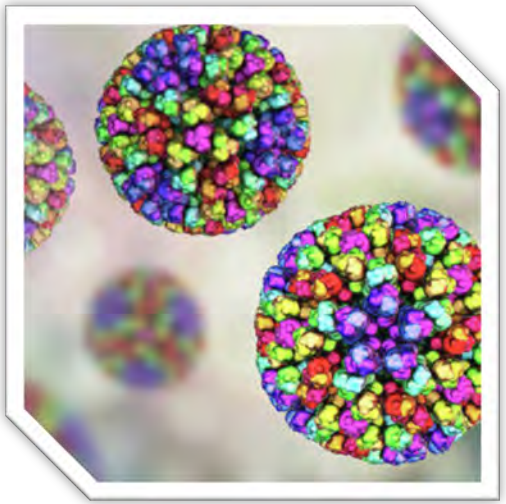
AVEKA Group

Particle Agglomeration

A Technical How-To Guide with Illustrative Examples

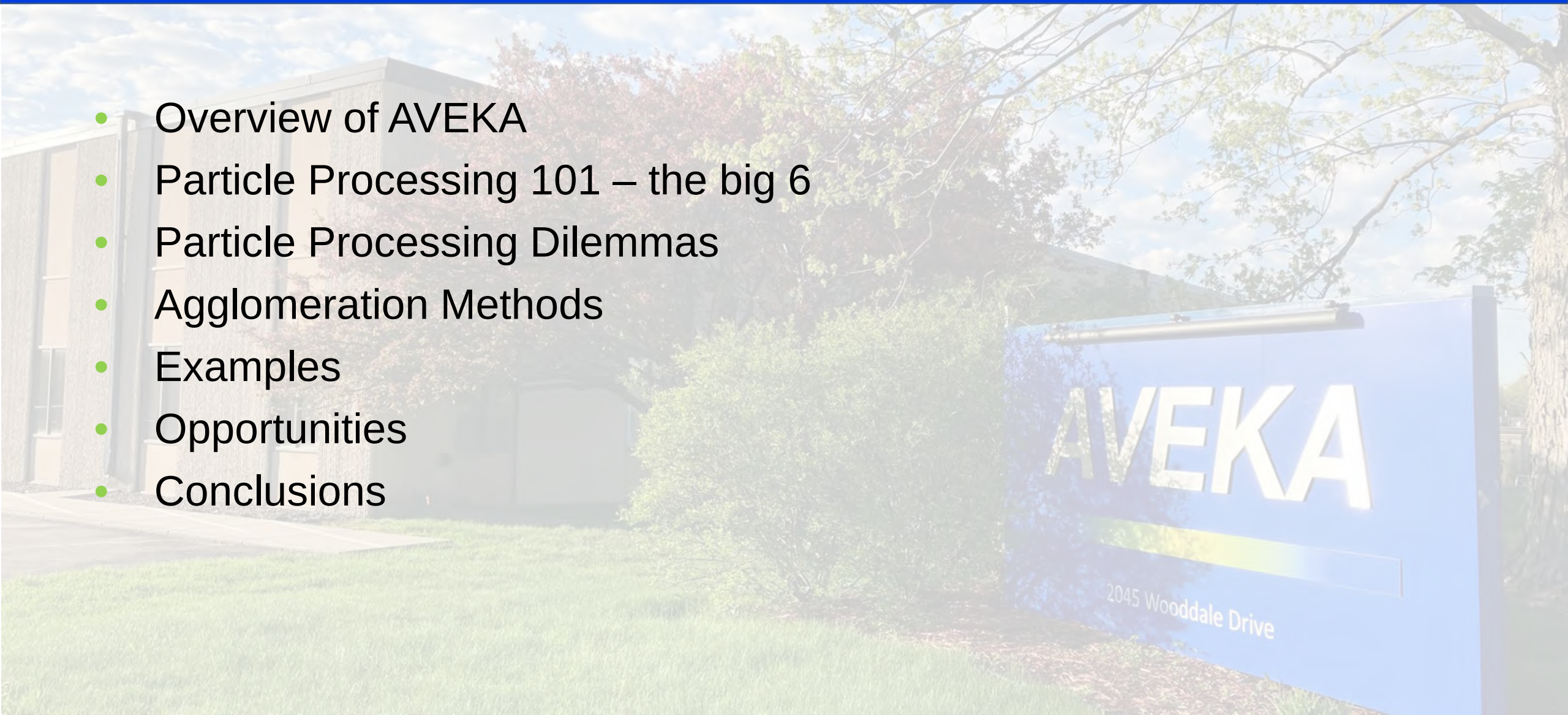


January 26, 2023

PRESENTED BY: WILLIE HENDRICKSON, CEO

Presentation Outline

- Overview of AVEKA
- Particle Processing 101 – the big 6
- Particle Processing Dilemmas
- Agglomeration Methods
- Examples
- Opportunities
- Conclusions



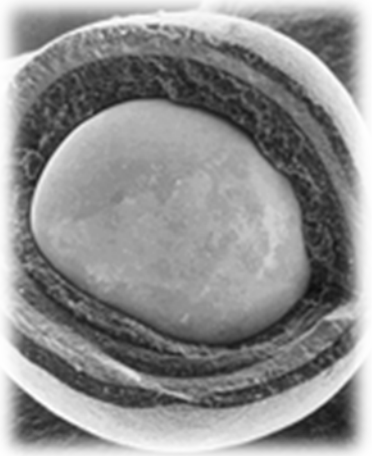
AVEKA Group Overview

- Particle technology company focused on contract manufacturing
- Spin-off of 3M in 1994
- Employee owned and operated
- Comprised of 5 Manufacturing Sites in Minnesota and Iowa
- ISO certifications / food-grade certifications
- Currently 290 employees

ISO 9001:2015 FDA APPROVED Food Safety System Certification 22000 NSF ISR QUALITY ASSURANCE INTERNATIONAL CERTIFIED ORGANIC

Particle Processing: The Big Six

- Characterization
- Flow/Blending
- Size Reduction
- Drying
- Agglomeration
- Particle Coating



Particle Processing Dilemmas

- Equipment Availability
- Volume / Scalability
- Powder Flow
- Functionality

What are Engineered Particles?

