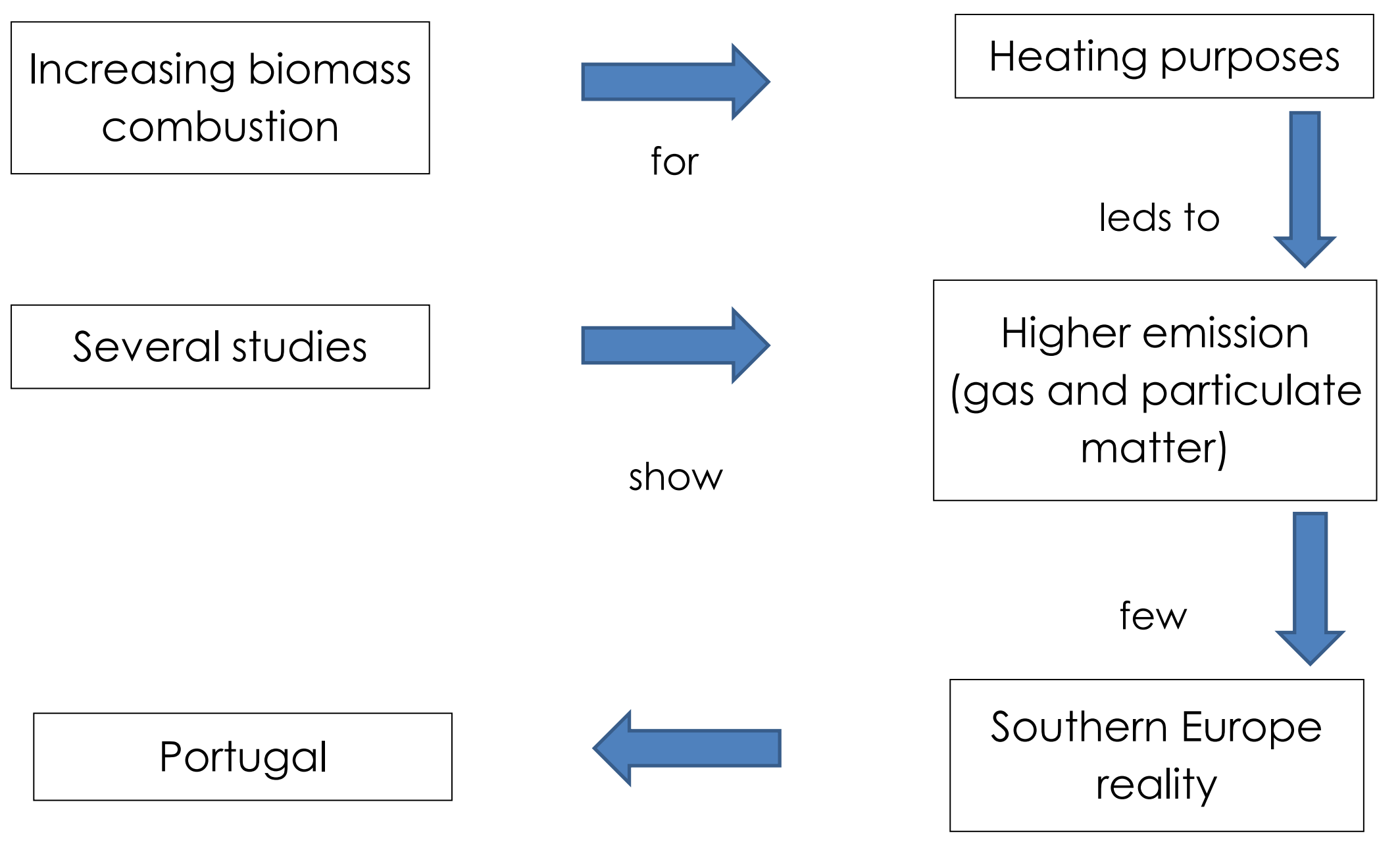
Residential wood combustion: links between ion content, organic and elemental carbon and aerosol size distributions

M. Duarte[1], A.I. Calvo[2], T. Nunes[1], L. Tarelho1, R. Fraile[2], A. Castro[2] and C. Alves[1]
[1] Centre for Environmental and Marine Studies (CESAM), Department of Environment and Planning,
University of Aveiro, Aveiro, 3810-193, Portugal
[2] Department of Physics, IMARENAB University of León, 24071 León, Spain
aicalg@unileon.es

1 INTRODUCTION

Biomass consumption for heating purposes in small scale appliances has been increasing in the last decade. However if not controlled, the emissions from biomass burning can cause problems on the air quality.



