IFPRI Reconstitution Workshop

Reconstitution Survey Results
April 1, 2024

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1. Problem Statement & Workshop Overview

Problem Statement :

In industry, there is often a disconnect between powder/filler suppliers and users. There can be changes in the powder characteristics that negatively impact how powders incorporate into various fluids and this step can influence the final product performance.

These gaps, areas where industry lacks knowledge/expertise, result in product failures, equipment failures, high product development cost, waste generation/disposal, delayed production timelines, etc. These costs can be significant.

For example, lithium ion batteries (LIB) require a slurrying/coating process to manufacture electrodes.

- The LIB market (2023) was valued $54.4 Billion[1] and is expected to grow to $182 B by 2030.
- Lacking a fundamental understanding of slurring/reconstitution puts all LIB products, and developing technologies, at risk of meeting production volumes and timelines at reasonable costs.
    - Process scalability & building large plants (gigafactories), new chemistries for high energy density batteries, fast charging battery development, etc, are all factors in this projected growth.

[1]Hawkins, Lenore. “The Current State of the Battery Market: What Investors Should Know.” November, 2023. Available online: https://www.nasdaq.com/articles/the-current-state-of-the-battery-market-what-investors-should-know

IFPRI Powder Reconstitution Workshop

At the 2022 IFPRI annual meeting in Brussels, member companies voted for and approved this workshop.

The purpose of the workshop is to provide context on challenges in understanding the phenomena of powder reconstitution, and to guide discussions among a small group of academics and industrial representatives. Output from the workshop is intended to contribute to IFPRI project proposals and research.

IFPRI International Fine Particle Research Institute

IFPRI BRIEF TEMPLATE

Check One: ☐**Project** ☐**Review** ☐**Collaboration** ☒**Workshop** ☐**Other**

Descriptive Title	How redispersion makes our lives hard and why we can't correctly characterize this
Working Title[1]	From dry (powder) to wet (slurry/solution)
Technical Area[2]	Wet systems, Dry systems, Characterization
Date	14 June 2022
Short Description	In industry there is often a disconnect between powder/filler suppliers and users. There can be changes in the powder characteristics that negatively impact how powders incorporate into various fluids and this step can influence the final product performance. This proposal is to gather a diversity of expertise (outside of the box) to discuss aspects that should be considered when wetting/incorporating powders. The objective is to help define: 1. Physical properties of powders that drive the ability and ease of wetting/incorporation 2. Recommended characterization tools to troubleshoot poor incorporation 3. Considerations for dry powder producers to help communicate how their powder should be handled and/or characterized in slurries and suspensions. Potentially the workshop can be used for these additional purposes: 1. Consider **sustainability** in powder/slurry supply chains → will the powder be dispersed? How should that impact the powder processes (e.g. drying)? 2. Create a roadmap for the interface between wet and dry systems and how IFPRI should address this moving forward

Reconstitution Definition

Our definition of “reconstitution” covers a wide range of materials not only foods, e.g., polymer powders, ceramic powders and the classic food cases such as milk powder and the process by which they generate an acceptable final or intermediary product when mixed with liquids. This process involves a surprisingly wide range of physics, including rheology, capillarity, sedimentation, imbibition, colloidal dispersion, dissolution, and mixing.

Workshop Format

There will be four half-day sessions with industrial and academic presentations followed by syndicate group discussions. Each small group breakout session should be focused on the following topics:

(1) outline the state-of-the-art in the relevant topic (see following slides for more detail);

(2) how can qualitative predictions evolve toward a quantitative understanding that will allow system design at the industrial scale

(3) define three scientific questions that IFPRI and other funding agencies should promote.

Participants will be divided into small groups to brainstorm the industrial and academic questions raised during the presentations. Each group has a syndicate leader who will report a summary of their groups ideas to the broader workshop participants after each breakout session.

Workshop Overview: Day 1

Session #1 (Morning): Industrial use cases and gaps in powder reconstitution.

- 5 industrial presentations, 25 min technical talks.
  - Industry Presenters: Corning, Dow Chemical, Nestlé, FMC, Johnson Matthey
- Short breakout session. Focused discussion to includes:
  - As an industry, what do we do well? Where are we?
  - What do we not do well? Where aren't we?
  - What specific tools would enable us to be more effective/efficient in our work
- Group leads report back to broader workshop

Session #2 (Afternoon): Fundamentals in the wetting of powders

- Keynote lectures: 3-4 speakers. Up to 30 minutes for each keynote presentation.
- Breakout session. Areas of interest include but are not limited to:
  - Challenges in material science & product formulation
  - Current state of the art in characterization, modeling, and kinetics.
  - Considerations when working with polar/nonpolar/ionic liquids, porous/non-porous input materials, etc.
- Group leads report back to broader workshop

