MECHANOFUSION FOR NEXT-GENERATION LITHIUM-ION BATTERY CATHODE MANUFACTURING

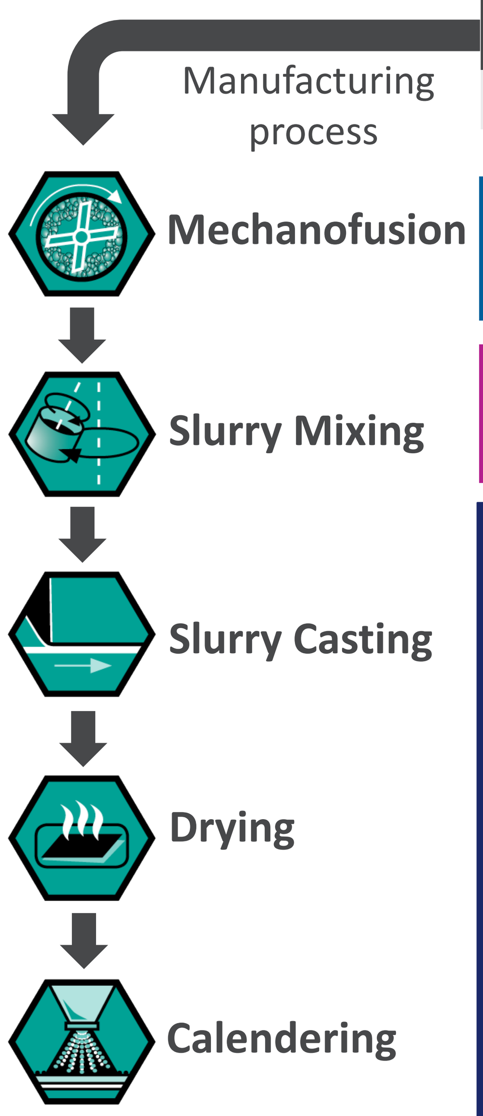
Correlating mechanofusion process parameters to CB deagglomeration behaviour through C65-coated NMC622 electronic conductivity

Prateek Verma[1], Guo J Lian[2], Rachel Smith[2,3], Denis Cumming[2,3]

[1] School of Chemical and Process Engineering, The University of Leeds, Woodhouse, Leeds, LS2 9JT
[2] Department of Chemical and Biological Engineering, The University of Sheffield, Mappin Street, Sheffield S1 3JD
[3] The Faraday Institution, Quad One, Becquerel Avenue, Harwell Campus, Didcot, OX11 0RA

ABSTRACT

Electrode Coating
(Active Material + Conductive Additive + Binder)
Current Collector



Factors involved in each process step affect final conductivity of electrodes[1].

No relationship interlinking these factors has been established yet!

This project aims at aiding ongoing efforts of transition to dry processing of cathodes by:

- Investigating CB deagglomeration behaviour through mechanofusion of NMC622 and C65
- Studying influence of **mechanofusion parameters** on CB deagglomeration
- Evaluating the percolation threshold of coated particles

MOTIVATION

WHY SOLVENT FREE PROCESSING?

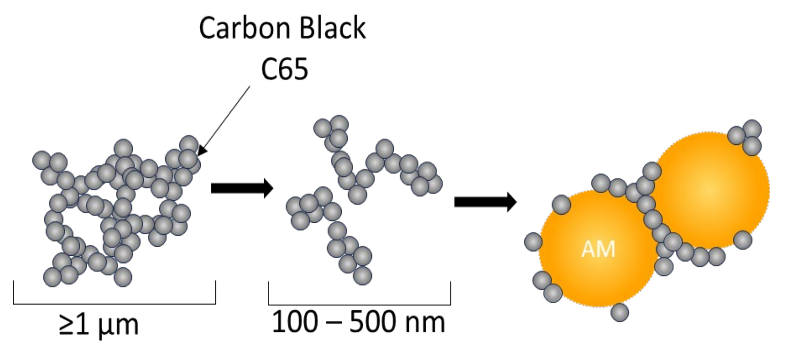
Shorten process time and **increase cost-effectiveness** by eliminating drying step

