Measurement of incipient soot particle size distributions down to nuclei size

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The formation mechanism of soot particles is still not clear. One of the chanllenges is to measure size distribution of nascent soot particles down to nuclei size. Attempts have been made in recent years using on-line dilution tube with DMA-FCE (differential mobility analyzer – Faraday cage electrometer) system (Commodo *et al*, 2015), while DEG-SMPS (diethylene glycol – scanning moblity particle spectrometer) has been developed for measurement of particles size distribution down to ~1 nm (Jiang *et al*, 2011). Here we report incipient soot nuclei and evolutions of nascent soot particle size distributions measured in a laminar premixed burner-stabilized stagnation ethylene flame, using both a DMA-FCE system and SMPS systems.

The experimental setup is shown in Figure 1. A laminar premixed flat ethylene flame was generated by a commercial McKenna burner. An online dilution tube was used to sample soot particles directly from the flame and to dilute them instantly. Flame temperature and dilution ratio were calibrated. Generated soot particles were measured by downstream electrical mobility spectrometers. A traditional butonal SMPS was used to measure particles larger than 3 nm. A DEG-SMPS including a specially designed cDMA for particles in the nanometer size range was used to measure sub-5 nm particles. A high-resolution half-miniDMA with FCE was used for particles and clusters spectra with higher resolution. Particle losses and instrument detection efficiencies were characterized.

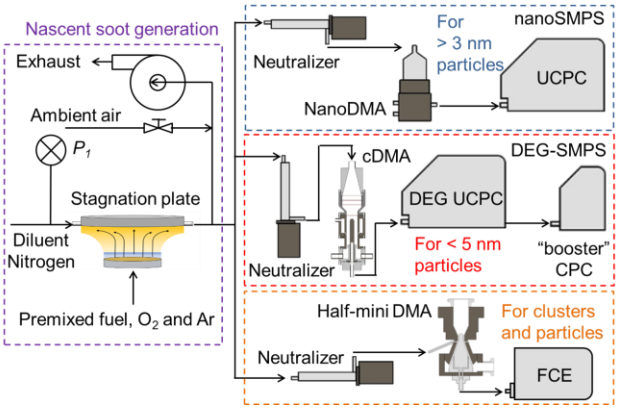

Figure 1. Schematic of experiment setup.

Figure 2 presents the measured and fitted particle size distributions at several selected representative burner-to-stagnation surface separation distances, H_p = 0.45 - 1.2 cm. At H_p = 0.45~0.5 cm, newly formed particles are characterized by the approximately symmetrical unimodal distribution, while the combined size distributions have shown a distinctively bimodal form at the heights from 0.6 to 1.2 cm. As H_p gets higher, total number density of 1~3 nm particles, the peak diameter and standard deviation of the first peak increase first and then decrease. At the height of 1.2 cm, the number density of the first peak decreases by an order of magnitude comparing with that at H_p=0.7 cm, indicating that the particle growth pattern has gradually changed from simultaneous coagulation and surface growth to surface growth dominant.

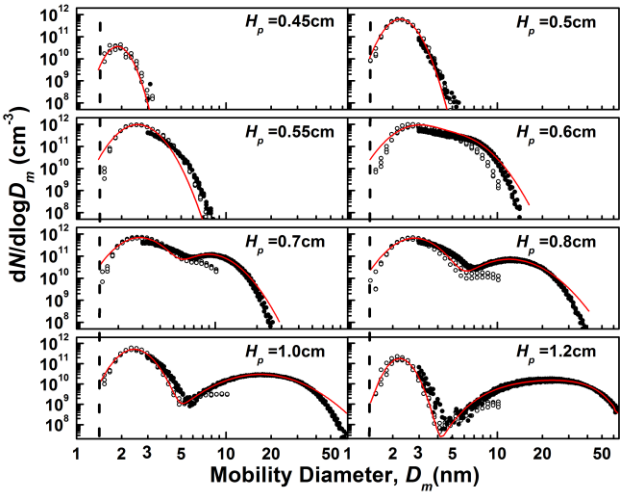

Figure 2. Evolution of PSDFs at different burner-to-stagnation separation distances.

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Commodo, M., Tessitore, G., De Falco, G., Bruno, A., Minutolo, P. and D'Anna, A. (2015) *Proc. Combust. Inst.* 35 (2) 1795-1802.

Jiang, J., Modi, C., Chongai, K., Michel A. and Peter M. (2011) *Aerosol. Sci. Tech.* 45 (4) 510-521.