

AVT-340 Research Workshop on Preparation and Characterization of Energetic Materials

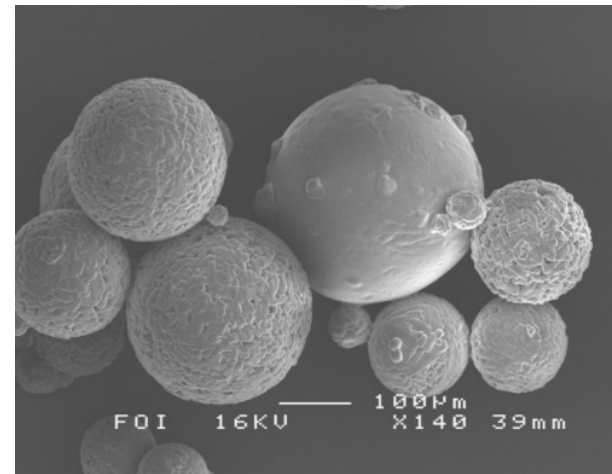
Processing of Ammonium Dinitramide Particles

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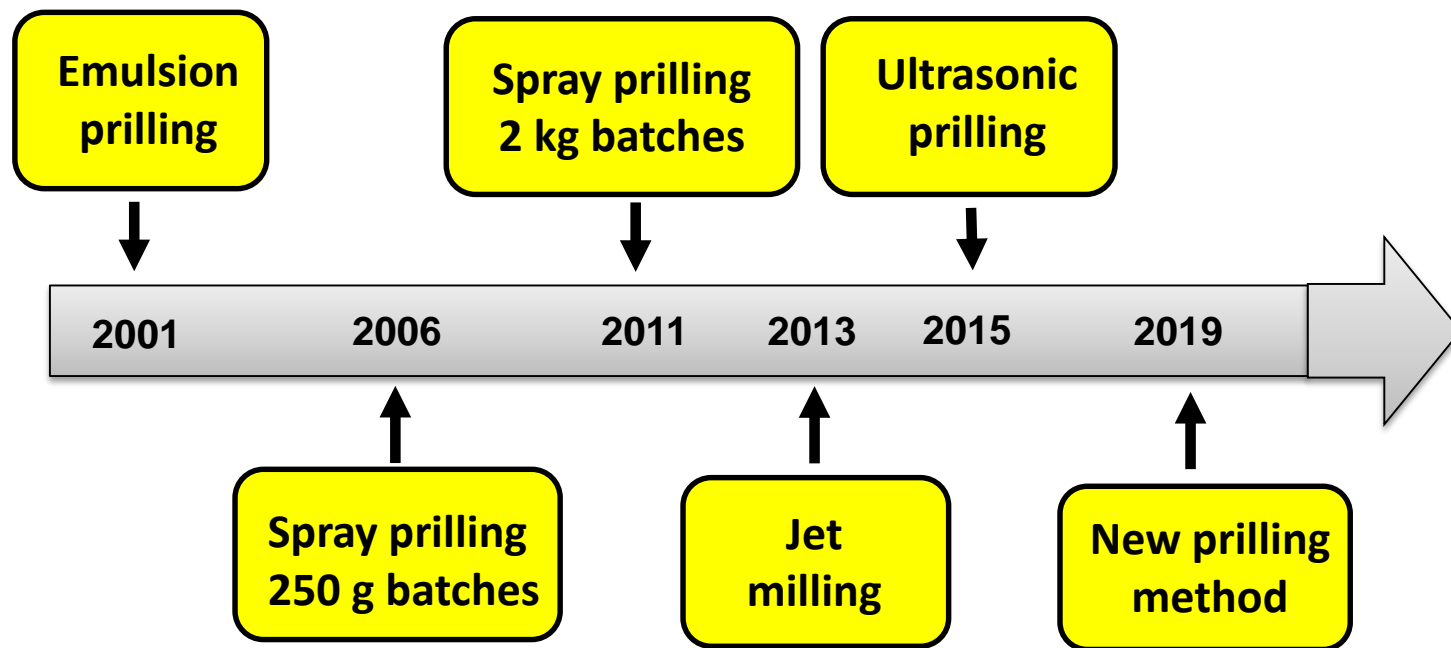


Why particle processing of ADN?



