AVEKA Group

IFPRI COHESION WORKSHOP

PARTICLE PROCESSING CONTRACT MANUFACTURING PERSPECTIVE ON PARTICLE COHESION

WILLIE HENDRICKSON

JANUARY 13, 2020

Outline

AVEKA

- AVEKA Overview
- Industrial Particle Technology Successes
- Cohesion Challenges
- Cohesion Modifications and Mechanistic Implications

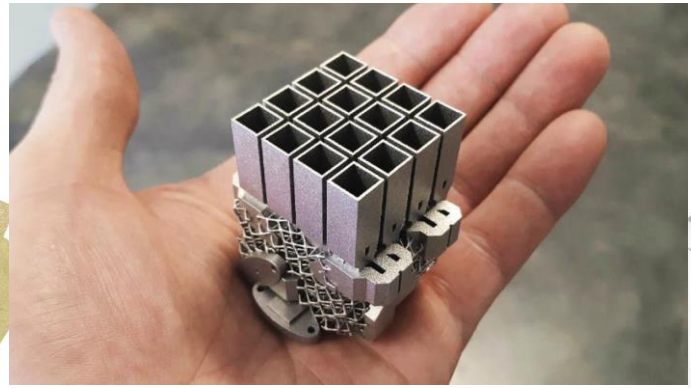
Overview

- Particle technology company focused on contract manufacturing
- Spin-off of 3M in 1994
- Comprised of 5 separate manufacturing sites
- ISO certifications / food-grade certifications
- Currently 280 employees

Industrial Particle Processing Successes

AVEKA

- Photocopying
- Taconite Ore Agglomeration
- Flour Milling
- Drug Inhalation
- Coated Abrasives (sandpaper)
- 3D Printing



Cohesion Challenges and A Solution

AVEKA

Challenges

- Feeding
- Bins and Hoppers
- Mixing
- Conveying
- Fluidization
- Classification (air and screening)
- Size Reduction

Solution

Potential Microscopic Cohesion Mechanisms

AVEKA

- Van der Waals Attractions
- Electrostatic Attractions
- Liquid Bridging
- Particle Jamming
- Formation of Solid Bridges
- Particle Surface Roughness
- Combination of Multiple Mechanisms
- Influence of Ambient Conditions
- Variation in Particle Surface Chemistry
- Particle Density/Particle Size

Surface Modification of Powders and Mechanistic Implications

AVEKA

- AVEKA Group and Freeman Technology
  - Charles Bowman and Katrina Brockbank
- With Input and Contributions:
  - Marty Murtagh (Corning), Paul Mort (P&G), Chris Rueb (AVEKA), Tim Freeman (Freeman Technologies)
- Enhanced Powder Flow

Powder Flow Modification and Measurement

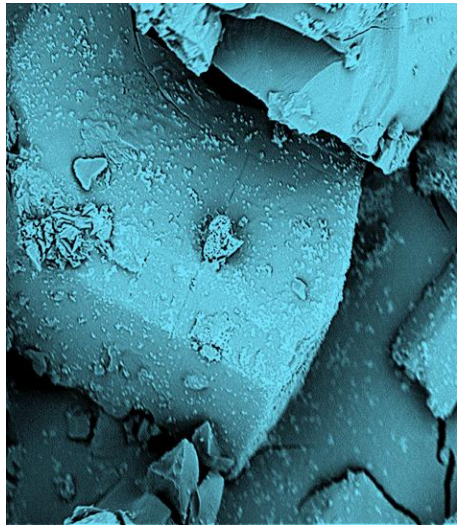
AVEKA

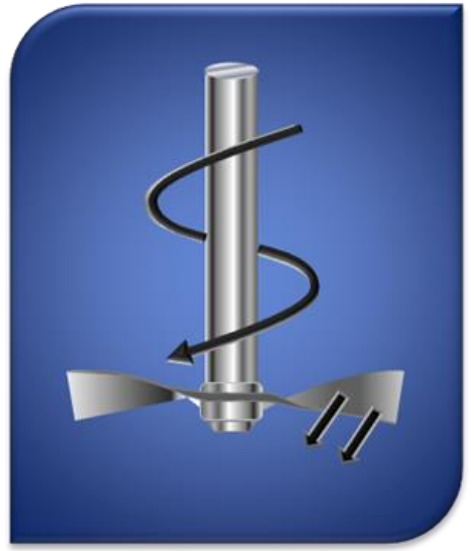
Powder Flow Modification

- Use of Fumed Silica and Mg Stearate as flow aids at various concentrations
- Compare V-Blend Mixing, Speed Mixing, MAIC Processing Methods
- Citric Acid, Starch, Acetominophen