Workshop Overview: Day 2

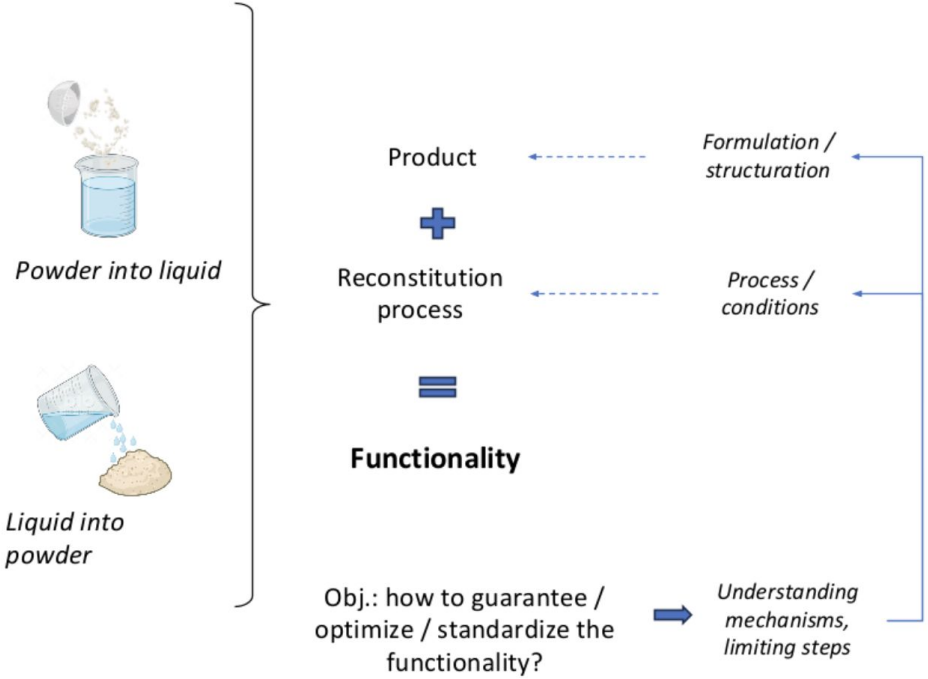
Session #3 (Morning): Fundamentals of the reconstitution process; dispersion, dissolution, swelling, gelling, process characterization, and achieving desirable product performance.

- Keynote lectures: 3-4 speakers. Up to 30 minutes for each keynote presentation.
- Breakout session. Areas of interest include but are not limited to:
  - State of the art in processing/modeling/kinetics
  - Fundamental mechanisms of reconstitution & how they are quantified
  - State of the art techniques in process characterization
  - Processing failures & root causes
- Group leads report back to broader workshop

Session #4 (Afternoon): Gap Identification

- Breakout session:
  - Identification of gaps in understanding, modeling, etc
  - Presentations/summary from discussion leaders
  - Documentation & capturing ideas

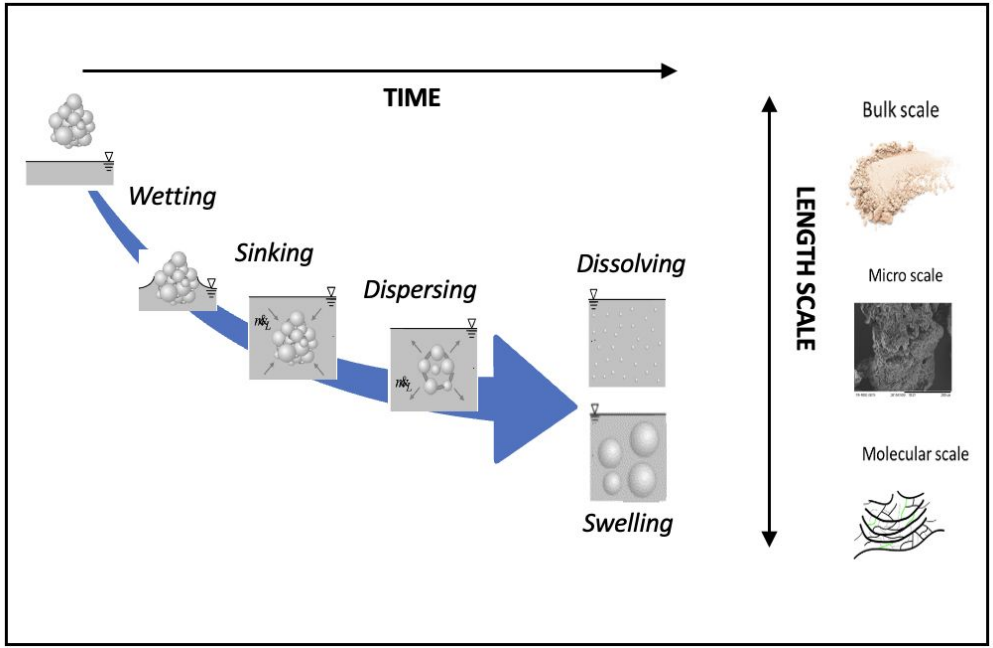
Fundamentals: “wetting” of powders



Questions for consideration

- *What are the key mechanisms & driving forces for each step?*
- *How do we know which properties to target, and which processing conditions apply?*
- *What product and process measurements are most impactful in resolving the chemistry and physics?*

