AVEKA Group

MASTERING THE PROCESSING METHODS OF ENGINEERED PARTICLES

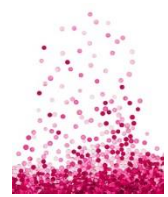
MAY 13, 2020

PARTICLE PROCESSING SERVICES

TOLL MANUFACTURING

RESEARCH & DEVELOPMENT

INNOVATIVE SOLUTIONS



PRESENTED BY: WILLIE HENDRICKSON, CEO & FOUNDER

Presentation Outline

- Overview of AVEKA
- What are engineered particles?
- How do you approach making engineered particles?
- General processing methods to consider
- Practical challenges
- Separation example
- Coating example
- Atomization example
- Conclusions

AVEKA Group Overview

- Particle technology company focused on contract manufacturing
- Spin-off of 3M in 1994
- Comprised of 5 separate companies
- ISO certifications / food-grade certifications
- Currently 290 employees

AVEKA's Vision

AVEKA's Vision

Building the legacy of leadership and innovation in **manufacturing solutions** for particle technology

AVEKA's Mission

Our team of employee owners will deliver custom solutions, quality manufacturing, and excellent customer service for the benefit of our customers, employees and communities.

The AVEKA Group

AVEKA Inc

- 75 people
- Corporate Headquarters
- R&D, Manufacturing, Specialty Process Suites

AVEKA Manufacturing

- 96 people – Fredericksburg, Iowa
- Large scale manufacturing
- Spray Drying, Hammer Milling, Fluid Bed Drying, Tumble Coating, Agglomeration

Cresco Food Technologies

- 50 people – Cresco, Iowa
- Food Processing
- Spray Drying, Prilling, Drum Drying, Extraction, Wet Blending

AVEKA Nutra Processing

- 40 people – Waukon Iowa
- Value Added Food Processing
- Spray Drying, Roll Drying, Microfiltration/Nanofiltration, Specialty Separations

AVEKA CCE Technologies

- 15 People – Cottage Grove, Minnesota
- Industrial Materials, Abrasives, Ceramics, Minerals
- Jet Milling and Classification

Particle Characterization

Particle size analysis

- Particles 1 nm to 2+ mm
- Particle size distribution (PSD)
- Sonic sieving
- Rototap

Imaging

- Optical microscopy
- Scanning electron microscopy (SEM) with EDS

Surface area analysis

True density analysis

- Helium pycnometry

Formulation analysis

- High performance liquid chromatography (HPLC)
- Thermogravimetric analysis (TGA)
- Spectrophotometer
- Differential scanning calorimetry (DSC)

Flow characteristics

- Freeman FT4
- Zeta potential analysis (ZP)
- Rheological analysis
- Moisture and solids analysis (MSA)
- Karl Fisher

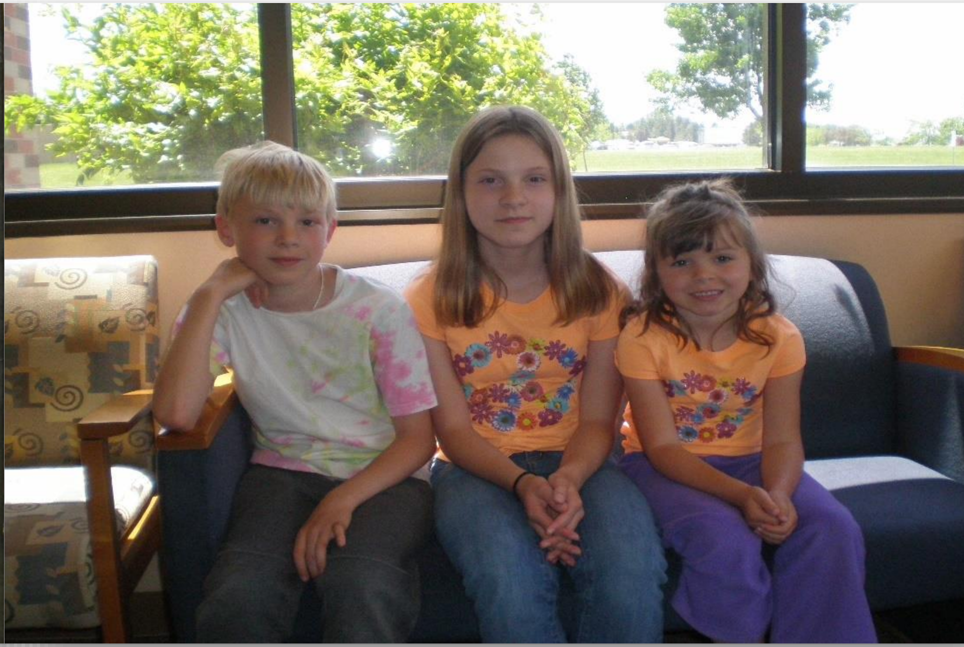
What are Engineered Particles?