Increasing biomass combustion → for → Heating purposes → leds to → Higher emission (gas and particulate matter)

Several studies → show → Higher emission (gas and particulate matter) → few → Southern Europe reality → Portugal

Experiments were conducted in a woodstove and a fireplace, with three types of fuel, pine, eucalypt and cork oak.
Particle emission and composition and aerosol size distribution were studied.

2 FUEL CHARACTERISTICS

Table 1 – Chemical composition of the fuels.

	Pine	Eucalypt	Cork oak
Proximate analysis (%wt, wet basis)			
• Moisture	9.65	9.98	8.22
Ultimate analysis (%wt, dry basis)			
• Ash	0.46	0.25	2.14
• C	51.4	48.6	51.6
• H	6.20	6.20	6.03
• N	0.16	0.16	0.18
• S	*bdl	*bdl	*bdl
• O (by difference)	41.8	44.8	40.0

Bdl – below detection limit

Wood logs

- ☐ 30 to 40 cm in length
- ☐ 0.3 to 0.7 kg each log
- ☐ 4 logs for batch
- ☐ 1.8 to 2.0 kg/batch
- ☐ 45 to 60 min cycle

Fig. 1 – Eucalypt logs.

3 INFRASTRUCTURE

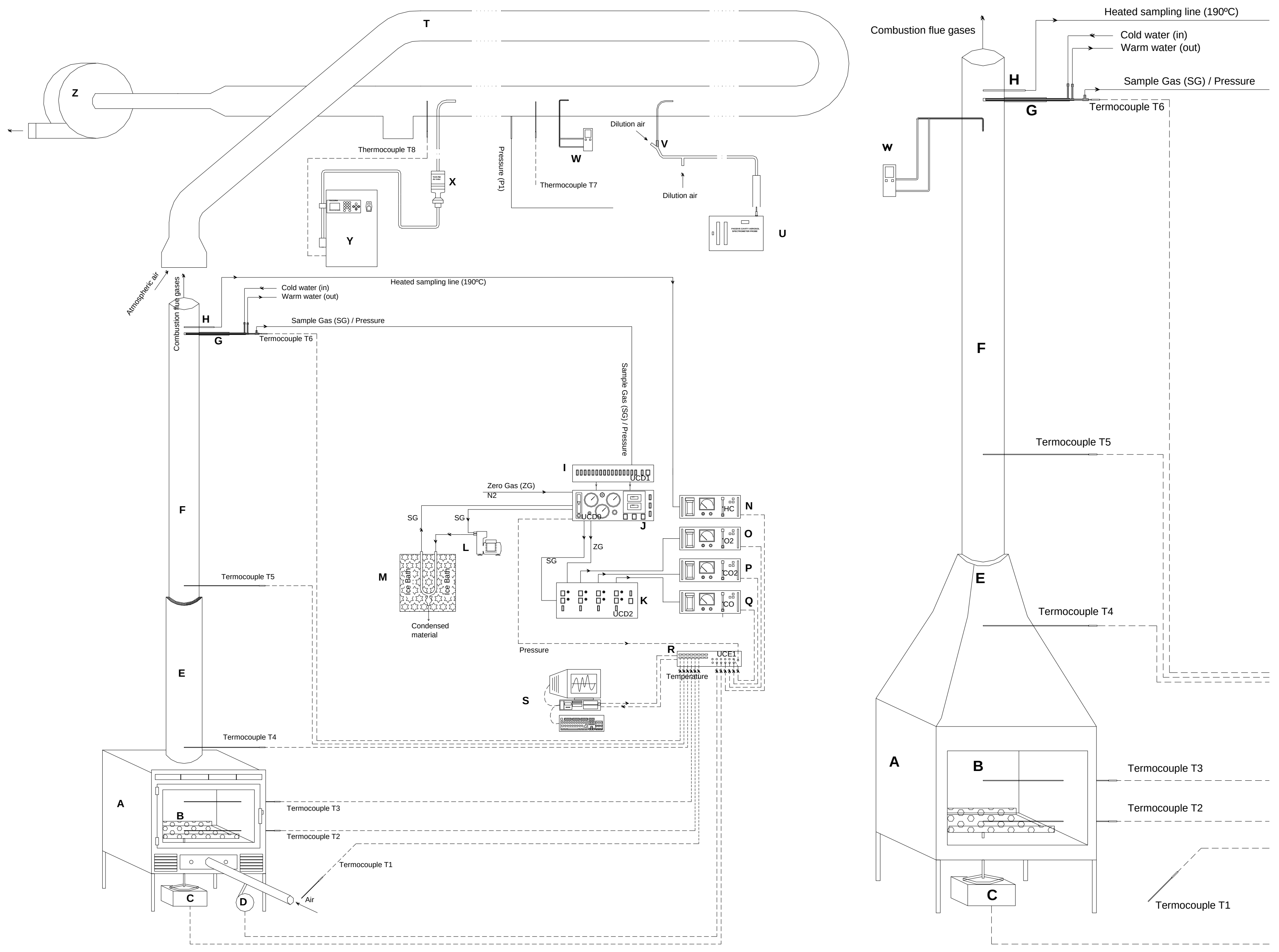


Fig. 2. a) Schematic representation of the experimental installation. Dashed line - Electric circuit, Continuous line - Pneumatic circuit. A - Stove, B – Grate of the stove, C – Load cell (weight sensor), D – Air flow meter, E – Thermal insulation of the exhaust duct, F – Exhaust duct (Chimney), G – Water-cooled gas sampling probe, H – Heated sampling line, I, J, K – Command and gas distribution units (UCD0, UCD1, UCD2), L – Gas sampling pump, M – Gas condensation unit for moisture removal, N, O, P, Q – Automatic on-line gas analyzers (HC, CO_2, O_2, CO), R – Electronic command unit (UCE1), S – Computer data acquisition and control system, T – Dilution tunnel, U–Aerosol size distribution probe (PCASP-X), V– Venturi system, W– Pitot tube, X – Sampling head for PM_{10} (TECORA), Y– TECORA control and data acquisition system, Z–Blower. b) Schematic representation of the fireplace. Excluding the reactive system (the stove), the remaining experimental installation coupled with the fireplace is the one presented in Fig. 1a.

