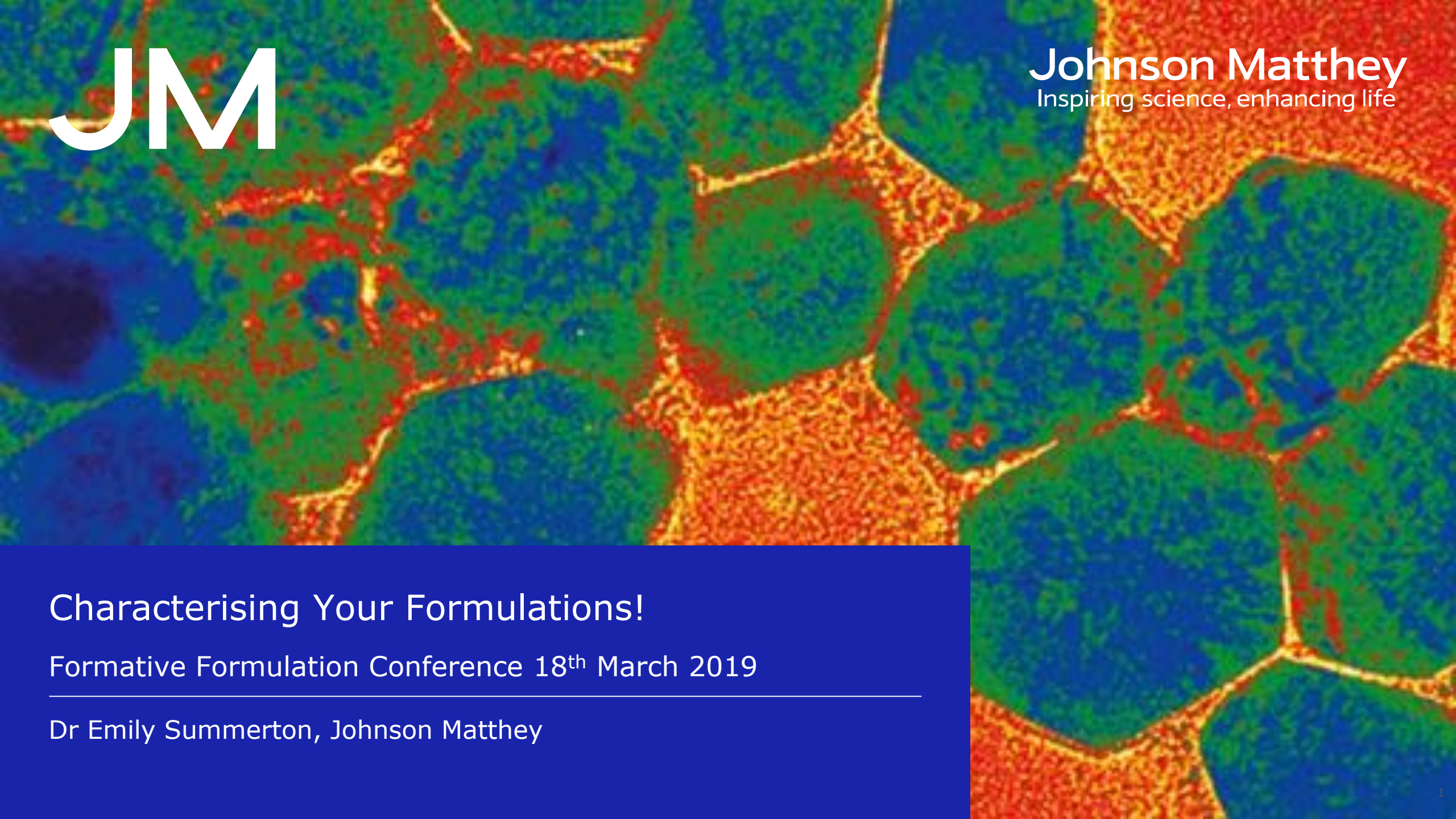

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Johnson Matthey
Inspiring science, enhancing life

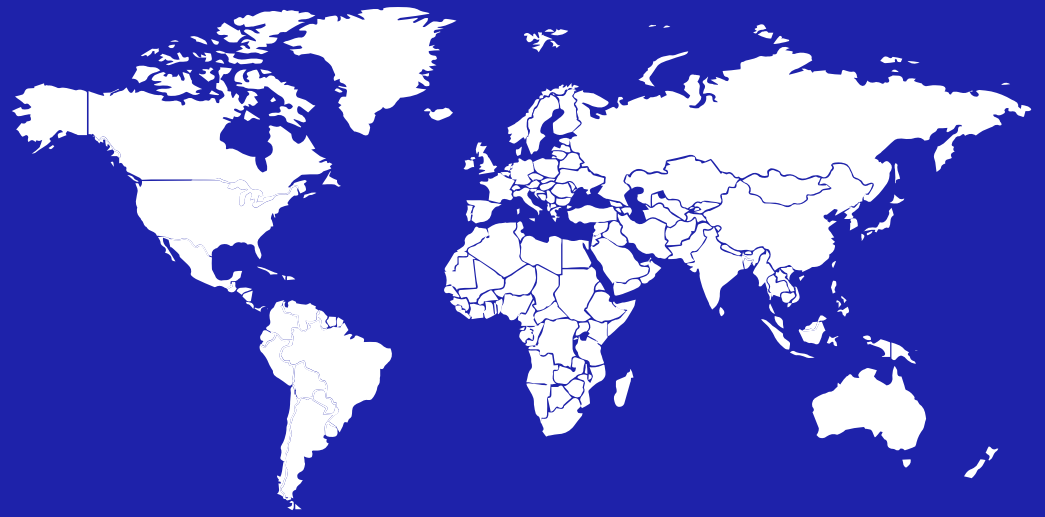
Characterising Your Formulations!

