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Particle charging in industrial process

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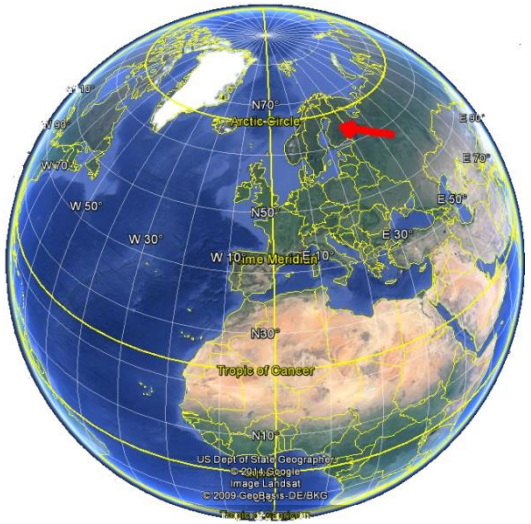
OUTLINE

- Background
- What is special about industrial processes
- Examples
  - packing
  - powder transport
  - storage: surface amorphicity
- Control methods
- Conclusions

Background

- Laboratory of Industrial Physics
  - R&D
  - Measurement services
  - Problem solving
  - Co-operation with
    - pharmaceutics, chemistry, paper, printing, …
- Finland
  - Long cold, relatively dry winter
  - Dry conditions inside facilities
    → promotes triboelectric charging



Industrial processes

- High production rates
  - Energetic contacts, high charging levels
- Large volumes
  - Charge build-up, high electric fields
- Synthetic materials
  - Low conductivity, slow charge decay
- Sensitive materials
  - Might require low humidity, antistatic additives inapplicable

Industrial processes

- Large facilities
  - Expensive and difficult air conditioning, uncontrolled (low) humidity
- Indoor and outdoor operations
  - Temperature and humidity variations, unpredictable charging
- Many different unit operations
  - Various contact materials, energies, operational parameters, unpredictable charging

Industrial processes

- Different batches in same production line
  - Surface contamination, residues, unpredictable charging
- Plant personnel & operators
  - No knowledge or training about static electricity
  - Tradition of "*we have always done it this way*"

- Charging is almost always unwanted phenomenon!

Example, packing

- Fine hygroscopic powder packed into plastic bags
  - Strong adhesion on plastic (opposite polarity)
  - Difficulties in sealing
  - High mass flow rate & Hydrogen → ~~Ionizers~~, ~~humidification~~

not actual unit

Example, packing

- Different options for plastic
  - choose the one with less charge
  - same polarity than powder
  - static dissipative
- Passive neutralisator

Example, powder transport

- Unexpected difficulties in handling pharmaceutical powders
  - Process flow chart unchanged
  - Identical raw material batches
  - Atmosphere controlled as usual