- Maximize solid loading in formulations
- Improve rheological properties of formulations
- Particles of different size is desired

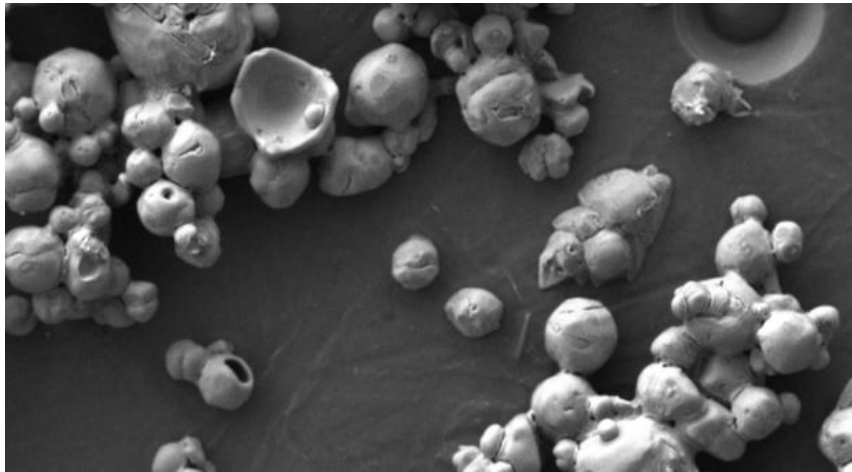
Timeline of ADN particle processing at FOI



