Ion Exchange Resin Testing

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Introduction

- Power Industry Background (MUWTP and CPP)
- Consider the Life Cycle of Ion Exchange Resins
- From Manufacture through to eventual Disposal

One Possible Approach

- Consider Ion Exchange Resin Testing as part of a
- RESIN MANAGEMENT PROGRAMME
- “Do you want to pay me now or pay later?”

Content

- Introduction
- When to Test
- Why Test
- How to Test
- Routine Tests
- Specialised Testing
- Sampling
- Test Results
- Conclusions
- Questions

When to Test

- Manufacturing/Production
- Pre-delivery
- Before Loading into Service Vessel
- Periodically
- Troubleshooting
- Prior to Disposal

Manufacturer and Production

- Sampling and Testing for :
- Quality Assurance
- Traceability etc
- Specification Compliance

Resin Specification 1

- Resin Properties:
- Application e.g. Softening
- Polymer Structure
- Appearance
- Functional Groups
- Ionic Form

Typical Resin Specification for Cation Resin

Total Capacity, Na^+ Form (min)	1.8eq/l
Moisture Retention, Na^+ form	48 – 53%
Mean Diameter	725 ± 125 µm
Uniformity Coefficient (max)	1.7
Reversible Swelling, Na^+ to H^+	4%(max)
Temperature limit, H^+ form	120 ºC
Temperature Limit, Na^+ form	140 ºC

Pre Delivery Samples

- Special Applications
- Check for Compliance with Specification
- Procurement Contract
- Demonstrate Informed Client

Prior to Loading into Service Vessel

- Last Chance !!
- ARCHIVE SAMPLES
- No of Batches
- No of bags
- Visual Inspection
- Visual Microscopy

Periodically

- Expected Resin Life?
- 2 years ?   5years ?   10 Years ?
- Condition Monitoring Programme
- Helps to identify a potential problem before it becomes a performance issue
- Trending Analysis
- Forward Planning, Purchases and Budgets

Troubleshooting and Problem Solving

- Plant Performance Problems
- Investigations
- Resin Sampling and Testing
- One part of the Process
- Caution

Resin Testing

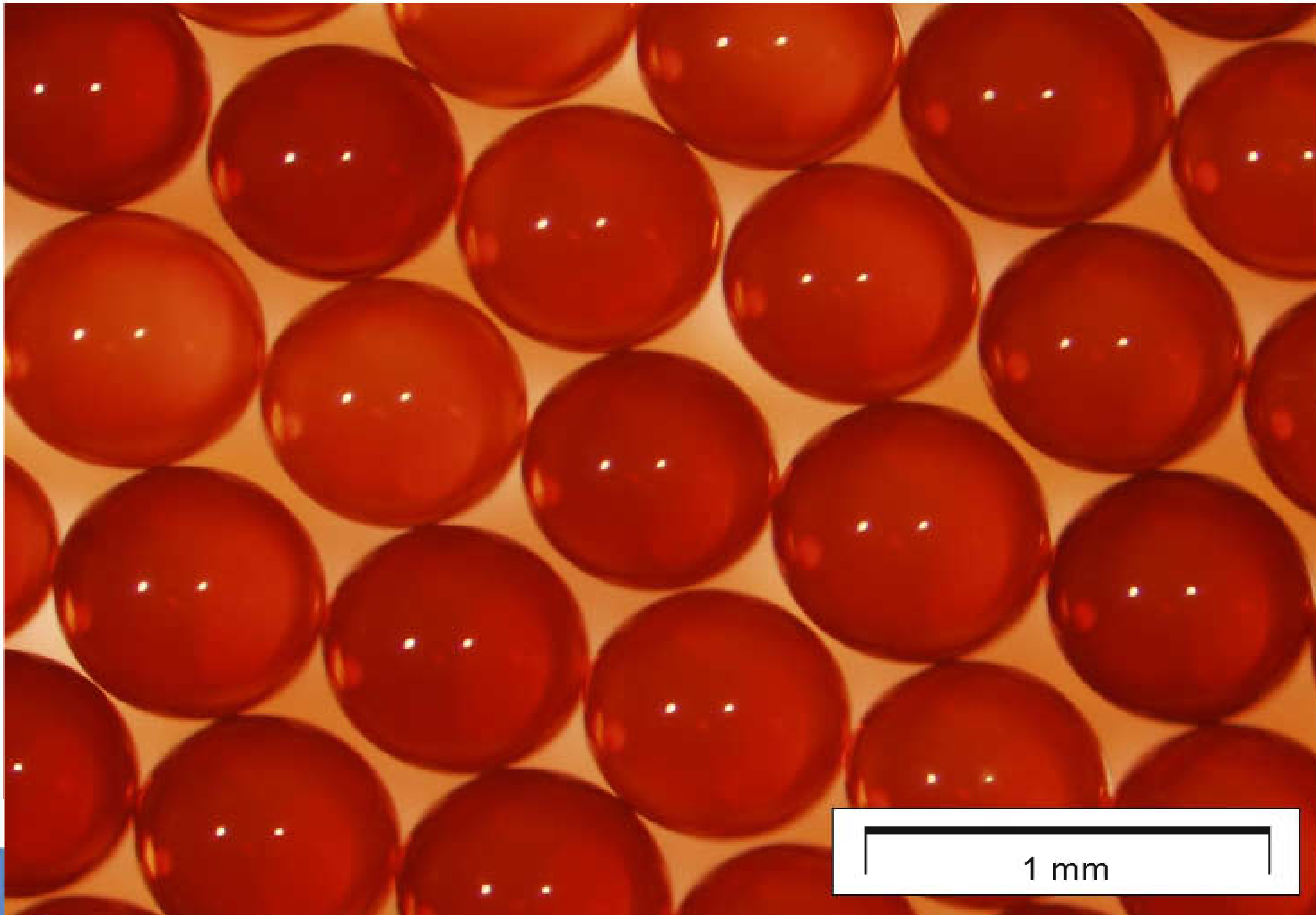
- Routine Tests
- More Specialised Testing