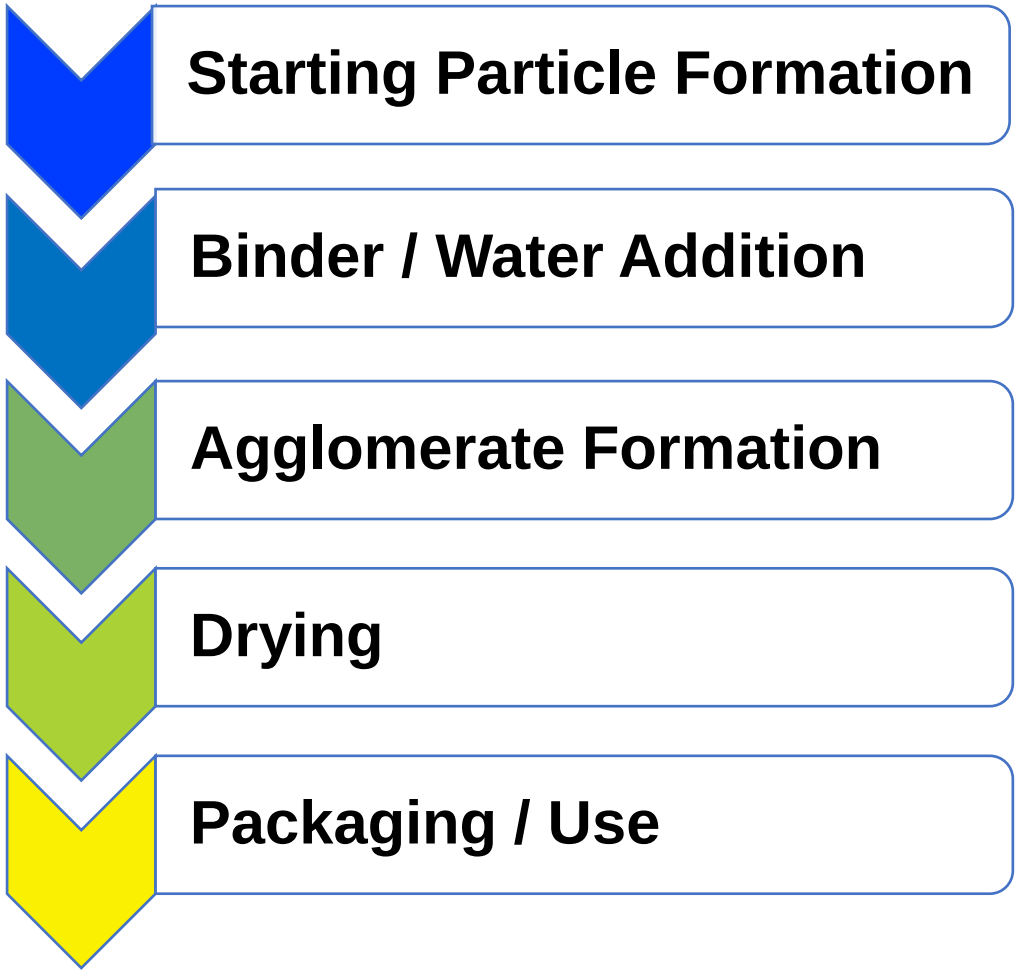
- Size Controlled
- Multicomponent
- Tightly Adjusted Composition
- Complex Structure or Shape
- Functional Property
- Chemically or Biologically Active
- Controlled Release

Uses of Agglomerated Materials

Functionality in Agglomeration Processing

- Dedusting
- Powder Flow
- Density Control
- Wettability
- Compositional Uniformity
- Tableting

Agglomeration Process Steps



So, What Can Go Wrong?

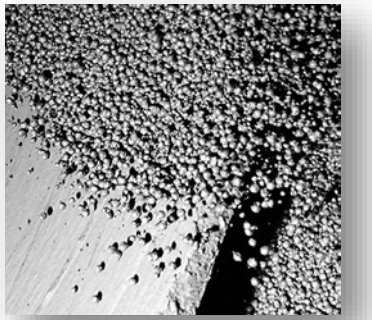
Everything !

- Water addition rate too fast
- Starting material inconsistent
- Agglomerate too weak
- Agglomerate forms wrong structure
- Drying into a too dry particle
- Functional character is wrong

Agglomeration Technologies

Multiple Options:

- High Shear Agglomeration
- Fluid Bed – Spray Agglomeration
- Extrusion Agglomeration
- Tableting
- Drum Granulation

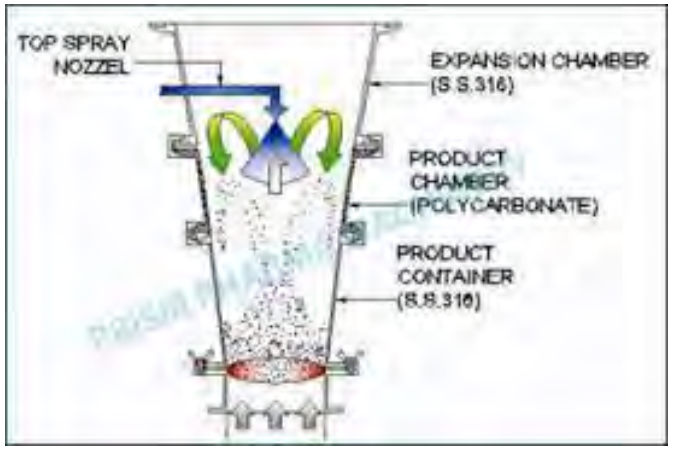


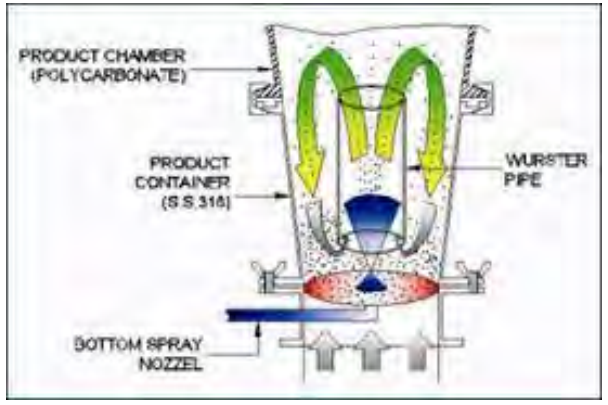
Drying Technologies

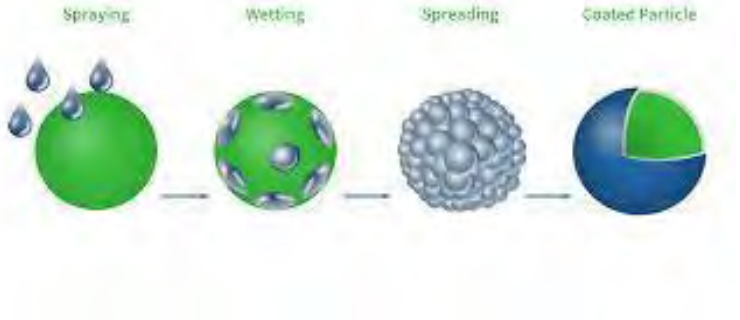
- Spray Drying
- Tray Drying
- Roll Drying
- Fluid Bed Drying
- Ring Drying
- Turbulizers

