Mass vs. Diameter - A new approach for analysing particle size and structure

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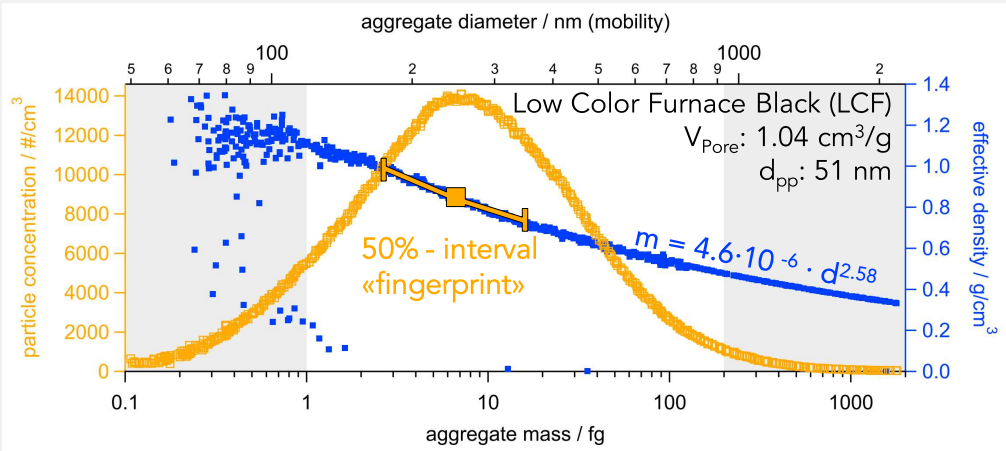
Unveiling structure

What is the meaning of the diameter for non-spherical particles?

Nanoparticle – named after a length, but traded in €/kg, grams, big bags, …

How many nanoparticles are in one gram of powder?

Analysis of particle mass and diameter
→ structure of engineered nanomaterials.
8-12 min per scan; 10-50 mio particles counted