Routine Tests

- Visual Inspection
- Microscopic Inspection
- Separating the Resin
- Cation Capacity (total, strong and weak)
- Anion Capacity (total, strong and weak)
- Particle Size Distribution
- % Moisture retention

Visual Inspection

- % Perfect Beads
- % Cracked Beads
- % Broken Beads
- Surface Condition
- Gel or Macroporous
- Particle Size Distribution
- Supernatant Liquor



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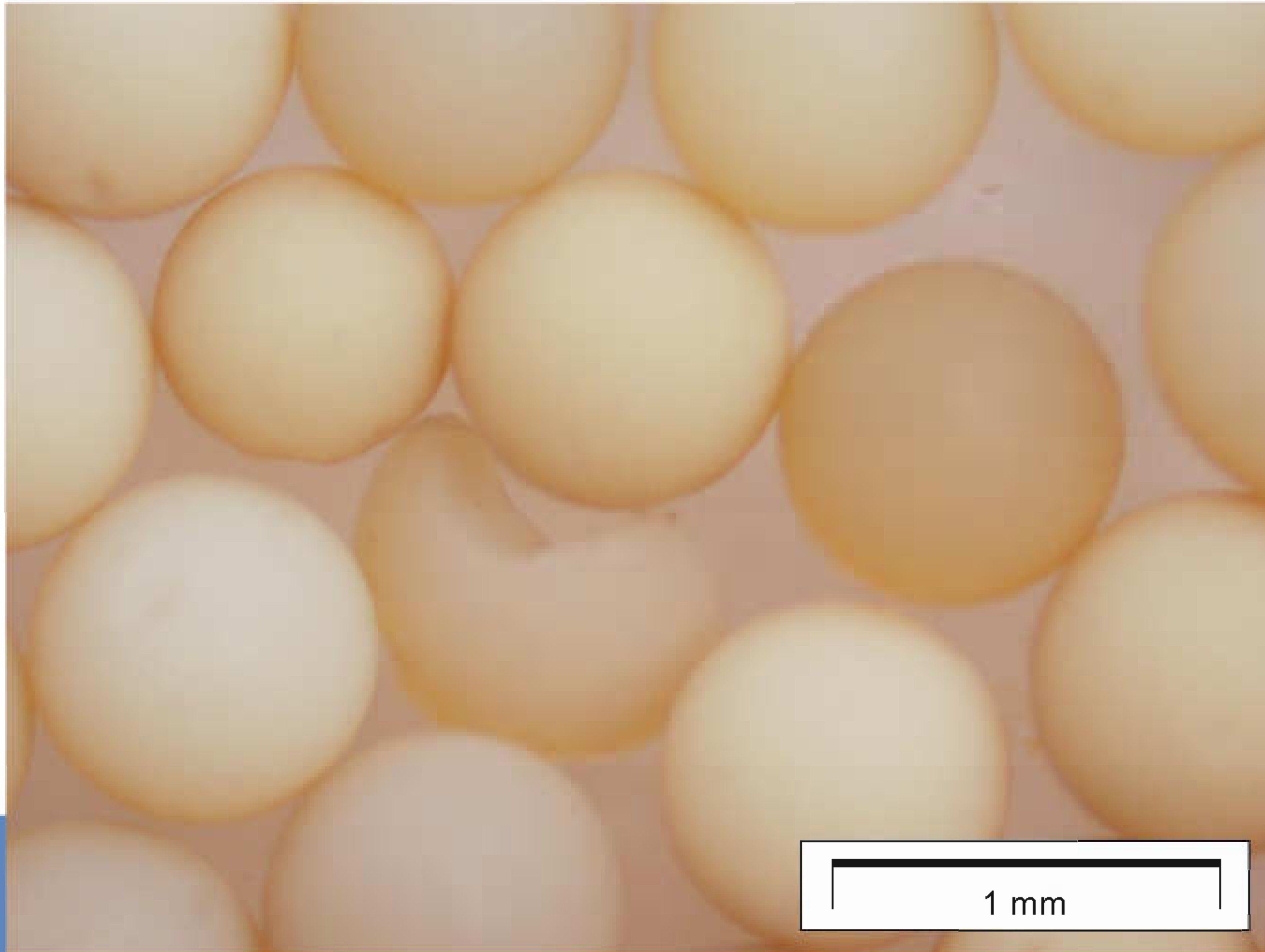