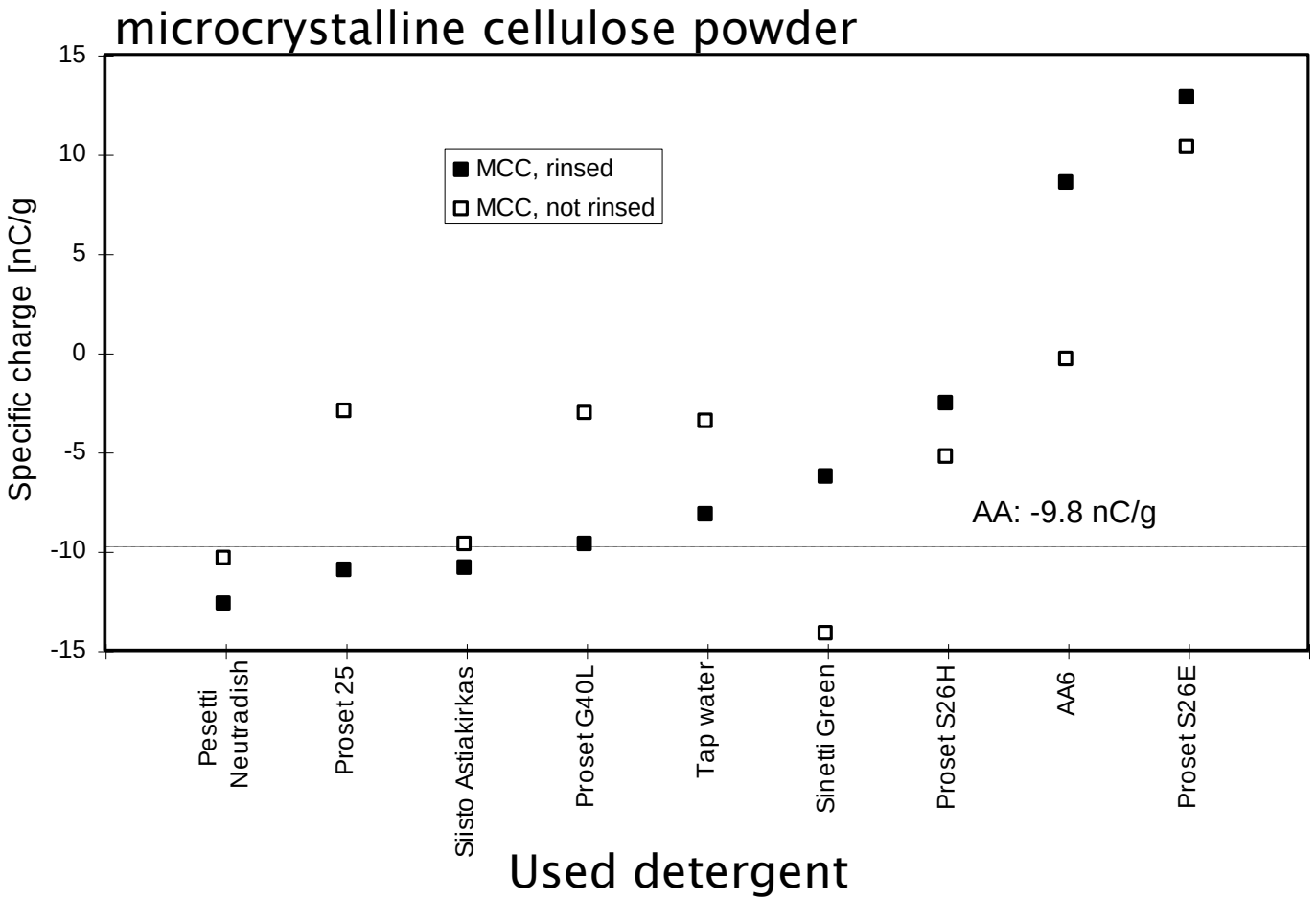
  - Similar cleaning procedure…
    but different detergent

Effect of washing on charging

- Powder samples (microcrystalline cellulose, polystyrene) charged by sliding in a steel pipe into a Faraday pail
- Washing procedure
  - tap water & brush
  - blow dried
  - polished mechanically
  - tap water & brush
  - rinsed with distilled water
  - rinsed with ethanol
  - blow dried