Fundamentals: the reconstitution process



The workshop planning committee has identified 3 Pillars to organize around:

- *Product formulation (material science)*
- *Processing (kinetics, modeling)*
- *Characterization of input materials, process analysis and monitoring, and product performance testing.*

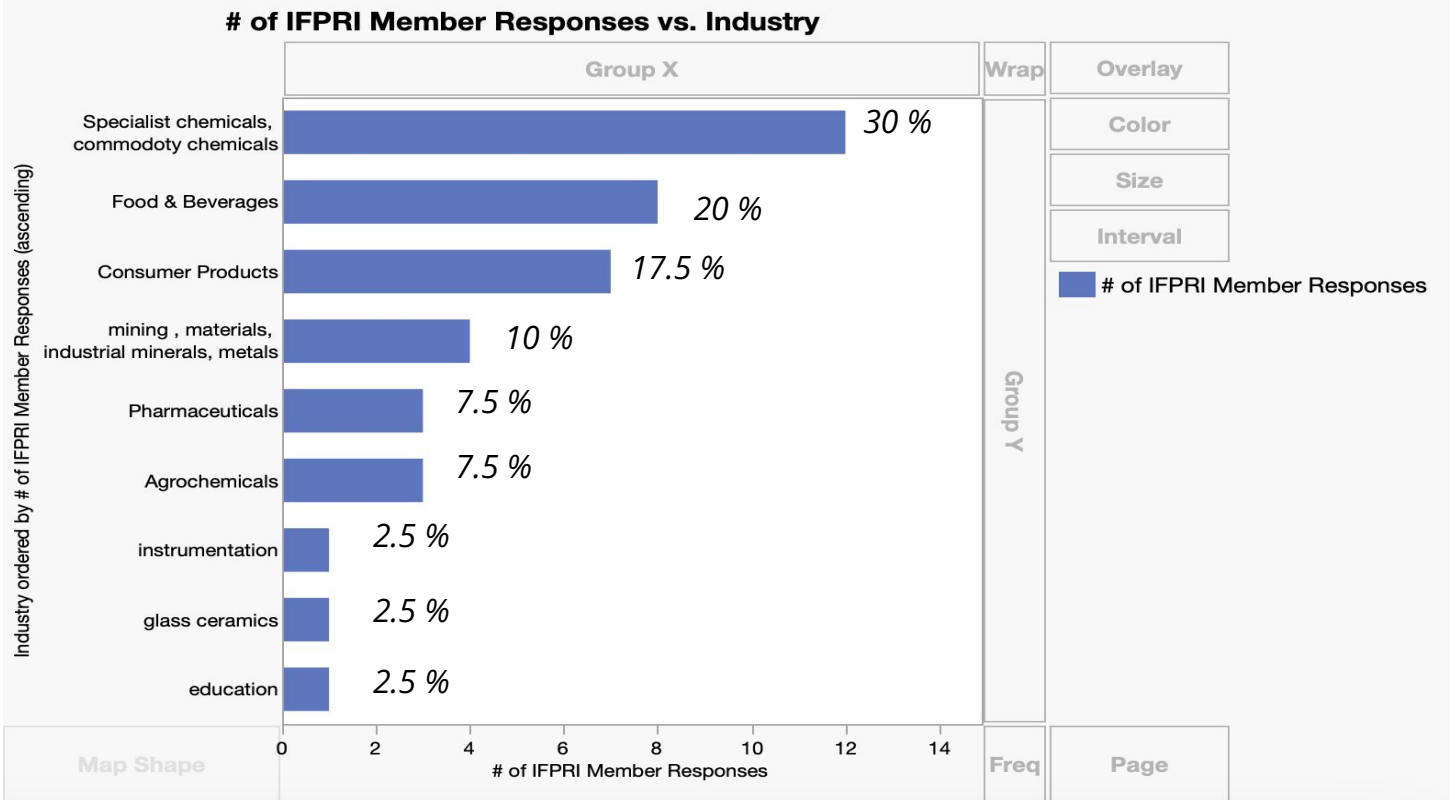
2. Survey of IFPRI Members on Powder Reconstitution

Overview

The workshop planning committee recently completed a survey with IFPRI members, capturing use cases and gaps commonly experienced in industry. The following slides review and summarize the survey results.