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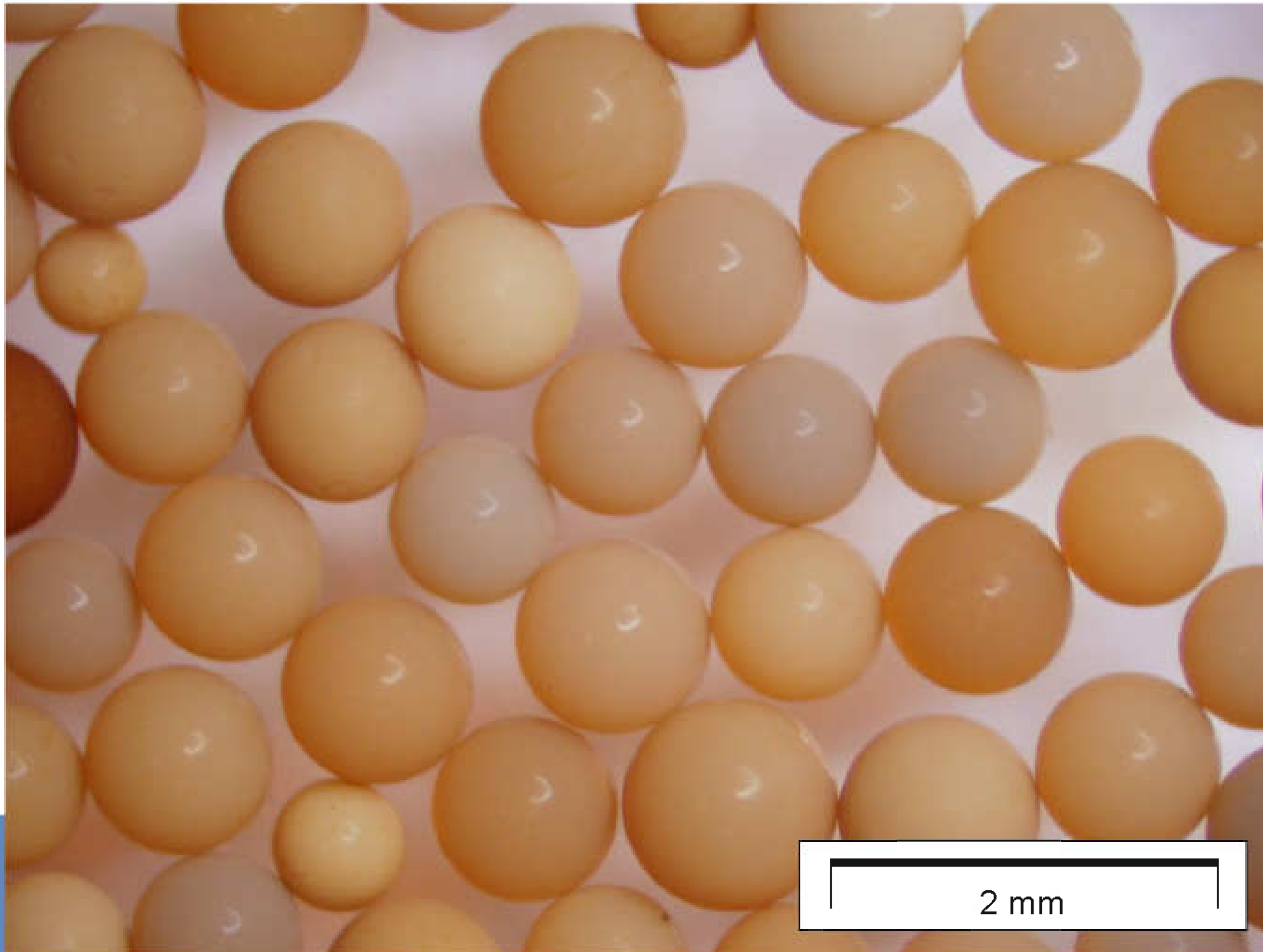
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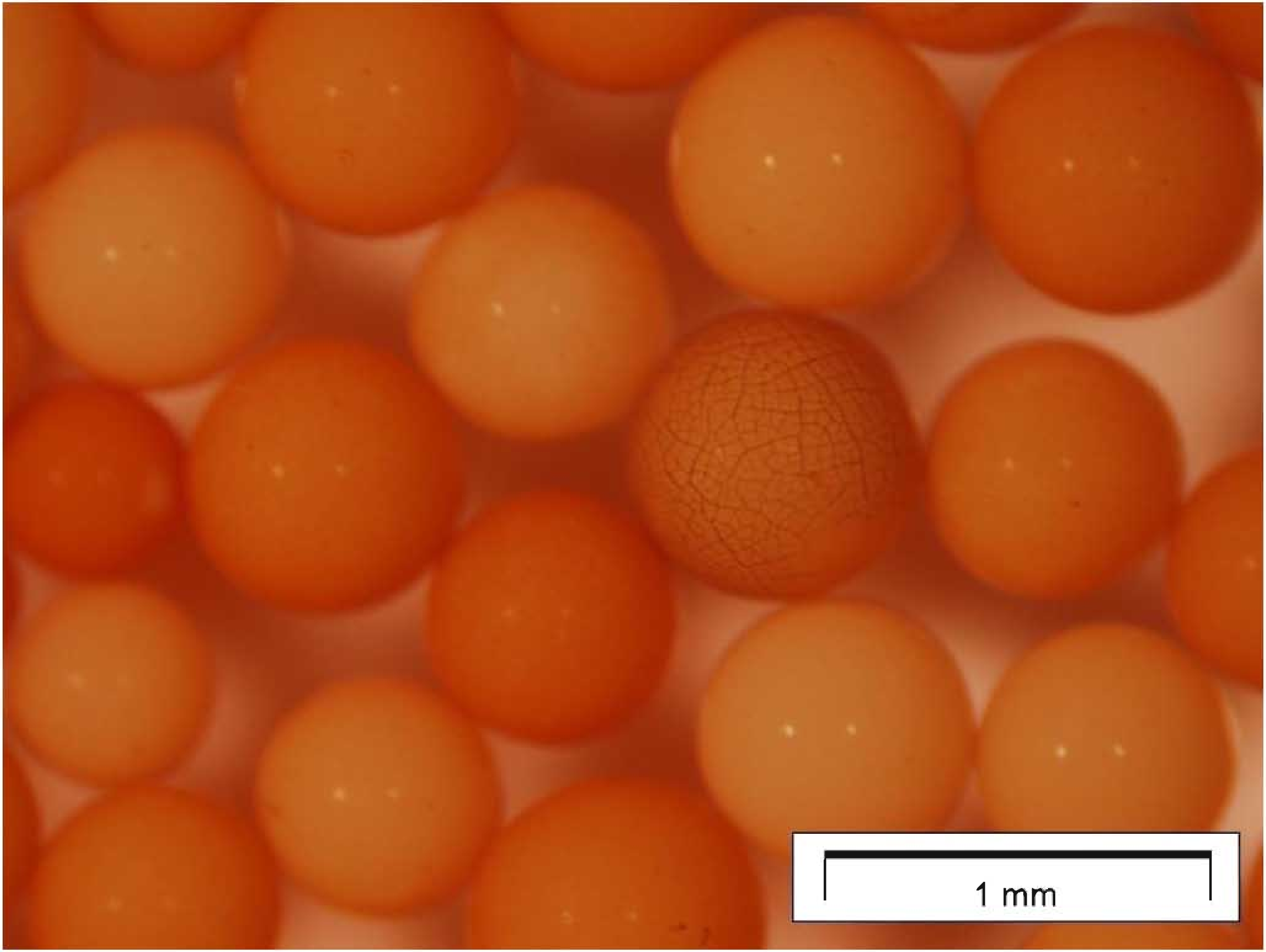
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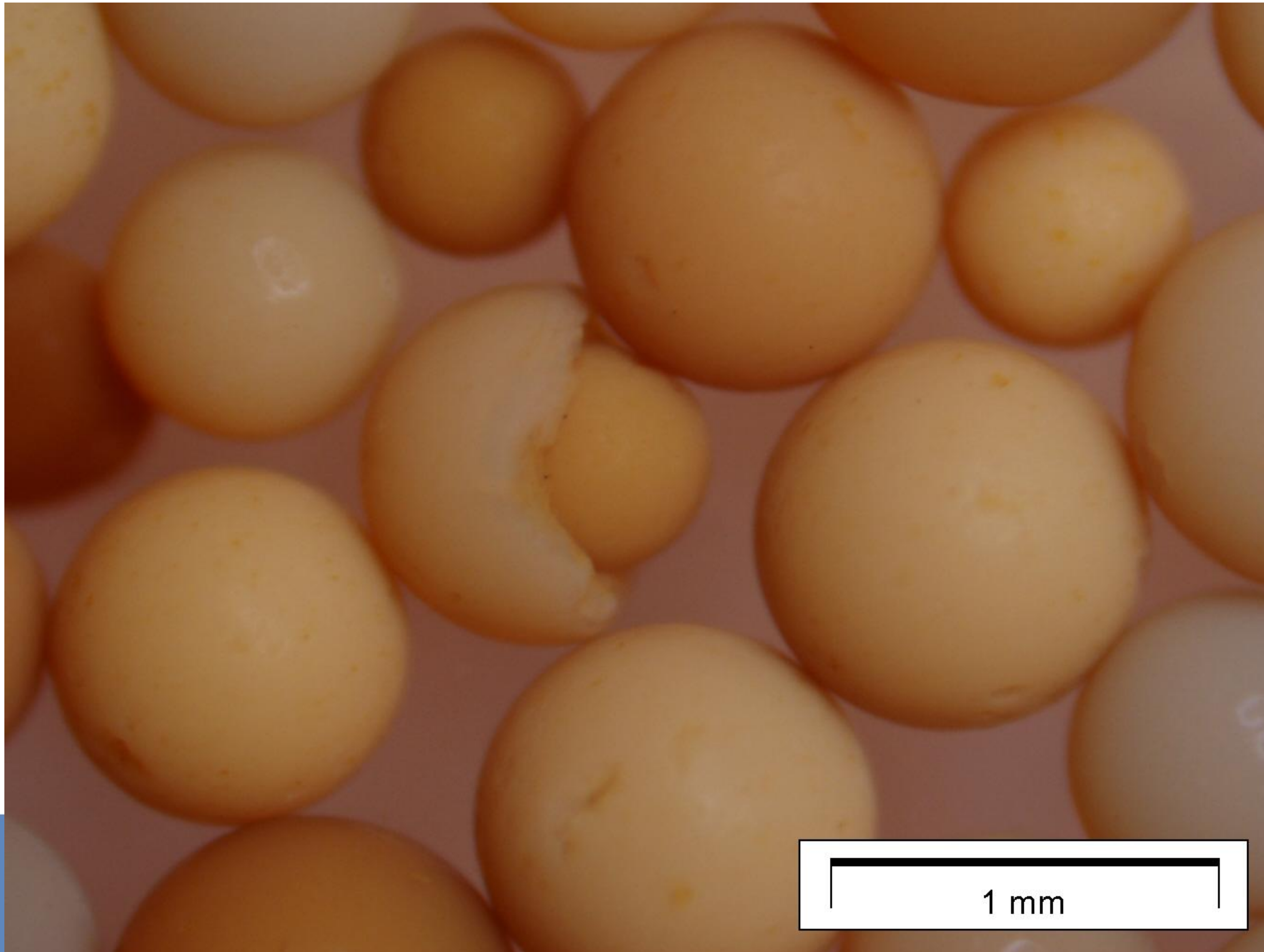