- Size controlled
- Multicomponent
- Tightly adjusted composition
- Complex structure or shape
- Functional property
- Chemically or biologically active
- Controlled release

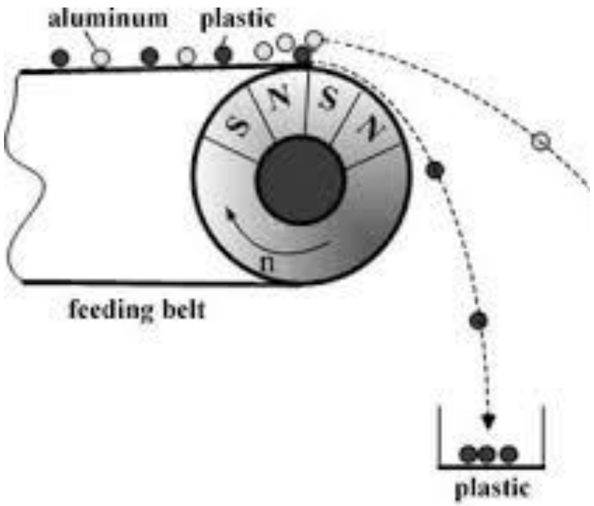
It's All About Knowing the Trick

CARL FRIEDRICH GAUSS

NORA, ORRIN, LAINA YATES



PARTICLE TECHNOLOGY TRICKS (EXAMPLES)



Particle Knowledge Sources

- Academic literature
- Patent literature
- General reading
- You Tube
- How it's made

What Do You Need to Know?

Chemistry Properties

M.p., b.p., solubility, pH, density

Functional Properties

Particle size, viscosity, powder flow

Financial Considerations

Cost, volumes, profitability

What equipment do you have available?

Processing Dilemmas

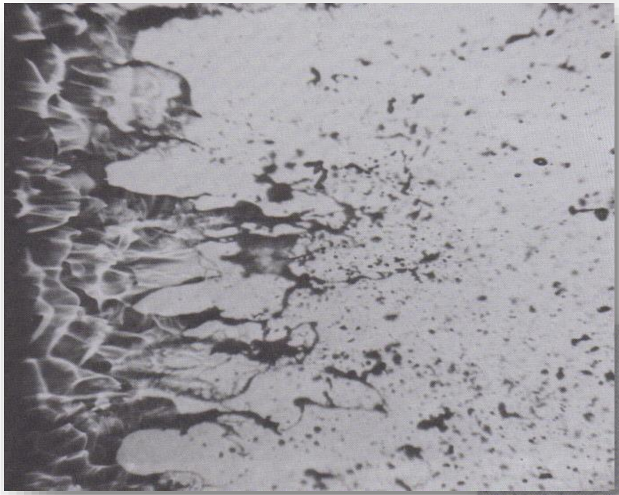
- Available equipment dilemma
- Spray drying dilemma
- Mass balance dilemma
- Scalability dilemma

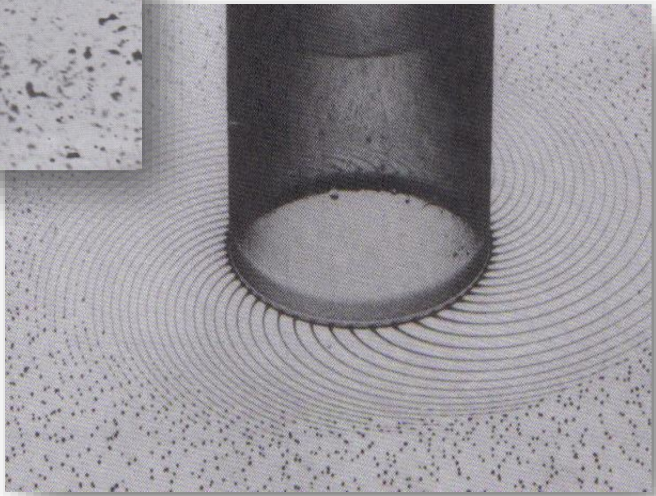
Particle Processing Tools

- GRANULATION
- DRYING
- ATOMIZATION
- GRINDING
- COATING
- SEPARATION

Spray Drying

- 5-120 micron particle size
- 10-60% solids (slurries or solutions)
- 1-200 cps Liquid viscosity
- Particles can be solid or hollow





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The Examples…. Finally

Cellulose Fiber Separation
- Water holding enhancement

Encapsulation of Omega-3 Oils
- Reduced oxidation and odor

Monodisperse Particles
- Medical device testing

- Statement of need
- How we approached the problem
- What went right
- What went wrong

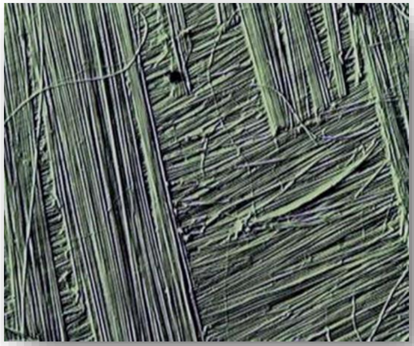
Preparation of Cellulose Fiber from Corn Bran

Statement of challenge

- Scale-up proven process
- Produce high concentration of cellulose fiber with high water holding property