Industry Sectors

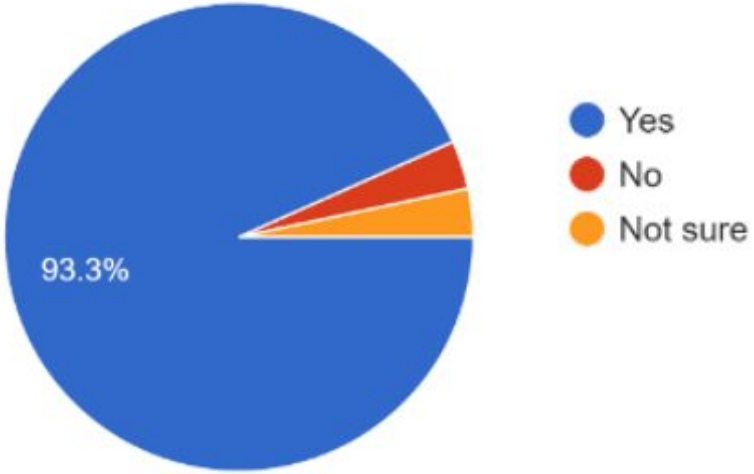
Question: What is your industry Sector?



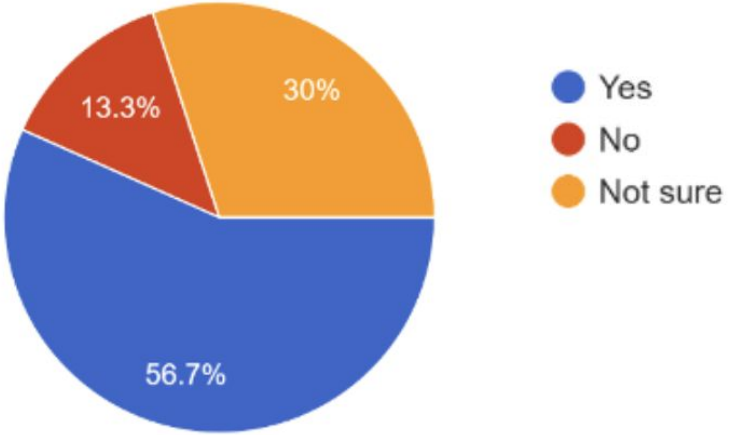
Importance of Reconstitution:

Survey Questions (Q):

Q: Is reconstitution/wetting transformations an important part of your business? (30 responses)



Q: Is Poor technical understanding in this field contributing to poor outcomes in your business? (30 responses)

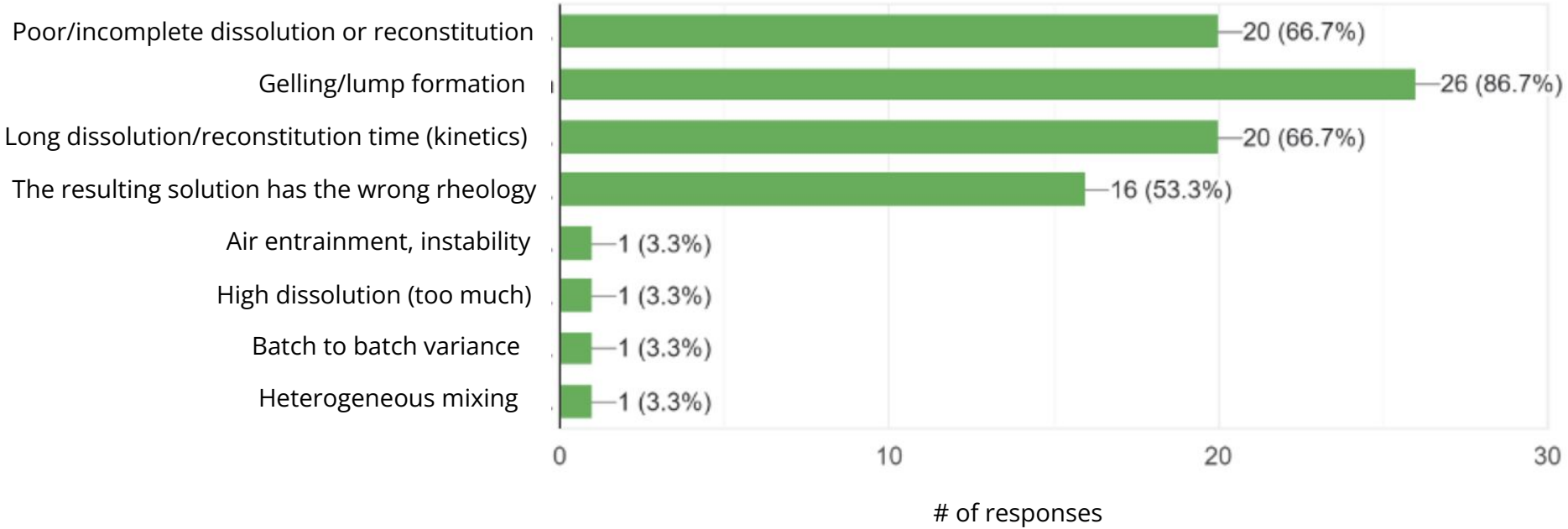


Gaps- Product Failures

Q: What are the common problems when faced with reconstitution/wetting transformations?