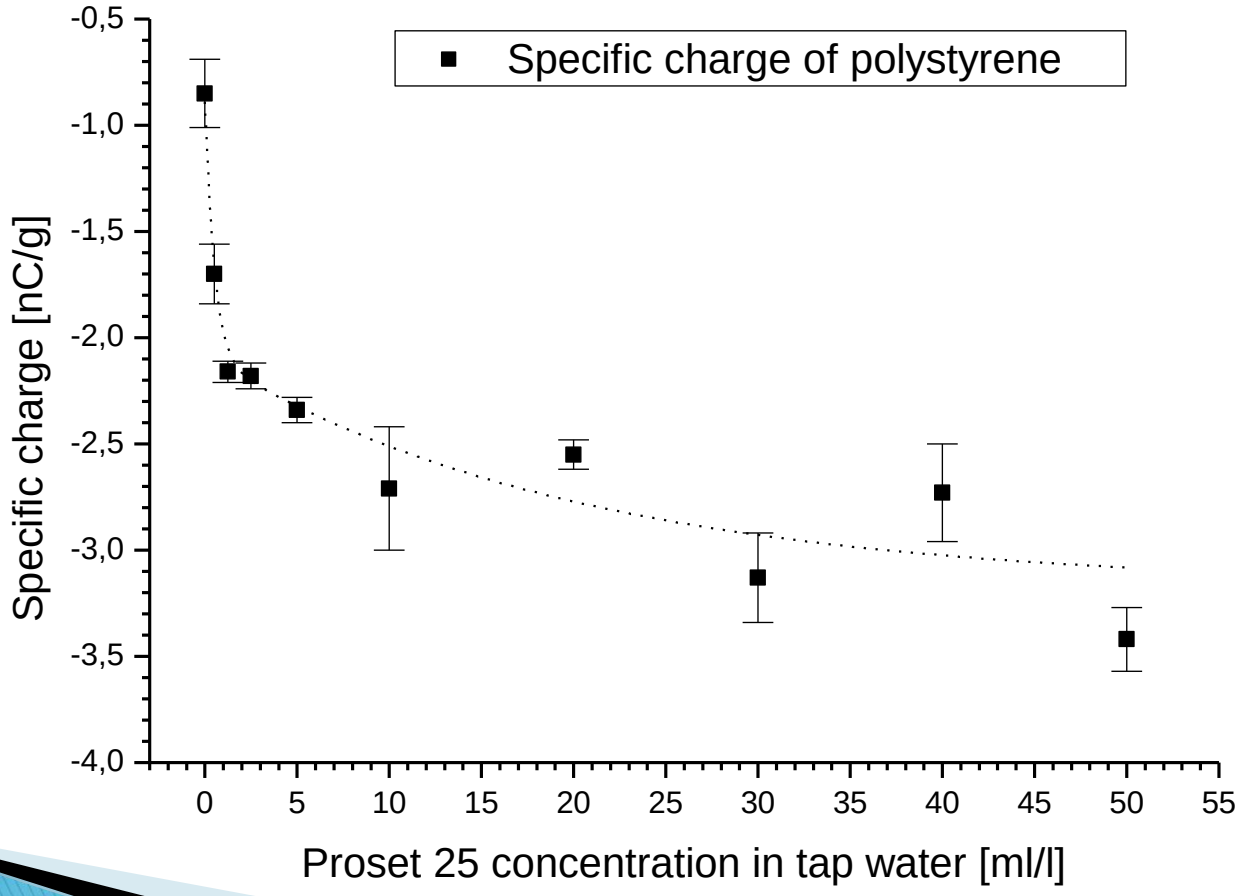
  - rinsed with detergent
  - (rinsed with distilled water)
  - blow dried

Effect of washing on charging



Murtomaa, M., et al., 2002: Effect of detergent on powder triboelectrification. Eur. J. Pharm. Sci. 17, 195–199