The Solution

Corn Bran Starting Material Composition	
Starch	1-10%
Protein	1-8%
Oils	0-2%
Ash	1-6%
Water	1-10%
Fiber	80-90%
• Cellulose	25-30%
• Hemicellulose	60-70%
• Lignin	1-6%



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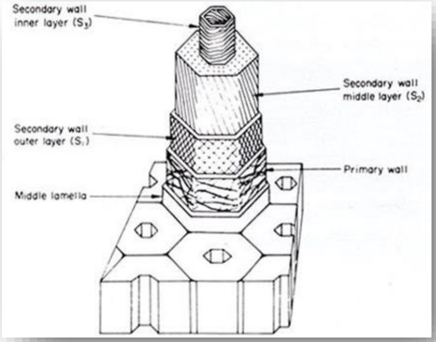
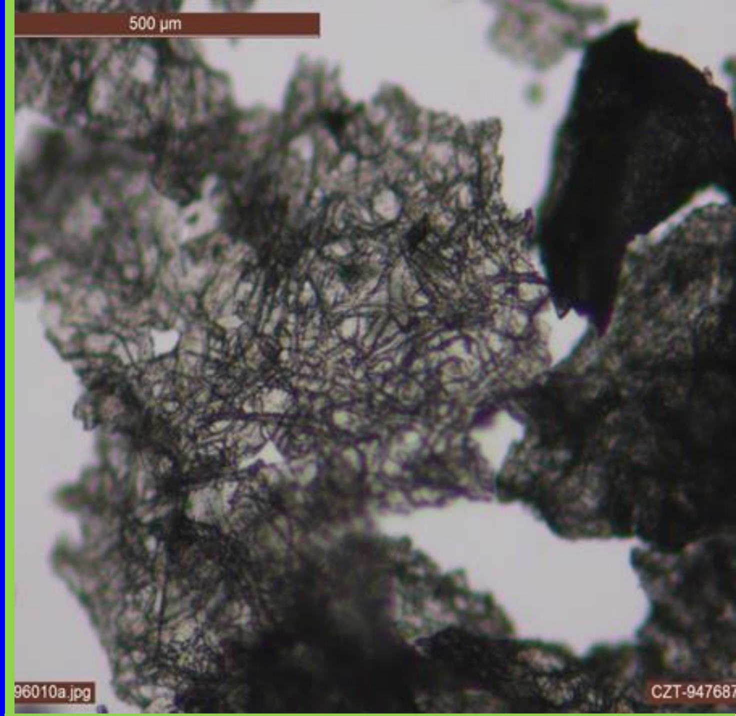
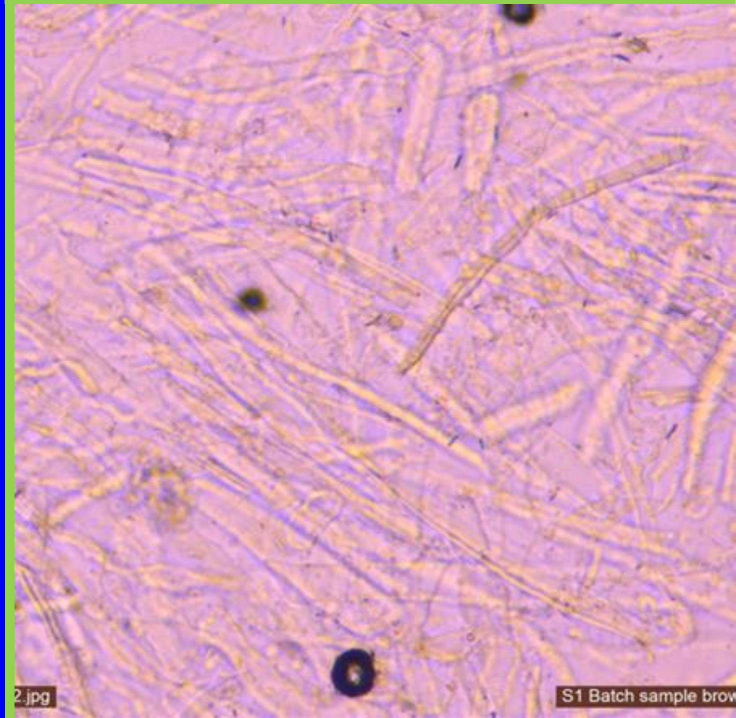


Process and Cellulose Images

- Slurry in Water
- Remove digested starch and fats
- Add caustic to solubilize hemicellulose and lignin
- Centrifuge and dry





WHAT WENT WRONG?