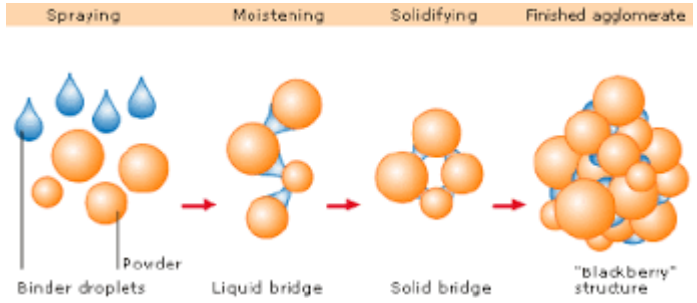
What Makes a Fluid Bed So Versatile

- Liquid Addition
- Top Spray – Agglomeration, Coating
- Bottom Spray – Coating
- Drying to Final Product









The Examples…Finally

Extrusion Agglomeration
- Mineral Example
- Food Example

High Shear Agglomeration
- Personal Care for Dissolution

Fluid Bed Agglomeration
- Protein for Dust Control
- Food for Dissolution
- Protein for Flow
- Protein for Density

Statement of need

How we approached the problem

Why we chose the particular agglomeration process and parameters

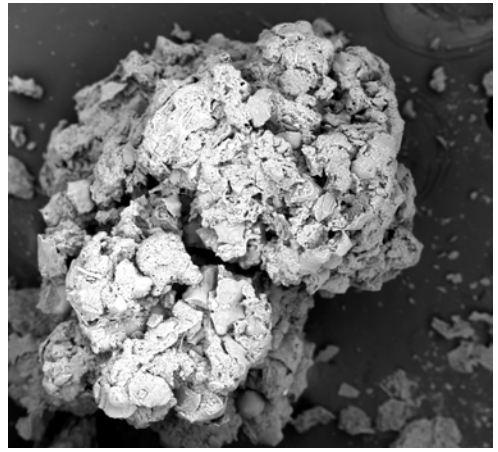
Extrusion Agglomeration

Statement of challenge

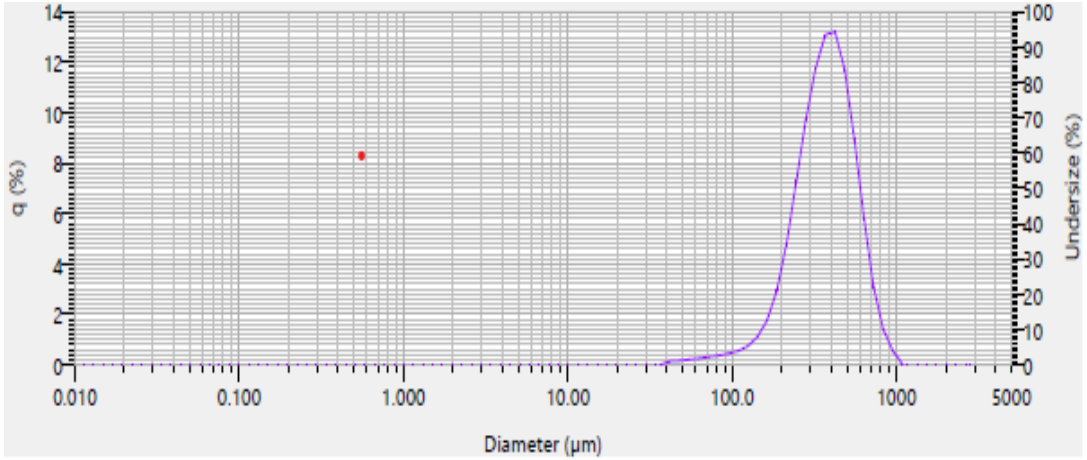
- Mineral Composition
  - Reduce Dustiness
- Agglomeration of mineral mixture
  - Dustiness reduced significantly

The Result

Extrusion



High Shear Granulation



WHAT WENT WRONG?

Mineral destroyed extruder

Beautiful product, but too abrasive for this process

THE REALITY

Switched to high shear agglomeration

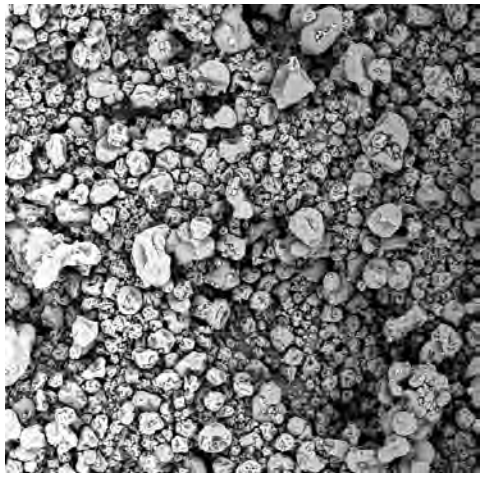
Product still caused substantial wear

Extrusion Agglomeration

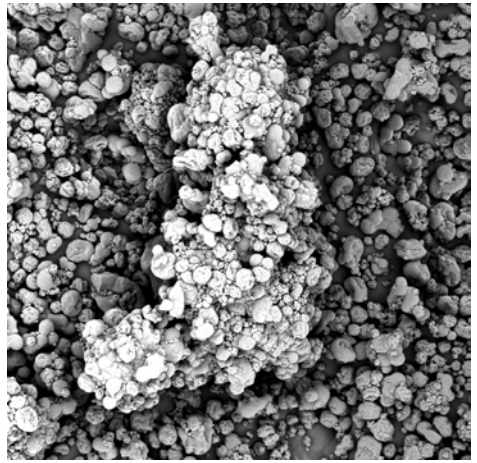
Statement of challenge

- Live Yeast
  - Improve wettability
- Agglomeration without added water or binder
  - Filtration
  - Low temperature drying

