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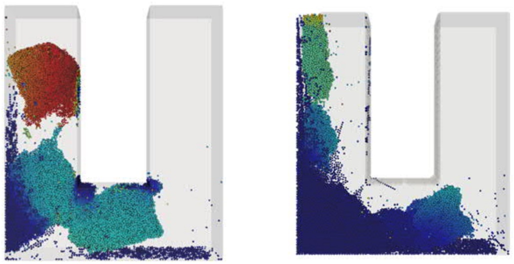
# Experimental and numerical analysis of the flow properties of different lactose grades

Xizhong Chen and James Elliott
Macromolecular Materials Laboratory,
Department of Materials Science & Metallurgy



# Powder Flow and Schulze Ring Shear Test

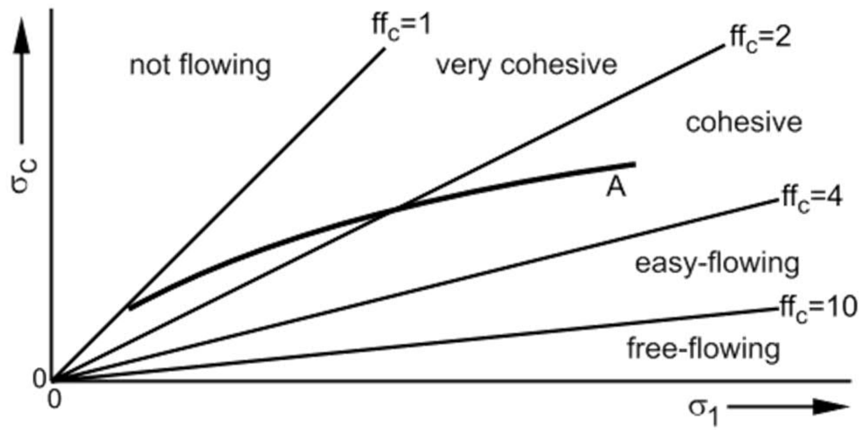


- Powder flowability can be characterised by a ring shear test :

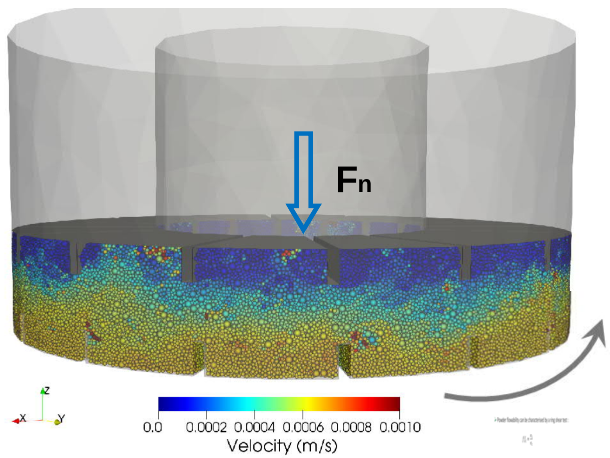
Flow function coefficient $$ff_c = \frac{\sigma_1}{\sigma_c}$$

RST-XS Mr (standard, ~ 30 ml)