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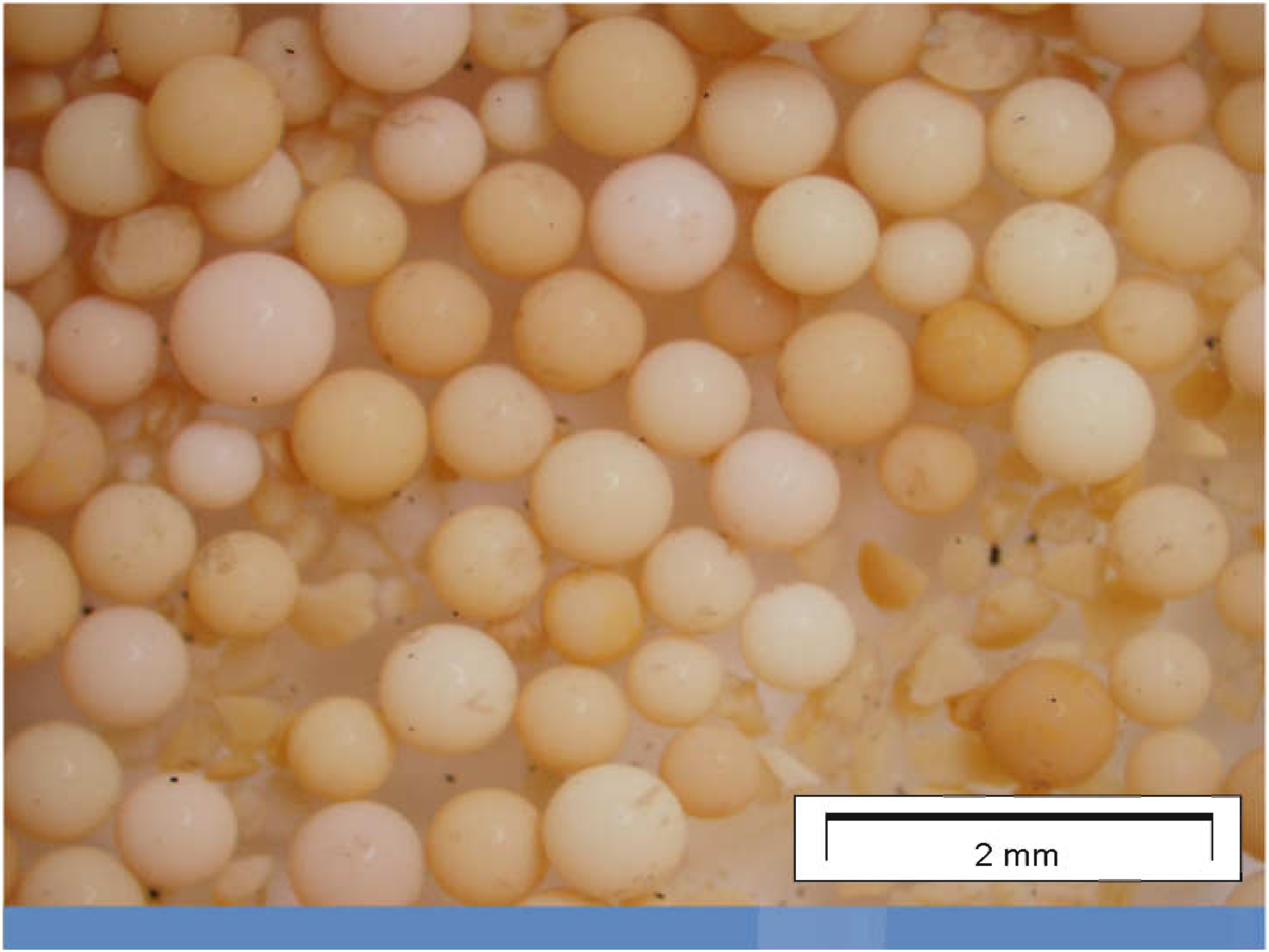
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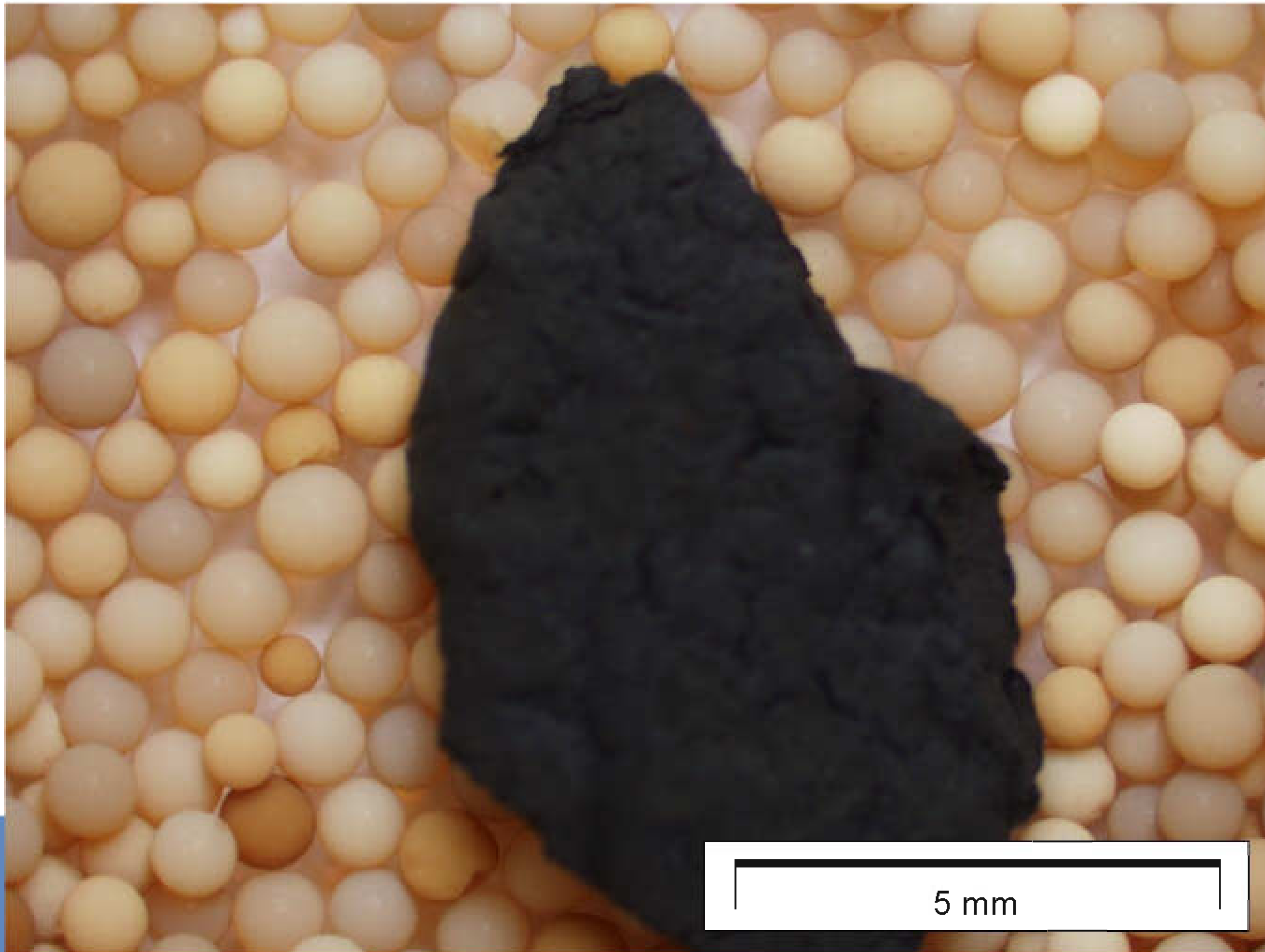
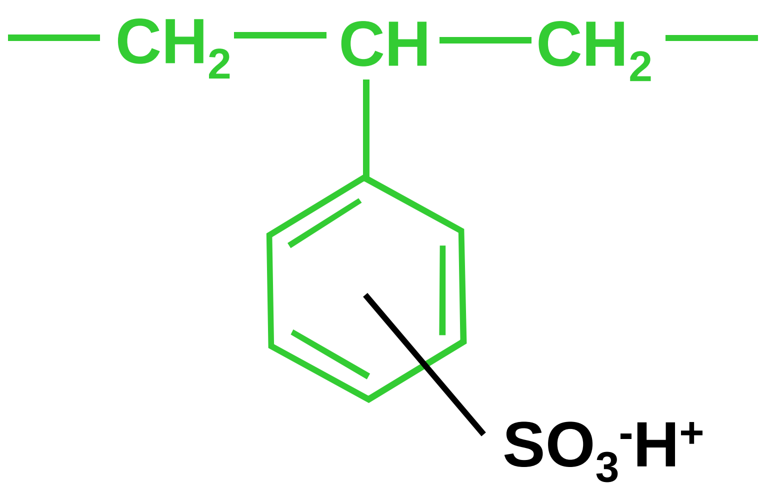

