. However, it is also possible for phenol to be formed through the oxidation of aromatic compounds like benzene or toluene when the pad undergoes heating during braking events.
- To determine concentrations, calibration using commercially available compounds has to be performed. Future experiments have to be pursued to further investigate the emissions of these various compounds under varying braking conditions.

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