Effect of concentration of detergent on charging



Example, surface amorphicity

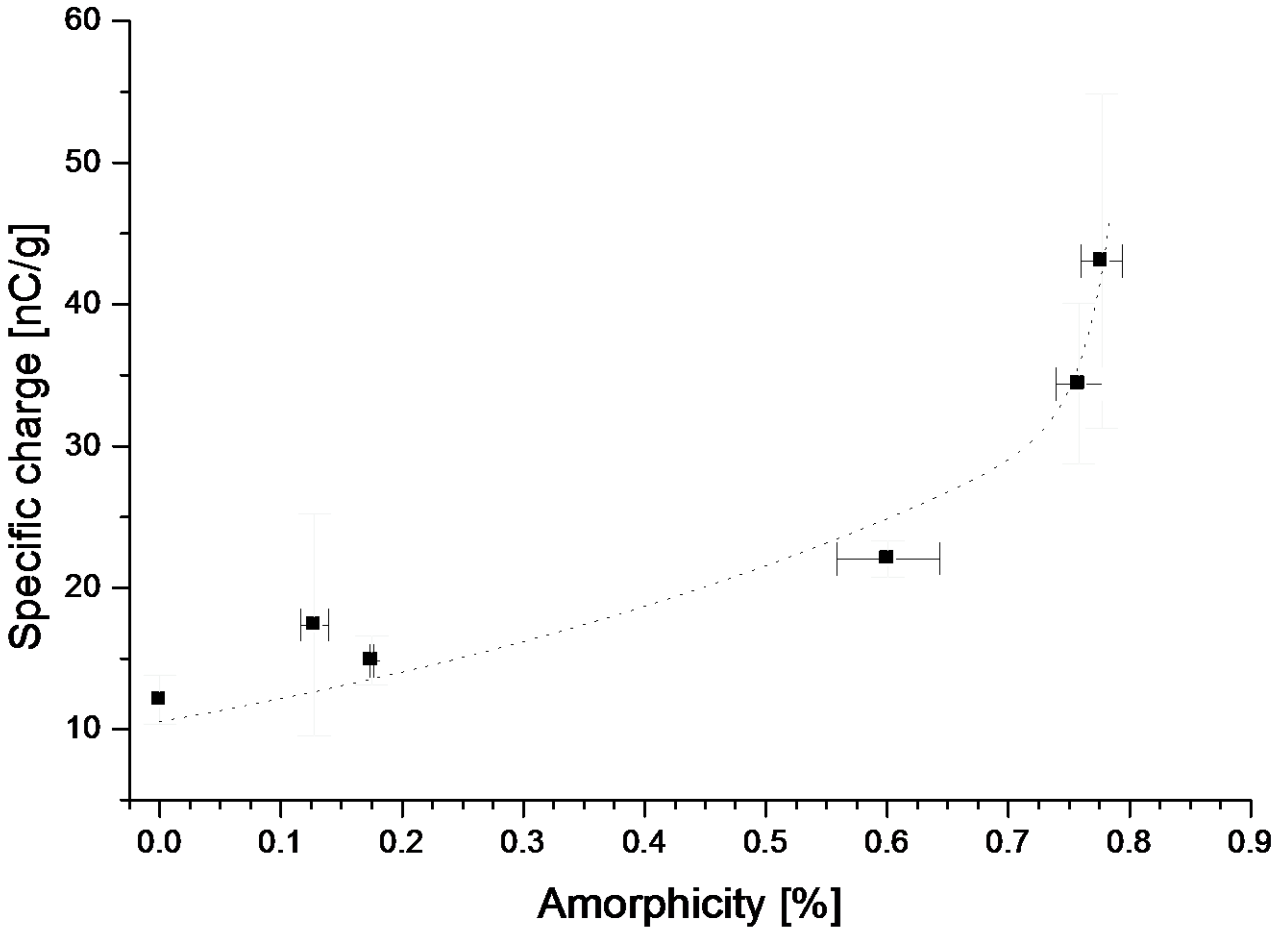
- Energetic contacts can give rise to surface amorphicity
  - pneumatic transport
  - milling ...
- Amorphous surface is usually unstable

- Effect on charging?

