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Rapid Characterization of Agglomerate Aerosols by in situ Mass-Mobility Measurements

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Transport and physical/chemical properties of nanoparticle agglomerates depend on primary particle size and agglomerate structure (size, fractal dimension and number of primary particles). Today, such particles are characterized reasonably well with respect to primary particle size (counting microscopic images, nitrogen adsorption, x-ray diffraction, light scattering) but rather poorly when it comes to agglomerate size and structure. This research reports on in situ techniques for measuring such properties.

Nanoparticle agglomerates of silica with a broad spectrum of primary particle and agglomerate sizes were generated by oxidizing hexamethyldisiloxane in a methane/oxygen diffusion flame. Upon leaving the flame, agglomerates of known electrical mobility size were selected with a differential mobility analyzer (DMA) and their mass was measured with an aerosol particle mass analyzer (APM) resulting in their mass fractal dimension, D_f, and dynamic shape factor, χ. Scanning and transmission electron microscopy (SEM/TEM) images were used to determine primary particle diameter, and to qualitatively investigate agglomerate morphology.

The DMA-APM measurements were reproducible within 5%, as determined by multiple measurements on different days under the same flame conditions. The effects of flame process variables (oxygen flow rate and mass production rate) on particle characteristics (single particle mass, D_f, and χ) were determined.

All generated particles were fractal-like agglomerates with average primary particle diameters of 12–93 nm and D_f = 1.7–2.4. Increasing the oxygen flow rate decreased primary particle size and D_f (Figure 1), while it increased χ. Increasing the production rate increased the agglomerate and primary particle sizes, and decreased χ without affecting D_f. The effects of oxygen flow rate and particle production rate on primary particle size reported here are in agreement with ex situ measurements in the literature (Mueller *et al*., 2004, Wegner & Pratsinis, 2003) while the effect of process variables on extent of agglomeration (χ) is demonstrated for the first time to our knowledge.

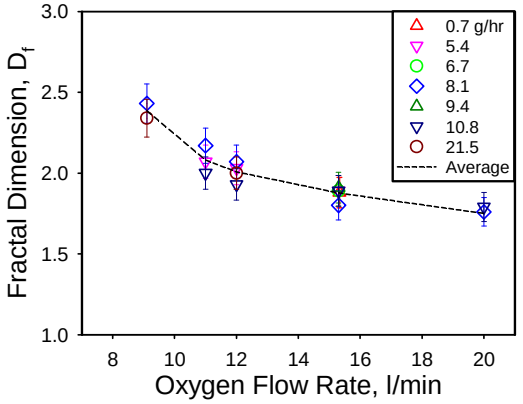

Figure 1. Fractal dimension vs O_2 flow rate for production rates from 0.7 to 21.5 g/hr. Dotted line connects the average of the measured fractal dimensions for each burner configuration. Error bars show 5% uncertainty in fractal dimension.

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