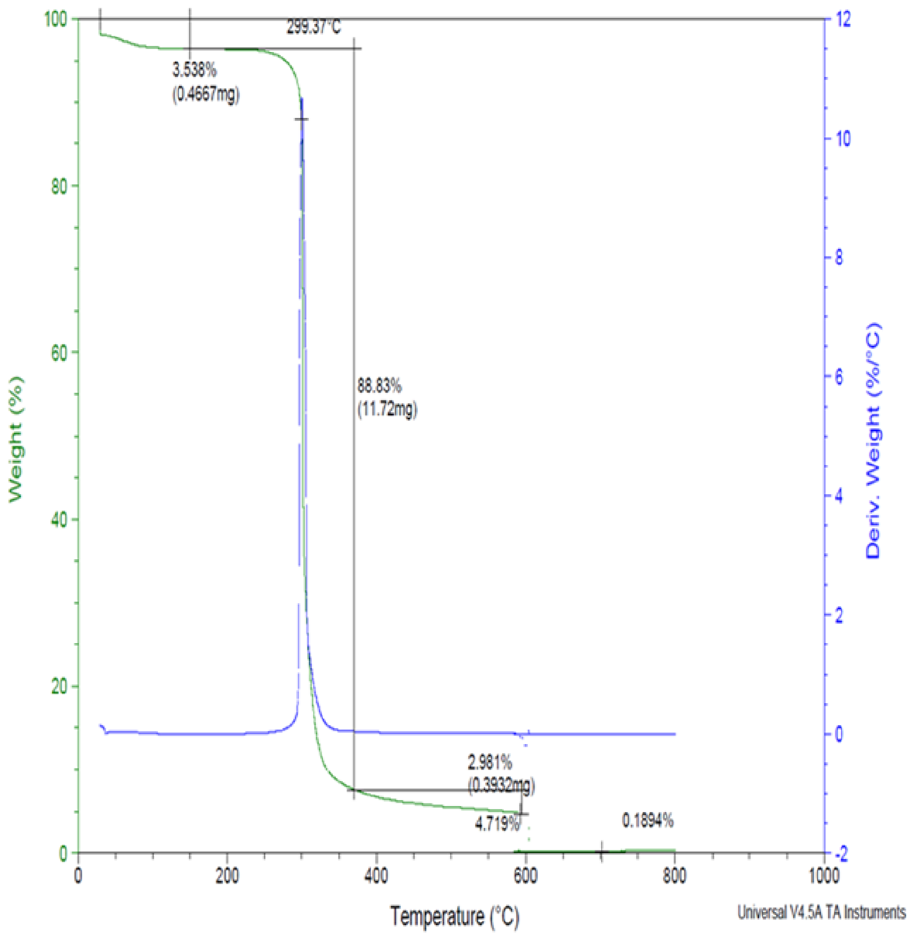
- Yields were poor
- Process incredible inconsistent
- Water holding results were inconsistent

