

# Size, volatility and morphology of nucleation particles in Diesel exhaust

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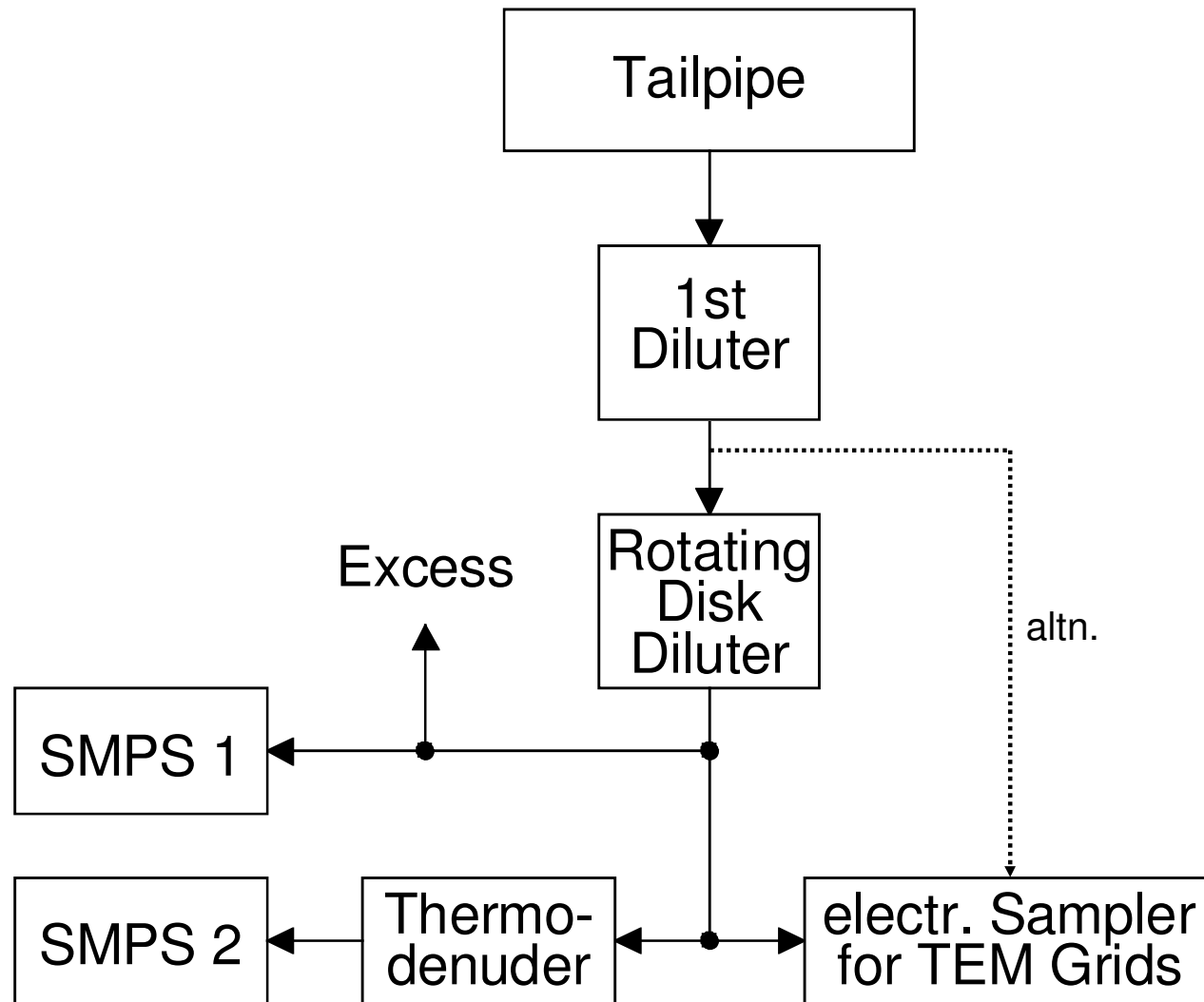
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# Introduction

- Prior studies showed that formation of nucleation particles in Diesel passenger car exhaust is related to high fuel sulfur, high engine load and the presence of an oxidation catalyst. Also, observed at idle.
- Nucleation particles mainly consist of sulfuric acid with a minor organic contribution
- There has been some speculation on solid residuals, like ash, or carbon, being present as cores inside the nucleation particles