Formative Formulation Conference 18th March 2019

Dr Emily Summerton, Johnson Matthey

Contents

A Global Footprint



14,000
employees worldwide

North America

12 major manufacturing facilities
33% of Group sales*
24% of employees

Europe

14 major manufacturing facilities
39% of Group sales*
53% of employees

Rest of World

5 major manufacturing facilities
9% of Group sales*
5% of employees

China

5 major manufacturing facilities
10% of Group sales*
8% of employees

Rest of Asia

6 major manufacturing facilities
9% of Group sales*
10% of employees

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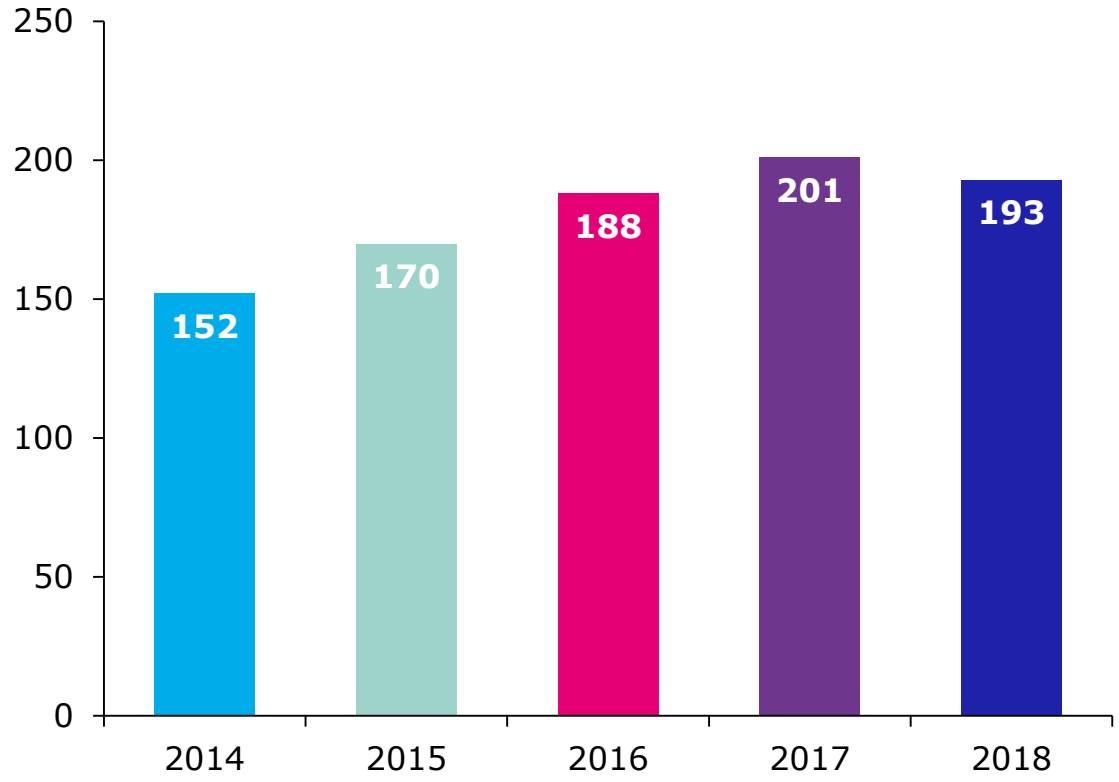
*Sales excluding precious metals

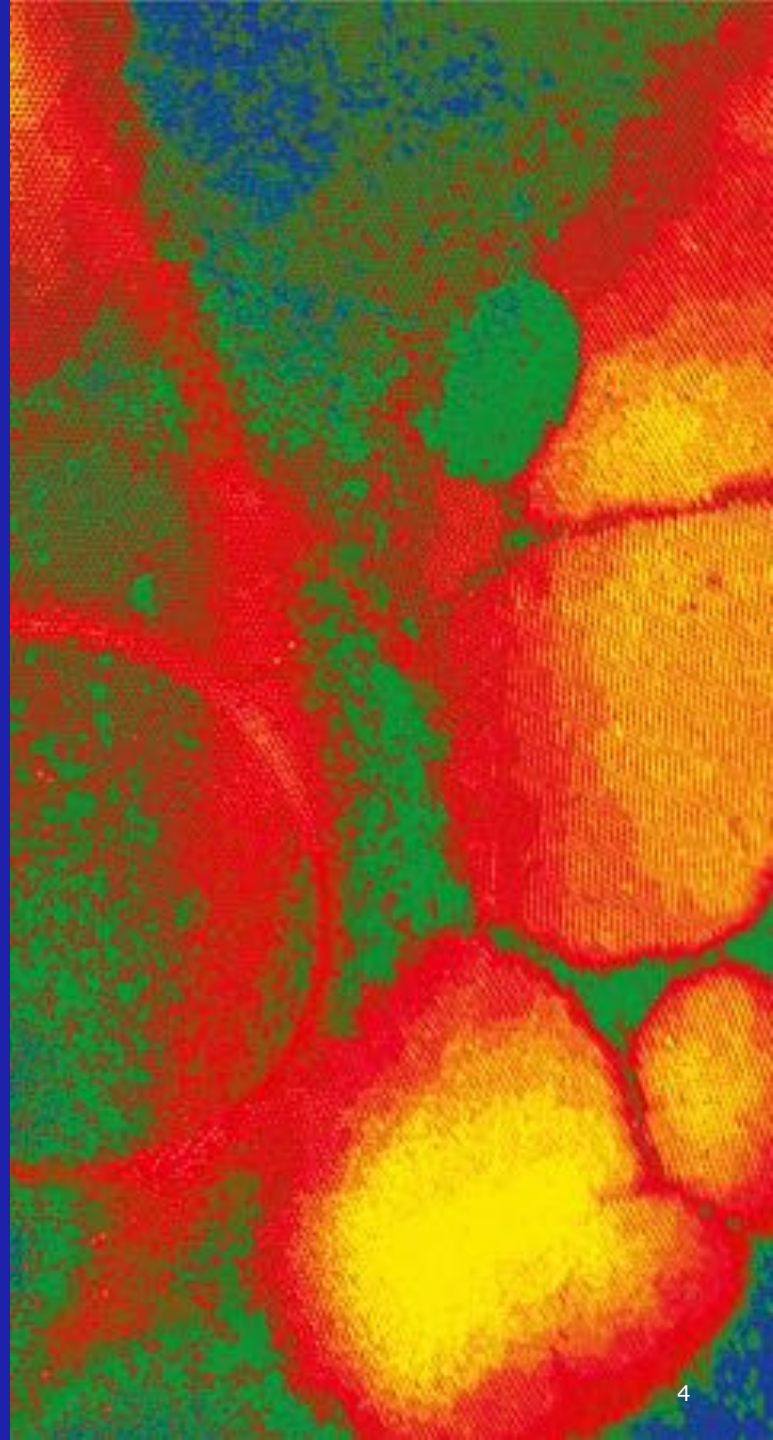
Investing in Science

R&D investment
£ millions



11%
of employees working in R&D

R&D investment at
~5%
of sales*



*Sales excluding precious metals

Global Markets

Automotive

Health

Chemical

Oil, Gas and Mining

Agrochemicals and Fertilisers

Food and Beverage

Energy Generation and Storage

Glass

Other Industrial

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The Power of Characterisation