Fig. 3 – Woodstove

Fig. 4 – Fireplace

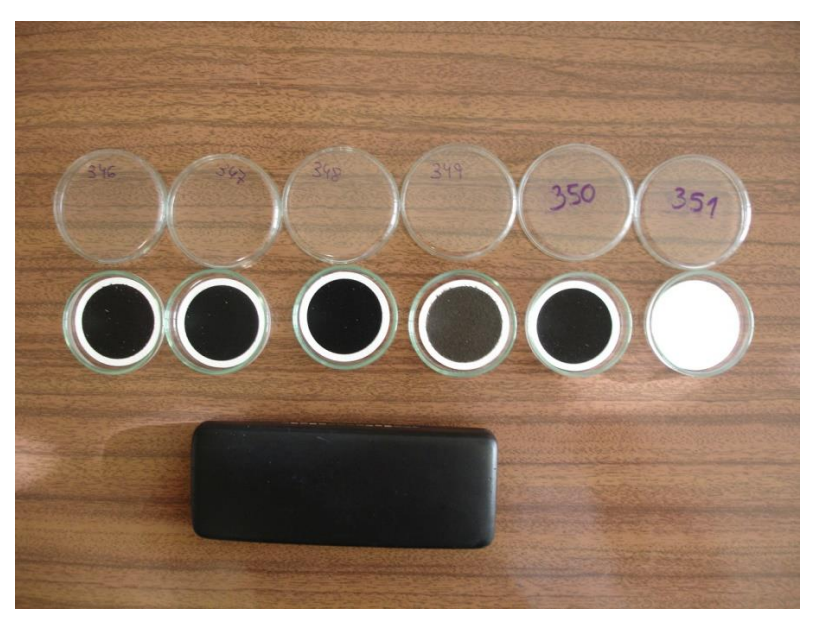
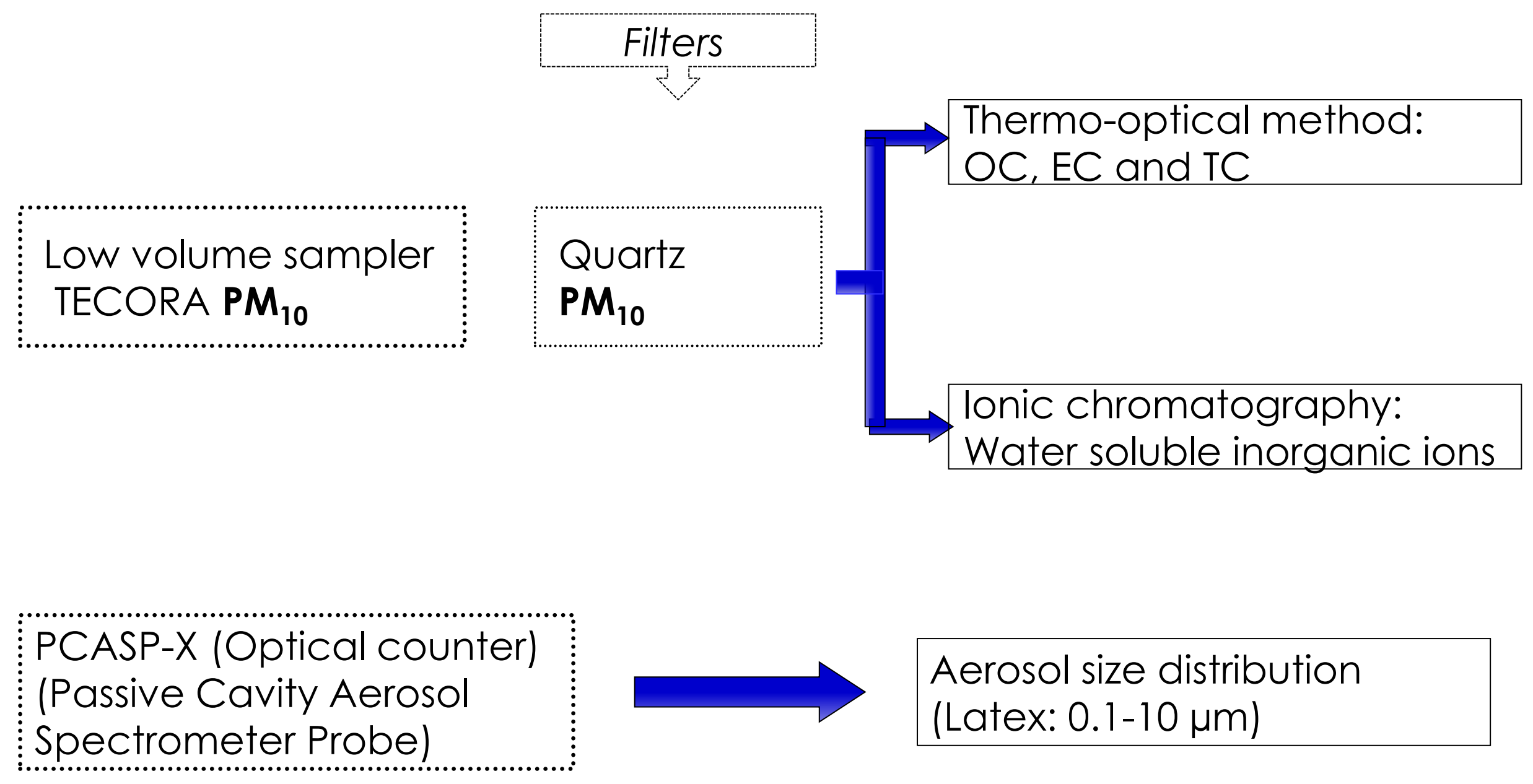


