

D. Bhattu¹, G. Stefenelli¹, P. Zotter², J. Zhou¹, T. Nussbaumer², A. Bertrand³, N. Marchand³, B. Temime-Roussel³, U. Baltensperger¹, J. G. Slowik¹, A. S. H. Prévôt¹, I. El-Haddad¹ and J. Dommen¹

¹Laboratory of Atmospheric Chemistry (LAC), Paul Scherrer Institute (PSI), CH-5232 Villigen PSI

²Bioenergy Research Group, Lucerne University of Applied Sciences (LUAS), CH-6048 Horw

³Aix Marseille Univ, CNRS, LCE Marseille, France

Email: deepika.bhattu@psi.ch

1 Introduction

- Residential wood combustion has been assessed to be one of the major source of particulate emission and gaseous pollutants, as well as an important contributor to adverse health and environmental effects (Schauer et al., 2001).
- Quantification of net secondary organic aerosol (SOA) formation and aging from residential wood burning remains unconstrained due to large variabilities in the fuel used, combustion devices and burning conditions (Alfarra et al., 2007).
- Models suggest a “missing large source of SOA precursors” that remained unexplained by including traditional SOA precursors and measured aerosol yields.
- Recently, inclusion of 22 non-traditional non-methane volatile organic compounds (NMVOCs) has been able to explain a large fraction (~84-116%) of the SOA formed (Bruns et al., 2016).

2 Objectives

- To quantify the emissions from wood combustion using different combustion technologies operated under varying conditions and their potential differences.
- To investigate the effect of different operating parameters such as high excess or lack of oxygen, different loads and combustion phases on relative contribution of primary particle and gas phase precursor species.
- To assess the SOA forming potential (SOAP) of the identified precursors under simulated photochemical aging conditions.

3 Methodology and Experimental Setup

On-line chemical characterization of the primary gas and particle phase emissions from beech wood logs, beech wood chips and pellets using seven types of combustion devices is performed.

- Pellet boiler (15 kW) with advanced combustion technology at different combustion conditions: optimum, lack and high excess of oxygen,
- Two-stage combustion logwood boiler (30 kW),
- An industrial wood chip grate boiler (150 kW) at full and part load operation (100% and 30% load) with electrostatic precipitator,
- Pellet stove with standard combustion technology (varying heat output: 2-6 kW),
- Single-stage combustion log wood stove (6 kW),
- Two-stage combustion log wood stove (4.6 kW),
- Two-stage combustion log wood stove (8 kW).