Particle size	X-ray scattering
Particle shape	DSC
Rheology	Microscopy
Wetting	Zeta potential

Why should you characterise formulations?

A few reasons……

- Formulation development
- Processing issues
- Processing improvements
- Product optimisation
- Stability and shelf life

*Image authorised for use by the Diamond Light Source

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Formulation Strategy

1) Many different components are present in our formulations – e.g. actives, binders, polymers, solvents

2) Compatibility is key for successful formulations

3) Determine a solvent or solvent mixture suitable for all components

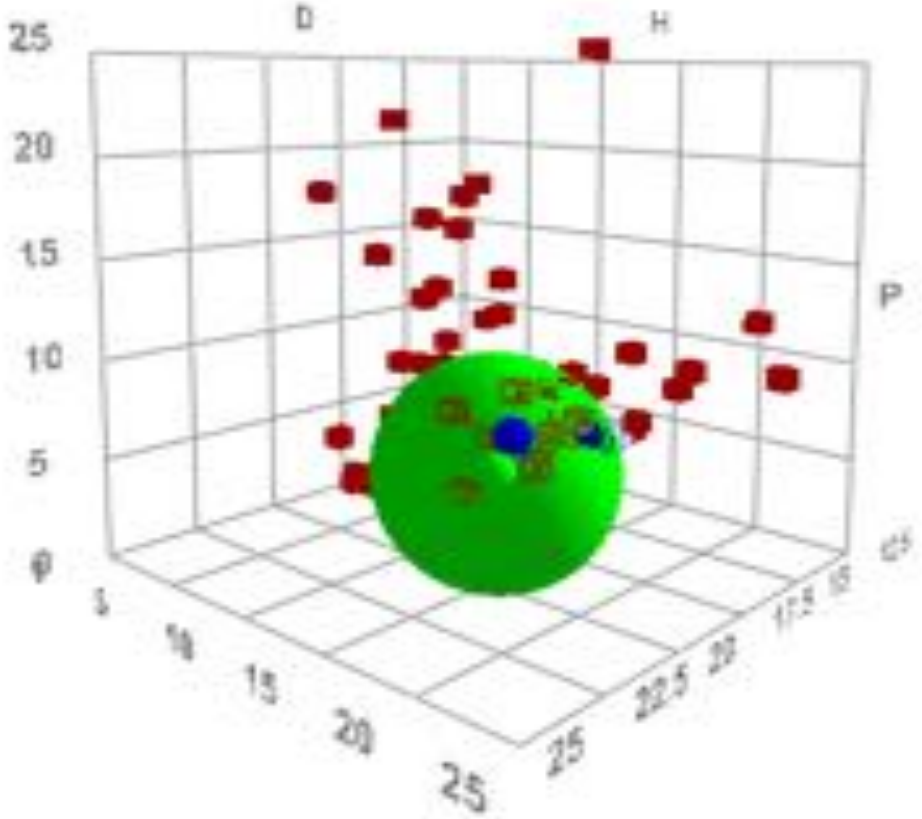
4) Determine if the properties such as **particle size, shape, viscosity** are within the **target** specification for the application

Determining a Suitable Solvent

Hansen solubility parameters are used to determine the suitability of a solvent for dissolution or dispersion of particulate materials

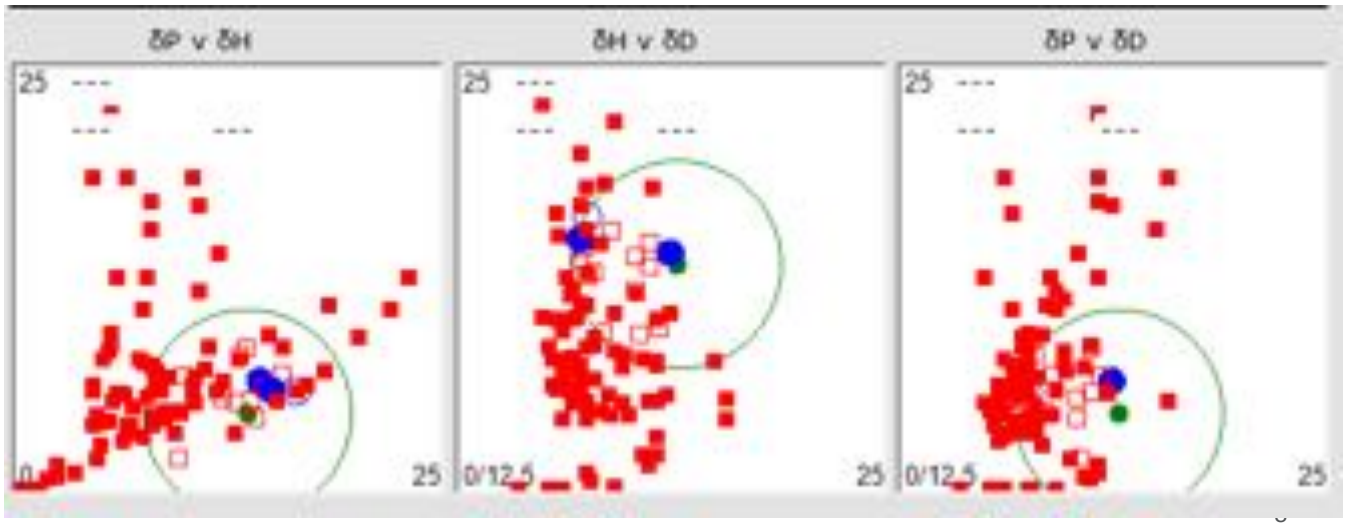
3 components:

δD	Dispersion
δH	Hydrogen bonding
δP	Polar



➡ **Dispersion or solubility?!**

Solvent	δD	δP	δH
Cyclohexanone	17.8	8.4	5.1
Butanol	16	5.7	15.8
Acetone	15.5	10.4	7
Water	15.5	16	42.3
Acetonitrile	16	12.8	6.8
Toulene	18	1.4	2
Xylene	17.6	1	3.1



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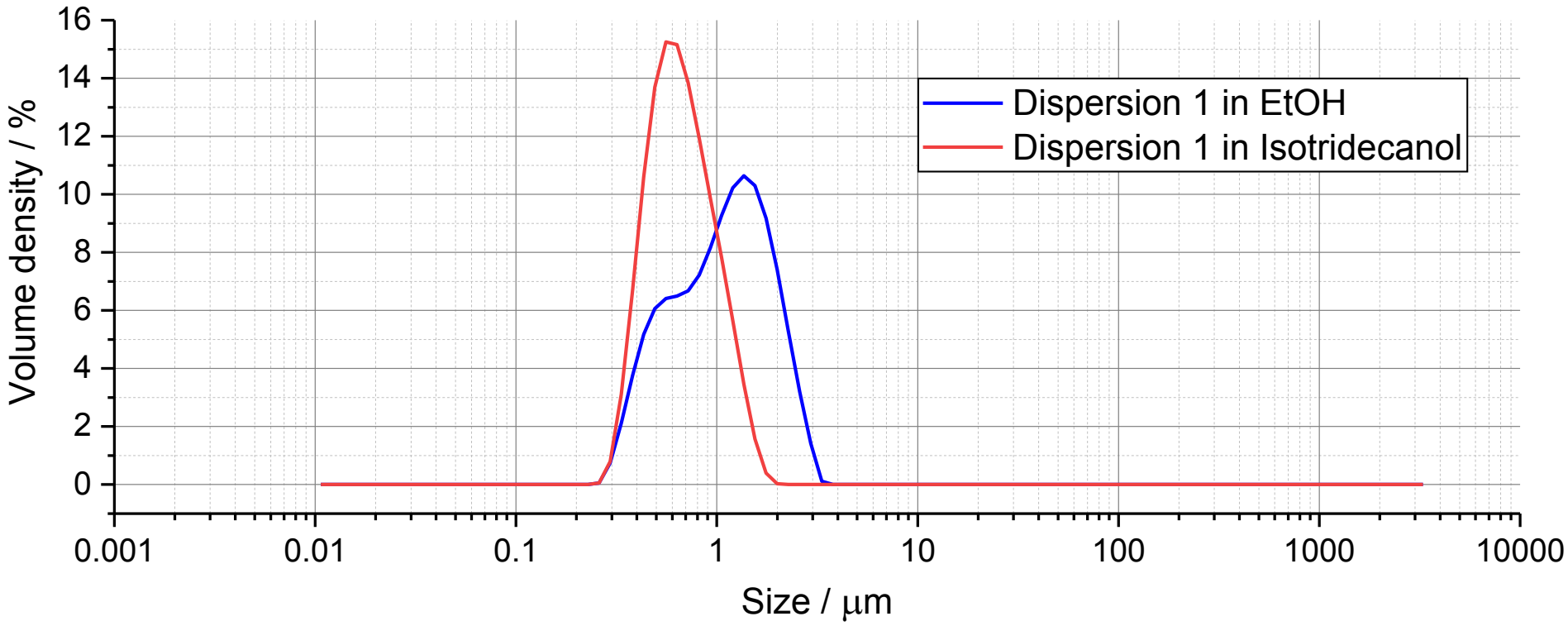
Particle Sizing – Importance of Solvent Choice



- Select solvent which is most representative of the process
- Compatibility between particulates and medium determines dispersion properties
- Perform 5 replicates at least!