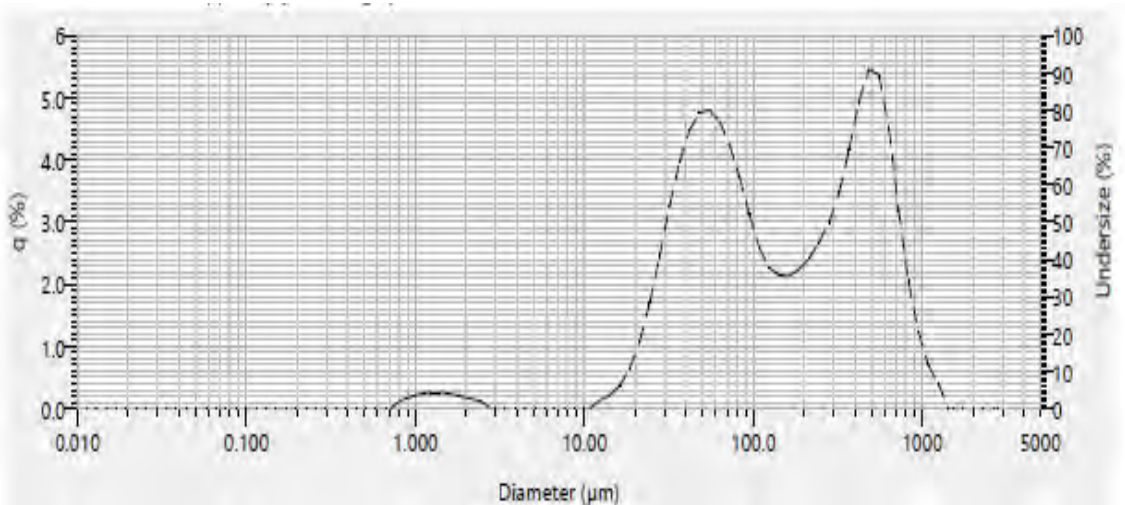
The Result



Live Yeast



After Agglomeration



WHAT WENT WRONG?

Nothing

Yeast was viable

Wettability met customer requirements

THE REALITY

Commercial process

Low strength of granule reflects lack of binder

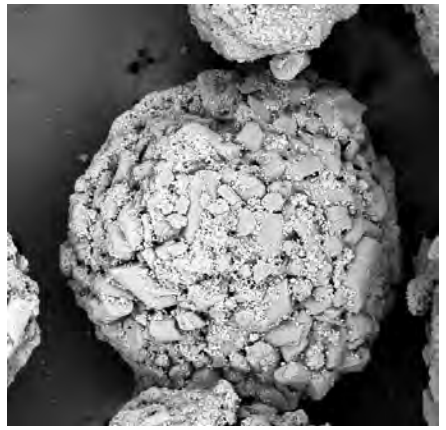
High Shear Agglomeration

Statement of challenge

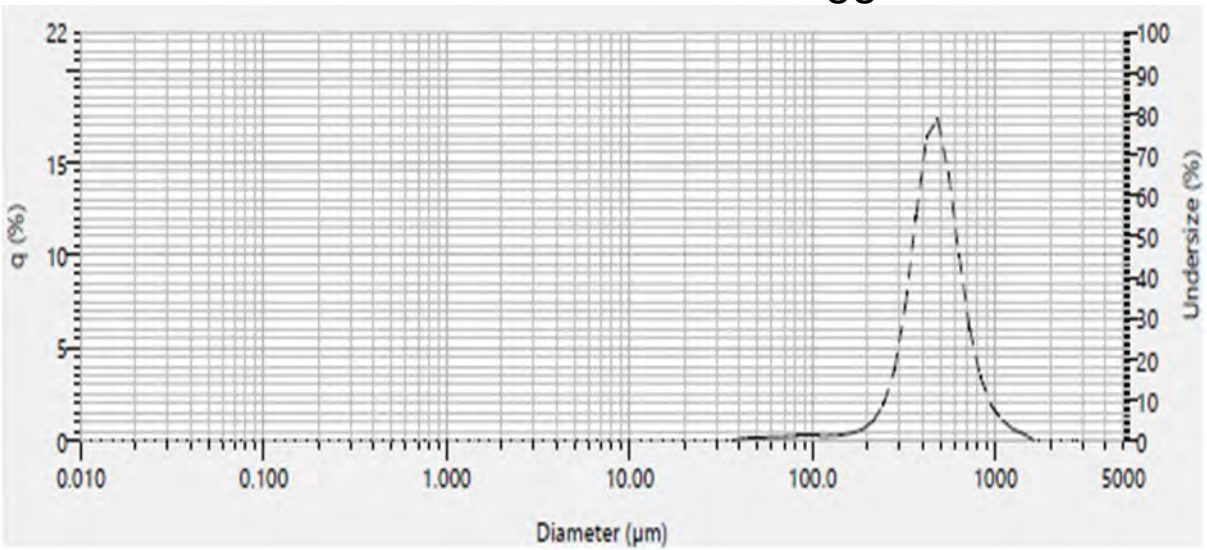
- Laundry Composition
  - Wettability
- Agglomeration of mineral mixture
  - Dustiness reduced significantly

The Result

Raw Material



After Agglomeration



WHAT WENT WRONG?