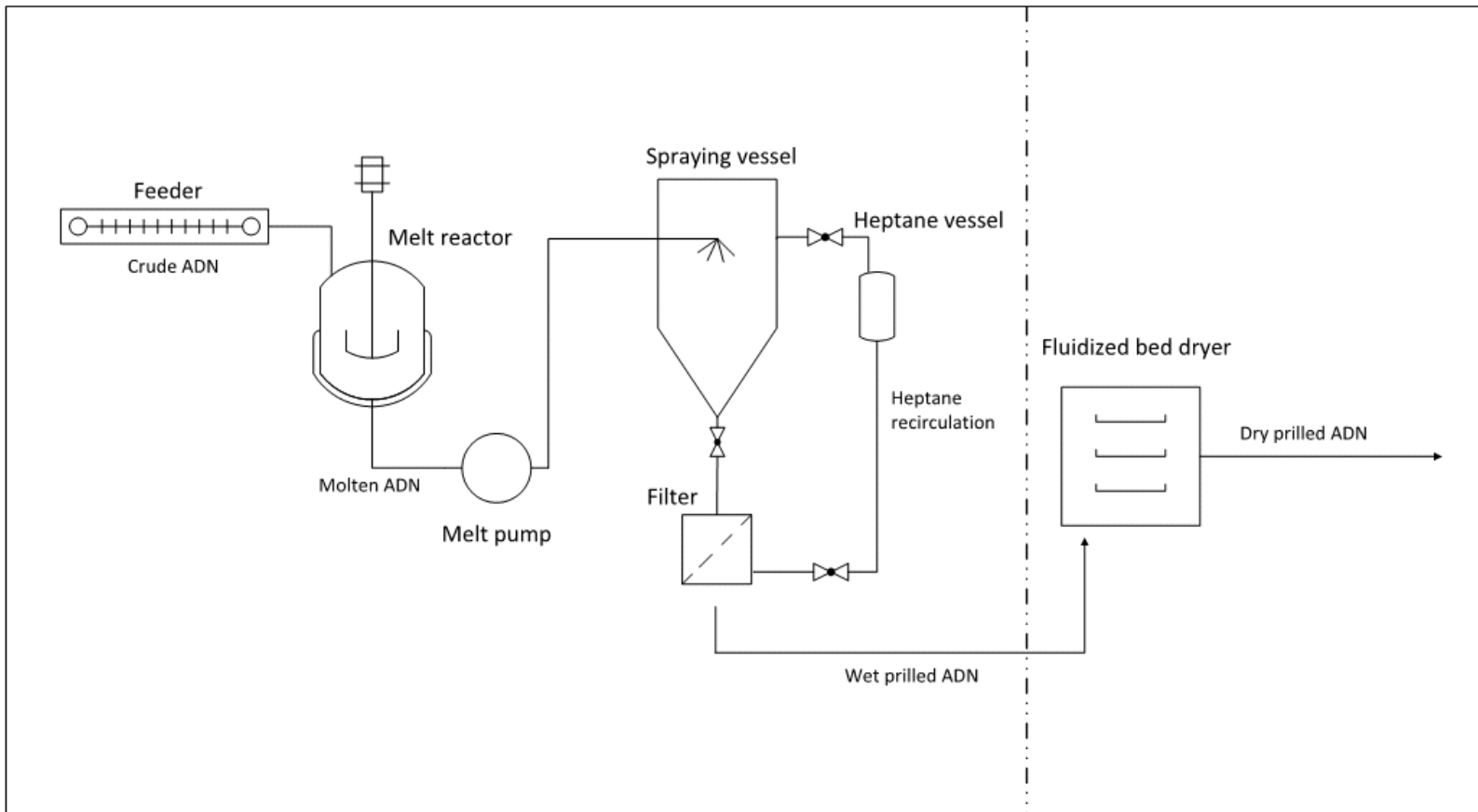
Emulsion prilling

- Spherical ADN particles produced which performed well in formulations
- Difficulties separating particles from oil
- Recrystallization during storage

Emulsion prilling

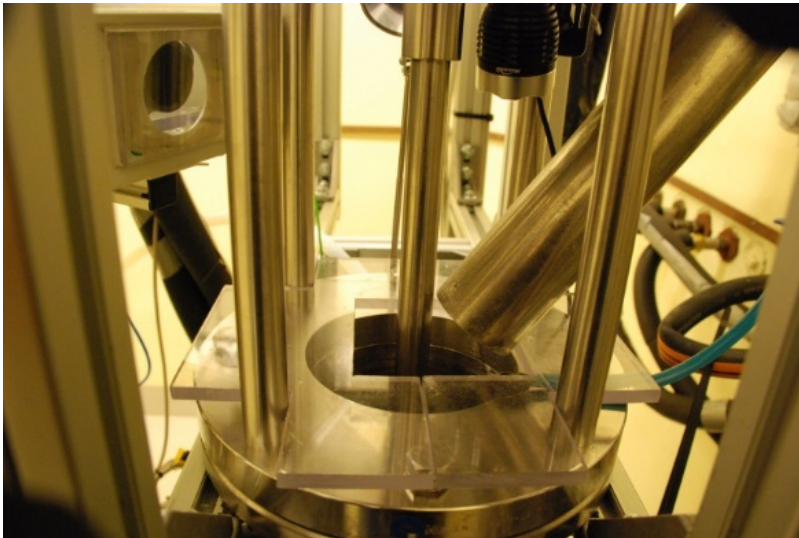


Spray prilling

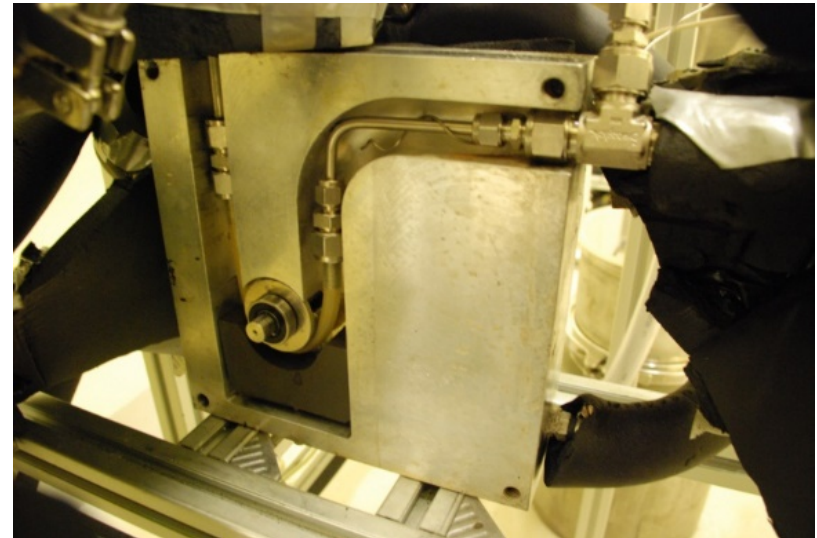


Schematic drawing of the ADN spray prilling process

Spray prilling



5 liter stainless steel melt reactor
Up to 2.5 kilo batches



Heated peristaltic pump
Adjustable pump speed

Time limit for melted ADN: maximum 1 hour

Spray prilling



Nozzle using compressed nitrogen gas (1-8 bars)