$\sigma_1$ is consolidation stress and $\sigma_c$ is unconfined yield stress



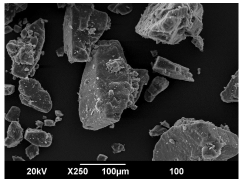

An instantaneous flow function (A) and lines of constant flowability, ffc

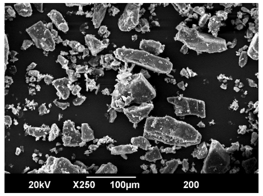


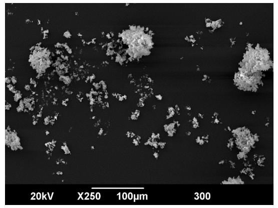

Ring shear test

# Shear cell results on lactose grades





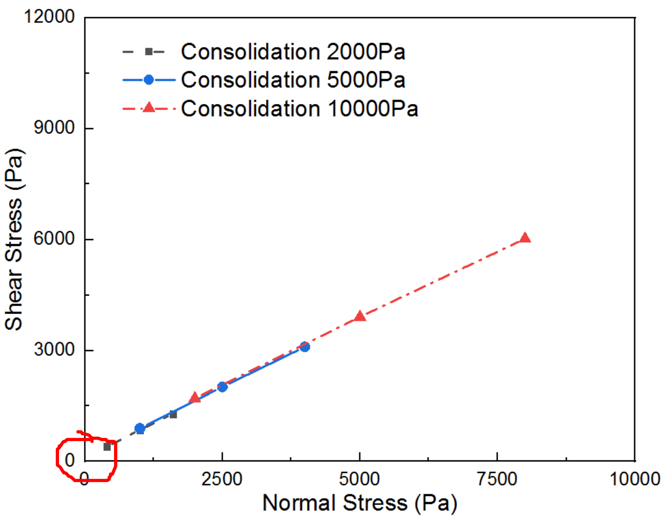



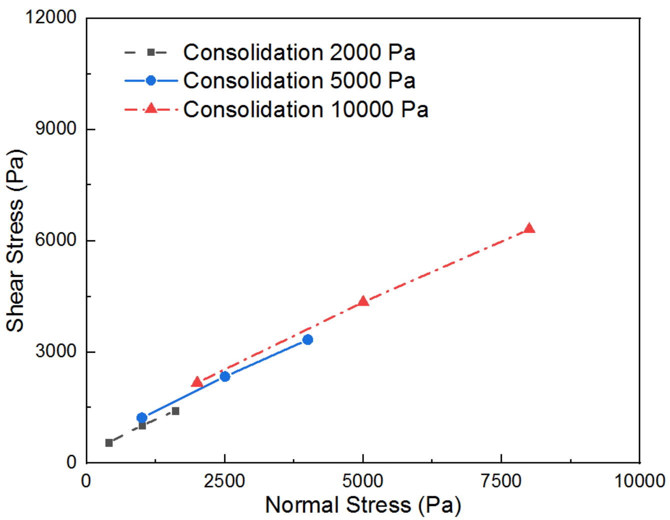

$D_{v10}$= 54 µm $D_{v50}$= 136 µm $D_{v90}$= 218 µm

$D_{v10}$= 10µm $D_{v50}$= 73 µm $D_{v90}$= 144 µm

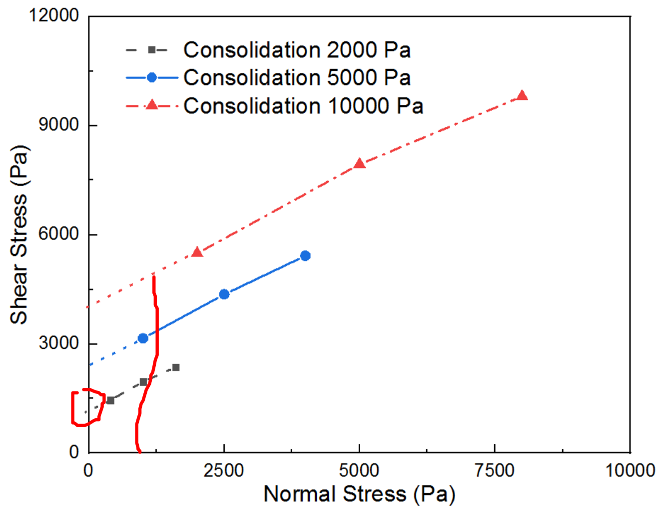
$D_{v50}$= 3 µm $D_{v90}$= 8 µm




Lactohale 100 (sieved)




Lactohale 200 (milled)




Lactohale 300 (micr.)