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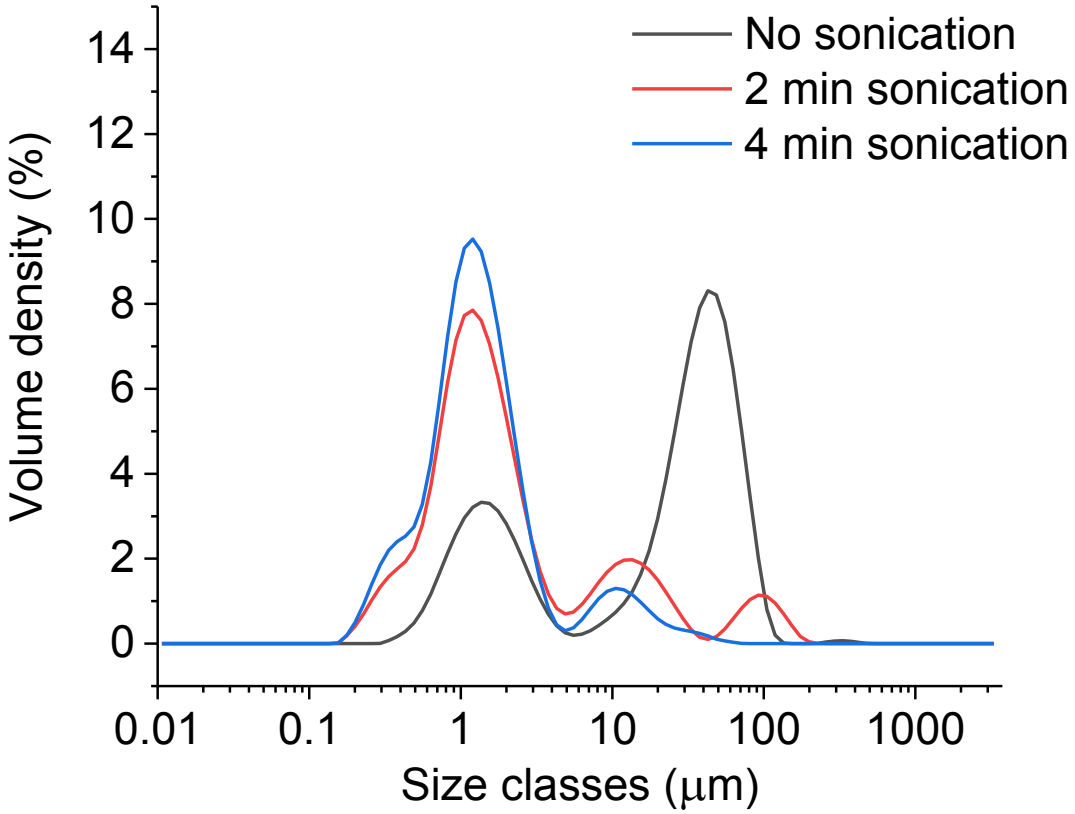
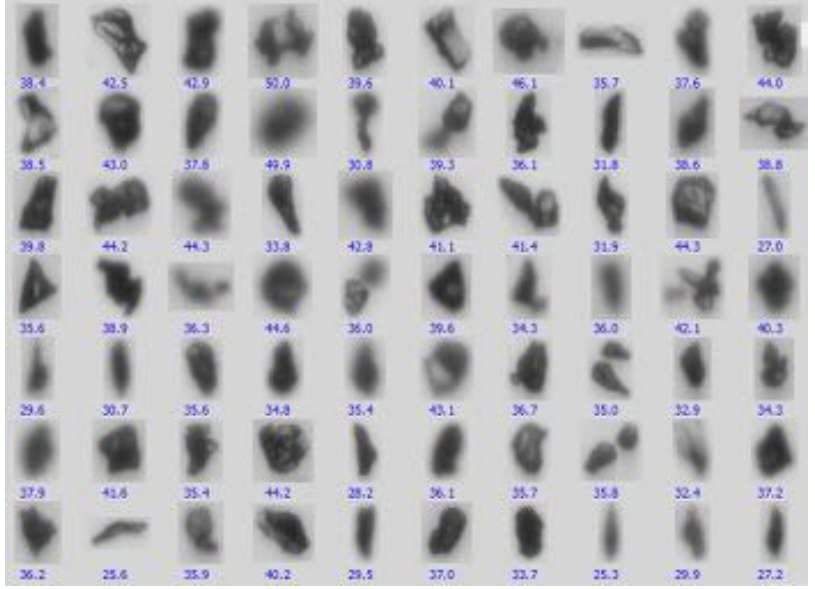
Particle Sizing - Presence of Aggregation

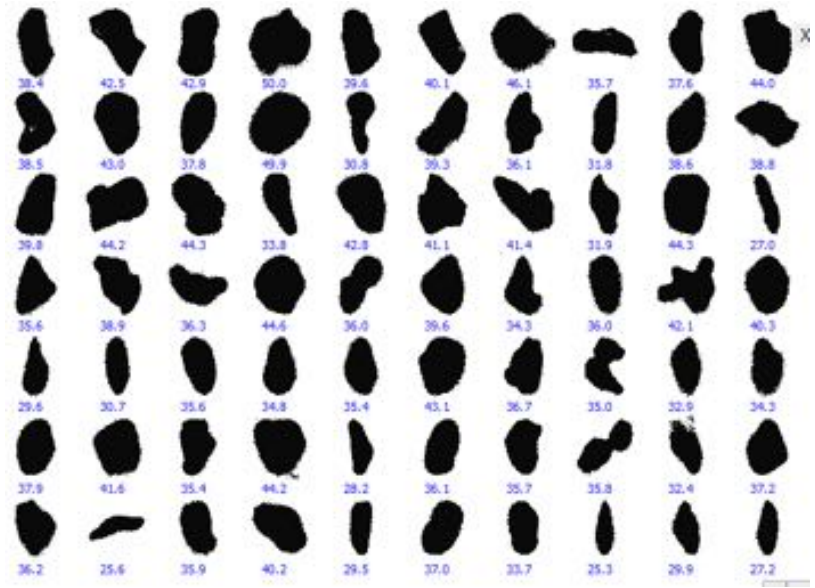


Percentiles

Condition	Dx (5) (µm)	Dx (10) (µm)	Dx (50) (µm)	Dx (90) (µm)	Dx (98) (µm)
No sonication	**0.837**	**1.11**	**29.5**	**66.4**	**90.7**
2 min sonication	**0.377**	**0.544**	**1.48**	**19.1**	**110**
4 min sonication	**0.335**	**0.46**	**1.23**	**5.52**	**19.6**