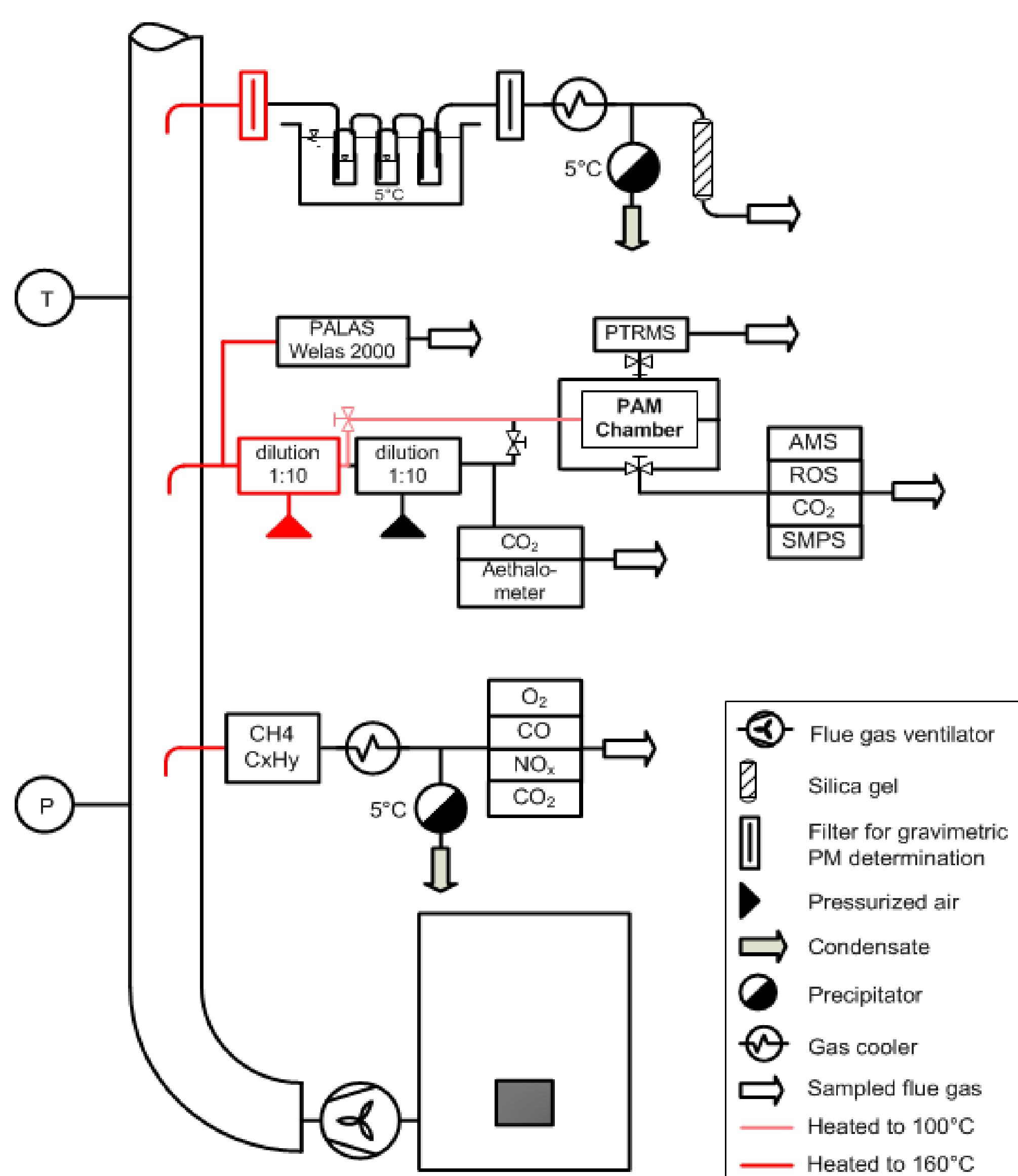


Figure 1: Schematic of the experimental setup.