Example, surface amorphicity

- Controlled surface amorphicity prepared by spray-drying lactose from water/ethanol mixture
- Samples charged in polypropylene pipe

Example, surface amorphicity



Murtomaa, M., et al. 2002: Effect of amorphicity on the triboelectrification of lactose powder. J. Electrostat. 56, 103-110

Example, surface amorphicity

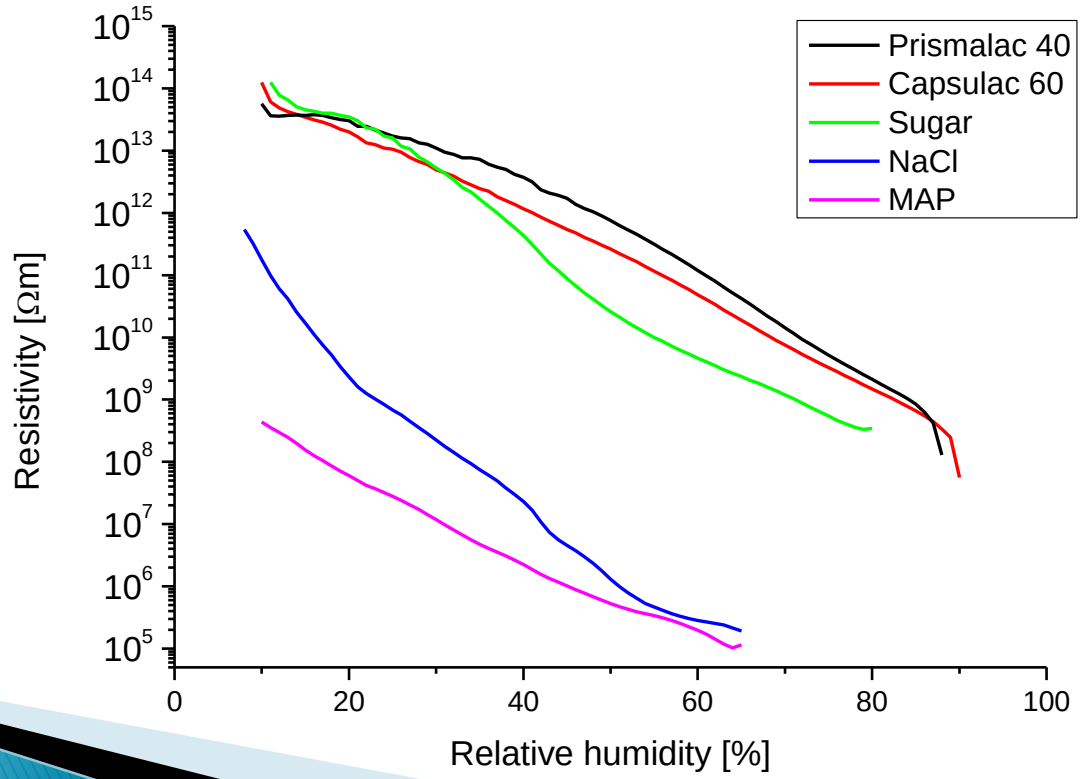
- Amorphicity increased charging
- Charging tendency of surface amorphous material is likely to be time-dependent
- Recrystallization, humidity, storage...