Nothing

Very consistent product with acceptable wettability

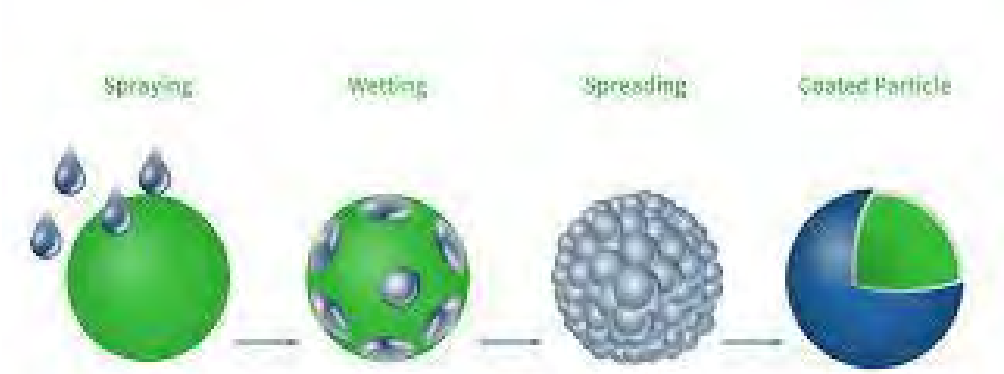
THE REALITY

Currently in production

Agglomeration Using Fluid Beds

Statement of challenge

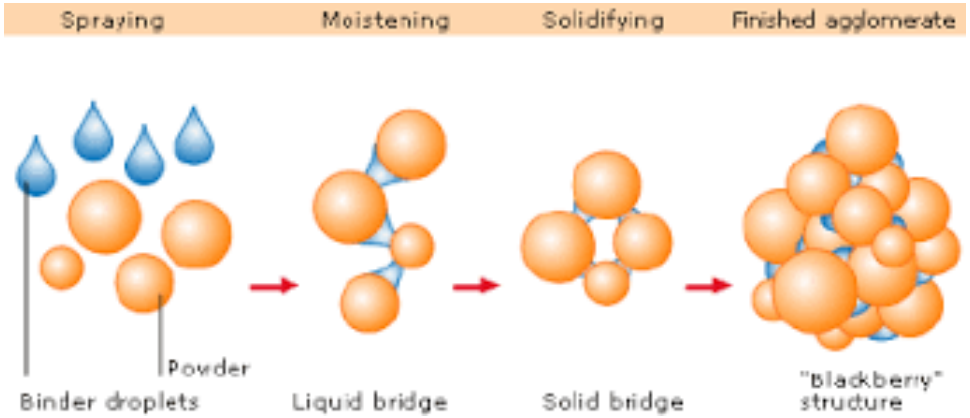
- Agglomerate Dairy Powders to improve dispersibility by capillary absorption



The Result

Dispersion Times

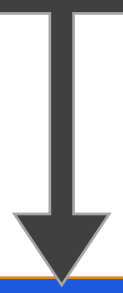
- Raw Material >90 sec
- Fast Water Addition >90 sec
- Slow Water Addition 24 sec
- Low Water Addition 17 sec



WHAT WENT WRONG?

Nothing

Agglomeration shown to produce better dissolution for dairy products



THE REALITY

Process proven

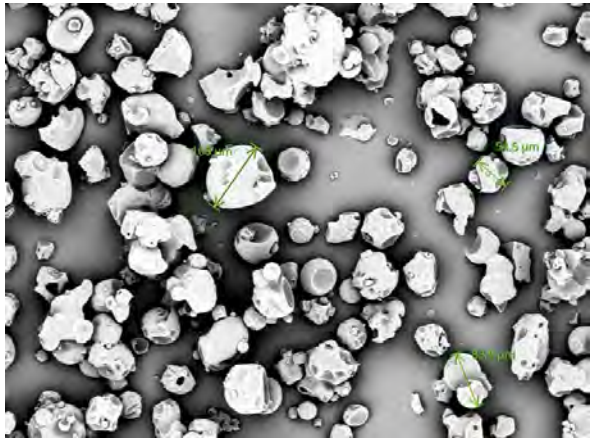
Customer took in house for processing

Agglomeration Using Fluid Beds

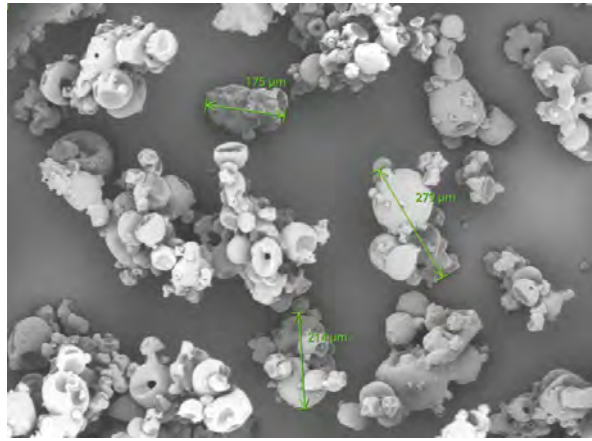
Statement of challenge

- Improve density of soluble fiber
  - Agglomeration with water
- Inconsistent results

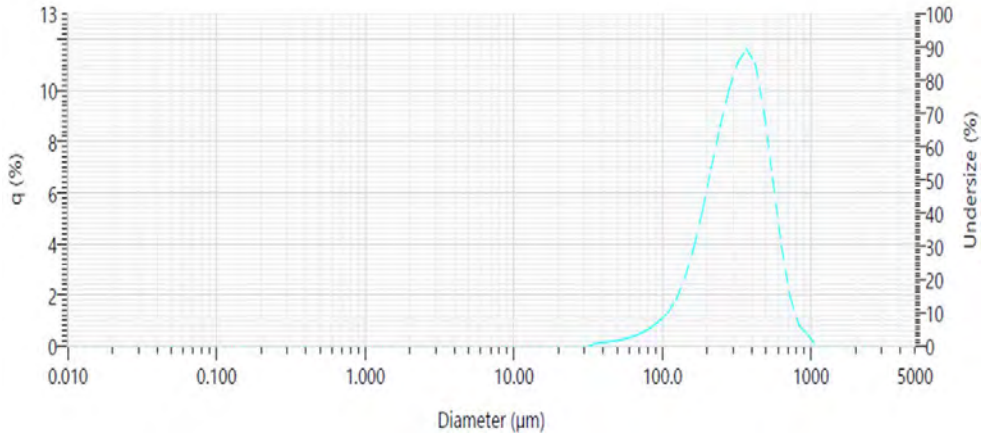
The Result



Raw Material



Agglomerated Material




WHAT WENT WRONG?
Inconsistent Results
THE REALITY
Process improvements still being looked at for production