5 mm

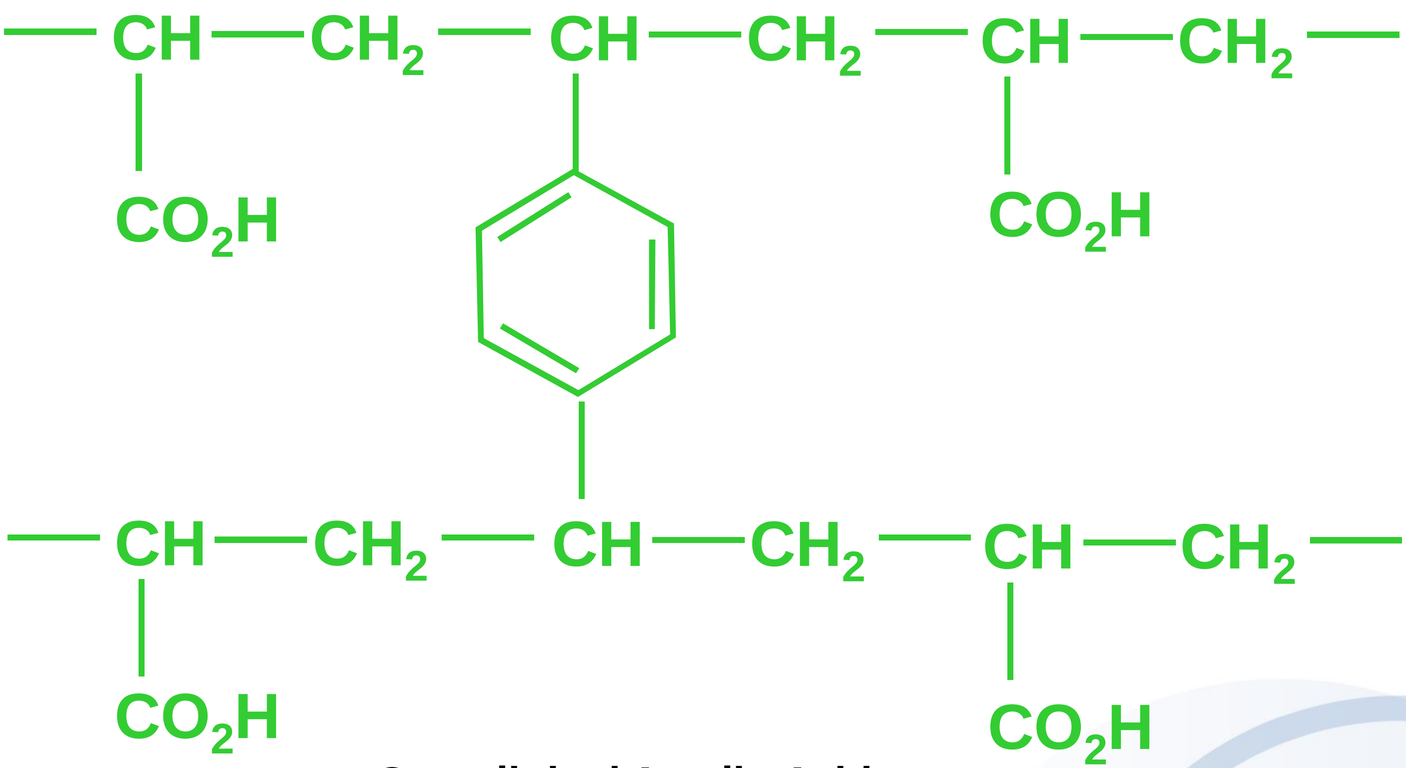
Capacity - Cation Resins

- Capacity
- Total
- Strong
- Weak (by difference)
- % Moisture Retention

Cation Capacity - Strong