# Experimental (1)

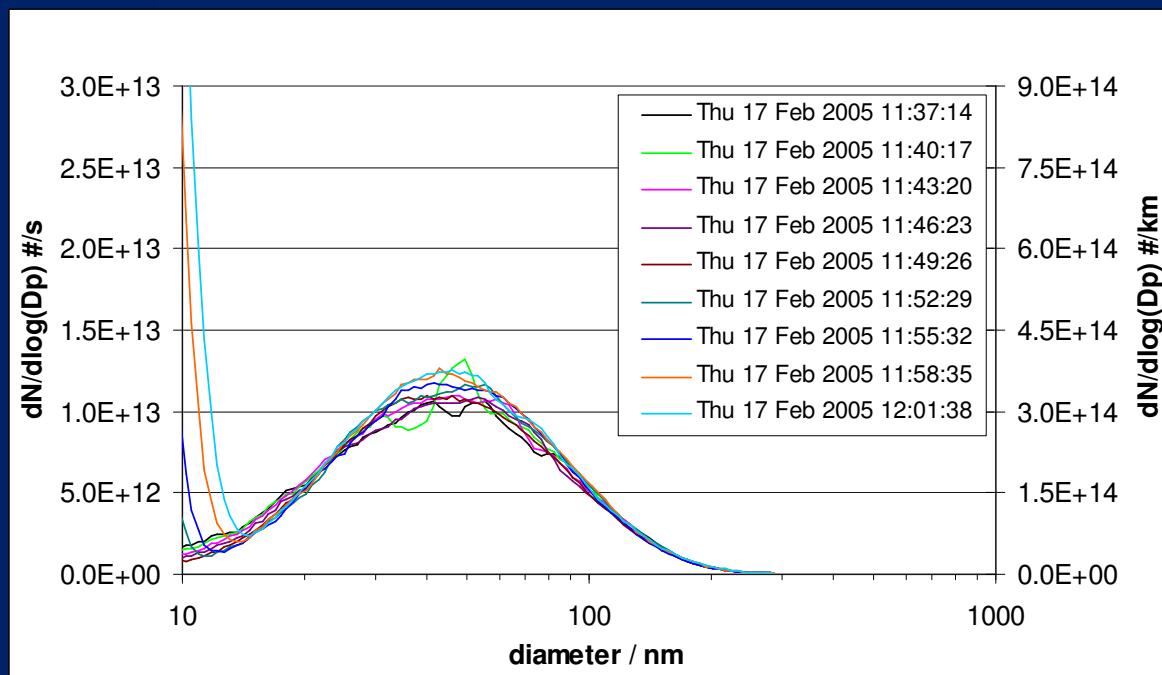


# Experimental (2)

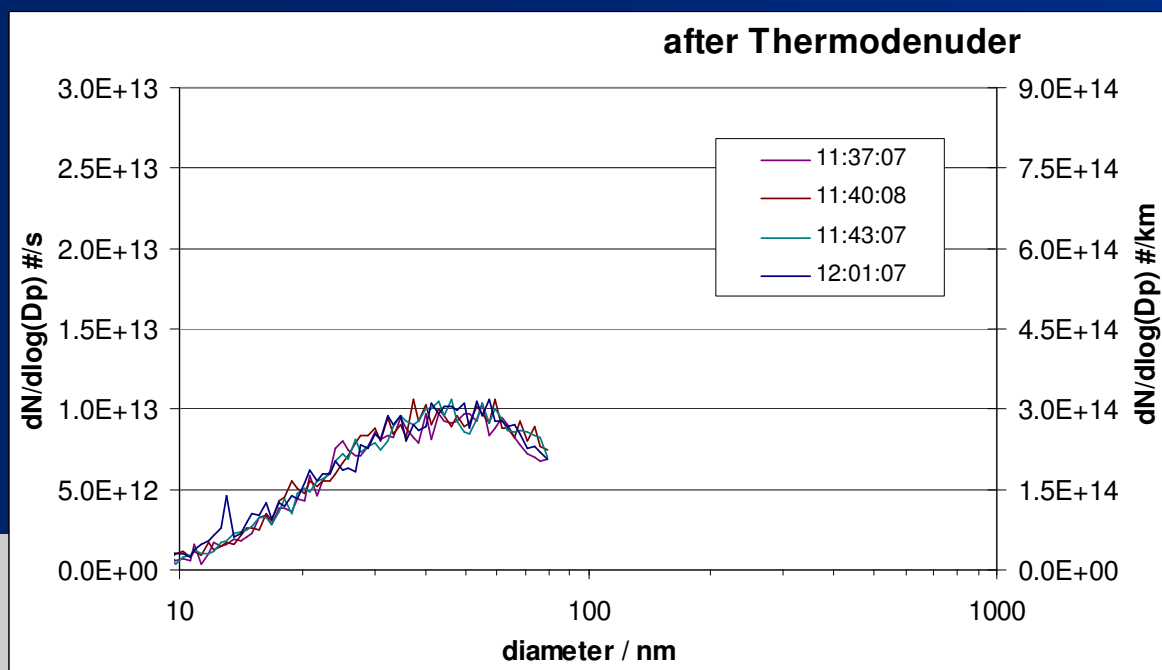
- Diesel passenger car (Euro-3); PM= 14-20 mg km<sup>-1</sup>
- European Reference Fuel:  
sulfur <10 ppm; aromatics = 23.5%
- For high sulfur experiments fuel was doped with S-  
compound to S= 310 ppm