Powder Flow Measurement

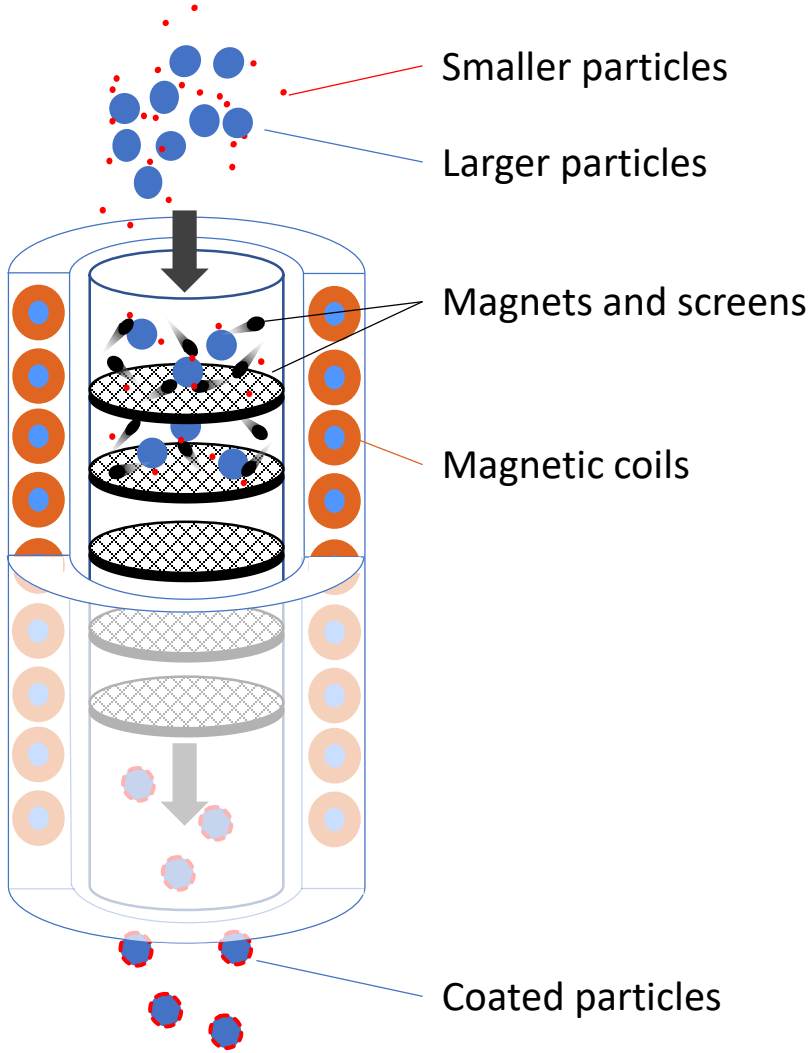
- Use FT4 to measure flow properties
- SEM Analysis
- Karl Fisher Analysis