Gain control over conductive additive distribution

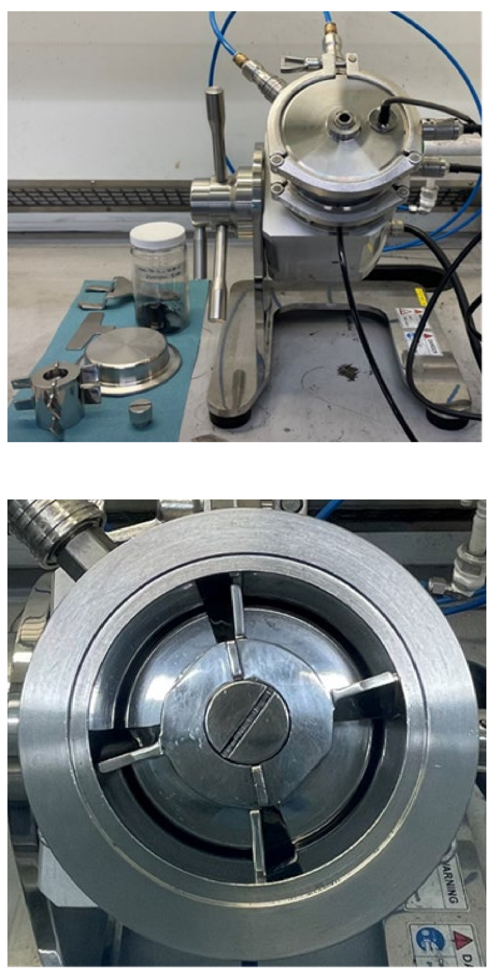
Remove use of toxic solvents e.g. NMP in wet slurry mixing[2]

CB DEAGGLOMERATION

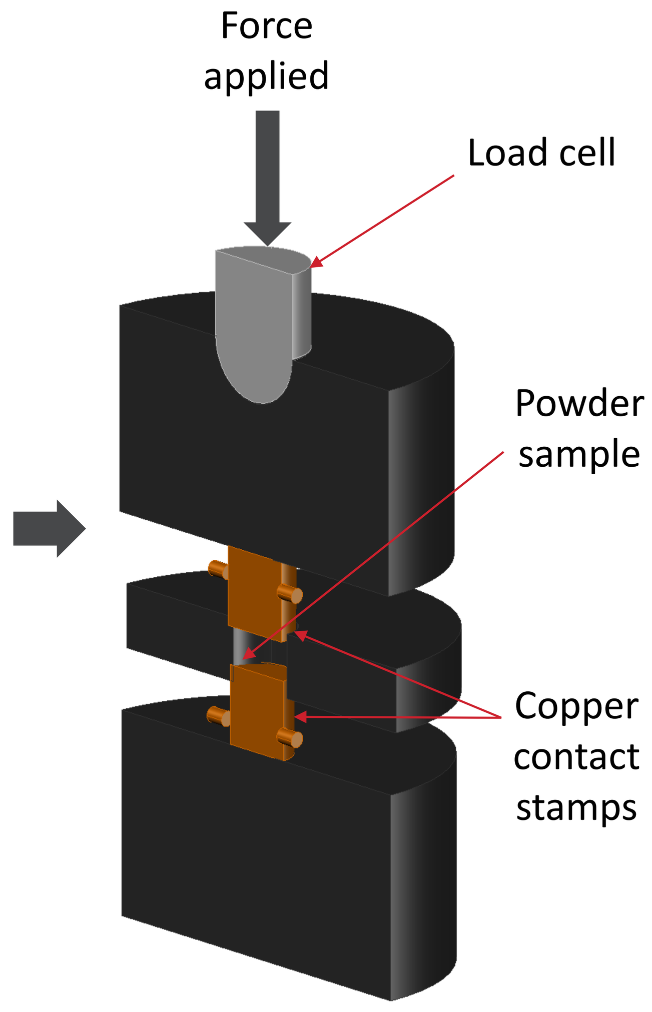
- CB agglomerates → CB aggregates → CB coated onto active material particles



METHODS



Mechanofusion mixing (Nobilta^{TM} mixer)



Volumetric resistivity measurement by compression of powder sample

RESULTS

PROCESS PARAMETERS

✓ **Greater mixing times** led to **increased resistivity**.
- **Spheronization** of carbon-coated NMC622 particles (Fig. c, d & e) results in coating with less large aggregates → less contact surface area with other NMC622 and C65 particles
- **Breakdown of "long-range" C65 aggregates** which form electronic pathways (Fig. f & g)

✓ Sensitivity of change in resistivity to mixing time **increases as CB loading is increased**
- Slower deagglomeration → greater retention of electronic pathways and contact points