Particle Shape





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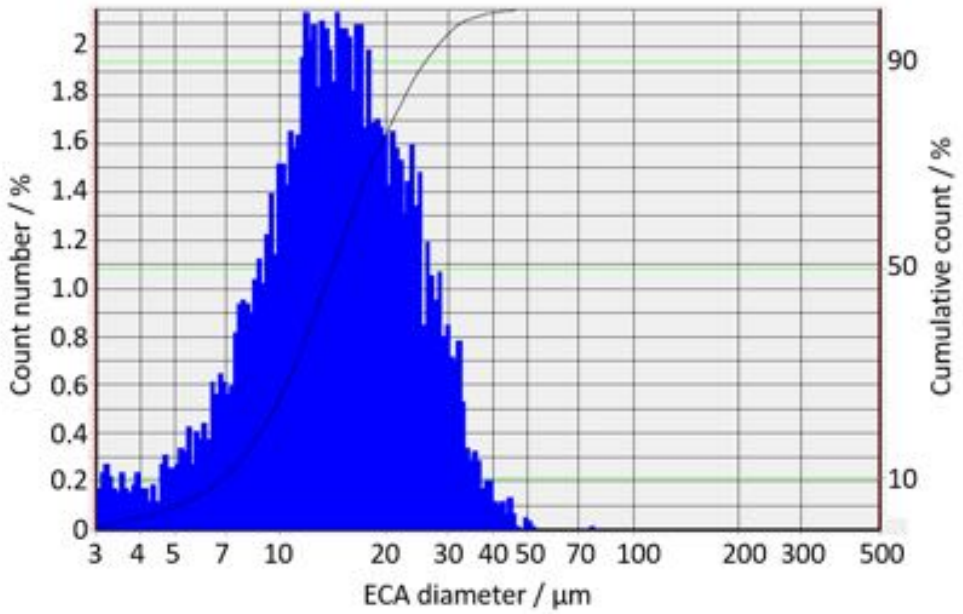
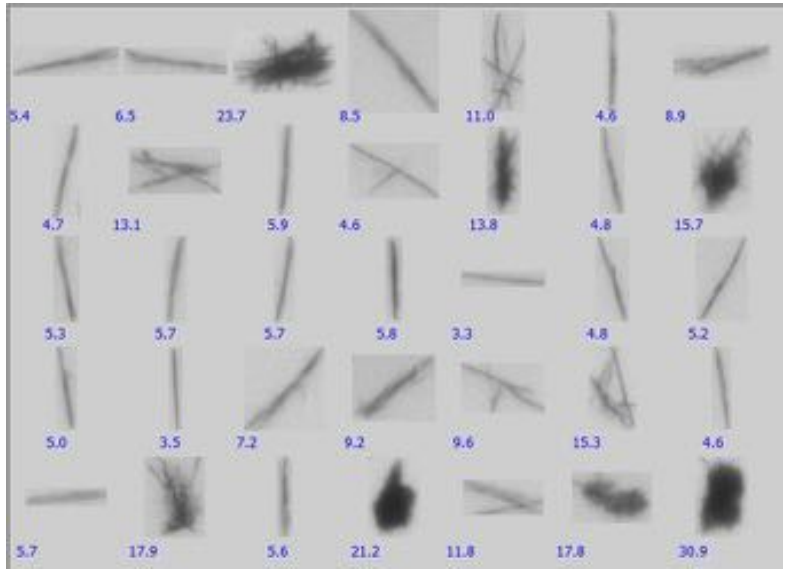
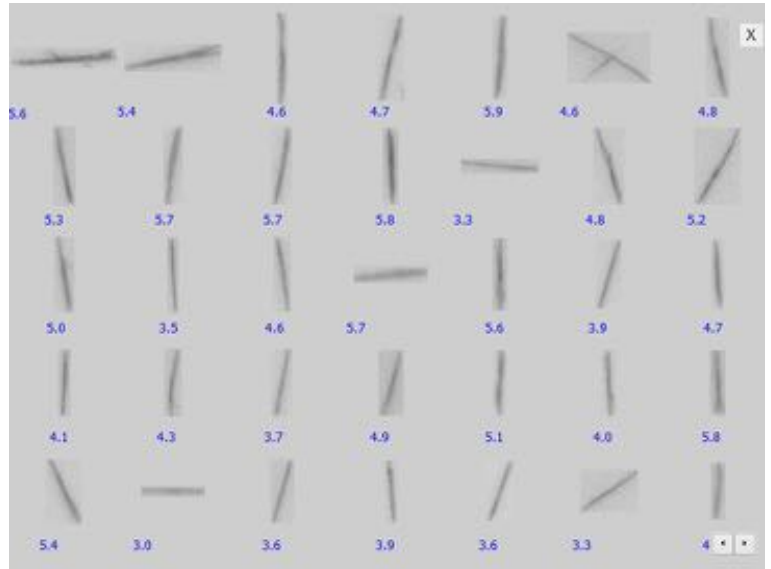
Particle Shape Output



- > 30 parameters
- Percentiles
- Percentage of particles in a desired range
- Thumbnail images
- Minimise cluster rejection