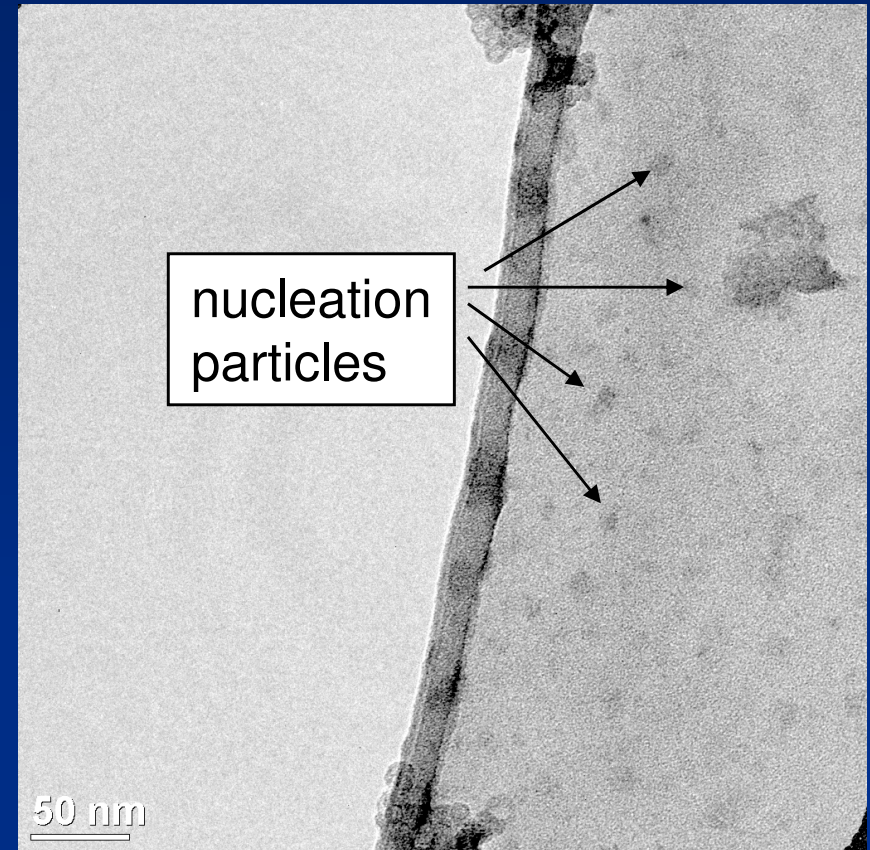
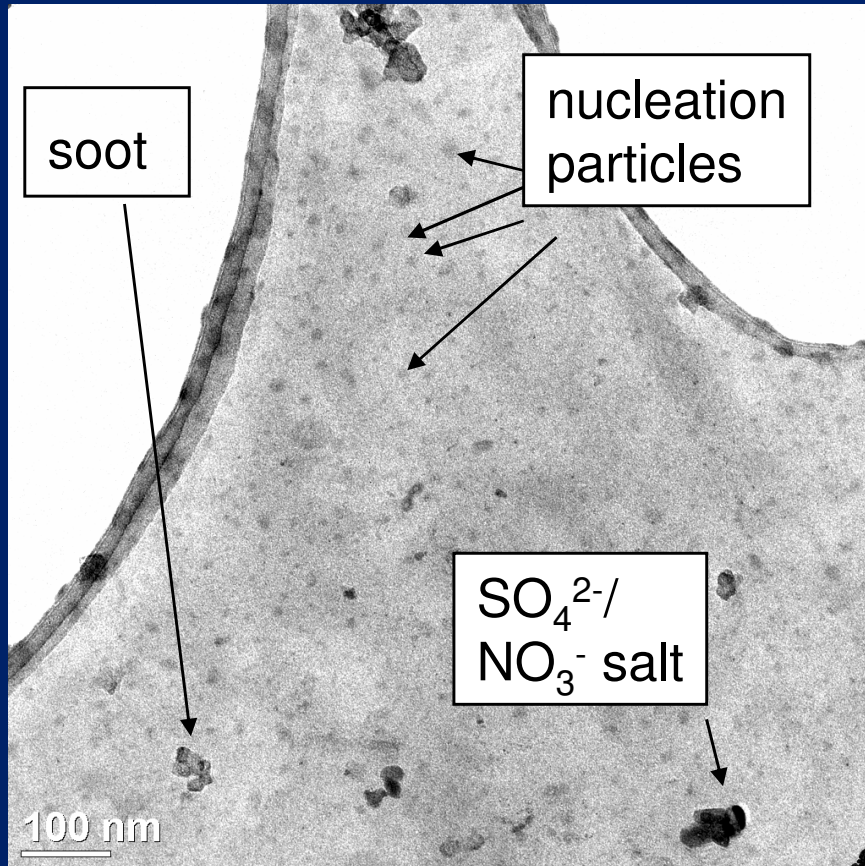
# 120 km h<sup>-1</sup> high sulfur: Size distribution (1)



- high S fuel and high load: bi-modal size distribution
- nucleation mode disappears in thermodenuder at 280 °C
- low-S fuel and high load: no nucleation mode