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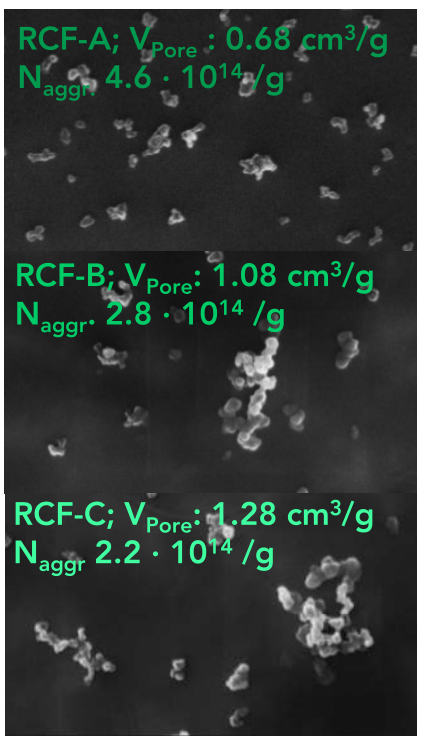
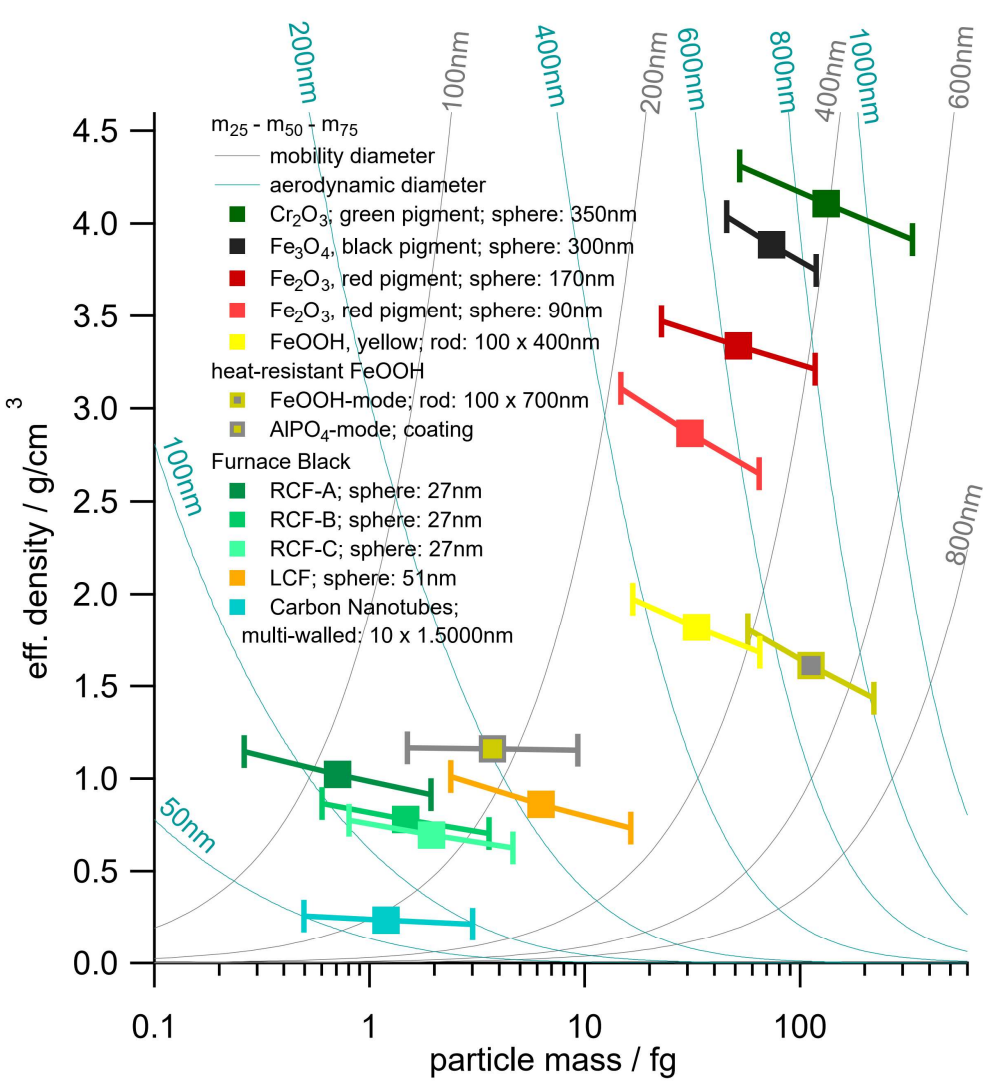
Carbon Black

Increase in aggregation level at constant PP-diameter of 27nm
→ Increase in mass and size
→ Decrease in density and aggreates/gram
V_{Pore} ≈ oil number ≈ density^{-1}

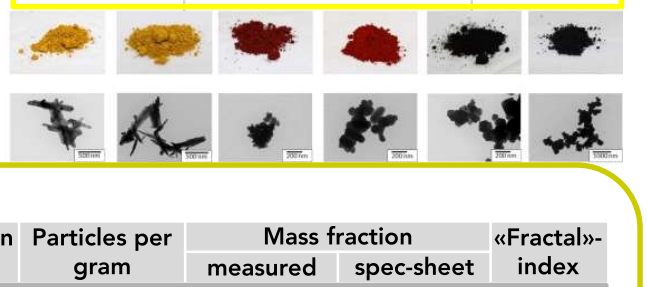




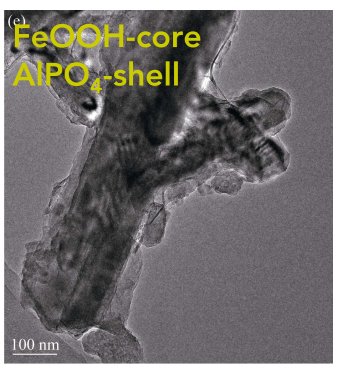
Inorganic Pigments

What is the true particle size?
Results from most sizing methods are affected by different refractive indices and structures