THE SOLUTION

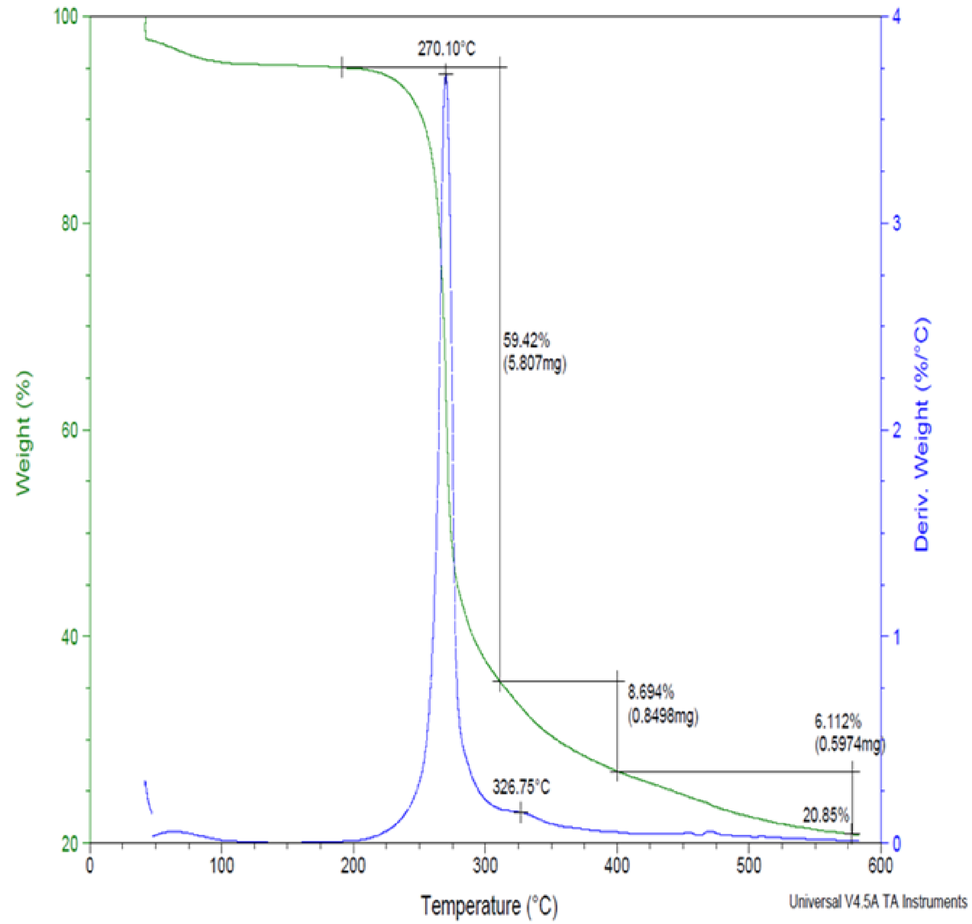
- Analyze
- Understand

TGA of Cellulose and Hemicellulose

Wood Cellulose

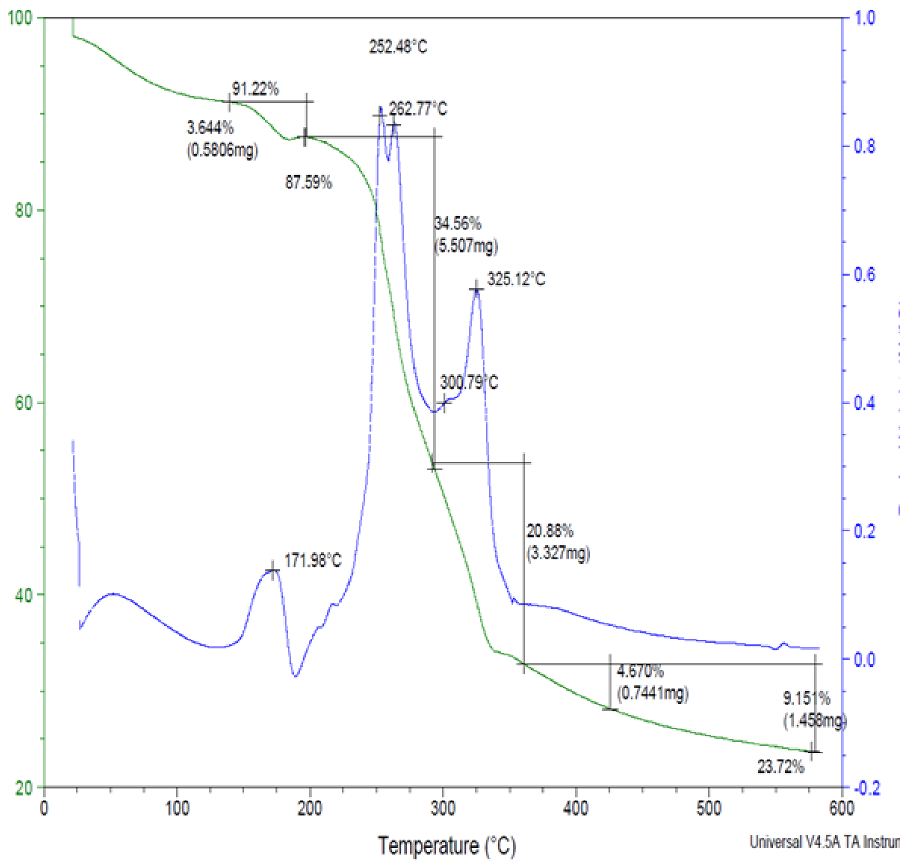


Hemicellulose

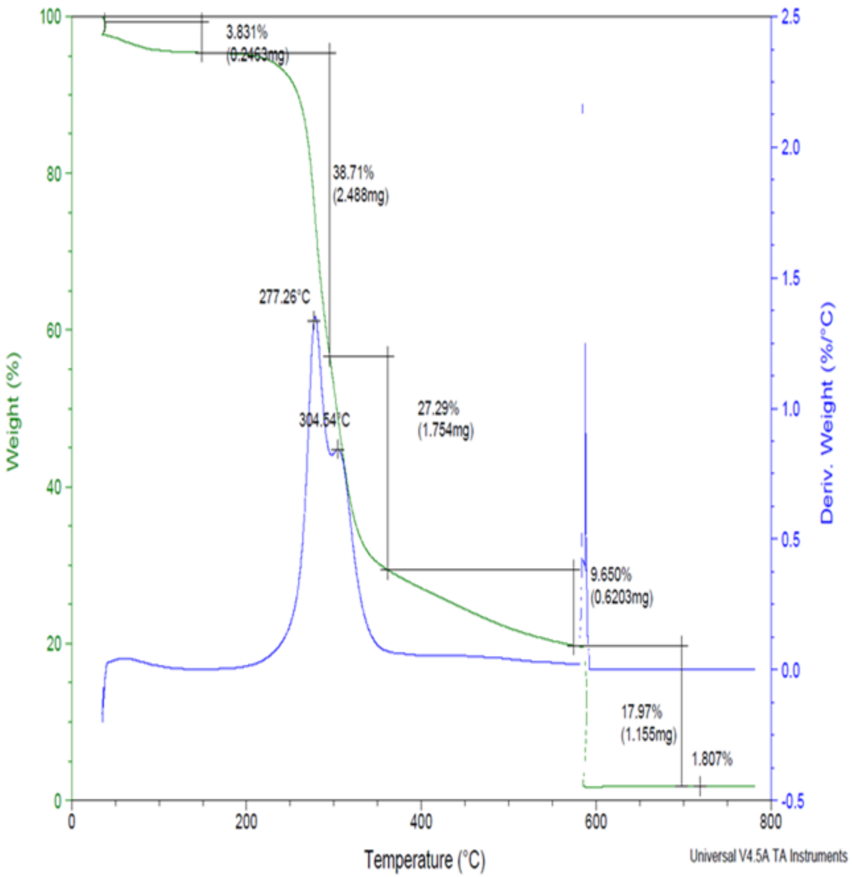


TGA of Corn Bran and Purified Cellulose

Corn Bran



Processed Cellulose

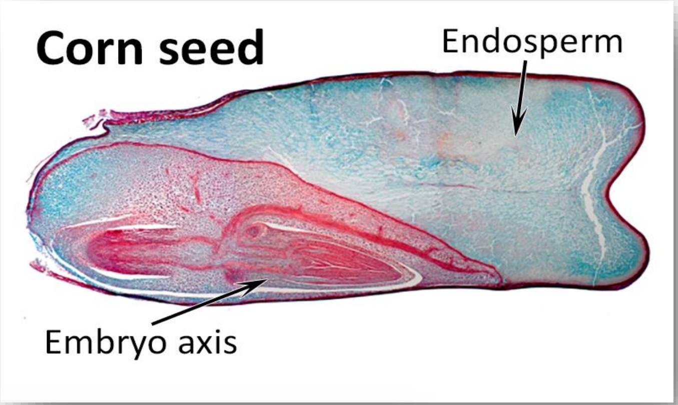


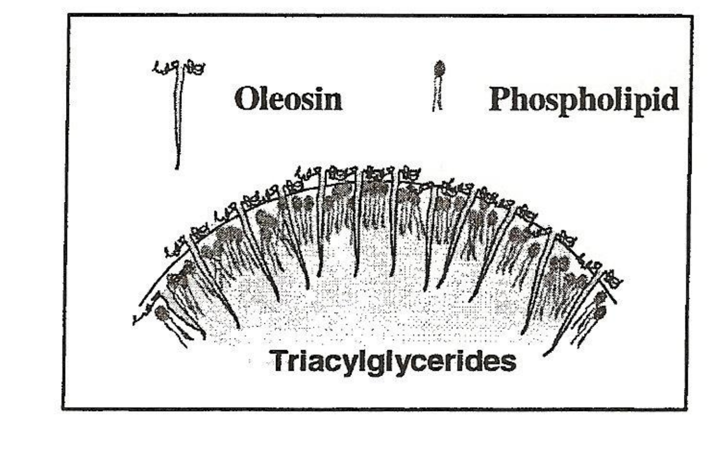
