Physical-chemical properties of ultrafine particle emissions from a domestic pellet stove

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Keywords: ultrafine particles, chemical-physical characterization, toxicological effects
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Numerous studies confirm the impacts of residential wood combustion (RWC) on human health (Naeher et al., 2007) and local air quality (Hellen et al., 2008). The TOBICUP (TOxicity of BIomass COmbustion generated Ultrafine Particles) project was designed to gain deeper insight on the possible negative health effects of ultrafine particulate matter (UFP, dp<100 nm) by verifying the toxicological responses of UFP samples collected both directly from the RWC emissions and in ambient air at a sampling site where biomass burning for residential heating is widely used. The present study describes the physical-chemical characterisation of particles collected during laboratory tests on a domestic pellets stove.

The combustion experiments were conducted on a commercially available 11 kW top-feed wood pellet stove without water heat exchanger, with fan assisted flue discharge and internal fuel hopper. The experimental set-up is shown in Figure 1. The 3-4 hour combustion cycles were designed to represent real-life usage of the combustion appliance. To this effect, the stove was operated by modulating the heat output between the maximum and minimum loads. Two types of wood pellets (softwood-fir and hardwood-beech) were used.

UFP sampling was performed in parallel using three multistage cascade impactors, considering only particles collected on stages with nominal cut-off lower than 100 nm. Different supports (polycarbonate, quartz fibre filters and aluminium foils) were used to ensure the possibility to perform the full chemical characterization and toxicological analyses. Table 1 summarizes the experimental conditions at which the UFP samples were collected.

The UFP mass concentration was determined by gravimetric approach on aluminum foils and was on average about 30 mg/m^3 (0°C, 1 atm, dry, 13%O_2).

The physical-chemical UFP characterization comprised the detection of metals by inductively coupled plasma atomic emission spectroscopy, main inorganic ions by ion chromatography, levoglucosan by high-performance liquid chromatography coupled to pulsed amperometric detection, elemental/organic carbon by thermal-optical approach, and PAH content by gas chromatography mass spectrometry. The measurement of the number size distribution was also performed by a fourth multistage cascade impactor.

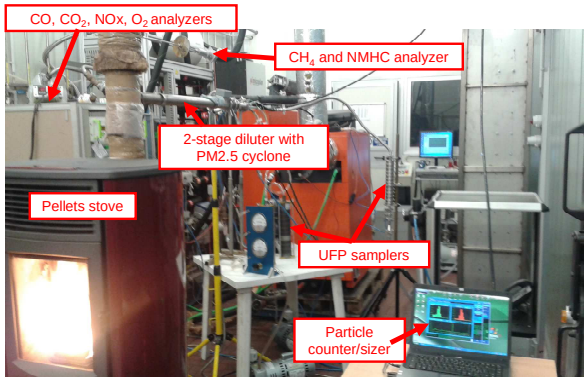

Figure 1. Experimental set-up.

	Pellet type	
	Fir (3 test runs)	Beech (3 test runs)
$T_{fluegas}$ (°C)	193	199
O_2 (%$_v$)	14	14
CO_2 (%$_v$)	7	7
CO (mg/m^3)	361	1067
NOx (ppm)	54	112
NMHC (mg/m^3)	8	11
CH_4 (mg/m^3)	1	7
NP (cm^{-3})	10^8	10^8

Table 1. Average test conditions (mass concentrations @ 0°C, 1 atm, dry gas, 13% O_2).

Work in progress comprehends investigations on the sampled UFP aiming at the determination of their toxicological potential.

This project is funded by Fondazione Cariplo (Project TOBICUP - Ref. 2013-1040).

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