# 120 kmh<sup>-1</sup>, high sulfur: Morphology (2) <sup>6</sup>



- EDX: weak S-signal

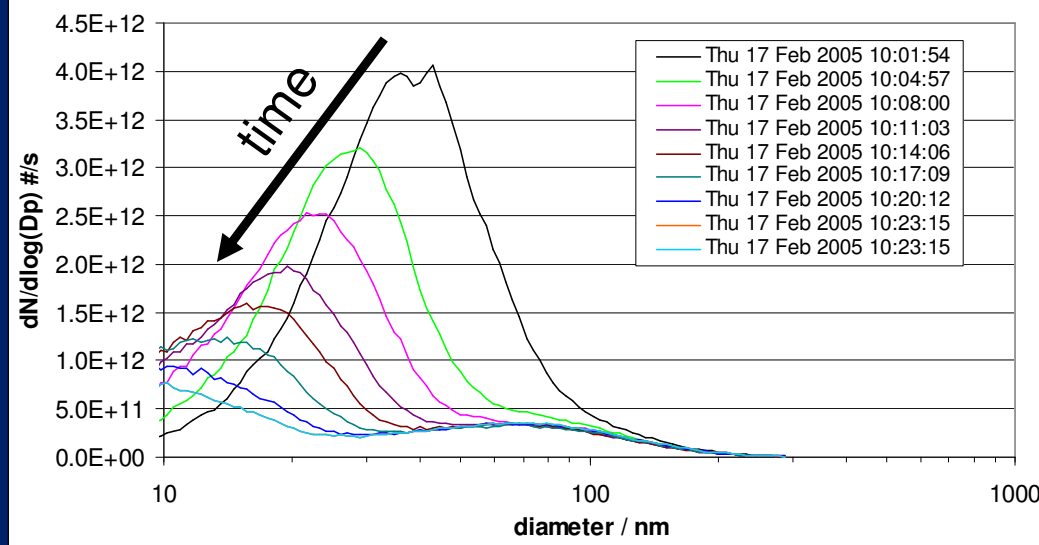
- Some NP contained smaller particles (1-3 nm) with a very high contrast. Under electron beam these particles disappeared