- *Multiple choice question, the survey prompted to "select all that apply" for responses.*

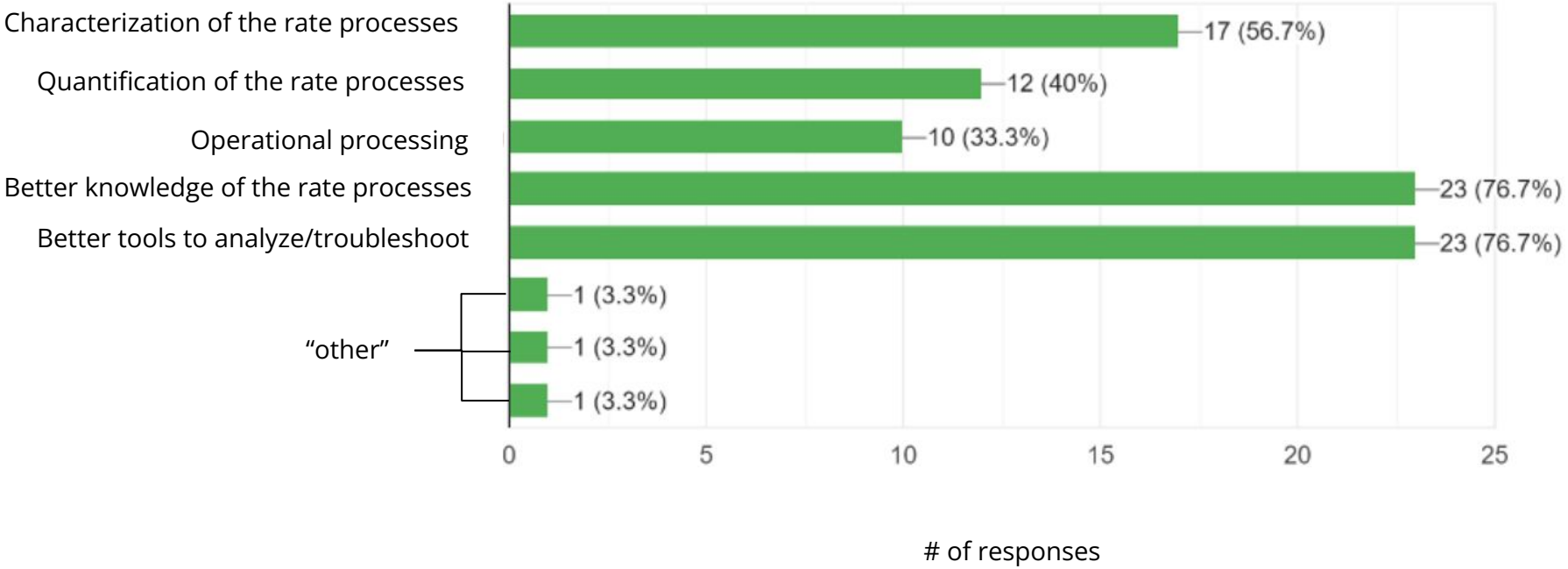
(30 responses)



Gaps- Processing & kinetics

Q: Where do industrial practices need to improve?

- *Multiple choice question, the survey prompted to "select all that apply" for responses. (30 responses)*



Gaps- Industry Feedback

Question: Where do you feel the gaps are in academia and industry?

(Summarized feedback)

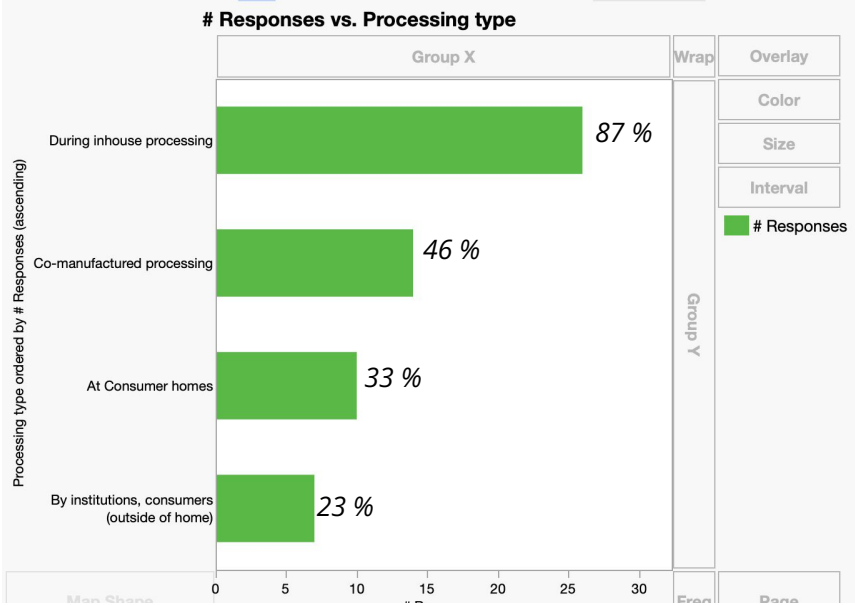
- IFPRI members struggle with modeling the behaviors of solid/liquid transformations. As a whole, Industry is not able to effectively predict and mitigate undesirable attributes that arise during the transformation process.
- Academics often pick simple systems to study, where industry cases are more complex. As a result, academic models don't always translate to industrial applications.
    - For example, use of narrow particle size distributions (2-5 microns) are often selected for academic studies, where industry applications have PSD ranges of 10's to 100's of microns.
- There are limited techniques to characterize the transformation process
    - For example, characterizing wetting behavior and how it changes throughout processing.
    - This makes process scale up difficult, long, and requires significant cost/time to complete
- There's a lack of data to support new technologies/equipment in mixing/transformation of solids & liquids. Studies and/or systematic validation or verification would drive faster acceptance/implementation of new technologies & equipment in industry.