Limit fibre width 1-6 microns



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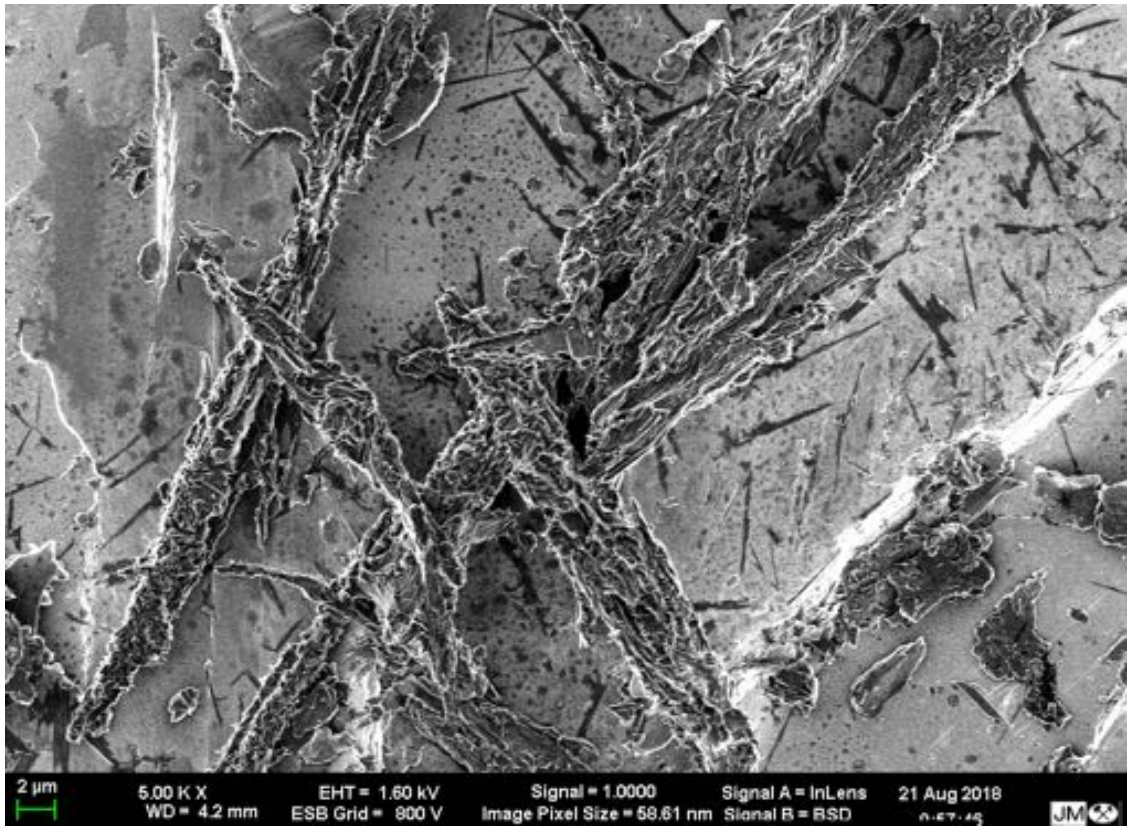
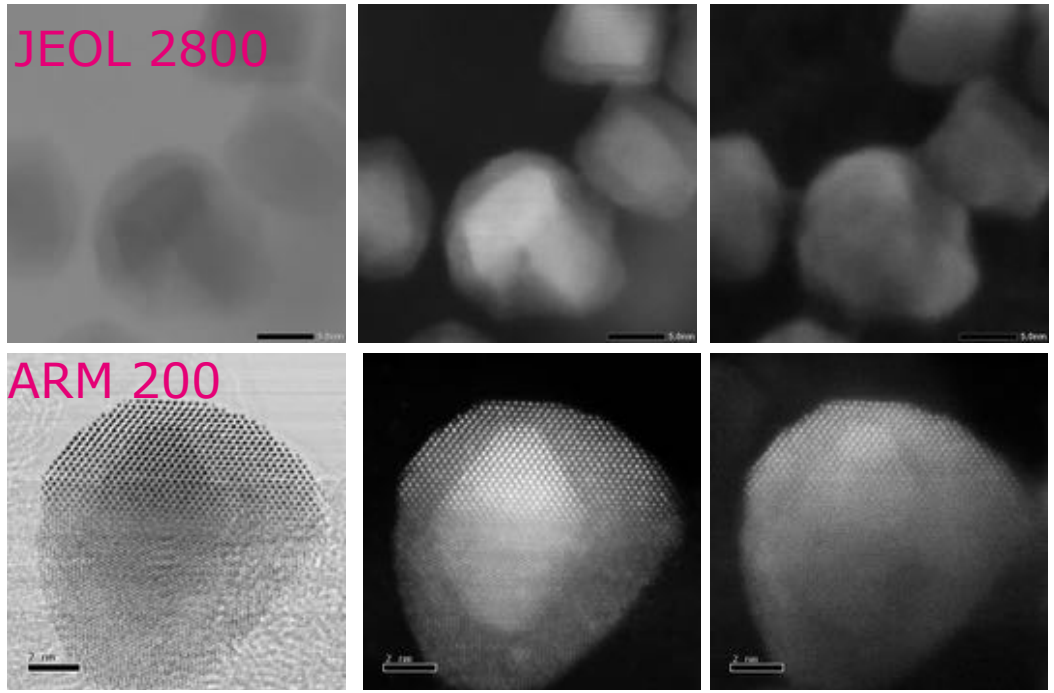
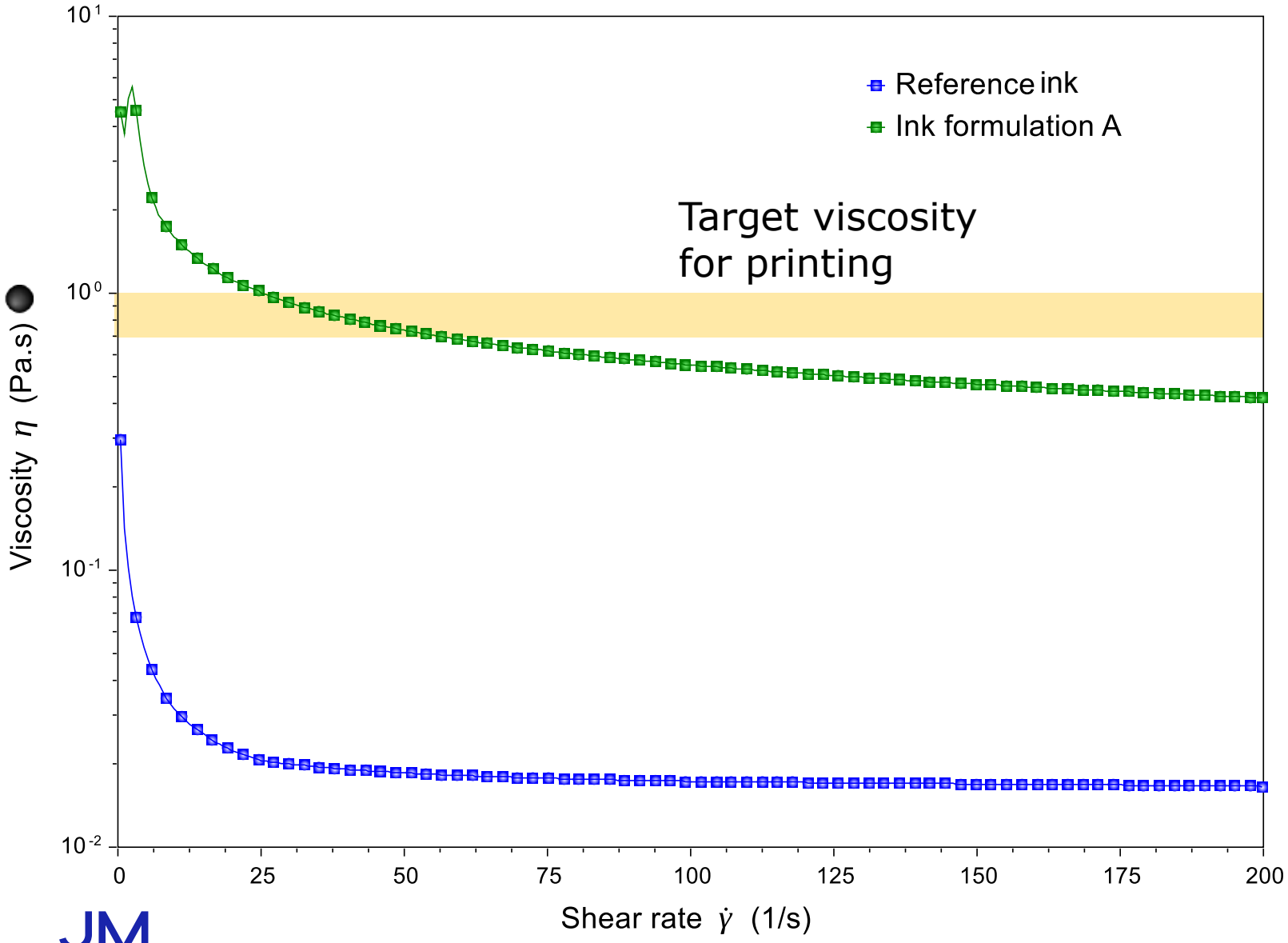
Electron Microscopy