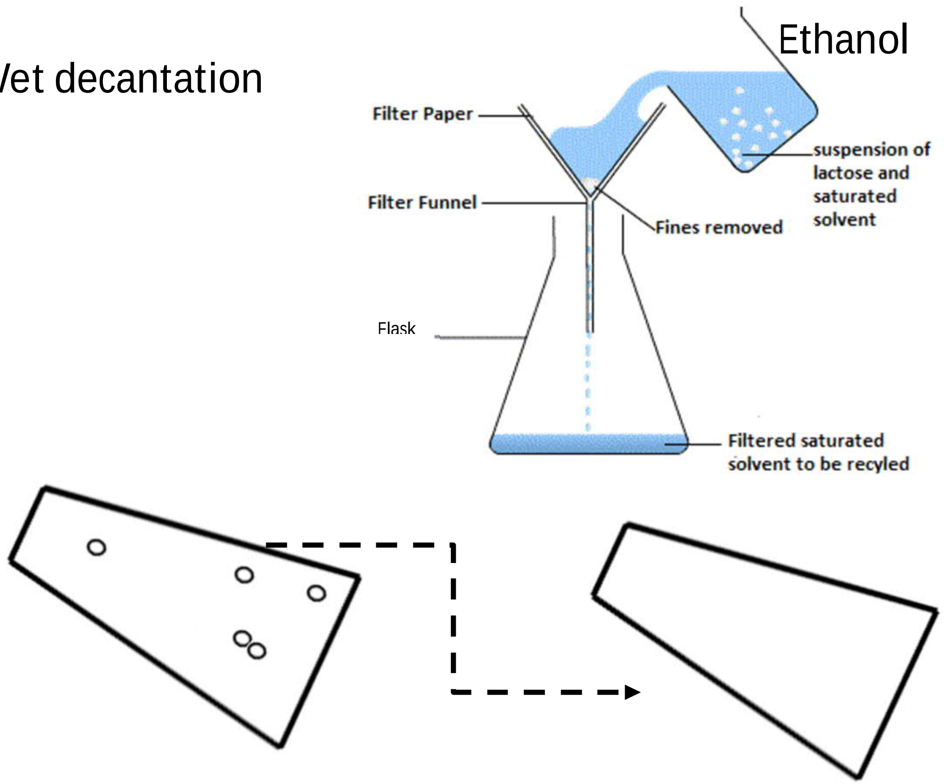
- Shear stress depends on pre-consolidation history (LH300)
- Bulk cohesion increases as pre-consolidation stress increases (LH300)

# Wet decantation process

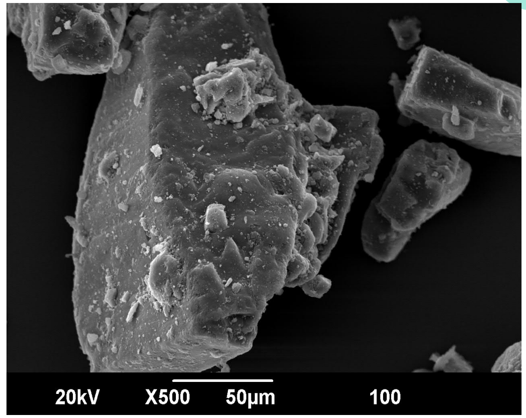


- Surface modification: To produce "clean" lactose carriers.

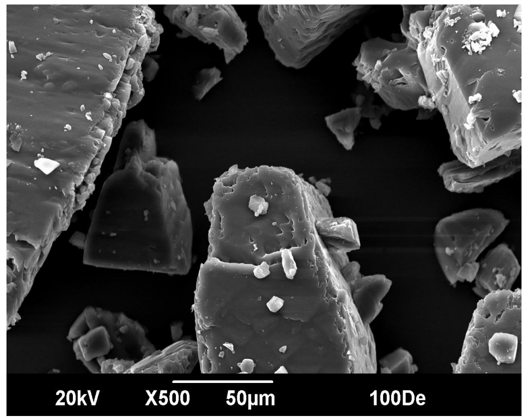
Wet decantation




[image credit: Ioanna Styliari (Hertfordshire)]




Lactohale 100 (sieved)

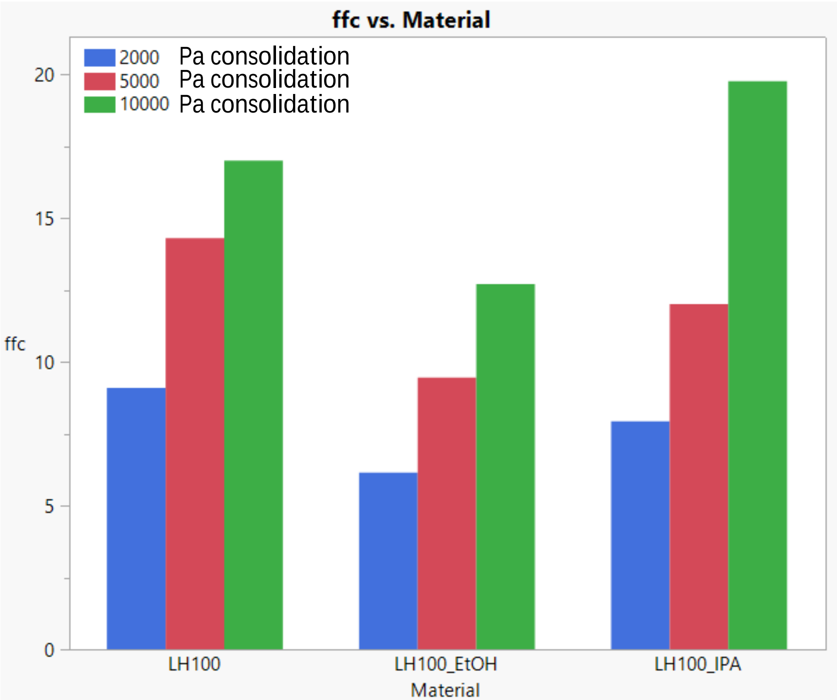



Lactohale 100 (Decanted)