Agglomeration Using Fluid Beds

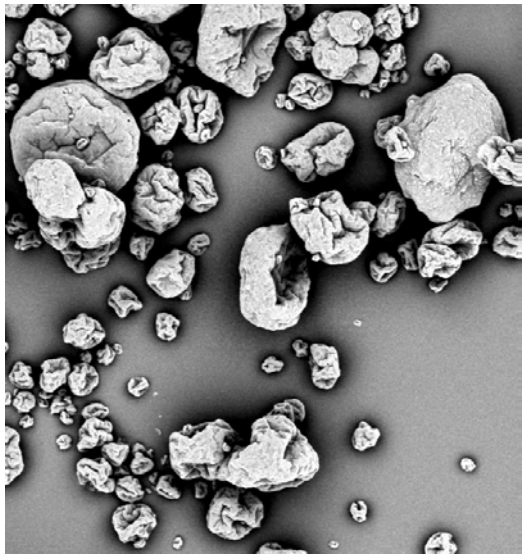
Statement of challenge

- Improve spray dried protein material flow
  - Agglomeration with water
  - Agglomeration with added binder

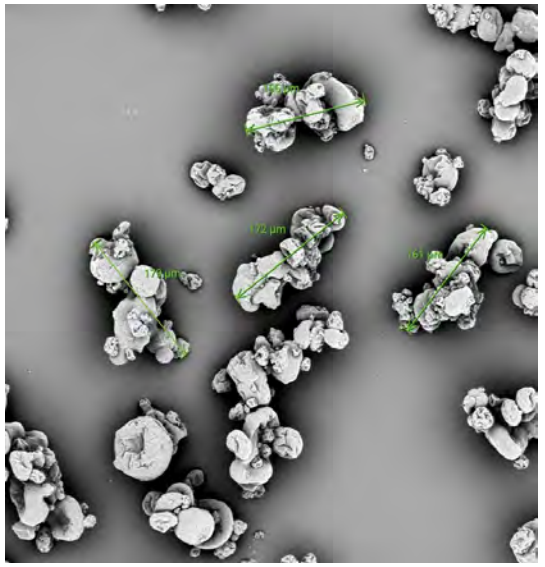
- Decreased Dustiness

Particle Size Distributions (microns)

	D_{10}	D_{50}	D_{90}
Raw Material	15	50	113
Agglomerated with Water	87	202	380
Agglomerated with Binder	75	174	324



Raw Material



Agglomerated Material

WHAT WENT WRONG?

Nothing

Fluid bed material flowed better and was less dusty

THE REALITY

Customer currently evaluating

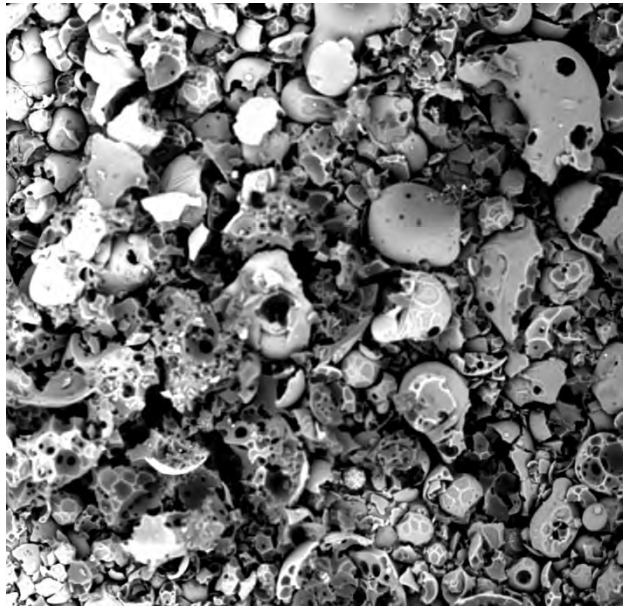
Agglomeration Using Fluid Beds

Statement of challenge

- Improve spray dried protein material flow
  - Agglomeration with water

- Improved flow and wettability

The Result



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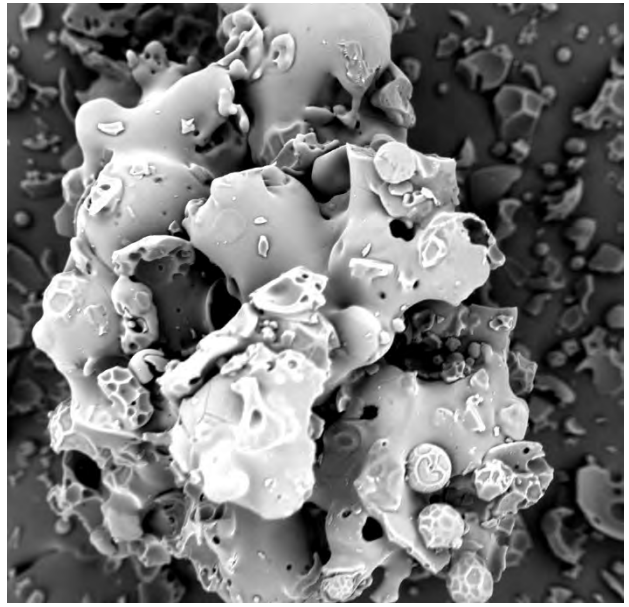
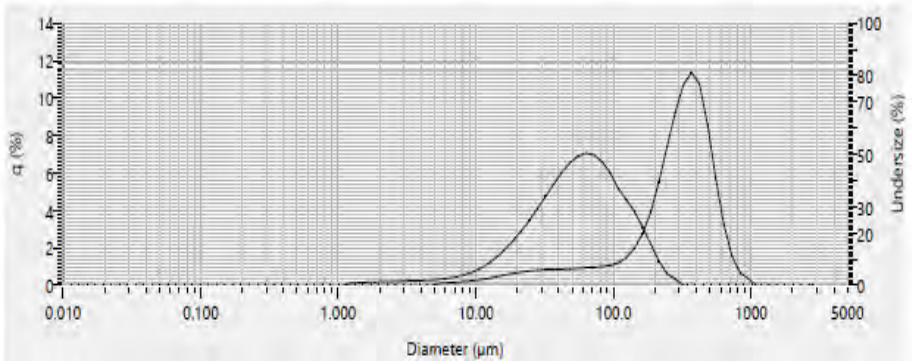


Agglomerated Material



WHAT WENT WRONG?