# Size distribution at cold start idle (1)

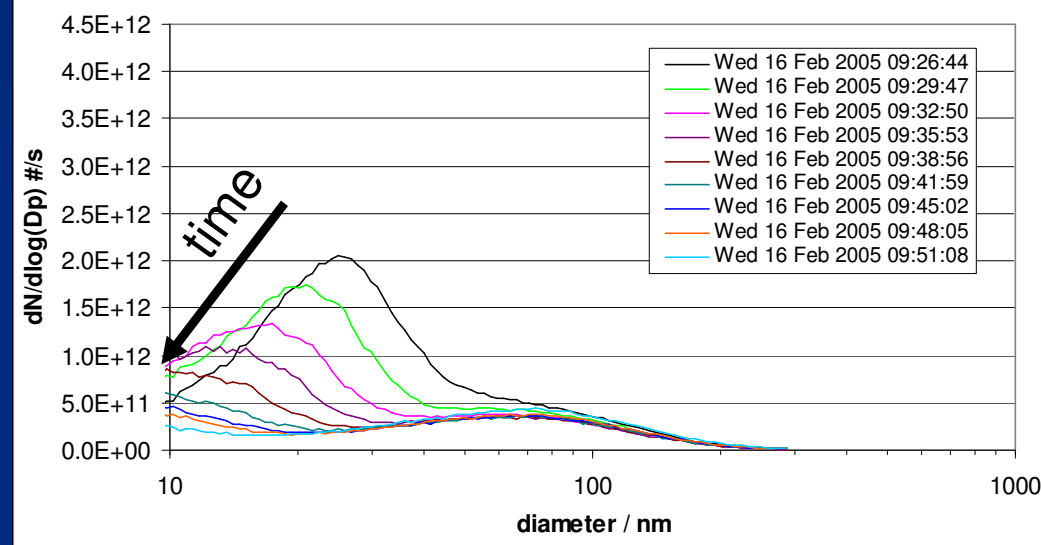
high S fuel

low S fuel

high S F108 cold idle



F24 (low S) cold idle

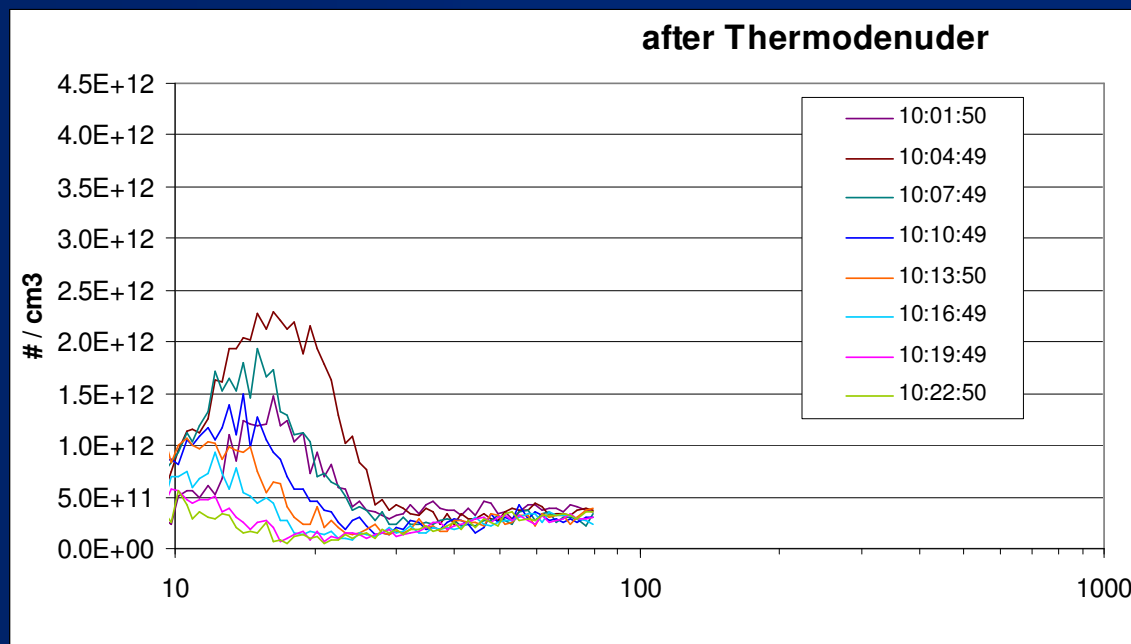


- nucleation mode appears at cold start
- disappears during warm-up; soot mode remains