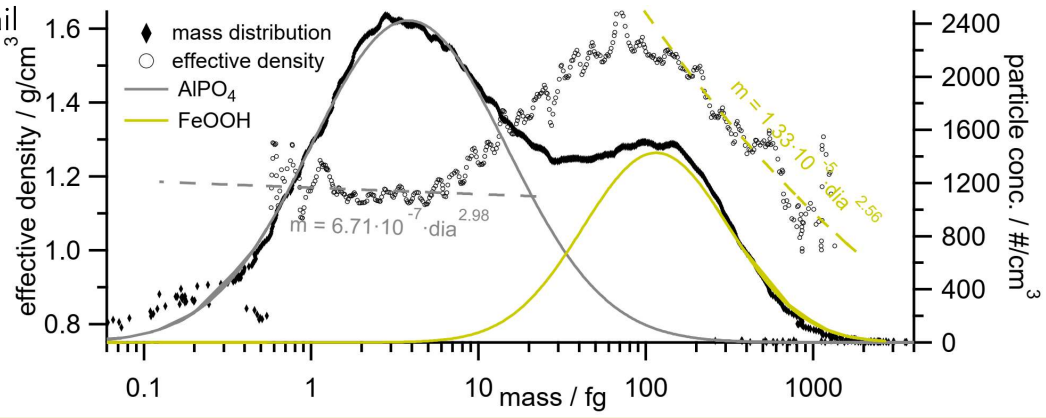
Median mass	Particles per gram	«Fractal»-index
Cr_2O_3 350nm sphere @ 5.2 g/cm³ m_{sphere}: 117fg → **isolated spherical particles**		
132 fg	**4.8 · 10¹² /g**	2.85
Fe_3O_4 - 300nm sphere @ 4.6 g/cm³ m_{sphere}: 65 fg → **isolated spherical particles**		
74 fg	1.1· 10¹³ /g	2.80
Fe_2O_3- 170nm sphere @ 5.0 g/cm³ m_{sphere}: 13 fg → **low aggregation level**		
52 fg	9.2 · 10¹² /g	2.88
Fe_2O_3- 90nm sphere @ 5.0 g/cm³ m_{sphere}: 1.9 fg → **fractal-like aggregate**		
31 fg	1.8 · 10¹³ /g	**2.72**
FeOOH **rods: 100 x 400nm** @ 4.0 g/cm³ m_{rod}: 16fg		
33 fg	9.5 · 10¹² /g	2.70



Two–component system,
→ Optical sizing methods fail



Coated and stabilized pigments



Median mass	Particles per gram	Mass fraction measured	Mass fraction spec-sheet	«Fractal»-index
$AlPO_4$ isolated non-aggregated particles				
3.8 fg	1.1 · 10¹³ /g	**10%**	**26%**	2.98
FeOOH rods: 100 x 700nm @ 4.0 g/cm³ (+coating) m_{rod}: 29fg (+7fg)				
115 fg	4.7 · 10¹² /g	90%	(74%)	2.56

Only 61% of the $AlPO_4$ is used for coating.
→ Reduced color strenght, loss of material, …

1. Sampling

a) from reactor:
- dilution
- cooling
- drying

b) powder
- dry-dispersion
- solvent-spray dispersion

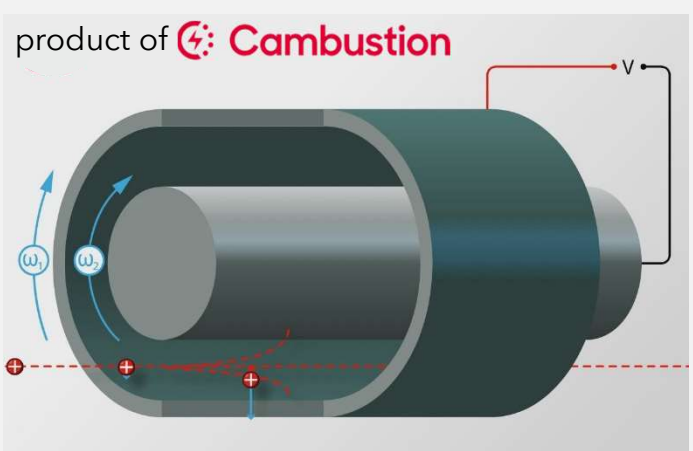
2. Deagglomeration

- ultrasound
- venturi-nozzles
- adjustable deagglo-meration intensity
- shear: 100-500 N/m²
- force: 5·10^{-10} N / particle

↳ probing particle stability

3. Centrifugal particle mass analyzer

- selection by mass to charge ratio



4. Particle sizing

- mobility to size ratio