Nothing

Fluid bed material flowed better

THE REALITY

Customer took process in-house

Note globby structure – function of starting material and processing conditions

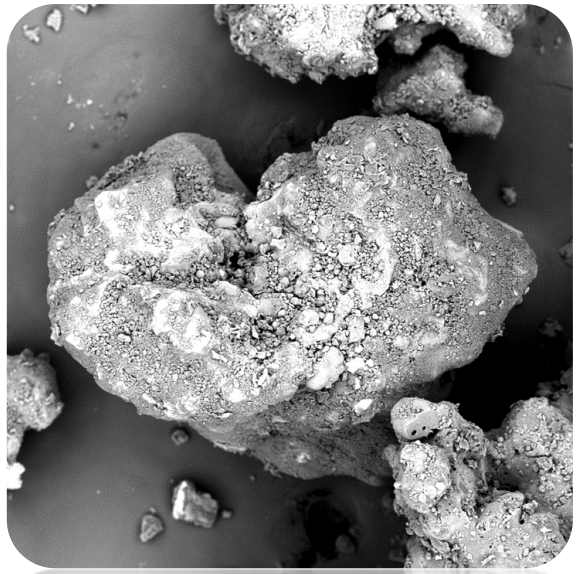
Agglomeration Using Fluid Beds

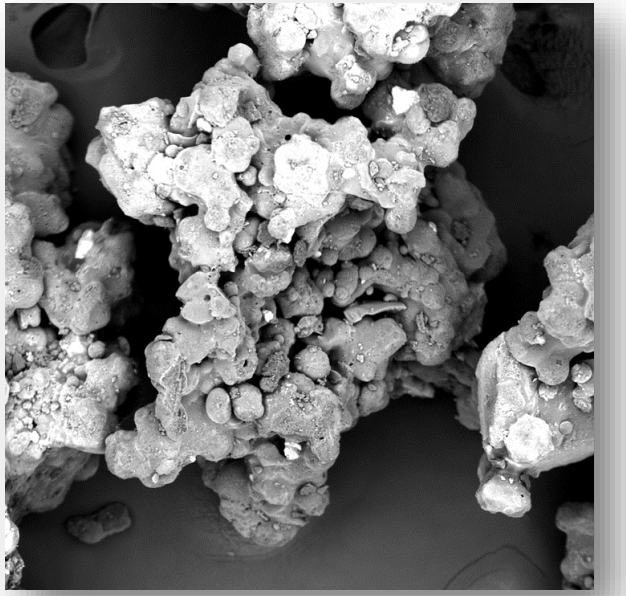
Statement of challenge

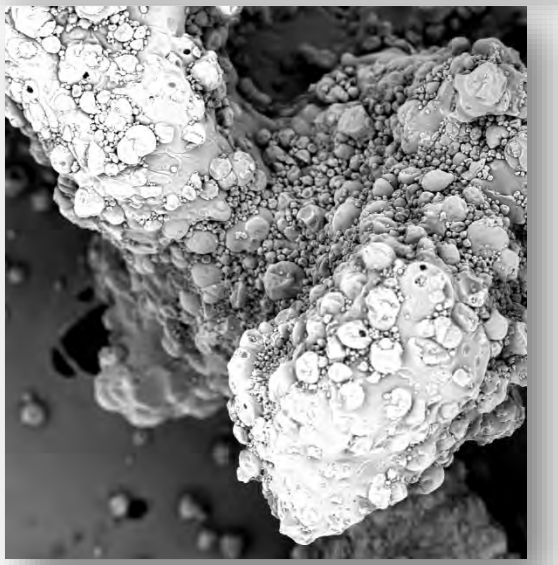
Improve spray dried wettability of drink additives

- Agglomeration with water
- Single component example
- Multi component examples

Variable final agglomerate structure



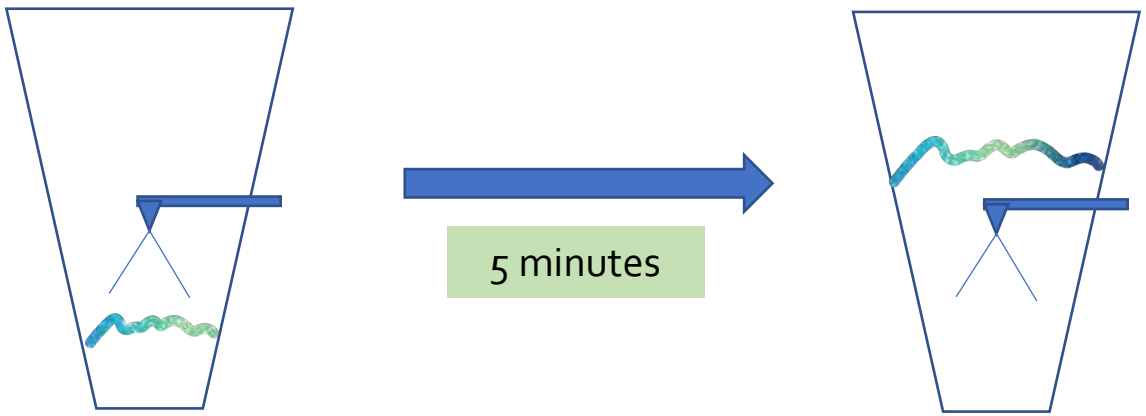




Fluid Bed Agglomeration of Protein
(Target D_{50} > 400 µm)

Challenges:

1. Very low bulk density of 0.079 g/ml (typical organics are ~0.5 g/ml). This means very little material can be loaded into the agglomeration chamber.
2. Large volume increase during agglomeration – the bed expansion quickly buries the spray nozzle before the target particle size is achieved.
3. Large masses of wet material - resulting in large yield loss.