- same behavior with high and low S fuel



# Size distribution at cold start idle (2)

high S fuel w thermodenuder



- nucleation mode is partially volatile
- remaining particles at 10-20 nm

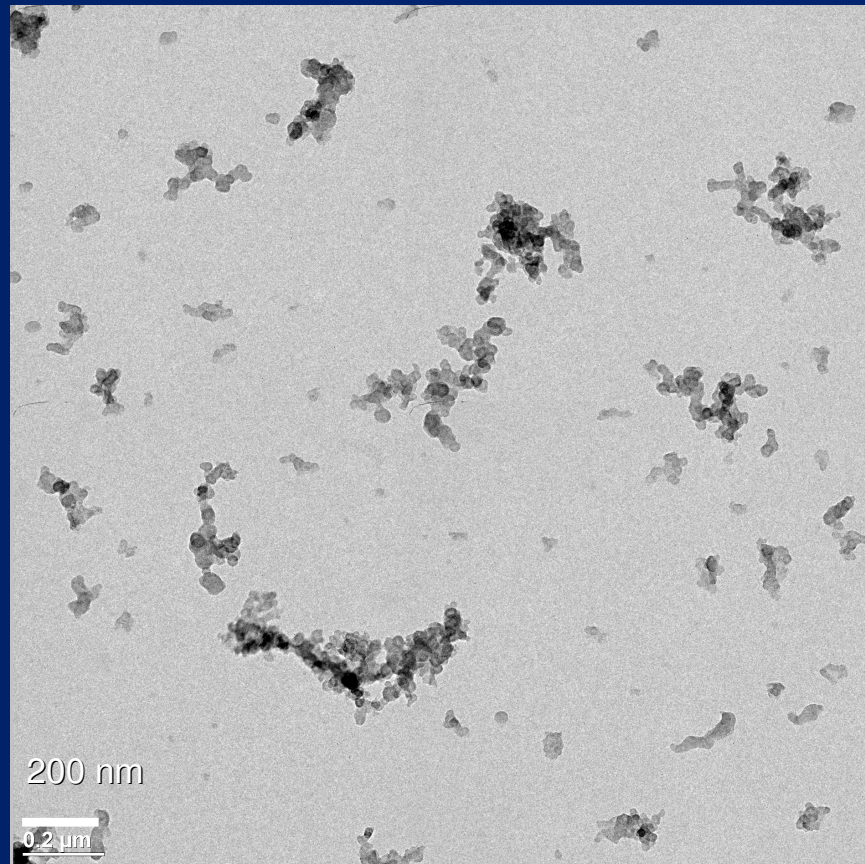




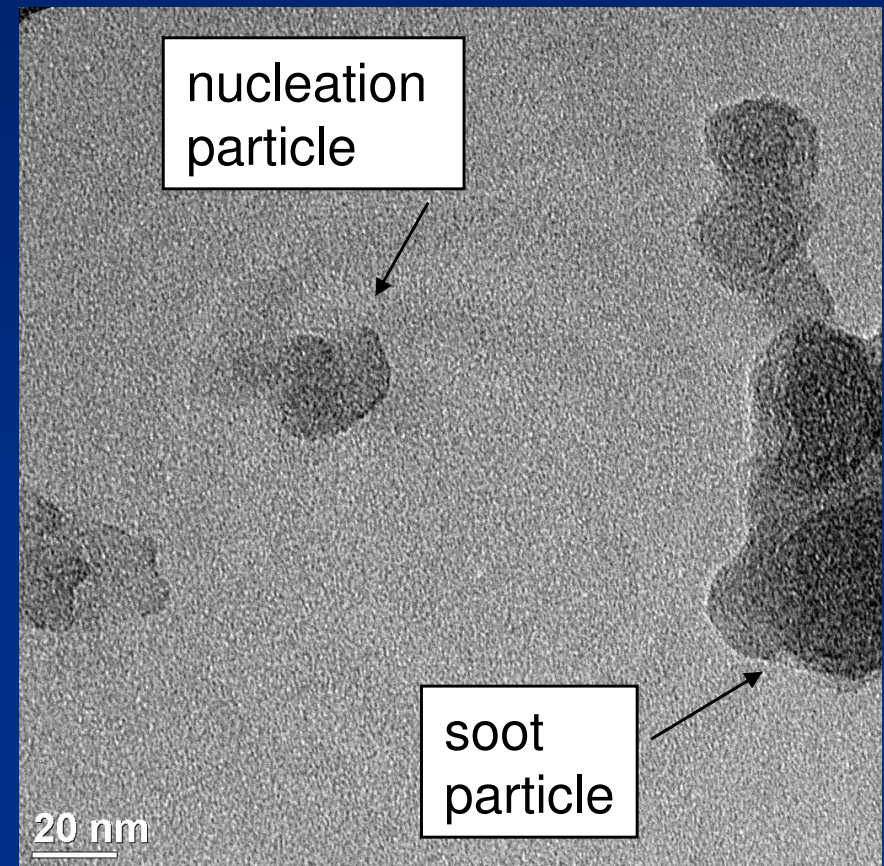
# Morphology at cold start idle (1)