Control methods

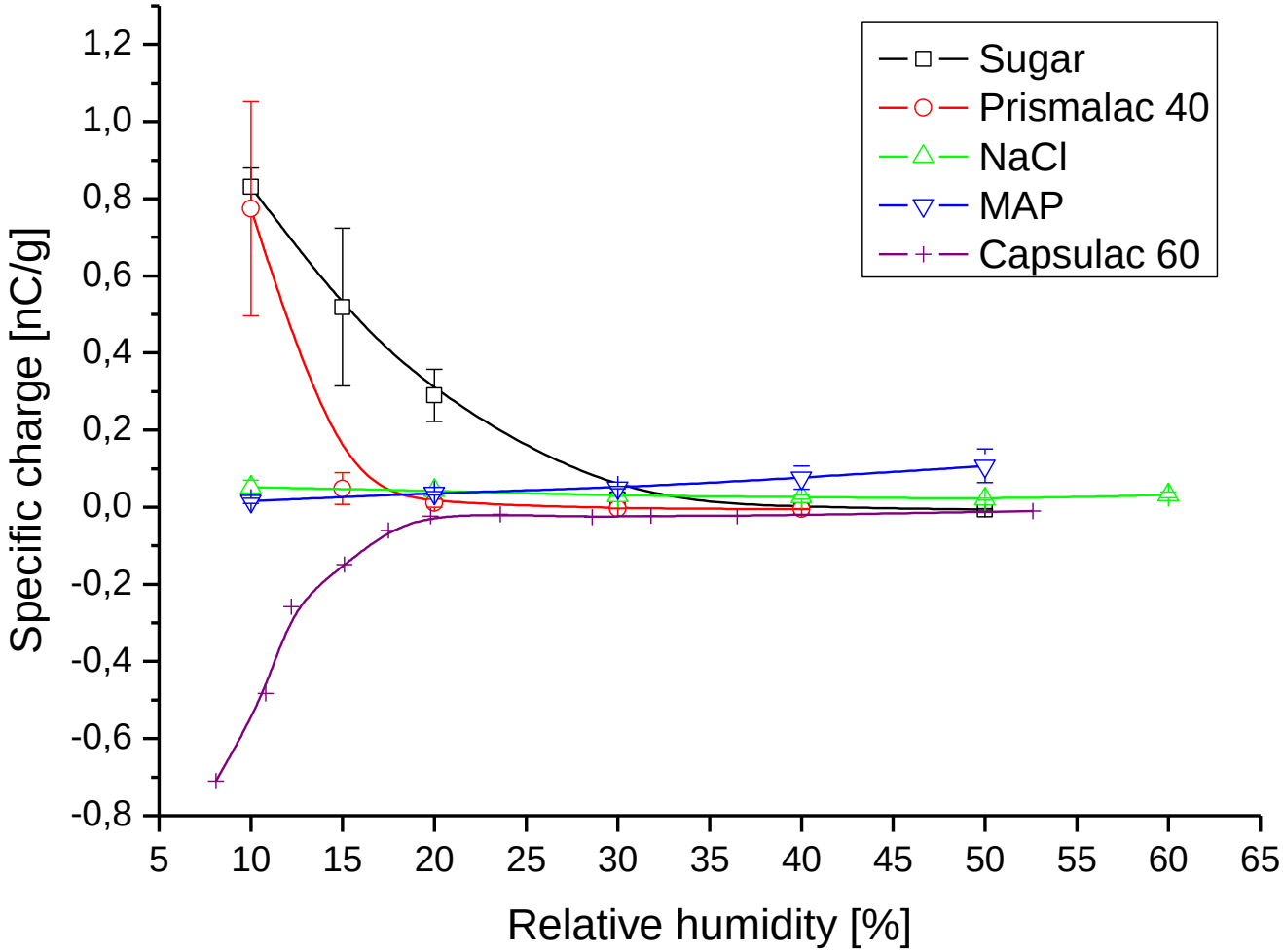
1. To prevent charging in the first place
   - reduce contact energy & area
   - selection of materials (triboelectric series)
   - coating, intentional adhesion
   - antistatic additives
2. Neutralization
   - ionizers
   - humidification
   - grounding

Humidification

- Very effective where applicable
- Does not prevent charging but increases conductivity and charge decay



Charging of various powders in a fluidized bed



Murtomaa, M., et al., One-step method for measuring the effect of humidity on powder resistivity, J. Electrostatics 71 (2013)
Murtomaa, M., et al., One-step measurements of powder resistivity as a function of moisture, Proc. ESA Annual Meeting 2014

Conclusions

- Industrial operations vs. laboratory studies

INDUSTRY	LABORATORY
large volumes	small samples
ambient atmosphere	controlled atmosphere
special conditions (*p, T...*)	impossible to obtain in lab
contamination	clean surfaces
variable process	reproducibility
plant operators	scientists

- Industrial operations are totally different game!
  - extra caution is needed when laboratory results are applied in industry

Thank you for your attention!

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