Preparation of Microencapsulated Omega-3 Fish Oil

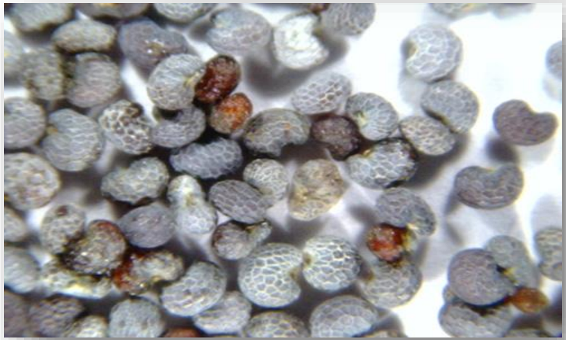
Statement of challenge

- No known method for protecting Omega-3 oils from oxidation
- Overcome oxygen disfusion through cell wall
- Consider biomimicry

The Solution







Proposed Structure

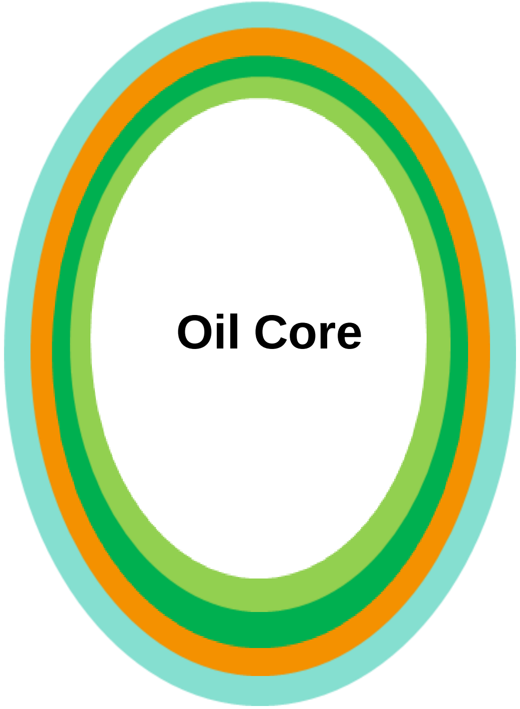
Oil core

Organelle shell

Alginate shell

Carbohydrate/protein/fiber shell

Fat/fiber shell



WHAT WENT WRONG?