Fig. 5 – PM_{10} samples from pine combustion

4 MATERIAL AND METHODS



Filters

Low volume sampler TECORA **PM_{10}** → Quartz **PM_{10}** → Thermo-optical method: OC, EC and TC; Ionic chromatography: Water soluble inorganic ions

PCASP-X (Optical counter) (Passive Cavity Aerosol Spectrometer Probe) → Aerosol size distribution (Latex: 0.1-10 µm)

5 RESULTS

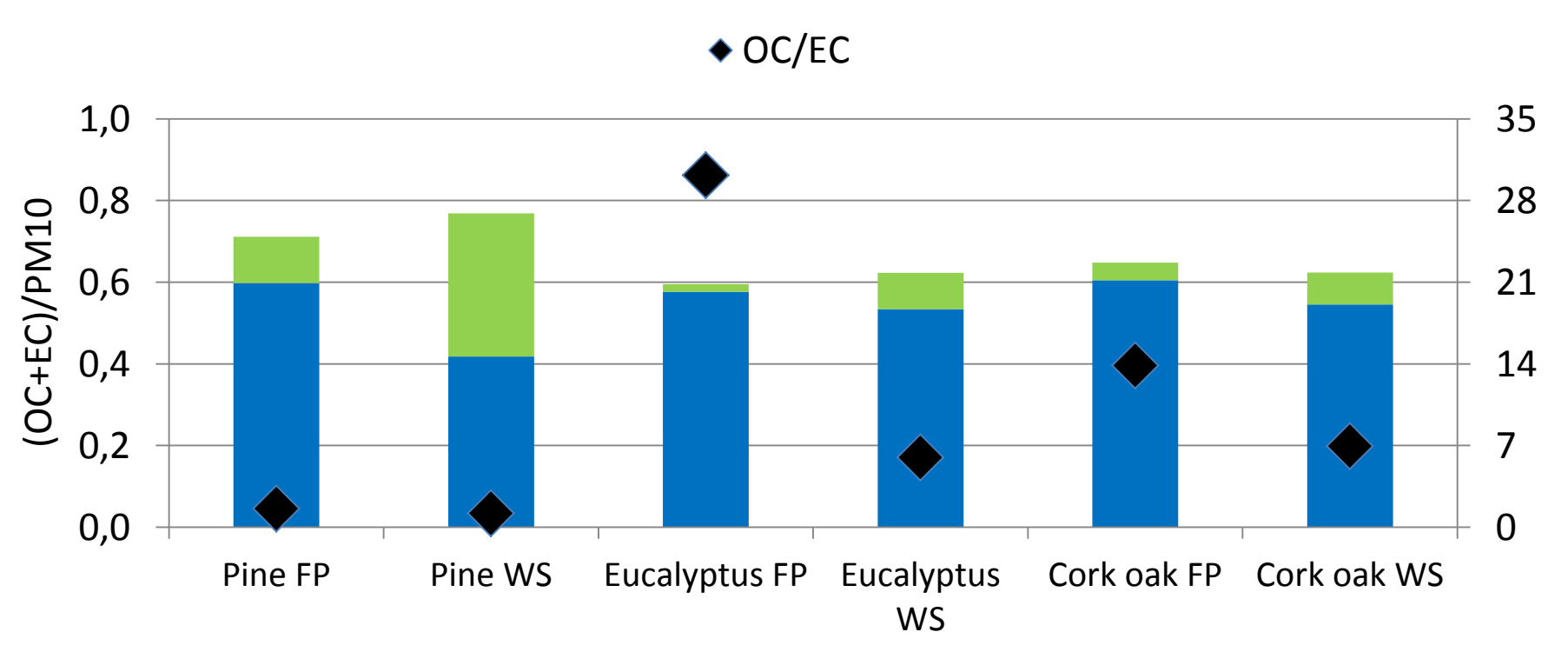


Fig. 6 – OC+EC content and OC/EC ratio.