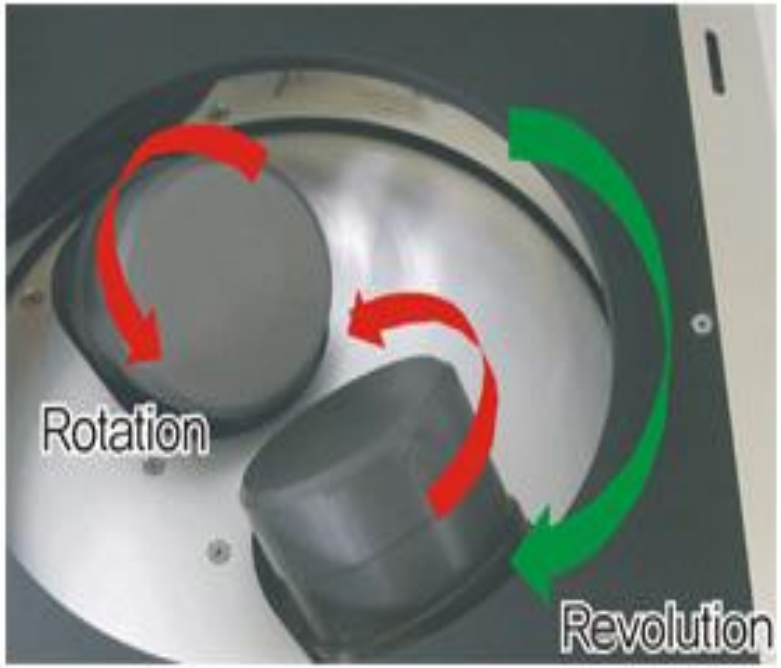




Mixing Processes

AVEKA





Experimental Parameters

AVEKA

Processing:

	B	C	D	E	A	G	F
% Flow Aid	0.00	0.00	0.05	0.50	2.00	0.50	2.00
Processing	None	MAIC	MAIC	MAIC	MAIC	V-blended	V-blended

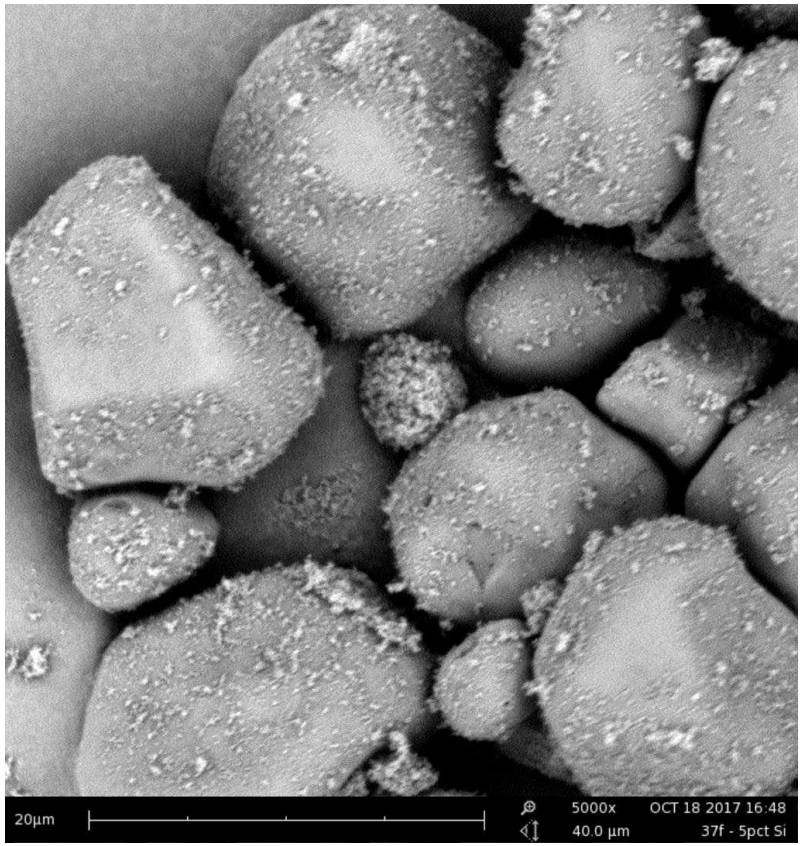
Sample Materials: *Citric Acid (5 µm), Cornstarch (7-12 µm), Acetominophen (18-150 µm needles)*

Sample Preparations and Testing:

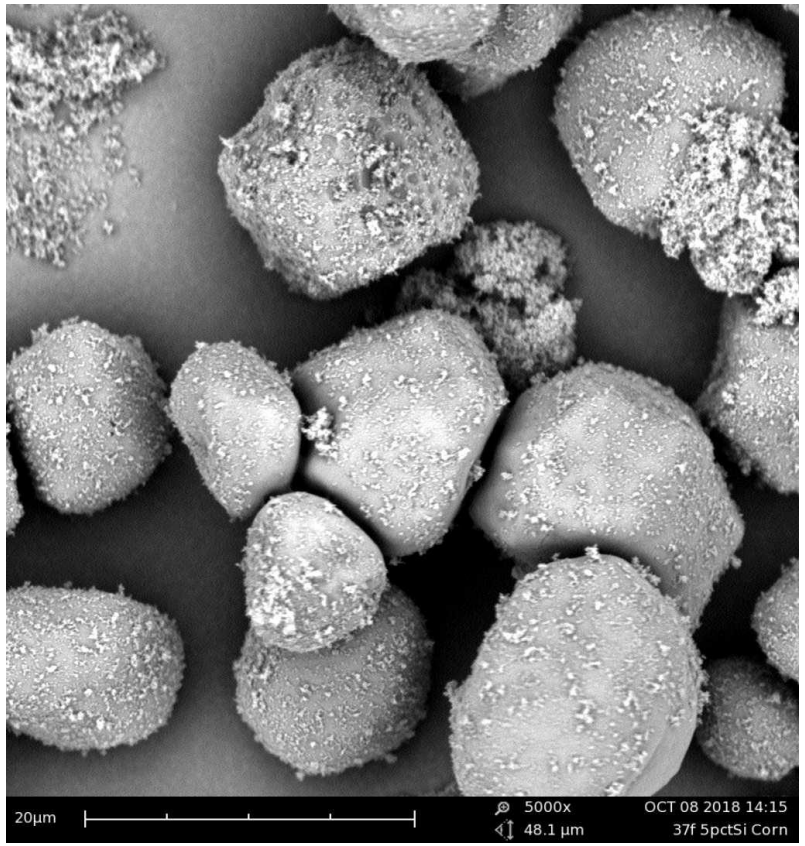
1) Substrate tested as is and substrate mixed without flow aid in each process (MAIC, V-Blend, and Speed Mixer)
2) Flow aid mixed with substrate (V-Blend, or Speed Mixer)
3) Remixed with second process (V-Blend/MAIC or Speed Mixer/MAIC)
4) Tested with FT-4 (BFE, SE, AE)
5) Retested after 9 months to 2 years

Cornstarch SEM Images

AVEKA



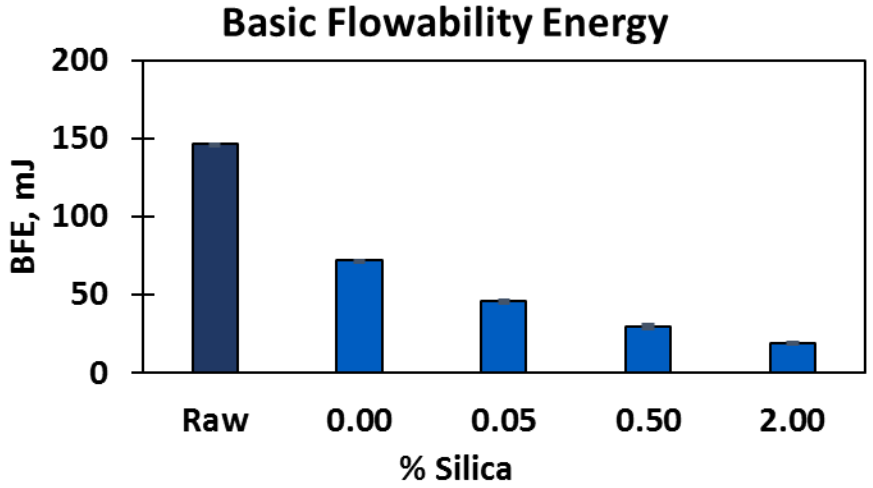
Cornstarch, 5% silica (V-Blend/MAIC), fresh



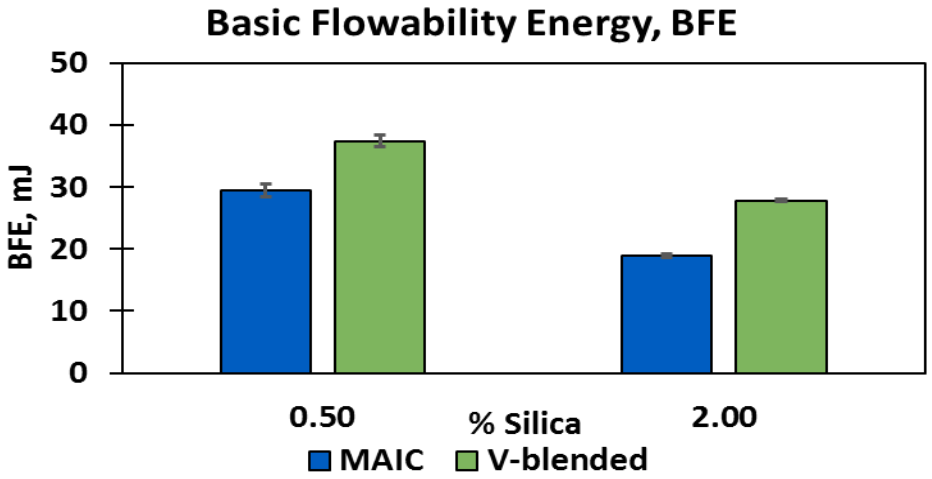
Cornstarch, 5% silica (V-Blend/MAIC),
1 year later