9

low S fuel



- soot particles and nucleation particles
- EDX: no sulfur



- nucleation particle is not  $H_2SO_4$ , not ash
- could be prim. soot with condensate
- could be high boiling HC

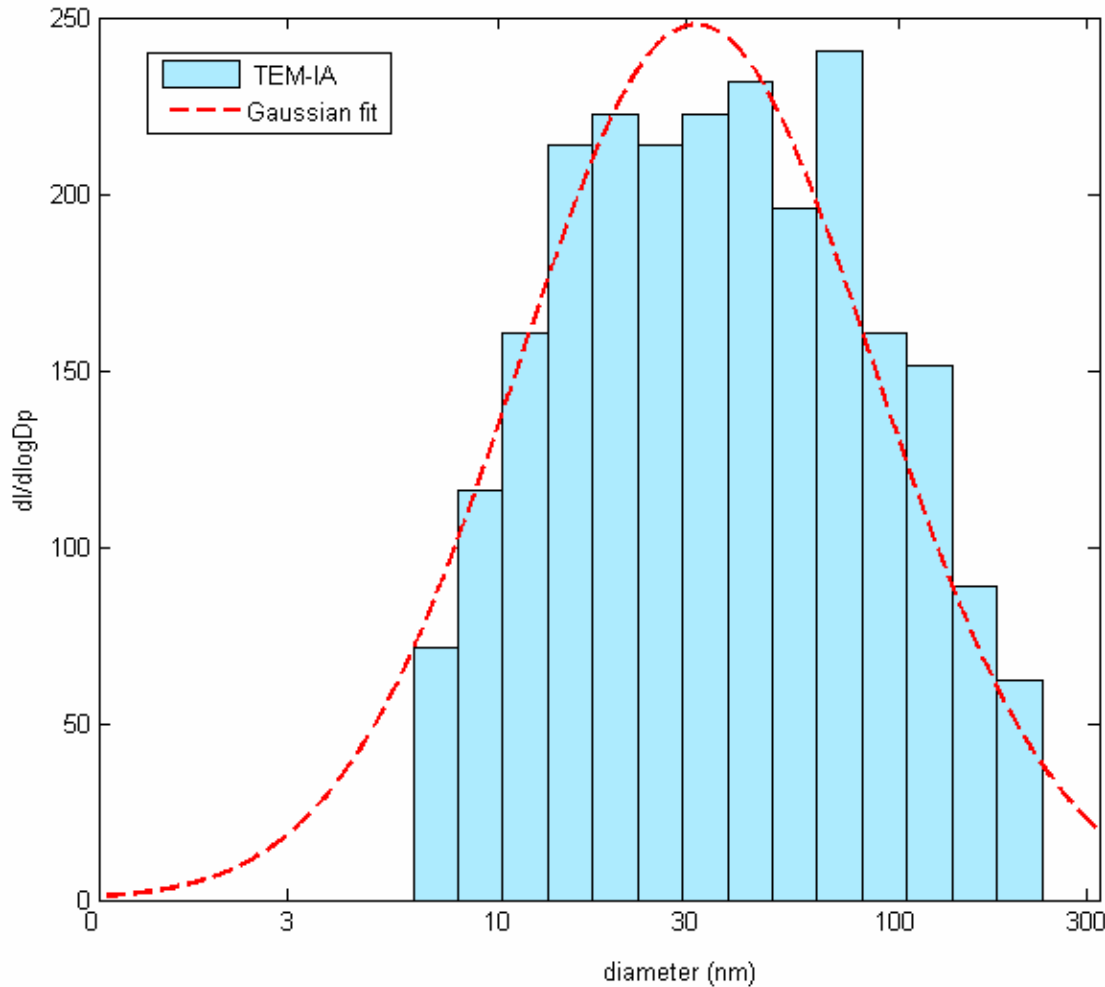


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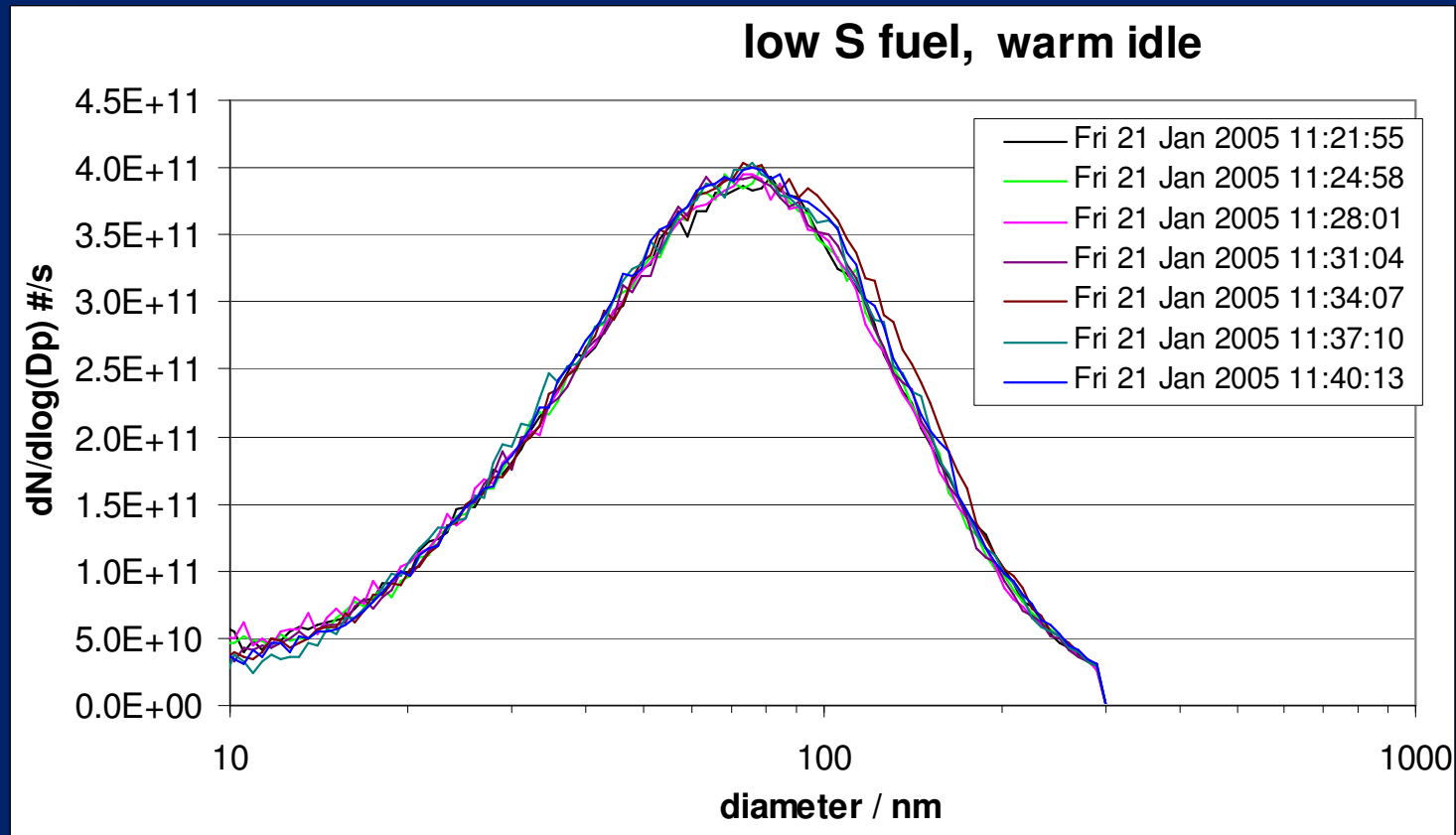
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# TEM particle size distribution