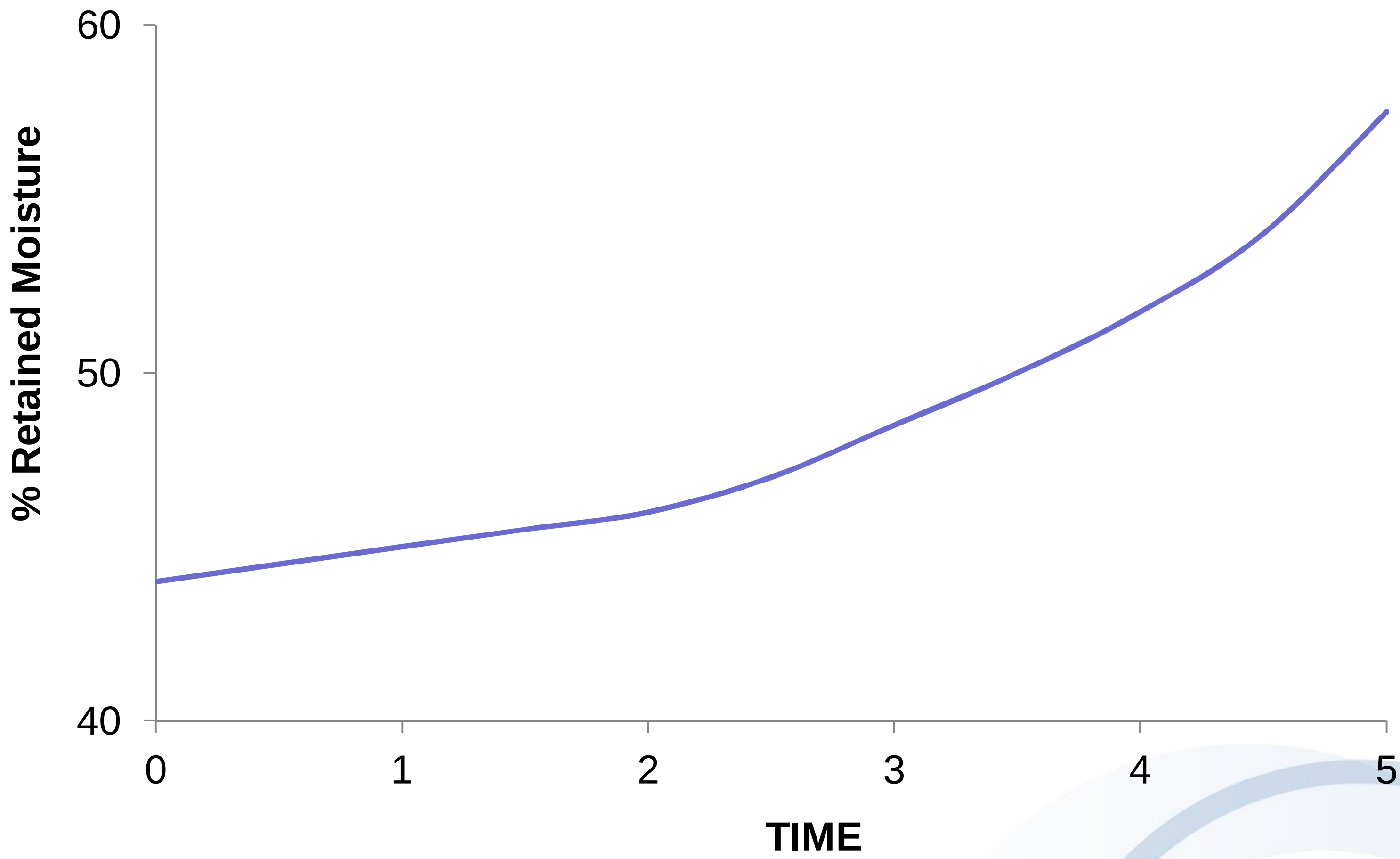


Cation Capacity - Weak



Crosslinked Acrylic Acid

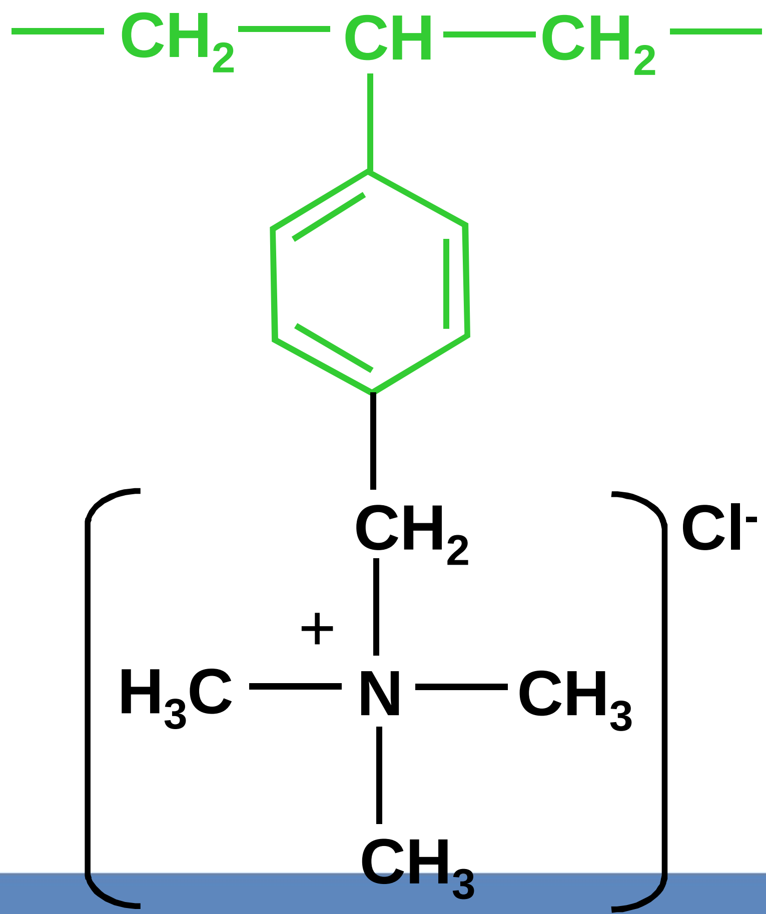
Cation Resin Degradation



Anion Resins