4 Results and Discussion

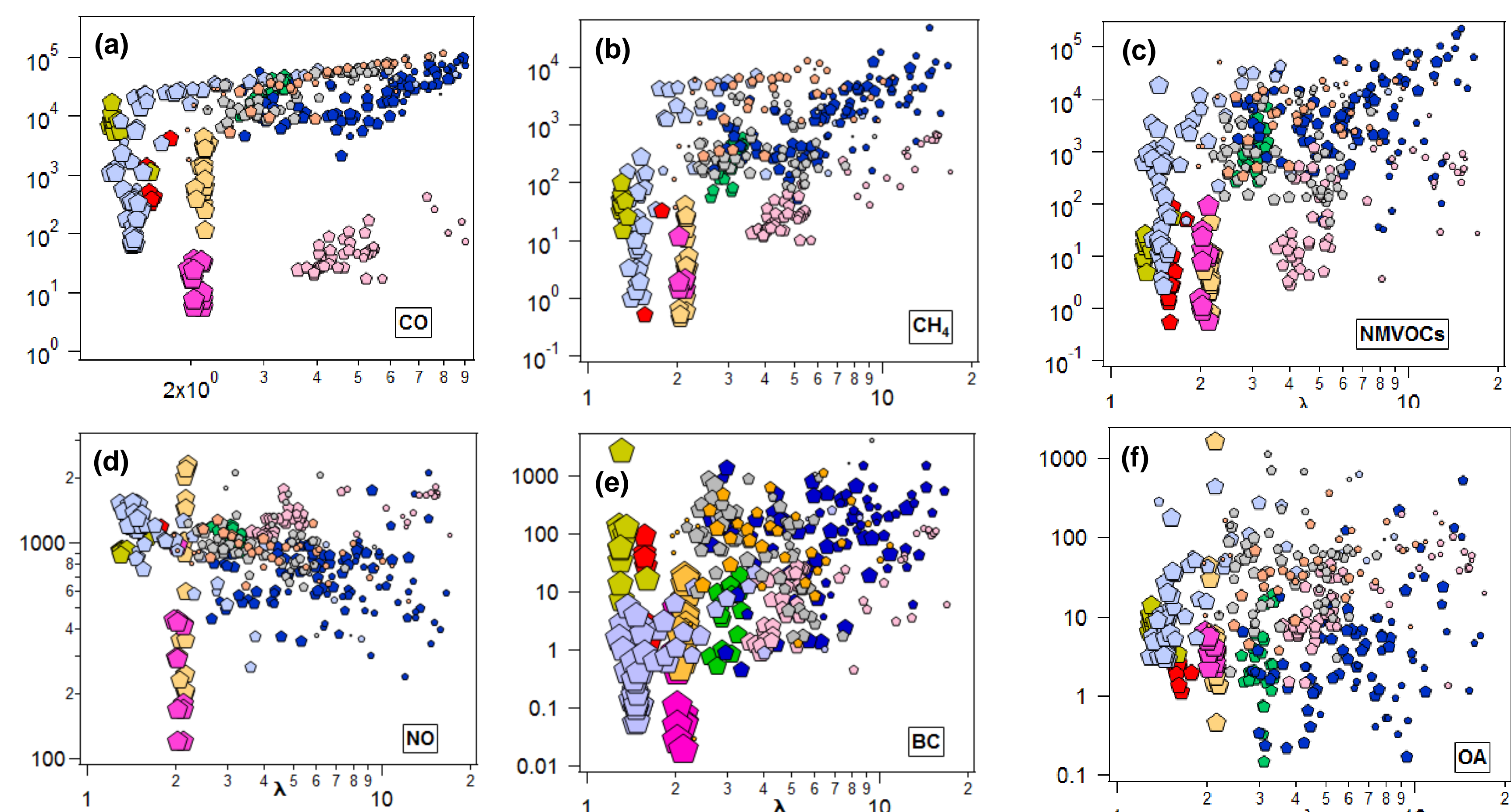


Figure 2: (a-f) Combustion phase averaged gas (CO, CH₄, NMVOCs (PTR-ToF-MS), NO) and particle (BC and OA) phase emission factors (EF, mg kg⁻¹ of wood) for seven residential heating combustion devices demonstrating inter- and intra-burn variability (marker size is the combustion chamber temperature). (g) Comparison of total NMVOCs detected by PTR-ToF-MS and flame ionization detector (FID).

CO, CH₄, BC and NMVOCs emissions amongst each device increased with increasing λ , part load conditions and decreased with temperature, whereas NO emissions decreased.

NMVOCs EF from PTR-ToF-MS and FID are comparable within one order of magnitude depending on the combustion phase. The difference is due to the lower sensitivity of PTR-ToF-MS to alkanes (C<8) and decrease in FID response per carbon atom for highly oxygenated molecules and for the ones with other heteroatoms.

Wood pellet operated devices (1 and 4) had highest NO emissions followed by wood logs (2, 5, 6 and 7) and chips (3).