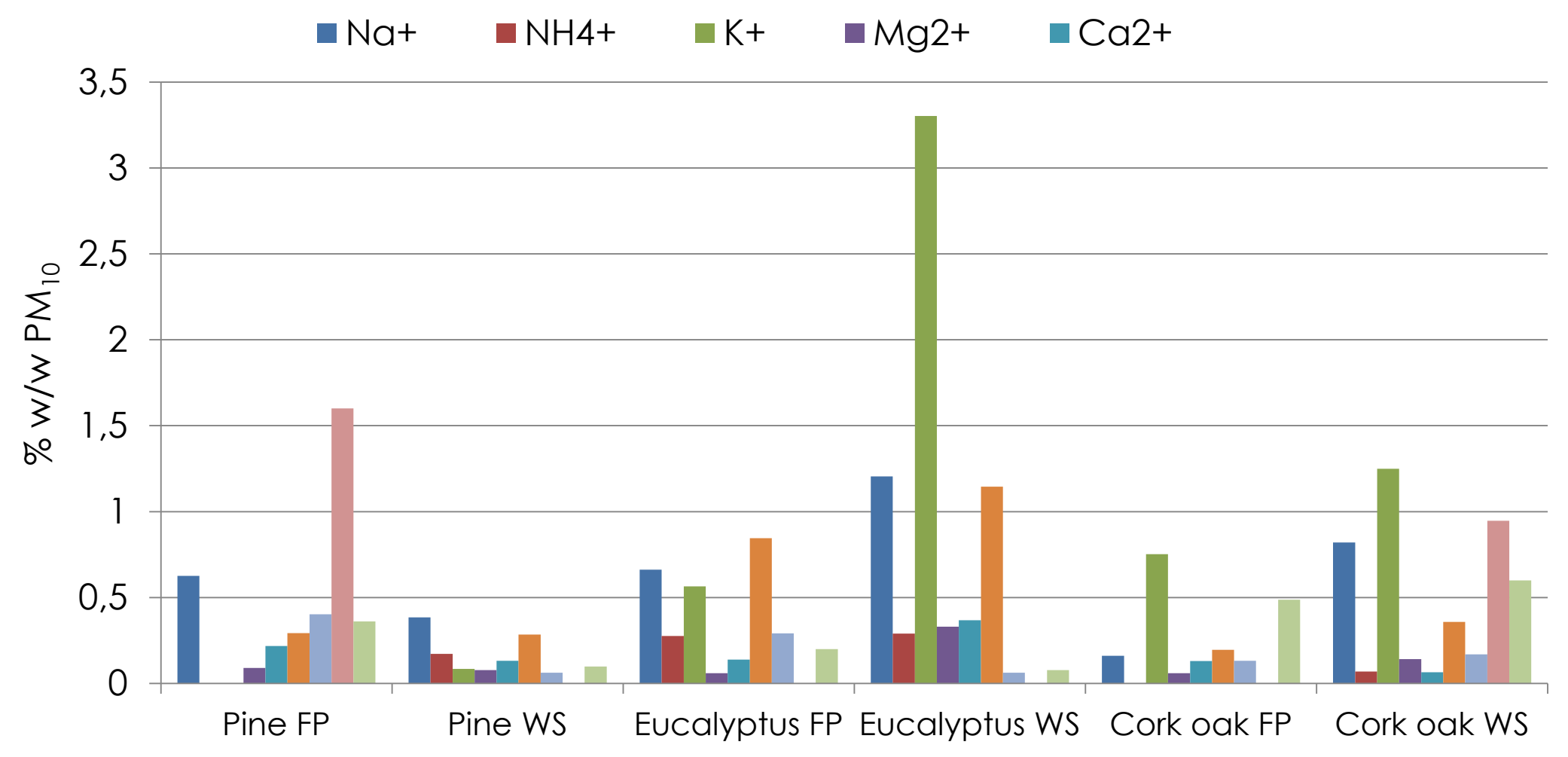


Fig. 7 – Ion content.