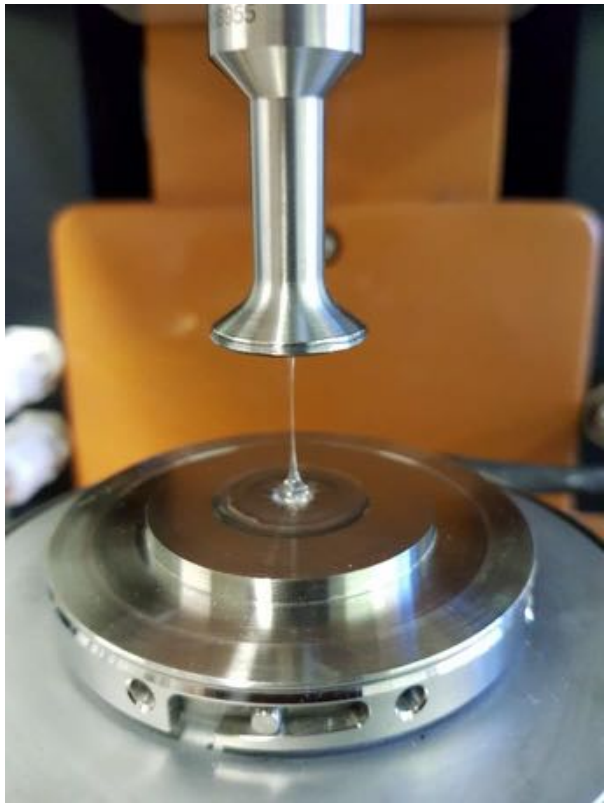
- TEM and SEM complements size and shape techniques
- Morphological detail
- Location of components by EDX analysis



The Power of Rheology

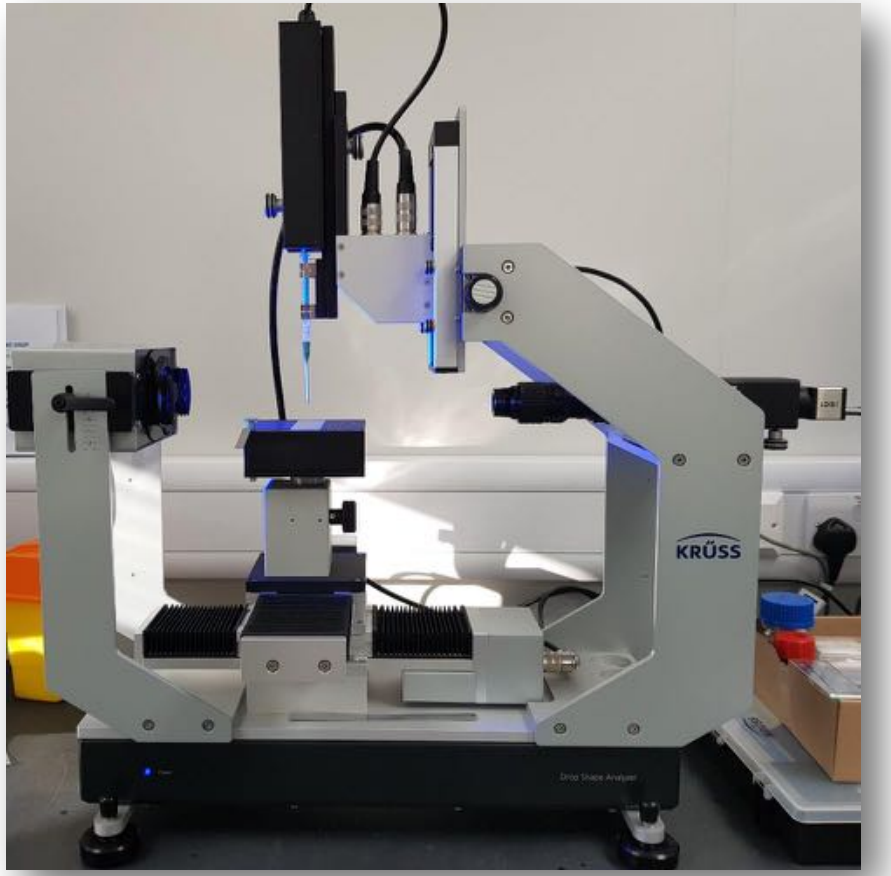


Viscoelastic properties!



Additional Techniques

- Surface tension
- Small angle scattering
- Zeta potential
- Thermal analysis



Apply a range of different techniques

Improved technical understanding of your formulation and process

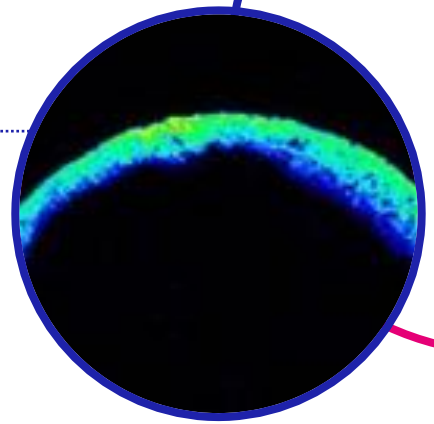
Turning Science into Customer Solutions

We know how to design processes

Scale up complex manufacturing

We know chemistry and materials

Provision of customised solutions



We know how to apply our science

New and next generation products, formulation and industrial process optimisation

Using world class science and technology to solve complex problems for our customers

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Thank You!
Any Questions?