The Asymptotic Structure & Size Distribution of Fractal-like Aerosols made by Agglomeration

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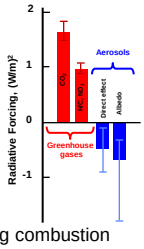
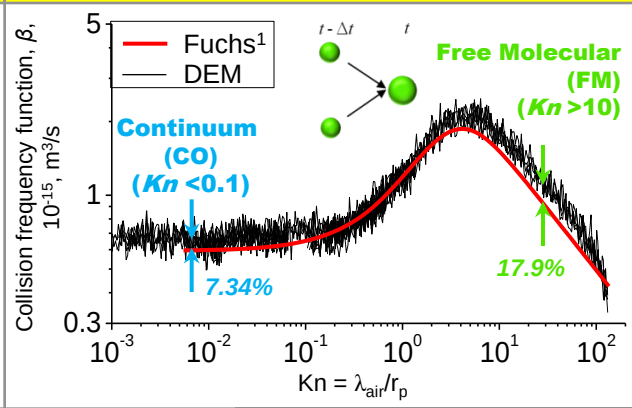
Motivation

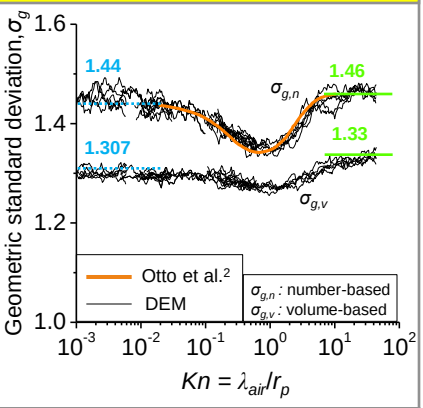
Brownian coagulation of fractal-like agglomerates is investigated by discrete element modeling (DEM) and population balance equations (PBE) in transition regime. Aerosols affect air pollution by absorbing & scattering light. Their structure affects handling & processing and finally agglomerate performance.



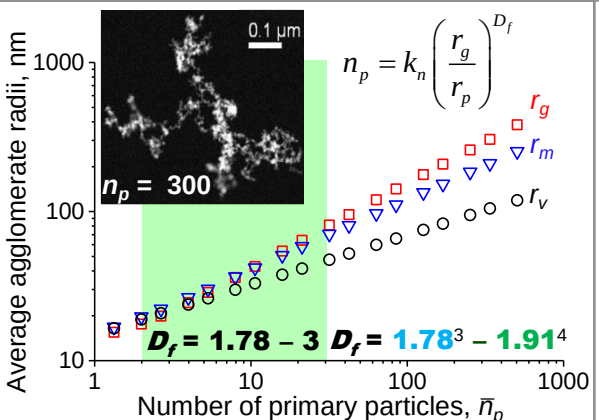
Understanding agglomerate dynamics can facilitate optimal process design of aerosols synthesis of materials, flocculation of suspensions , monitoring combustion emissions and climate modeling.

Validation – Full Coalescence



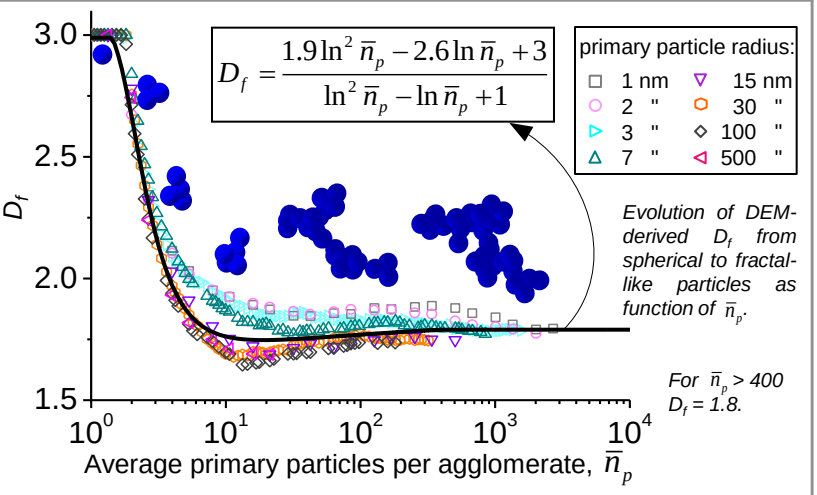


Agglomerate Dynamics



Evolution of the geometric mean gyration, r_g, mobility, r_m, and volume-equivalent, r_v, radii as a function of the number of primary particles per agglomerate, $\bar{n}_p$.