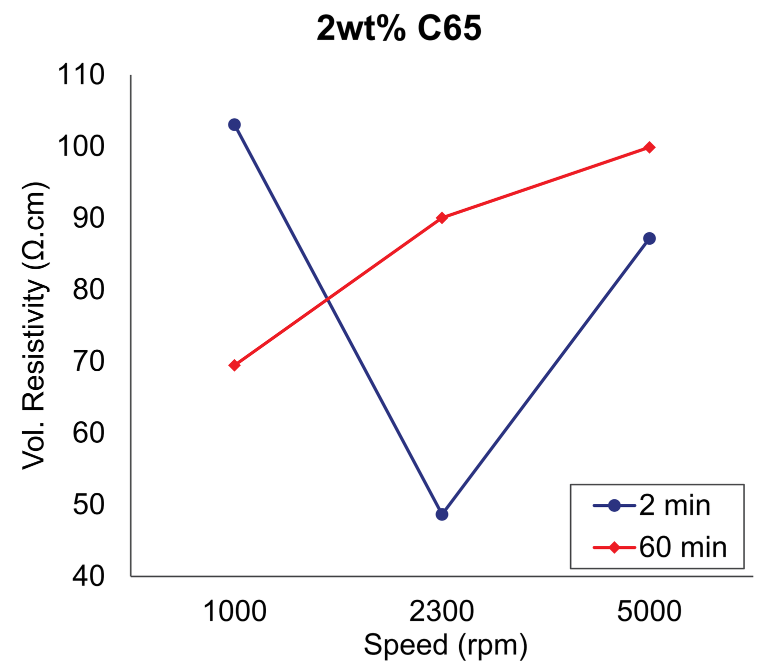
✓ The higher the proportion of carbon black used in the formulations, the more it dominates bulk resistivity.

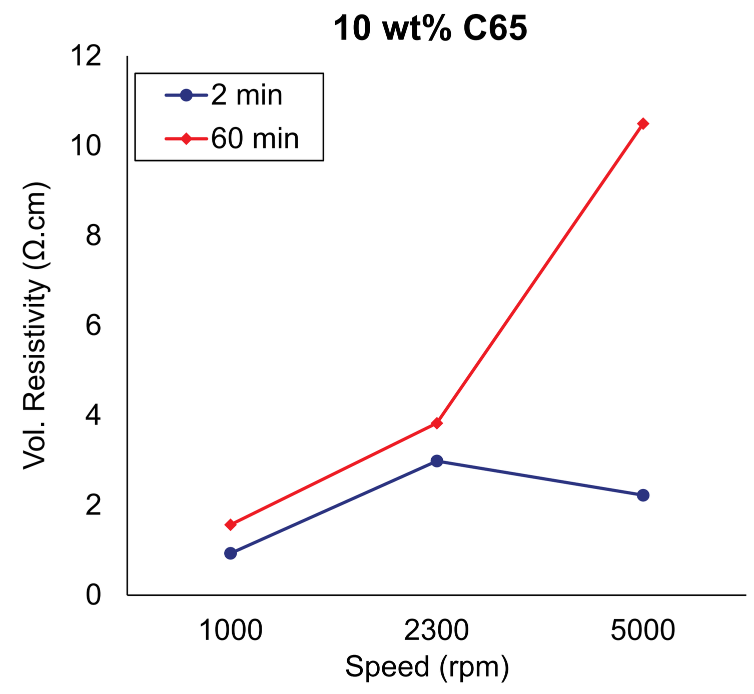
✓ For low carbon loadings:

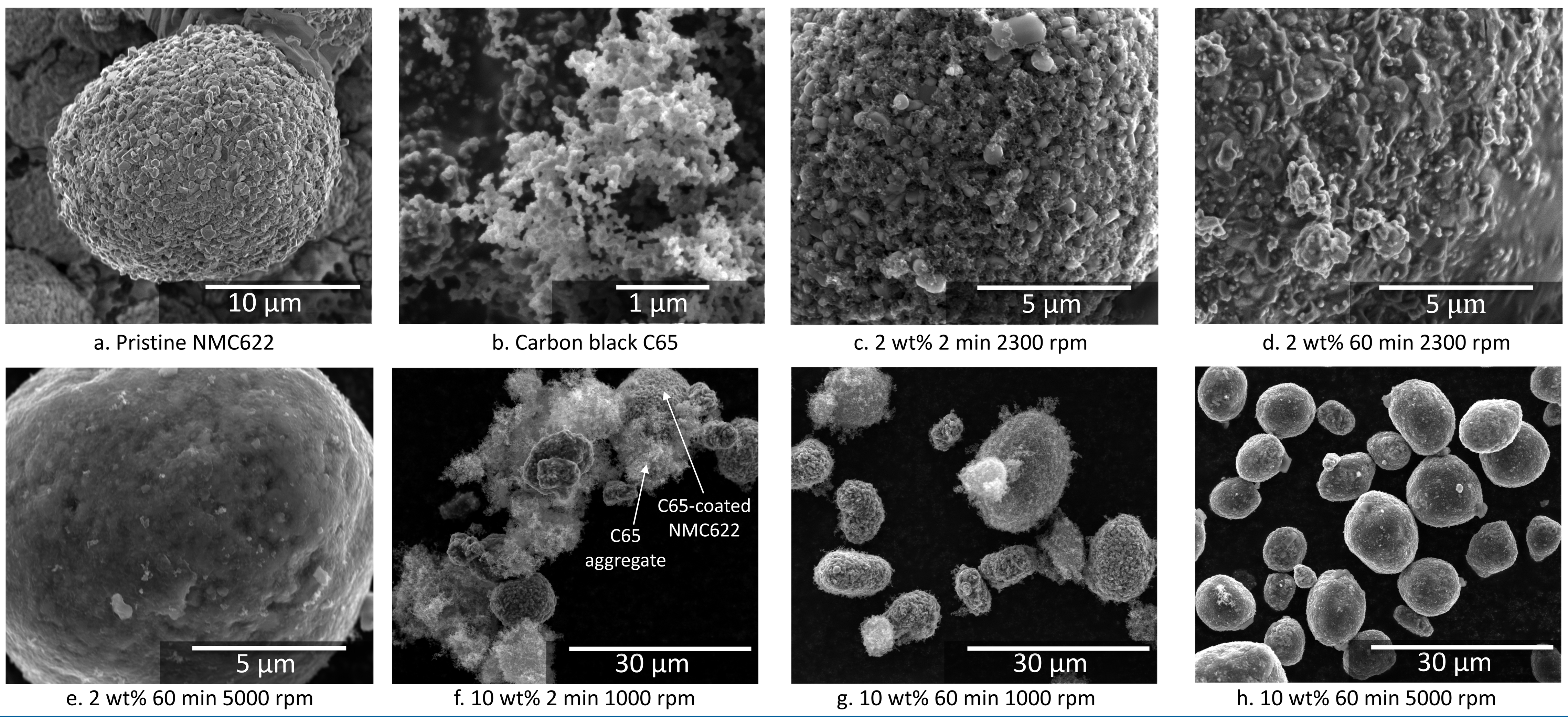
i. Low speeds desired for high mixing times
- Greater retention of long CB chains and less spheronization of CB coated NMC622 (Fig. c)

ii. Medium speeds desired for short mixing times
- Optimal deagglomeration of CB to achieve low resistivity

✓ For high carbon loadings: **low speeds favoured** (Fig. g, h)
- Lower degree of deagglomeration of interconnected CB chains which form the bulk of the electronic conductive pathways

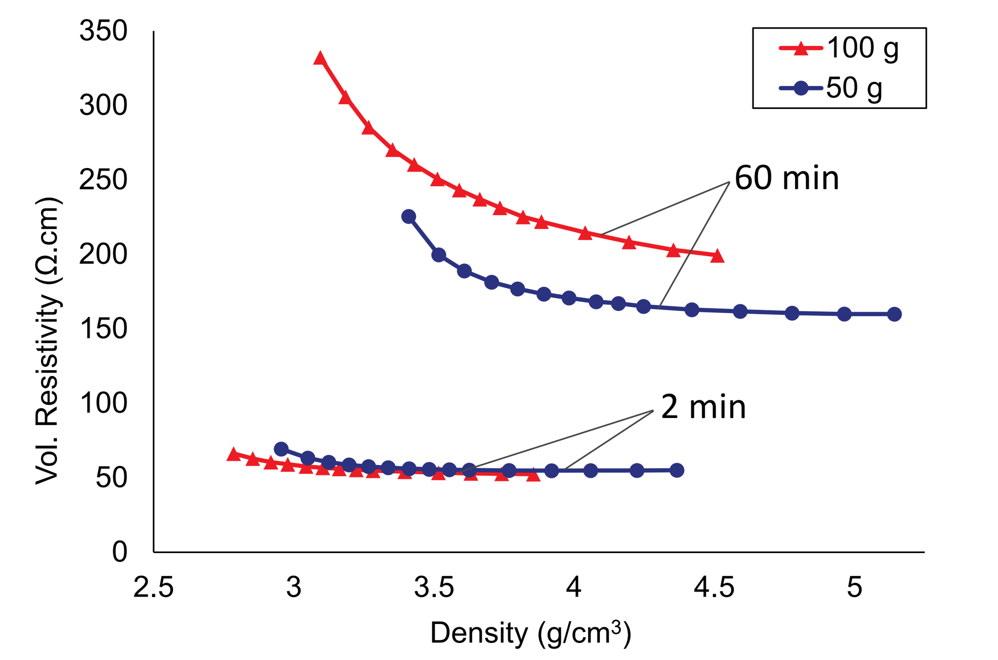






a. Pristine NMC622
b. Carbon black C65
c. 2 wt% 2 min 2300 rpm
d. 2 wt% 60 min 2300 rpm
e. 2 wt% 60 min 5000 rpm
f. 10 wt% 2 min 1000 rpm
g. 10 wt% 60 min 1000 rpm
h. 10 wt% 60 min 5000 rpm