Flow Measurement Results for Citric Acid

AVEKA



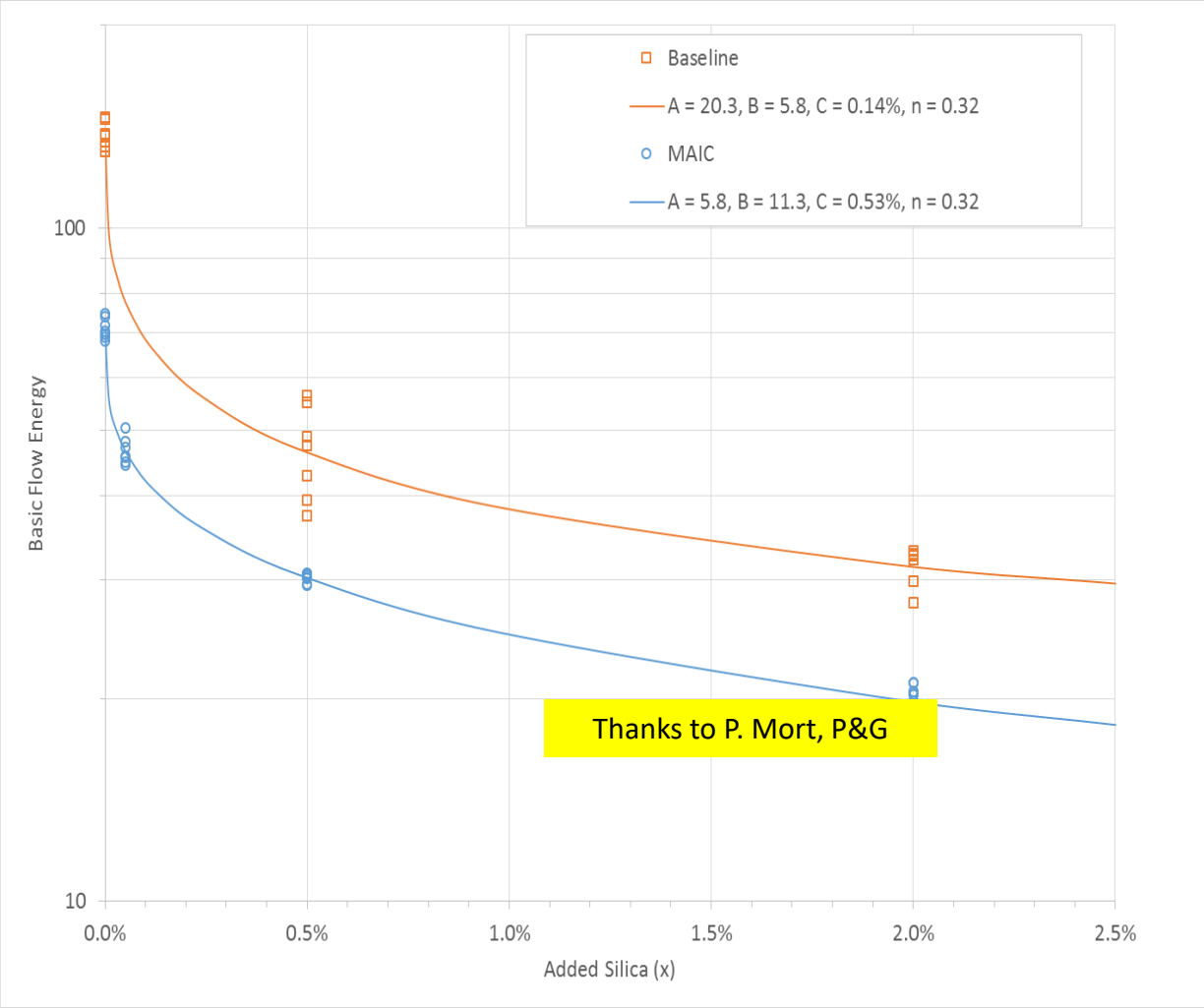
- Clear decreases in BFE with increasing % silica
- Marked decrease between the raw and MAIC treated sample (0% (w/w) silica)