- Multilayer structure was made using atomization and spray drying methods followed by coating process
- Results were as good as industry standards – not better

THE SOLUTION

- Change materials
- Improve on oleosin usage

Preparation of Monodisperse Wax Beads

Statement of challenge

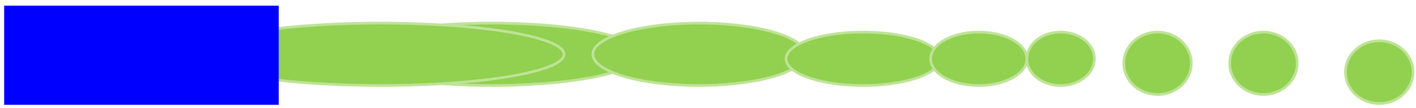
- 4mm monodisperse beads needed for bio assay end use
- Need to be sterile
- Need to be tight size and weight
- Minimal waste of raw material

The Solution

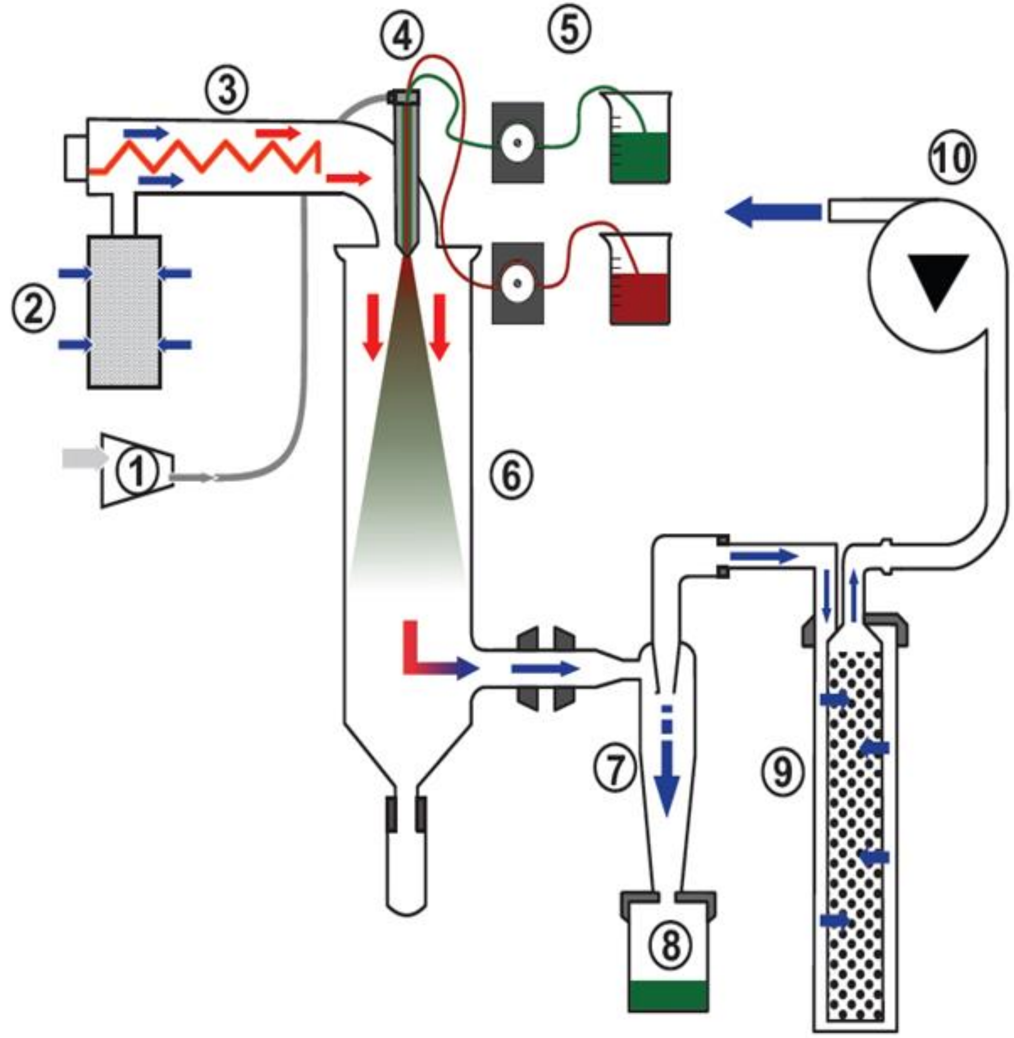
- Prilling process
- Underwater formation and cooling
- New atomization method needed