Reconstitution: Use Cases

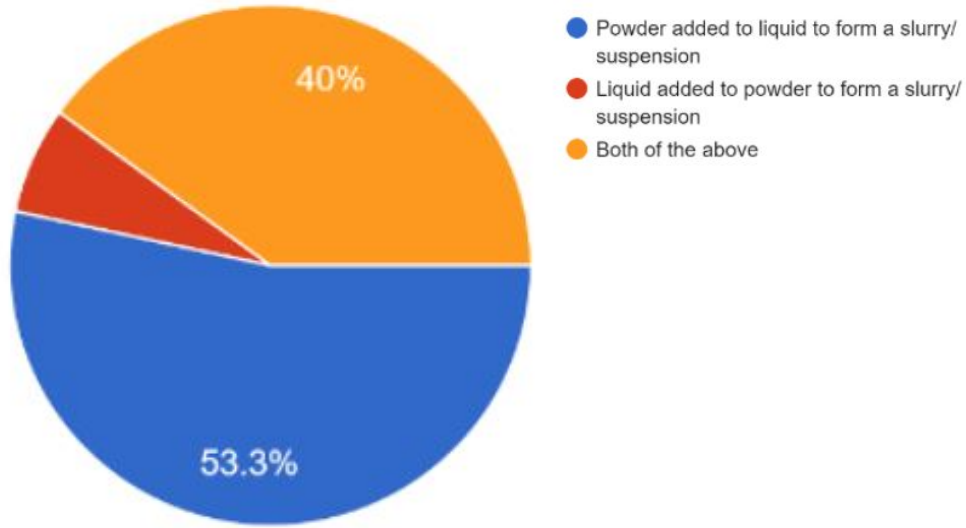
Survey Questions:

Q: Where are your reconstitution transformations performed?

- *Multiple choice question, the survey prompted to "select all that apply" for responses. (30 responses)*

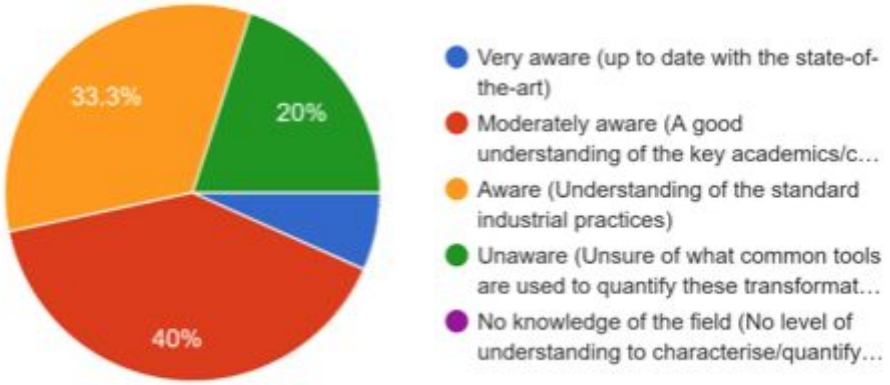


Q: How do you categorize problem transformations of powders and liquids?
(30 responses)