- At equal silica loadings, MAIC samples show lower BFE
- 0.5% MAIC and 2.0% V-blend near equal

Comparing MAIC to V-Blending For Citric Acid

AVEKA



$$BFE = A * (1 + Be^{-\left(\frac{x}{C}\right)^{0.32}})$$

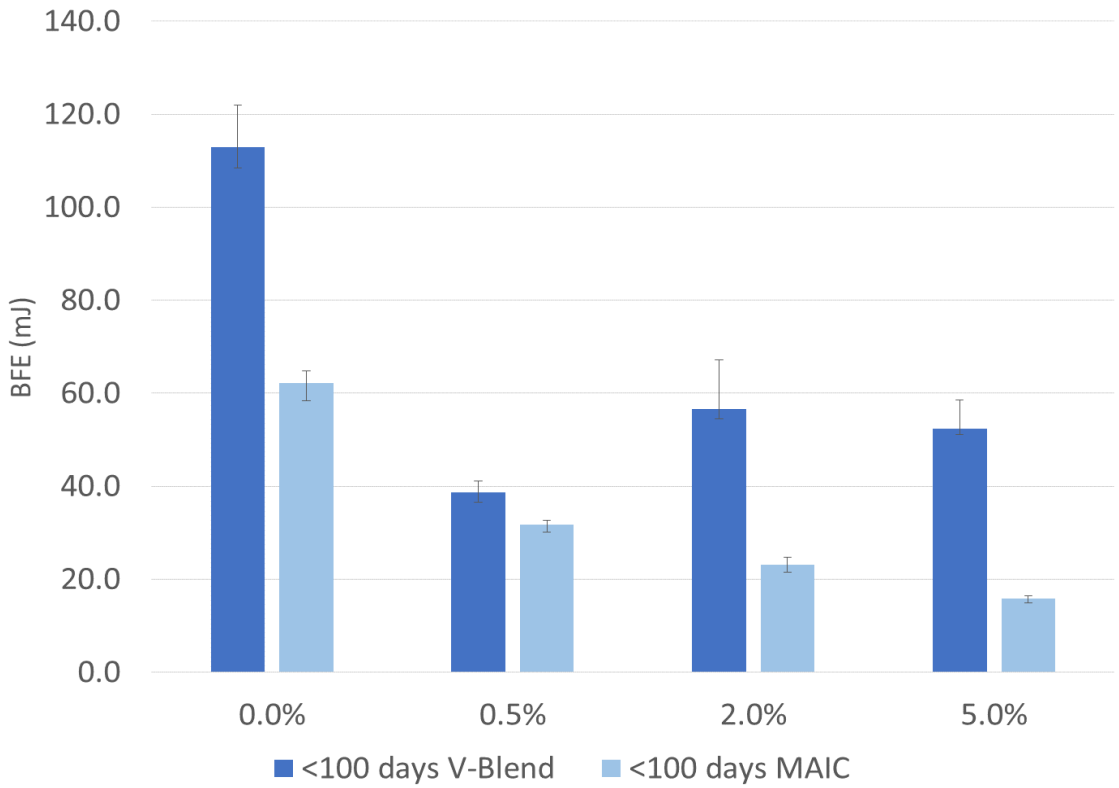
BFE Results

AVEKA

Process	Citric Acid (BFE in mj)		Starch (BFE in mj)		Acetominophen (BFE in mj)	
Test Time from Preparation	Short	Long	Short	Long	Short	
As Received	150		74		156	
0% Silica MAIC	62		87		71	
0% Silica VB	112		94		103	
0% Silica SM	-		-		115	
0.5% Silica VB/MAIC	35		100		72	
0.5% Silica VB	39		114		76	