Vessel with n-heptane ESD-PTFE coating

Ejected particles travelling < 30 cm

→ Reduced risk of electrostatic discharge compared to "prilling tower" method

Spray prilling



Fluidized bed dryer - heated

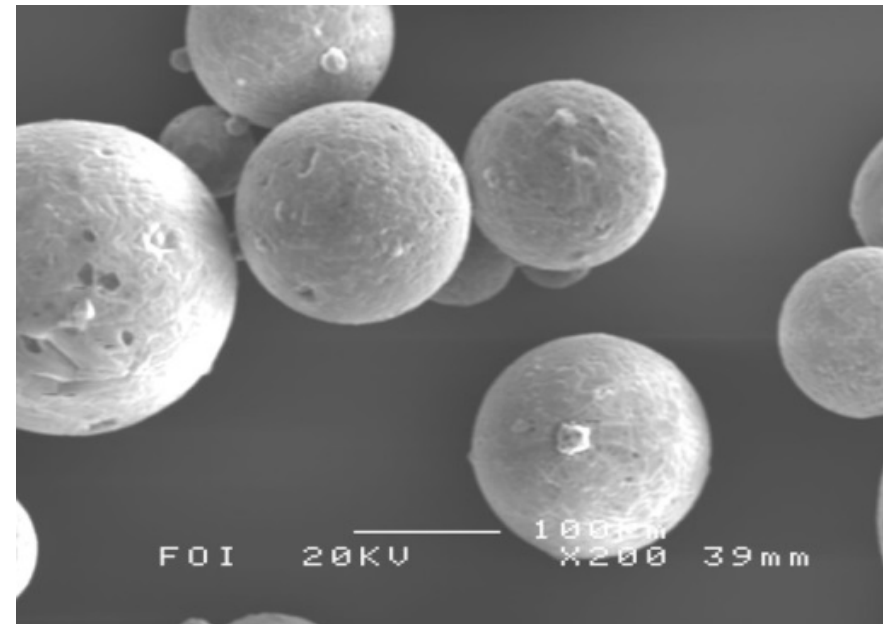
Pre-heated and dried air

Sieving and addition of anti-caking agent (0.2-0.5 wt-%)

Grounding of personnel and equipment!

Spray prilling - results

- Spherical particles
- Free flowing
- $\sim 1.79 \text{ g/cm}^3$ (99% TMD)
- Control over particle size
- Sizes: 60-250 μm
- Approx. 30 kilos per day (200 μm)
- Production and storage environment are preferably <30% RH



Jet milling

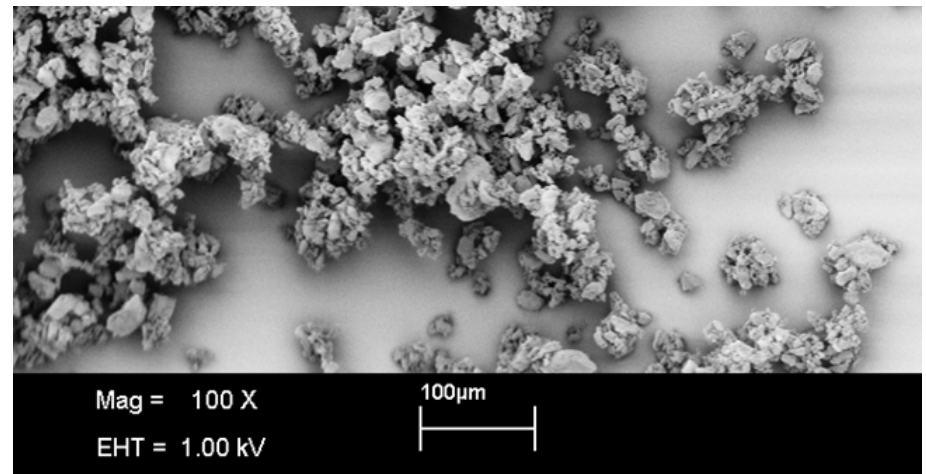


Jet milling - results

- + Milling of crude ADN possible (if pre-mixed with anti-caking agent)
- + Capacity depending on size of mill
- + Easy to mix into formulations
- Hygroscopicity/storage life
- Irregular shape

$d_{50} \sim 15 \mu\text{m}$

1.81 g/cm^3 (100% TMD)