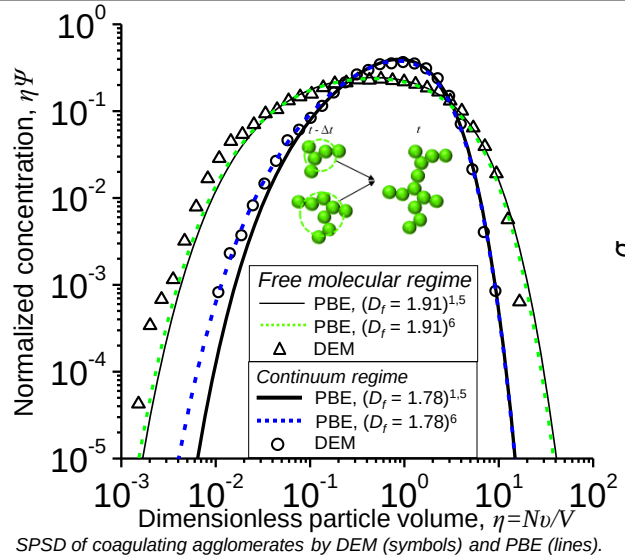
Evolution of Fractal Dimension, D_f



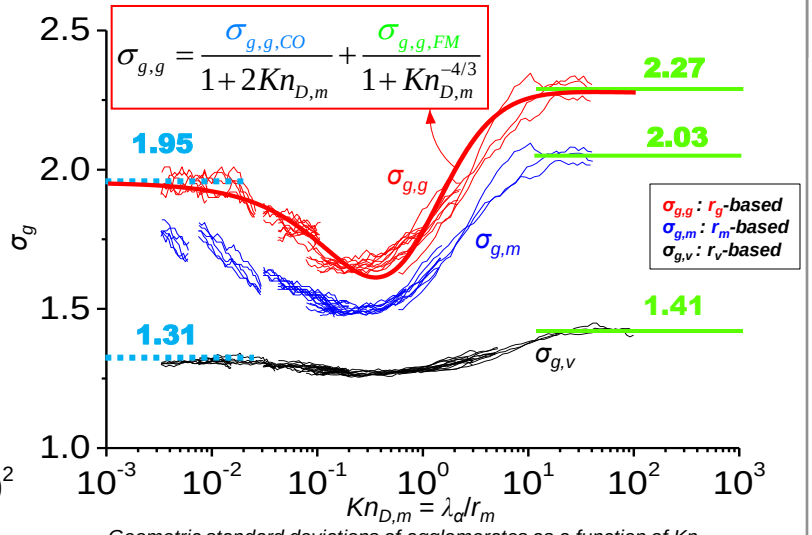
Evolution of DEM-derived D_f from spherical to fractal-like particles as function of $\bar{n}_p$.

For $\bar{n}_p > 400$ $D_f = 1.8$.

Self-Preserving Size Distribution (SPSD) & Geometric Standard Deviation, σ_g



SPSD of coagulating agglomerates by DEM (symbols) and PBE (lines).



Geometric standard deviations of agglomerates as a function of $Kn_{D,m}$.

References

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Conclusions

1. The r_g, r_m and r_v of the same agglomerate can be significantly different for $\bar{n}_p > 10 – 30$.
2. The asymptotic D_f is attained for $\bar{n}_p > 10 – 30$.
3. Agglomerates obtain SPSD with $\sigma_{g,g} = 2.27$ and $\sigma_{g,m} = 2.03$ in the free molecular and $\sigma_{g,g} = 1.95$ in the continuum regime going through a minimum of 1.65 and 1.50, respectively, at $Kn_{D,m} \approx 0.2$.
4. The relations of D_f and $\sigma_{g,g}$ can be used in detailed particle dynamics simulations coupled to fluid dynamics for industrial process design, air pollution, meteorology and climate dynamics.