Effective density measurement of ultra-fine particles emitted from residential coal combustion

Zhen Li[1], Lei Duan[1,2], Jingkun Jiang[1,2]

[1]School of Environment, Tsinghua University, Beijing, 100084, China
[2] State Key Joint Laboratory of Environmental Simulation and Pollution Control, Beijing, 100084, China
Keywords: effective density, ultra-fine particle, CPMA, residential coal combustion.
Presenting author email: l-z12@mails.tsinghua.edu.cn

Residential coal combustion emits a large amount of fine particles and has been identified as a major source of air pollution in China. In this study, size distributions, effective density, chemical composition of particles emitted from typical residential stoves were tested. The objective is to investigate how the particle size distribution and chemical composition affect their effective density.

The experimental setup is shown in Figure 1. The stove was placed in a sealed chamber. A PSD spectrometer was used to monitor particle size distributions. It includes a regular SMPS and a Nano SMPS for obtaining particle size distribution from 3-800 nm(Liu, *et al*, 2014). We employed a DMA-CPMA system to measure the effective density. A NMCI(Chien et al., 2015) was used for simultaneous particle size-selective sampling. Elemental analysis of the collected particles were carried out by using energy dispersive X-ray spectroscopy equipped with TEM, X-ray fluorescence spectroscopy.

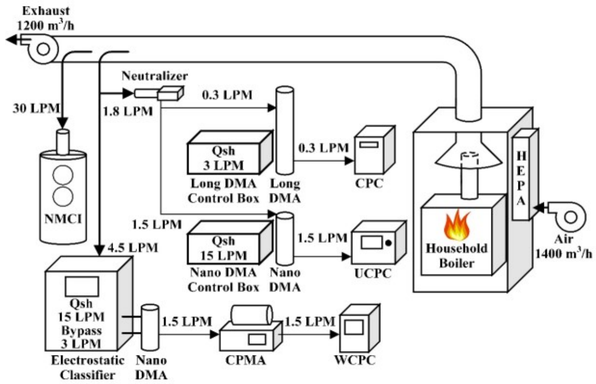

Figure 1. Experimental set-up to study particles emitted from residential coal combustion.

Particle size distribution and effective density evolution are shown in Figure 2. A large amount of particles in the size range of 100-800 nm was emitted during the coal ignition stage during which devolatilized organic compounds escape from the combustion region. After that, a significant amount of ultra-fine particles smaller than 50 nm were observed. Especially, mean particle diameters increased from 3-6 nm to ~20 nm. Following that, mean particle diameter decreases back to 3-6 nm. As mean particle diameter increases, their effective density decreases. Off-line composition analysis indicates that ultra-fine particles emitted from residential coal combustion consist primarily of metal oxide and rare earth oxide. With the increase in combustion temperature, combustion degree and oxidation degree, the carbonaceous particle (soot) formation was promoted and this consequently increases their coagulation rate lead to an increase in particle diameter and a decrease in particle effective density. Correlations between particle composition and the effective density will be discussed. In addition, the DMA-CPMA system seems to be able to measure the ultra-fine particle effective density.

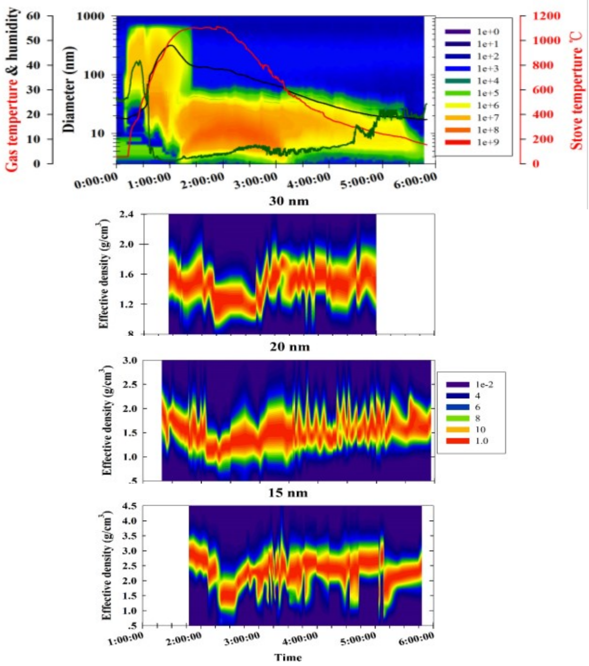

Figure 2. Top, the particle size distribution between 3 and 800 nm. Bottom, the lower three images show the effective density of 3 size fractions evolution.

Chien, C., *et al.* (2015). *Aerosol Science and Technology, 49*(10), 1009-1018.

Liu, J., *et al.* (2016). *Frontiers of Environmental Science & Engineering*, 10(1), 63-72.