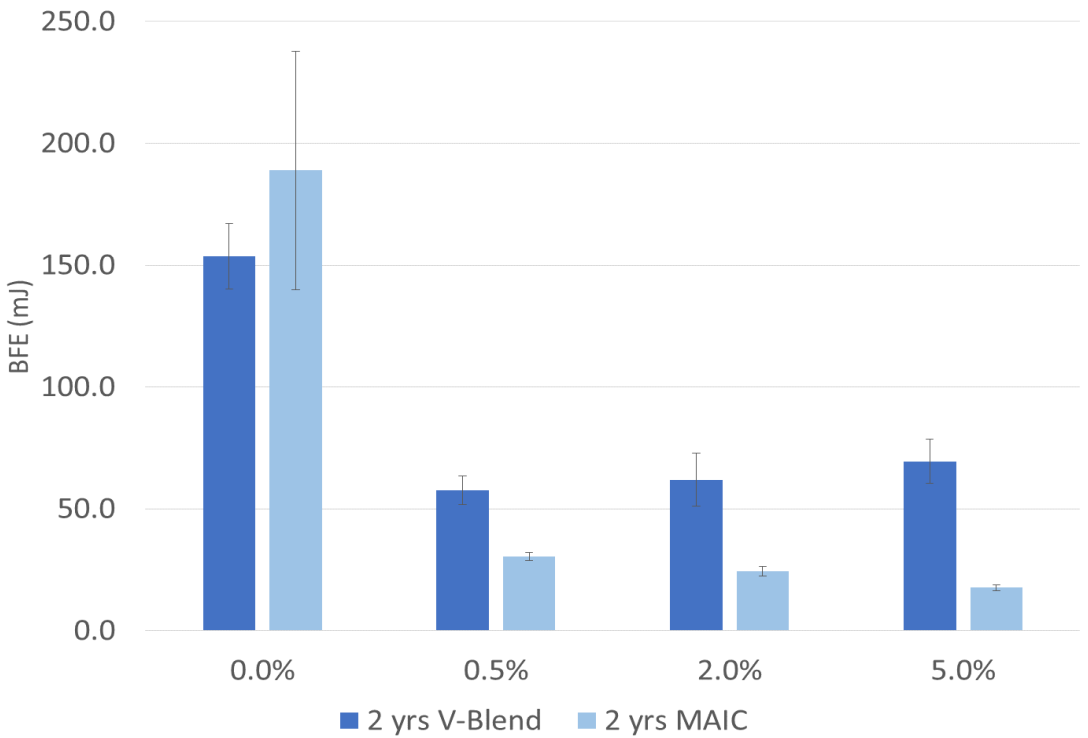
Citric Acid – Short Term

AVEKA



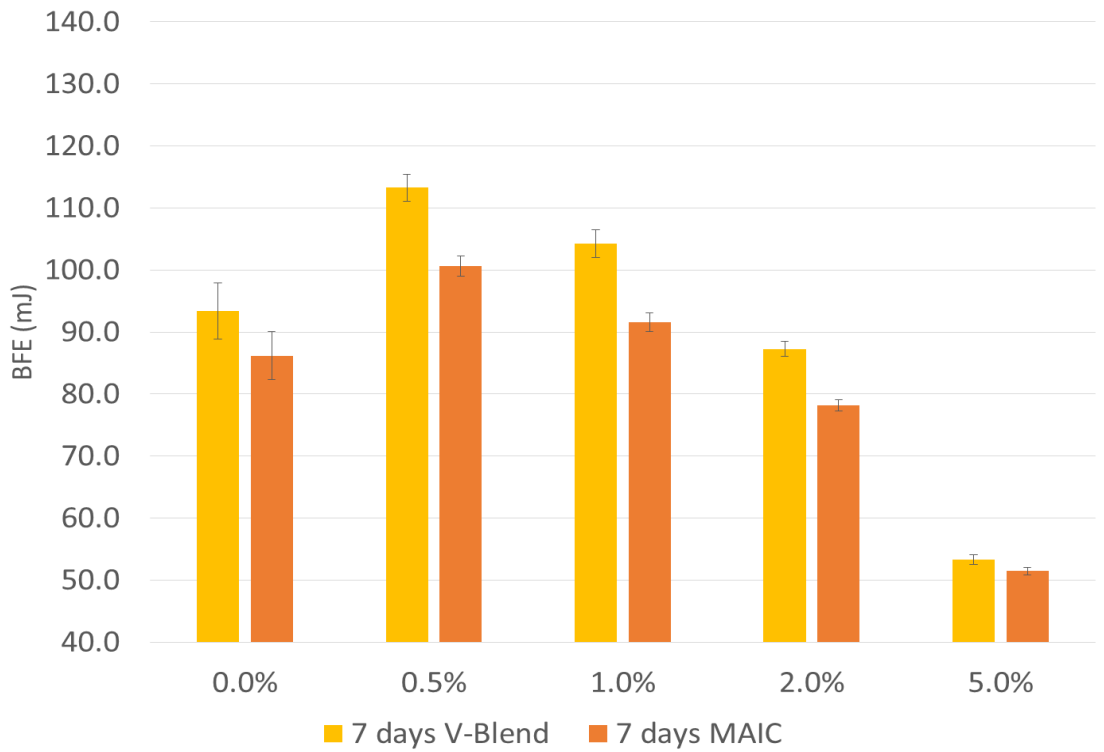
Citric Acid – Long Term

AVEKA



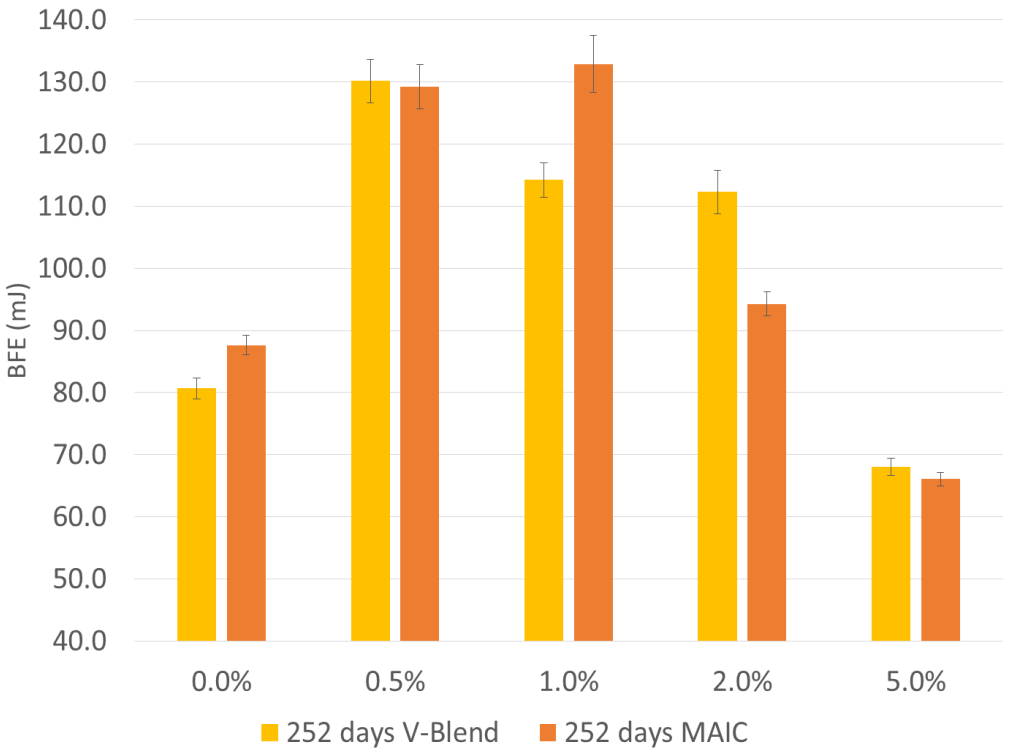
Cornstarch – Short Term

AVEKA



Cornstarch – Long Term

AVEKA



BFE Results

AVEKA

Process	Citric Acid (BFE in mj)		Starch (BFE in mj)		Acetominophen (BFE in mj)	
Test Time from Preparation	Short	Long	Short	Long	Short	
As Received	150		140		156	
0% Silica MAIC	62	190	87	88	71	
0% Silica VB	112	150	94	80	103	
0% Silica SM	-		-		115	
0.5% Silica VB/MAIC	35	35	100	129	72	
0.5% Silica VB	39	60	114	130	76	

Observations and Conjectures

AVEKA

- Mixing reduces BFE and is process dependent
- BFE levels can have a time dependence
- BFE modification effect is material dependent
- MAIC process provides lowest and most consistent BFE, SE, AE

- Is magnetic field interacting with particle – electrostatics or surface water?
- Can fumed silica react with surface?
- Is mixing changing meso-particle structure/size?