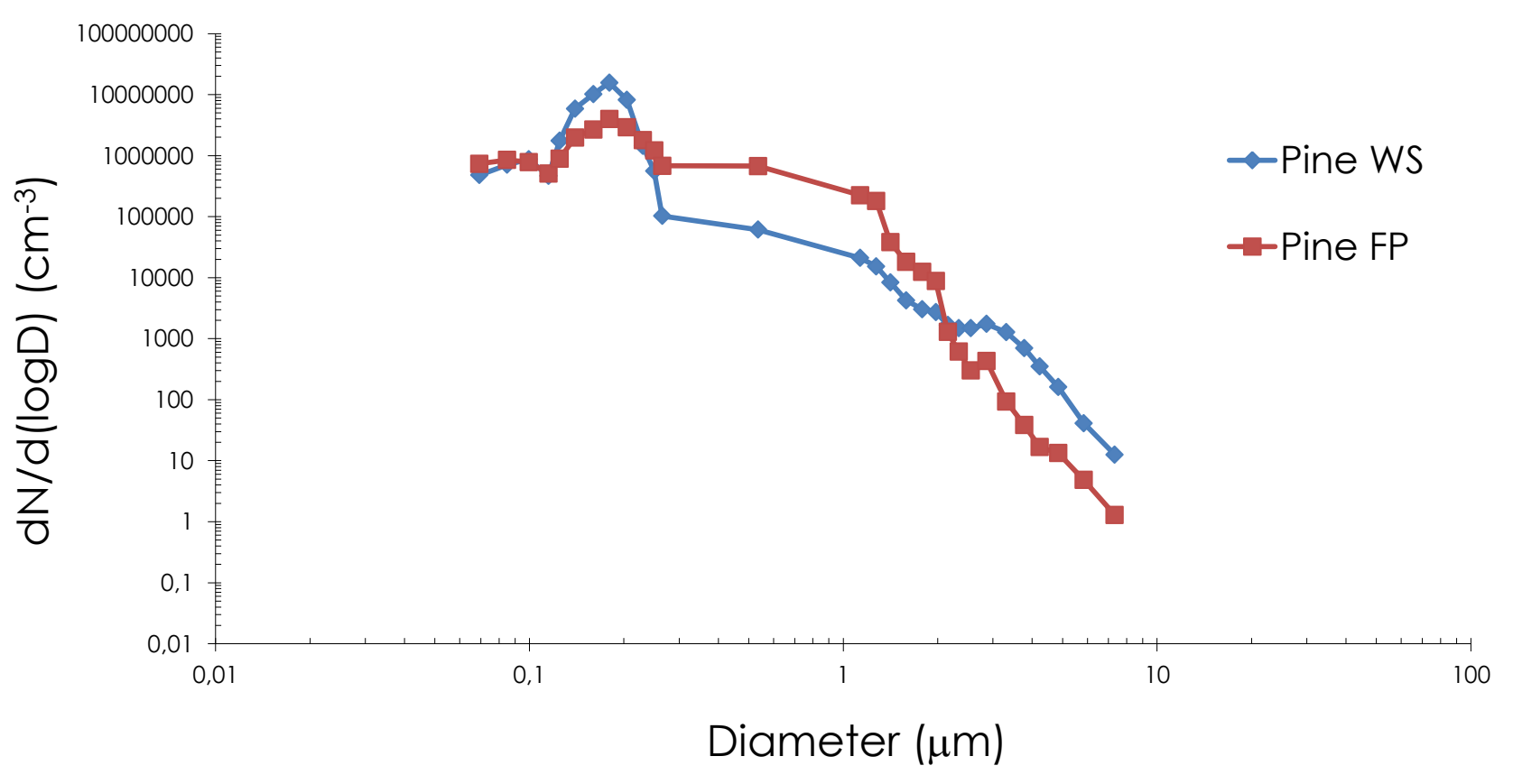


Fig. 8 – Particle number variation, with diameter for pine combustion.