Particles from Liquids: Prilling

Rayleigh Breakup



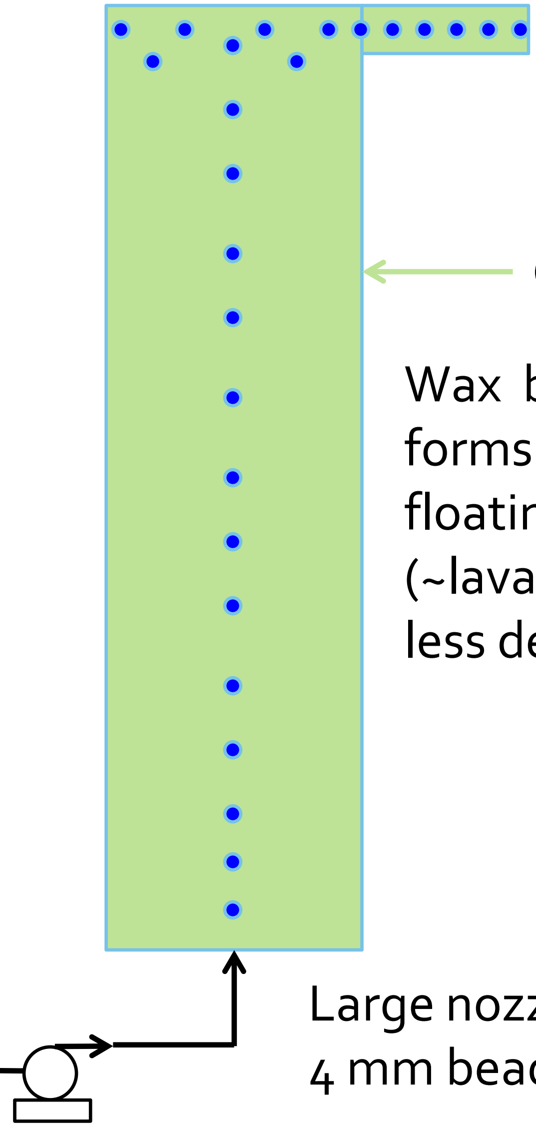
- Spherical particles (10-2000 micron)
- Up to 50% active loading
- Matrix: phytosterols, hydrogenated oils, PLA
- Actives: oils, flavors, particles, CMC, biocides
- Throughputs: 1 – 2000 lb/hr

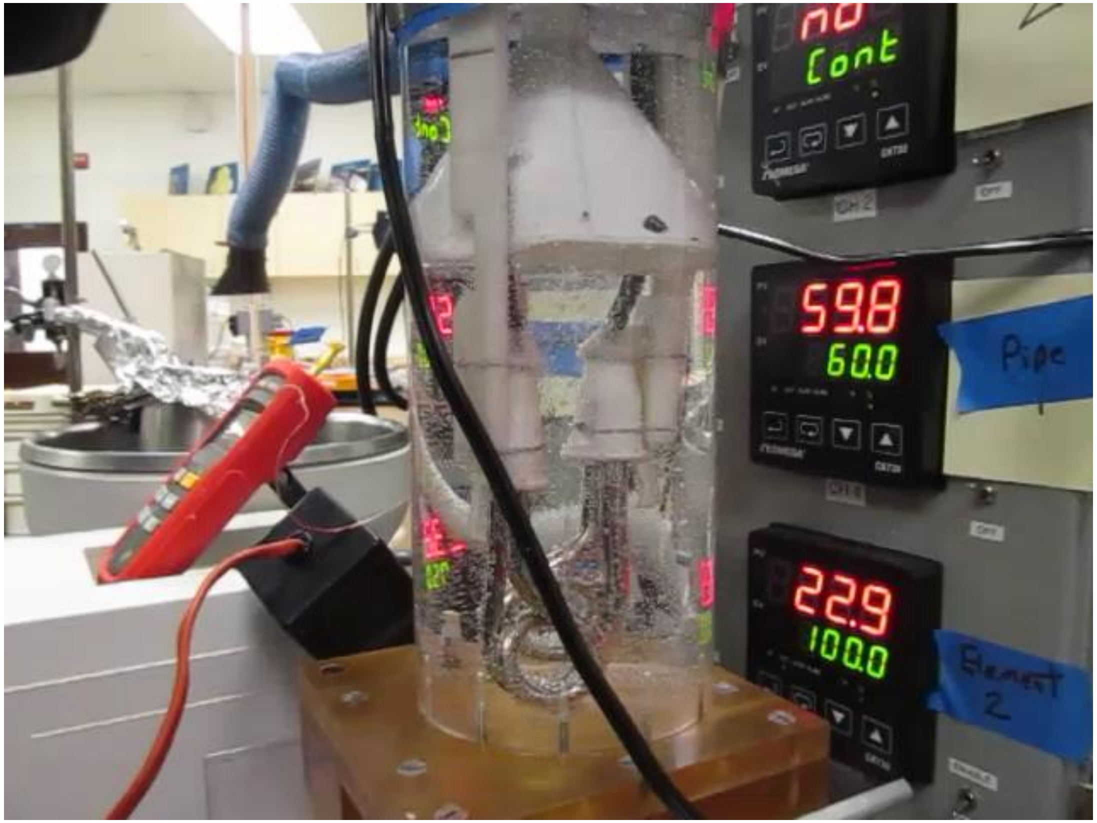


Microencapsulation via Prilling

- Process Parameters
  - Melts not solutions(50-200 °C)
  - Melt viscosities < 300 cps
  - Atomizers
    - Drip
    - Spinning disk
    - Two-fluid
    - Single fluid
  - Chamber temperature
  - Throughput (1-5000 kg/hr)
- Product Parameters
  - Particle size (10-5000 µm)
  - Matrix particle with 5-50% active inclusions

Underwater Prilling





Under Water Prilling Process

Underwater Prilling Results

WHAT WENT WRONG?

- Under water prilling process produced beads in the correct size and consistency
- Water inclusion (holes) were not expected

THE SOLUTION

- Vacuum drying worked
- Customer went to another technology due to timing

Summary

- Knowing the tricks and applying them are Critical
- Multiple methods should be considered for every problem
- It is hard to analyze and know too much

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