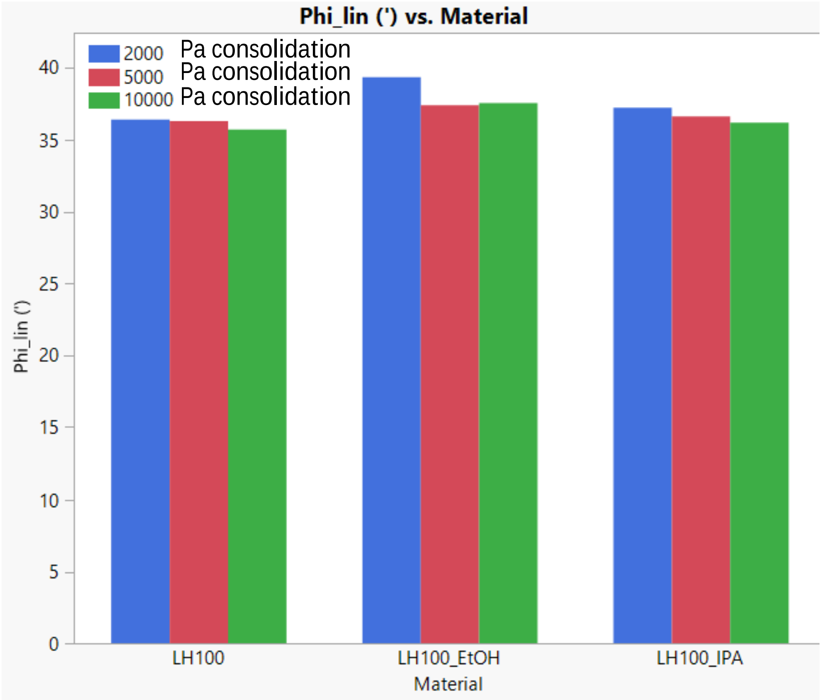
Islam et al. Lactose Surface Modification by Decantation: Are Drug-Fine Lactose Ratios the Key to Better Dispersion of Salmeterol Xinafoate from Lactose-Interactive Mixtures? Pharmaceutical Research, Vol. 21, No. 3, March 2004

# Wet decantation results






Flowability




Friction angle

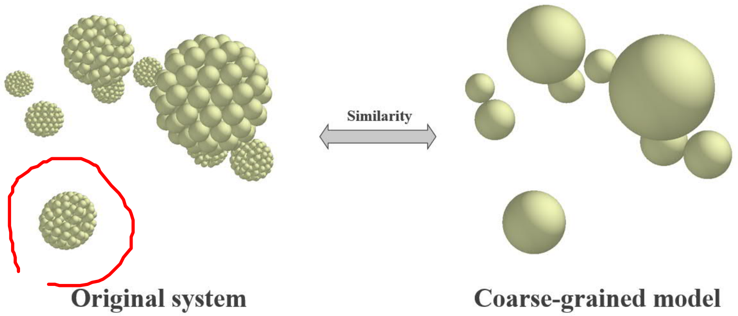
Surface energy (mJ m$^{-2}$): LH100_IPA (43) > LH100 (42) > LH100_EtOH (41)

D50 (µm): LH100_IPA (135)> LH100 (131) > LH100_EtOH (119)

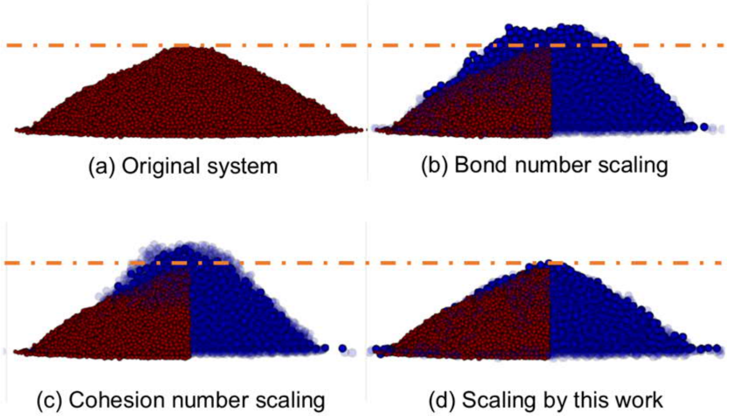
- Flowability decreases after decantation by ethanol and IPA
- Internal friction angle of particles is less sensitive to decantation