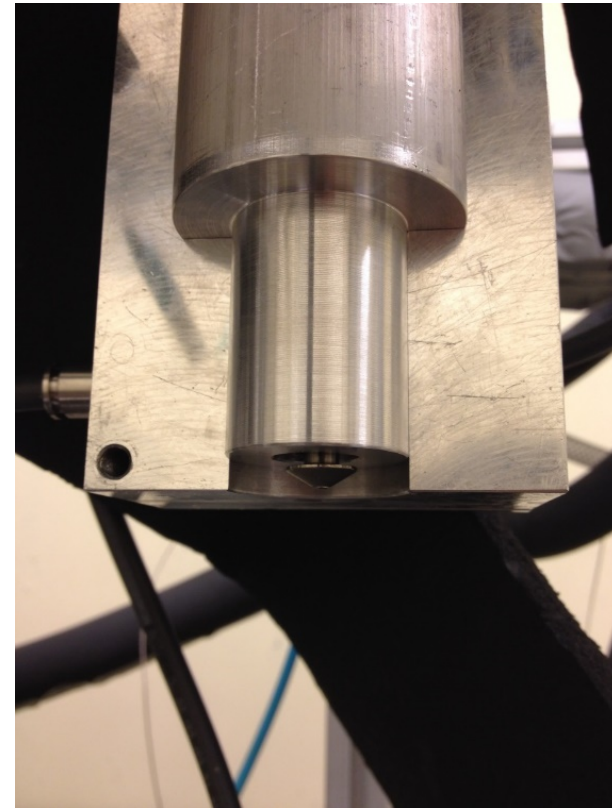
Ultrasonic prilling

Ultrasonic nozzle

Improvements in density, sensitivity,
particle size distribution?



Ultrasonic prilling



Ultrasonic prilling - results

Successful atomization



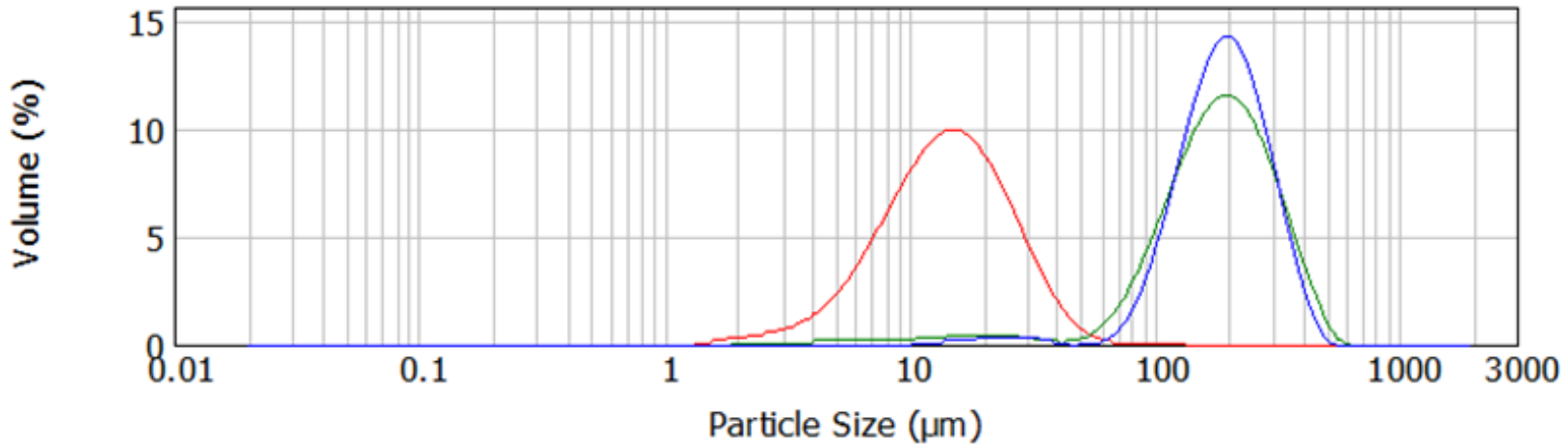
$d_{50} \sim 200 \mu\text{m}$

1.81 g/cm^3 (100% TMD)

- + Particle size distribution comparable to commercial AP
- + More narrow particle size distribution and slightly less sensitive to impact than spray prilled material
- Production capacity – low, a few kilos / day
- Small orifice → risk of clogging

Summary

Particle size and particle size distribution



- Jet milled ADN
- Prilled ADN (spray prilled)
- Prilled ADN (ultrasonic nozzle)

Conclusions

- Several different methods of processing ADN-particles developed
- Control over particle size
- Ability to make particles with 100% TMD

Suggestions for future work

- Develop a high capacity production method for spherical ADN particles in the range of 5-200 μm
- Reducing moisture sensitivity and improving bonding properties by coating
- Reducing particle size distribution even further
- Implement continuous feeding of crude ADN