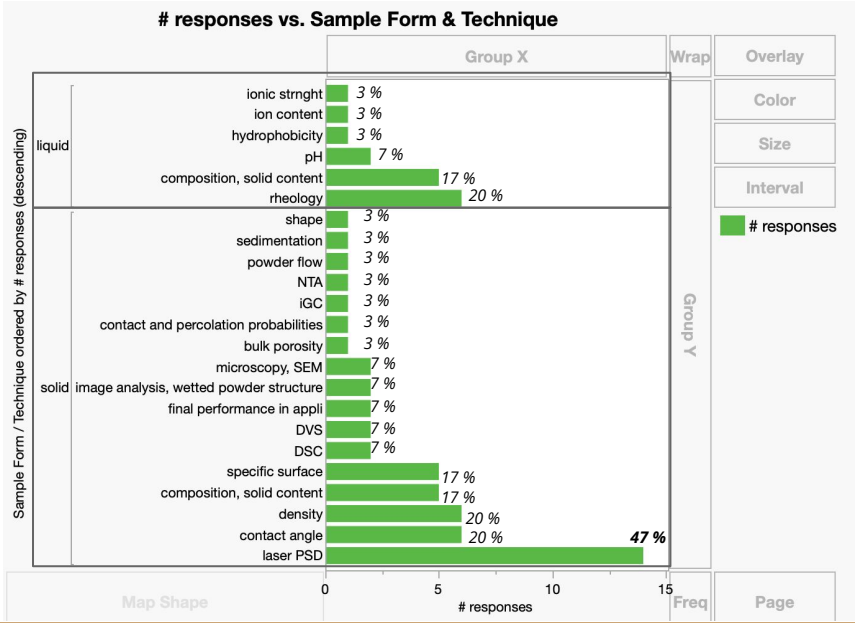
Characterization: raw materials (before reconstitution)

Q: What level of awareness does your business have on the measurement quantification tools within the field of reconstitution/wetting. (30 responses)



Q: If you characterize liquids/powders, how do you do it?

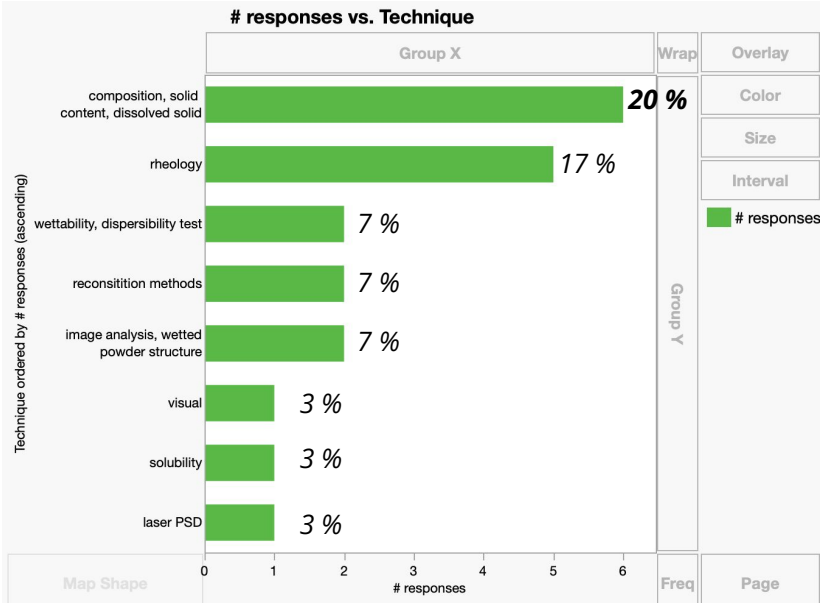
- *Multiple choice question, the survey prompted to "select all that apply" for responses. (30 responses)*



Characterization: Process & final product

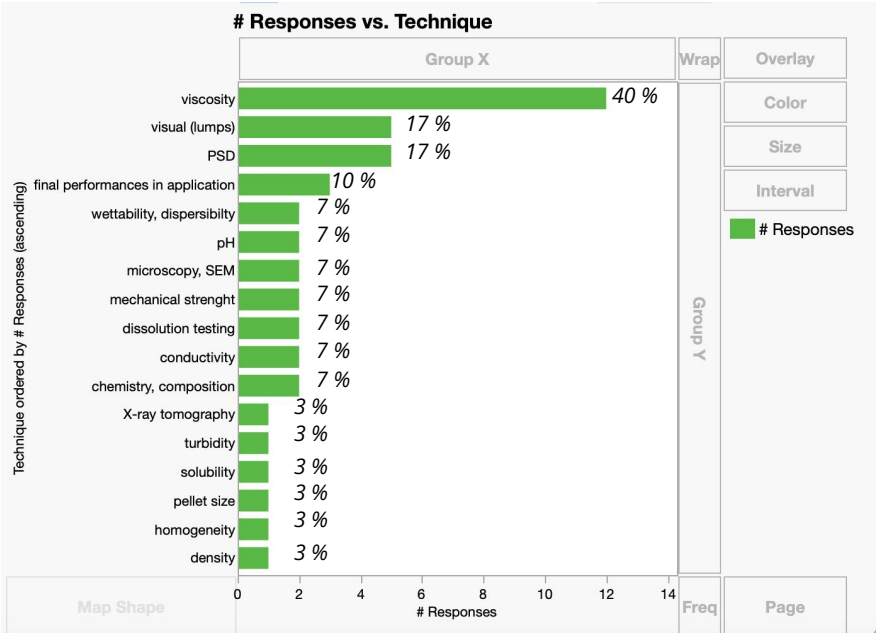
*Q: If you characterise the **transformation process**, how do you do it? (30 Responses)*