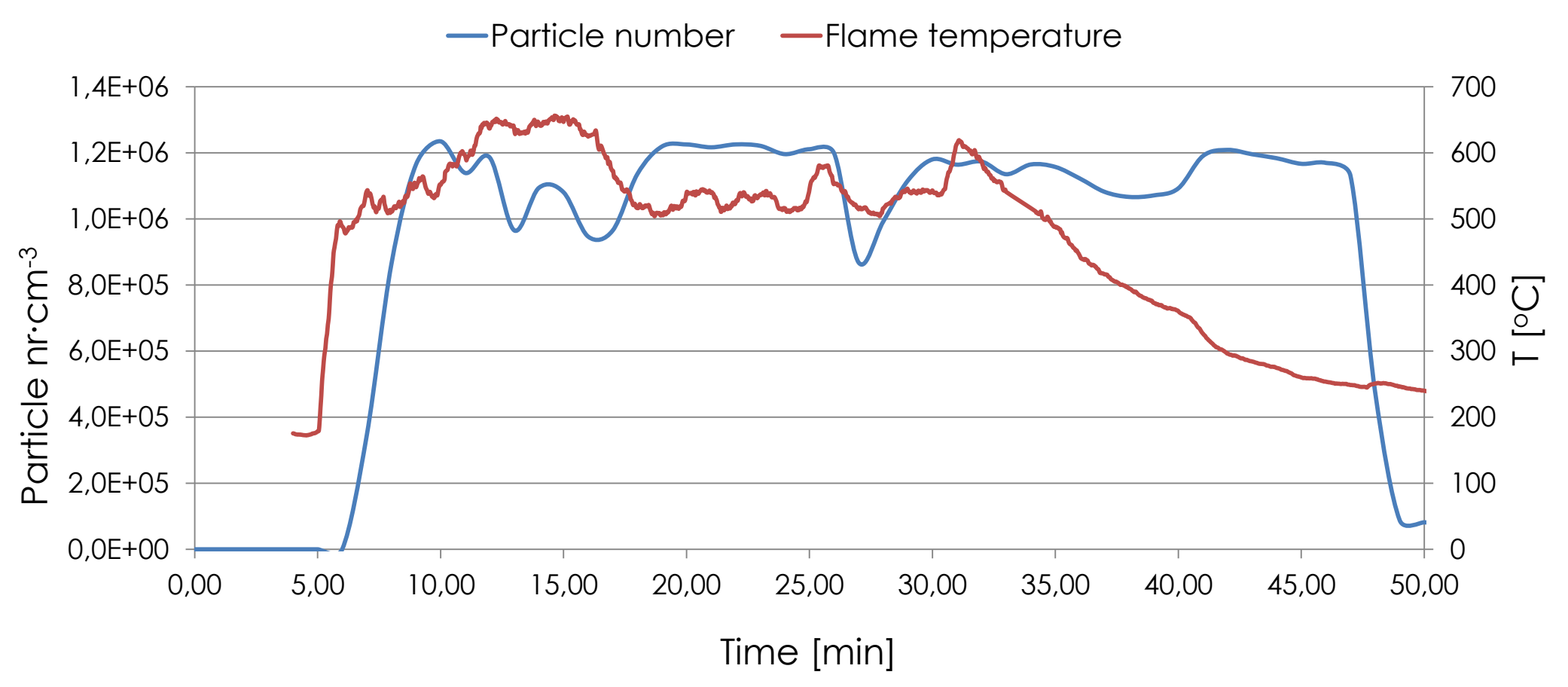


Fig. 9 – Relation between particle number and flame temperature (pine in the woodstove)

6 CONCLUSIONS

- ➢ OC+EC represents, on average, 60% of PM_{10} mass
- ➢ Pine has the higher OC+EC content for both the woodstove and the fireplace
- ➢ Eucalypt in the fireplace has the highest OC/EC ratio, indicating an inefficient combustion
- ➢ All fuels present higher OC content when burned in the fireplace
- ➢ Ion content represents on average 3.5% of the particle mass
- ➢ The burning of eucalypt in the woodstove, produced the higher ion content, with potassium representing 3.2% of the particle mass
- ➢ Eucalypt and cork oak have the higher ion content for the woodstove, while pine has higher values in the fireplace
- ➢ Combustion of pine in the woodstove, produces higher particle number for diameters lower than 0.2 µm and higher than 2 µm. Eucalypt and cork oak, showed a similar trend.
- ➢ Particle number emission is influenced by the flame temperature, for any of the fuel tested, any temperature variation tends to alter the particle number in the flue gas.

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