# Numerical Simulations of cohesive flows

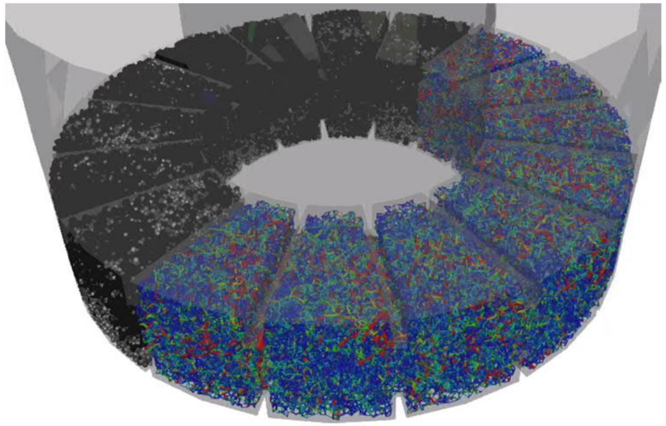




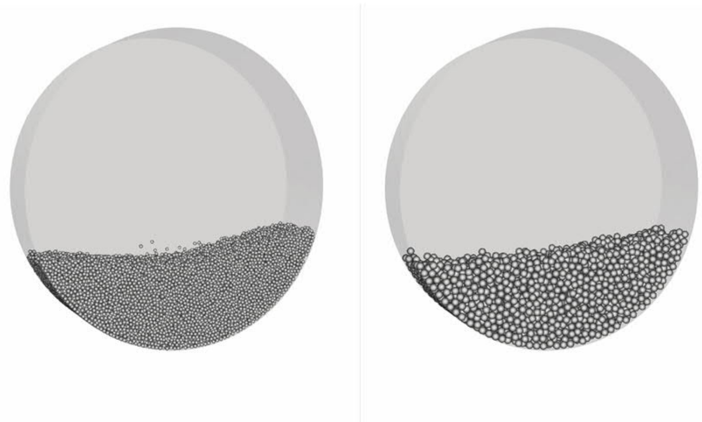

Coarse-grained JKR model
https://doi.org/10.1016/j.ces.2020.115906



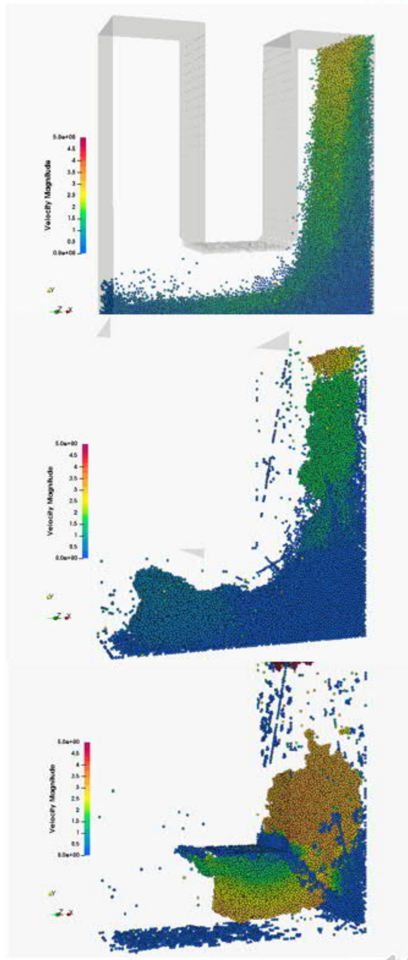

Angle of repose modelling



Shear cell DEM modelling



Rotating drum simulations



CFD-DEM simulations

# Conclusions & Acknowledgements



- The shear stress of lactose powder depends on the particle sizes. Wet decantation will modify the surface properties and change the powder flowability.
- DEM simulations with a coarse grained JKR model can be used to efficiently predict the cohesive powder flows in shear cell, rotating drum and fluidization

UNIVERSITY OF LEEDS

MANCHESTER 1824 The University of Manchester

UNIVERSITY OF BATH

University of Hertfordshire UH

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AstraZeneca

3M Drug Delivery Systems Division

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