- *Multiple choice question, the survey prompted to "select all that apply" for responses. (30 responses)*



*Q: If you characterise your **final product** (the transformation outcome), how do you do it? (30 Responses)*

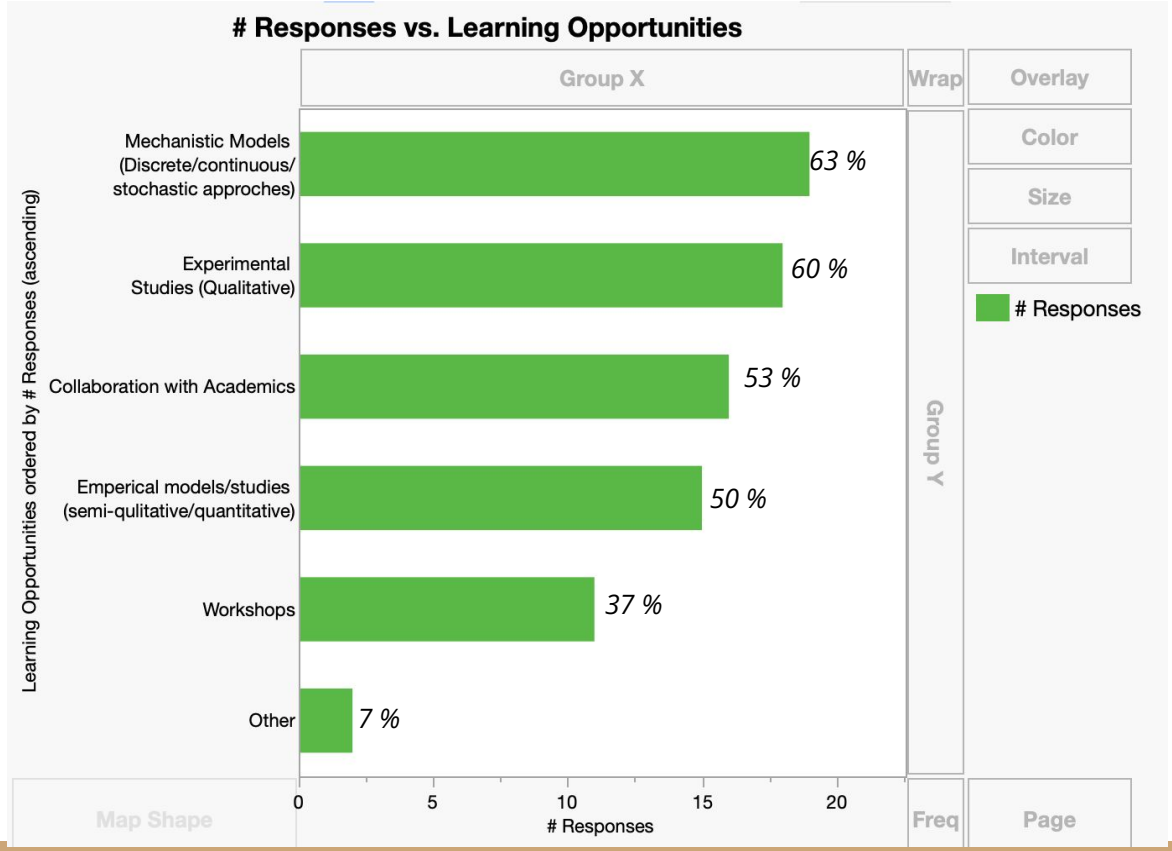
- *Multiple choice question, the survey prompted to "select all that apply" for responses. (30 responses)*



Further education, research:

Q: What Academic studies/education would your business value in this field?

(30 Responses)



3. Roles, Responsibilities, and Workshop Preparation

Workshop Roles

Roles and Responsibilities:

- Keynote Speakers (7 total)
  - Present 30 minute keynote lecture on a relevant field/topic to powder reconstitution. Use input from the IFPRI member survey to inform topics and focus areas for your presentation.
- Industry Speakers (5 total)
  - Present 25 minutes on problems, use cases relevant to powder reconstitution. When appropriate, give examples of common problems. Do **NOT** share intellectual property!
- Syndicate group leader
  - During workshop, lead small group discussions, take notes, and consolidate/present group input, summaries, proposals, etc.
- Workshop Participants
  - Participate, engage in discussion, & propose/document ideas.

Request for Keynote Speakers

By April 15 th:

- Share a presentation title with the workshop planning committee
- Follow up with questions/concerns you may have
- Start planning for a 30 minute keynote presentation

Appendix

Reconstitution Workflow (backup)