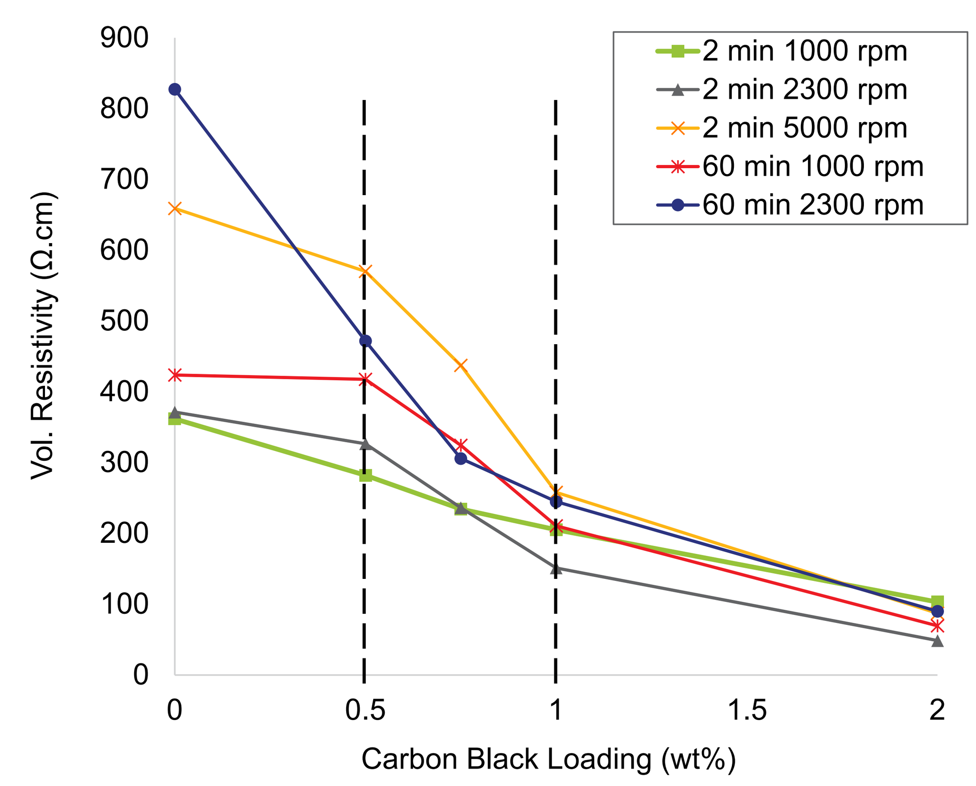
LOADING



✓ Resistivity **increased with increasing powder loading**.

✓ Mixing is less efficient - energy supplied per unit mass is lowered as loading is increased.

PERCOLATION THRESHOLD



✓ Concentration after which sharp decrease in resistivity is observed.

✓ **Percolation threshold = 0.5 – 1 wt% CB**

✓ 2 min 1000 rpm powders are simply homogenized with minimal coating, making it difficult to determine the threshold[3].

✓ Additional CB is added during slurry mixing. Determining the percolation threshold will prevent excess CB added to the slurry.

CONCLUSIONS

- C65 successfully deagglomerated and coated onto NMC622 via mechanofusion
- Deagglomeration of C65 with respect to varying process parameters evaluated using powder resistivity
- Determined percolation threshold of particles

NEXT STEPS

- Identifying advanced characterisation methods to quantify CB deagglomeration (e.g. tap density measurement)
- Relating dry mixing with CB deagglomeration through dimensionless numbers
- Electrochemical testing of coated particles

REFERENCES

[1] Westphal, B.G. et al. Journal of Energy Storage. **11**(2017) 76 – 85.

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[3] Zheng, L. et al. MRS Communications **1**(2018)

INTERN BIO

Prateek is a 3rd year student of Chemical Engineering at The University of Leeds. He is interested in solutions which are aiding global energy transition.

http://www.linkedin.com/in/prateek-verma-88924b1a8

THE FARADAY INSTITUTION ELECTRODE MANUFACTURING
NEXTRODE
University of Sheffield
UK Research and Innovation