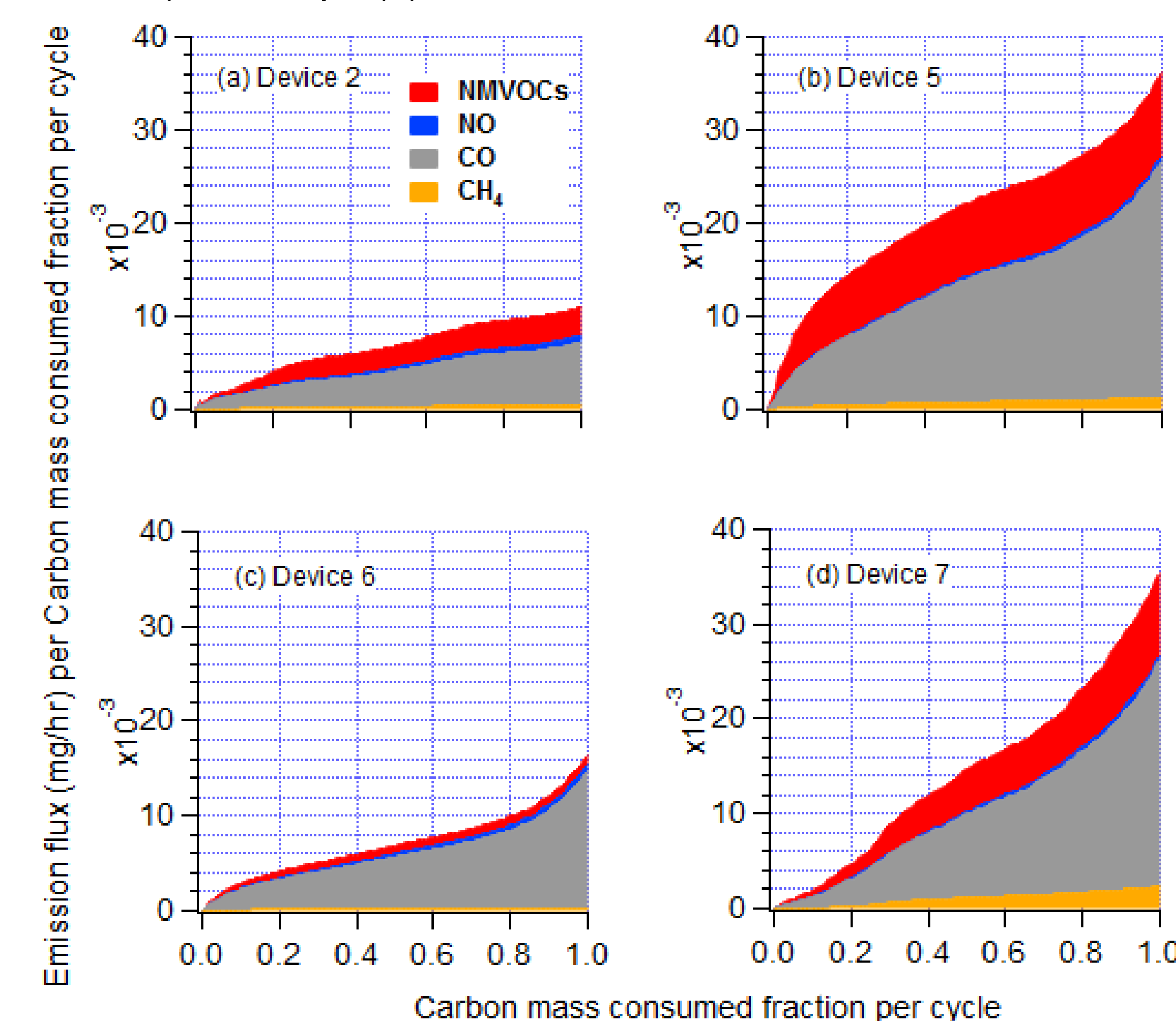


Figure 3: Averaged emission fluxes (mg/hr) of gas phase species emitted per carbon mass consumed fraction for different batch (2, 5 and 6) and semi-continuously (7) operated combustion devices.

Overall, the dependence of chemical composition on both combustion phase and technology has been also observed.

Further, we also aim to investigate the SOA formation potential of the precursors for all the tested devices to ascertain the contribution of residential wood burning to the total carbonaceous OA budget.

For more information please also see poster no. 78.

Figure 3b and 3d show highest total emissions from log wood stoves (device 5 and 7).

Contrary to device 7 (semi-continuously fed), device 5 has prominent NMVOCs emitted in the cold start/reload phase i.e. at low C mass consumption of each burn cycle in device 5.

CO is continuously increasing as the burn progresses for all devices. It increases with the C mass consumed fraction, due to incomplete combustion of volatiles and char in the flaming phase and burn out phase, respectively.

Two stage combustion technologies (device 2, 6 and 7) have low emissions in cold start/reload phase compared to Old technology (device 5).

References:

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Acknowledgements:

- Swiss National Science Foundation (NRP 70 “Energy Turnaround”;