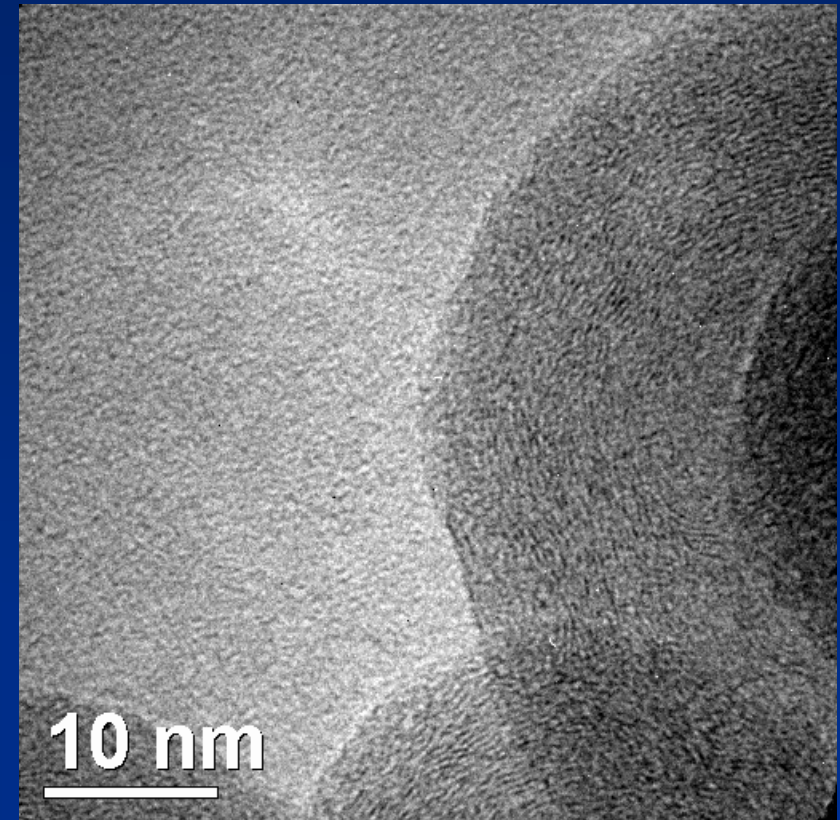
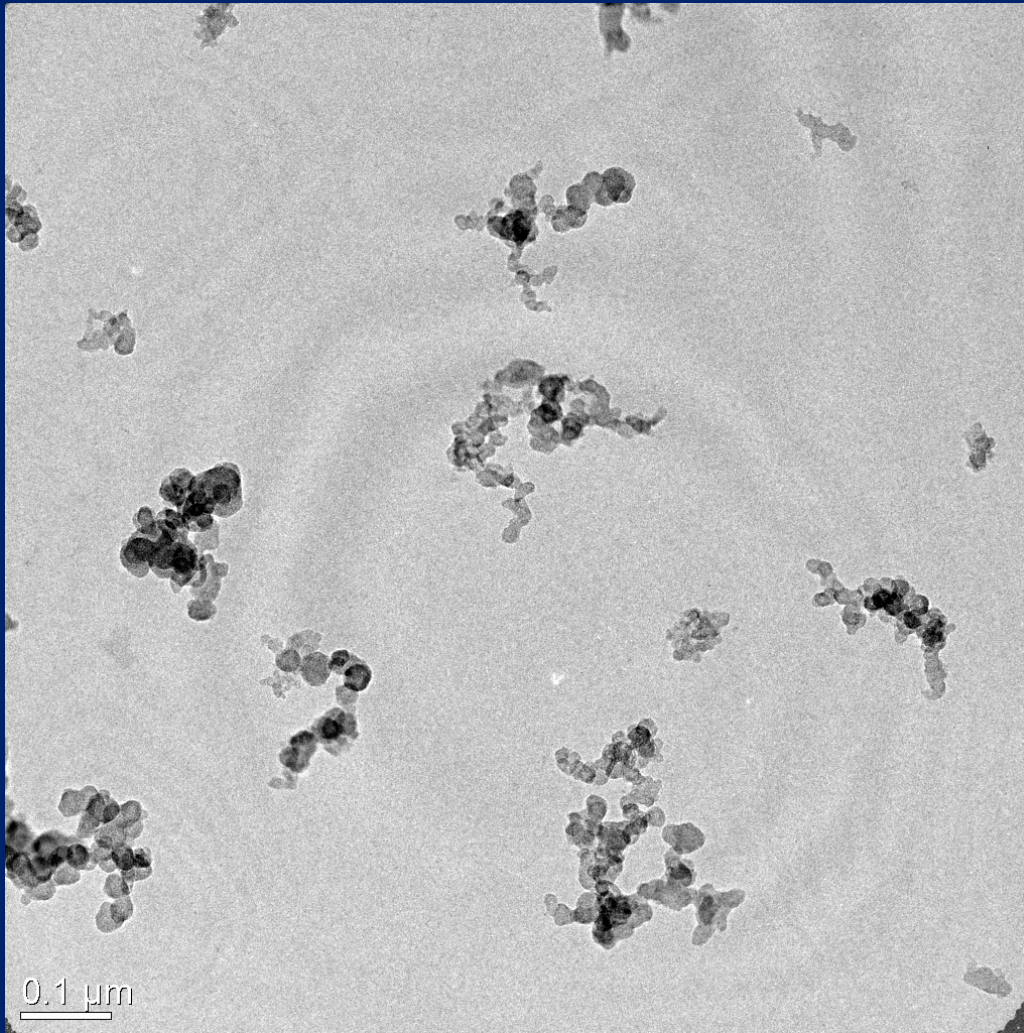
- low S fuel, cold start idle
- graphical analysis of 280 particles
- considered only >7nm
- show representative sampling

# Warm idle: size distribution (1)



- no nucleation particles; soot mode only

# Warm idle: Morphology (2)



- soot particles only
- no nucleation particles

# Conclusions

- At high load and high S fuel 10-20 nm nucleation particles observed by SMPS and TEM in the exhaust of a diesel passenger car
- Thermodenuder and TEM show all particles are volatile (EDX: weak S-signal); some NP contained smaller particles (1-3 nm) with a very high contrast. Under electron beam these particles disappeared
- At cold start idle with low and high S fuel nucleation particles observed; thermodenuder shows partly volatile nucleation mode; TEM: not sulfate, not ash; could be high boiling hydrocarbons, or primary soot particles
- At warm idle: only soot particles in SMPS and TEM