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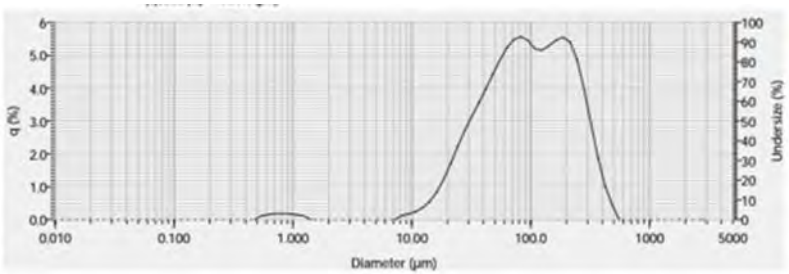
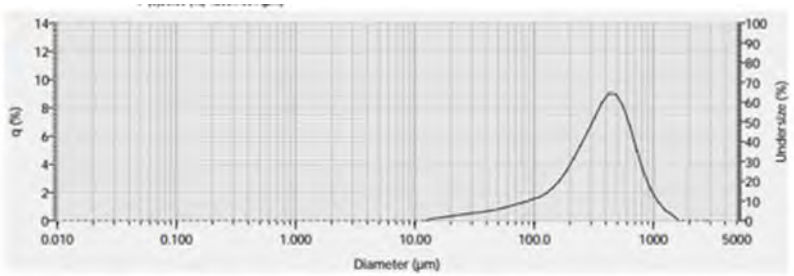
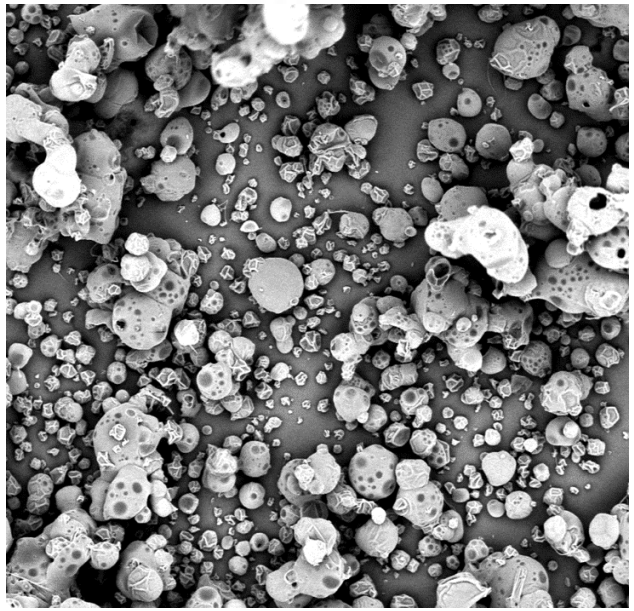


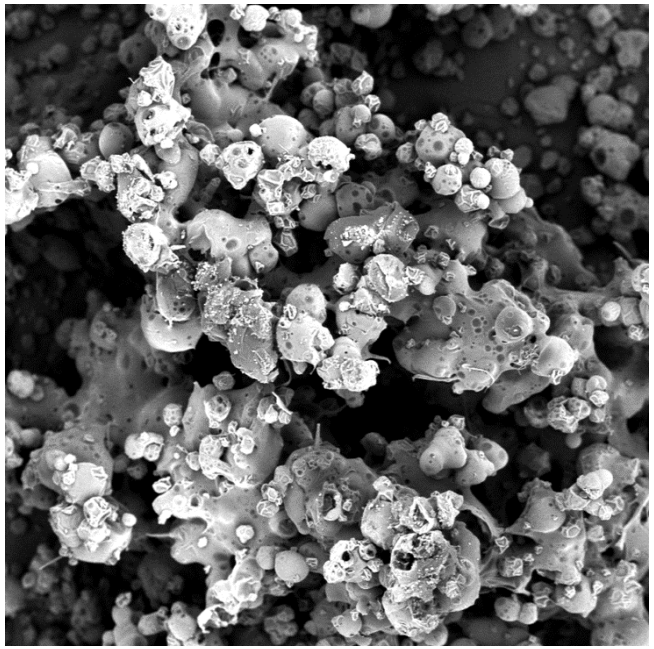
5 minutes



Raw Material (D50 = 124 µm)



After 5 Minutes of Processing
(D50 = 369 µm)



What Did I Leave Out?

Major Uses of Agglomeration

- Pharmaceutical Agglomeration
- Tableting and Briquetting

Equipment Variations

- Batch vs. continuous fluid beds
- Spray drying/fluid bed combined systems
- Agglomerating Spray Drying
  - Particle injection into spray chamber
- Process Conditions

Fluid Bed Processing Thoughts

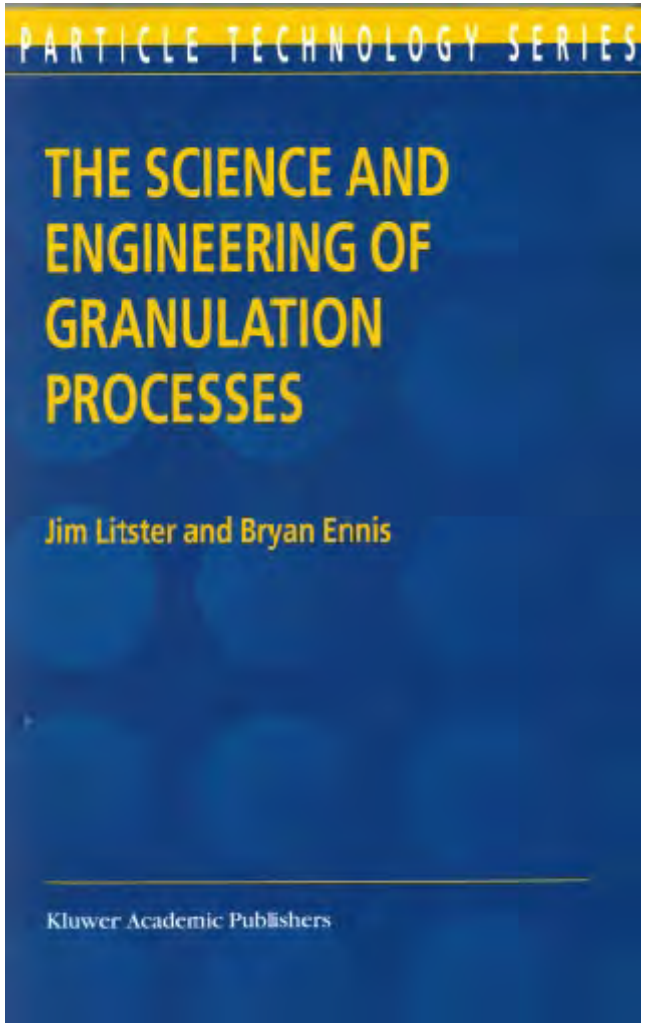
Resources

International Fine Particle Research Institute (IFPRI)
www.ifpri.net

Rachel Smith University of Sheffield (Rachel.Smith@sheffield.ac.uk)

Paul Mort Purdue University (pmort@purdue.edu)

Glatt, Vector, GEA



Summary

Agglomeration has multiple advantages

- Functionality
- Many processing options

Process conditions and materials are critical

It is hard to analyze too much

Contact Information:

AVEKA Group Inc
AVEKA@aveka.com
651-730-1729