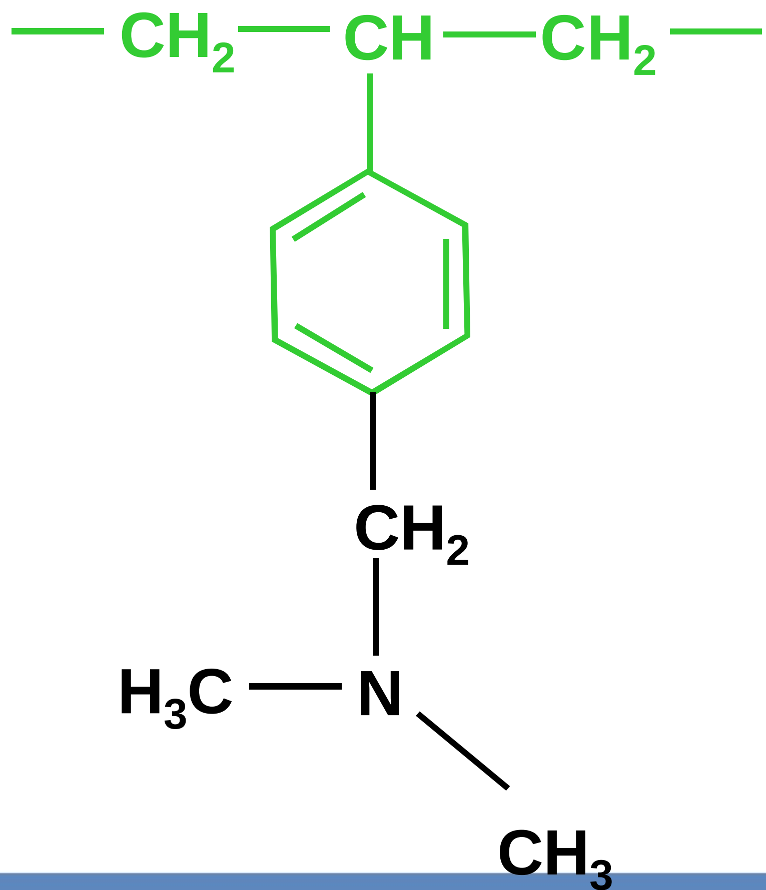
- Capacity
- Total
- Strong
- Weak (by difference)

Anion Capacity - Strong

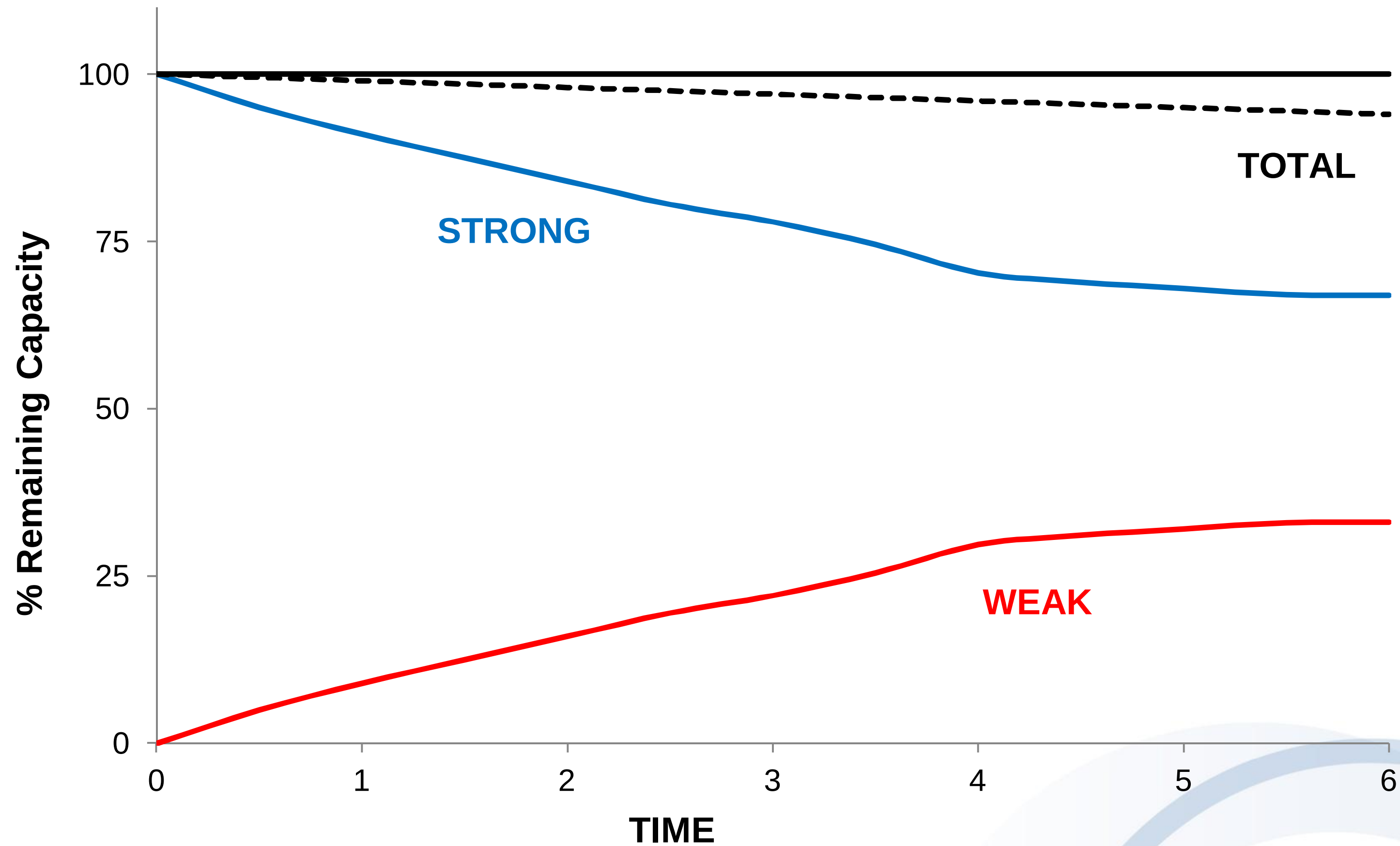


Type I

Anion Capacity - WEAK



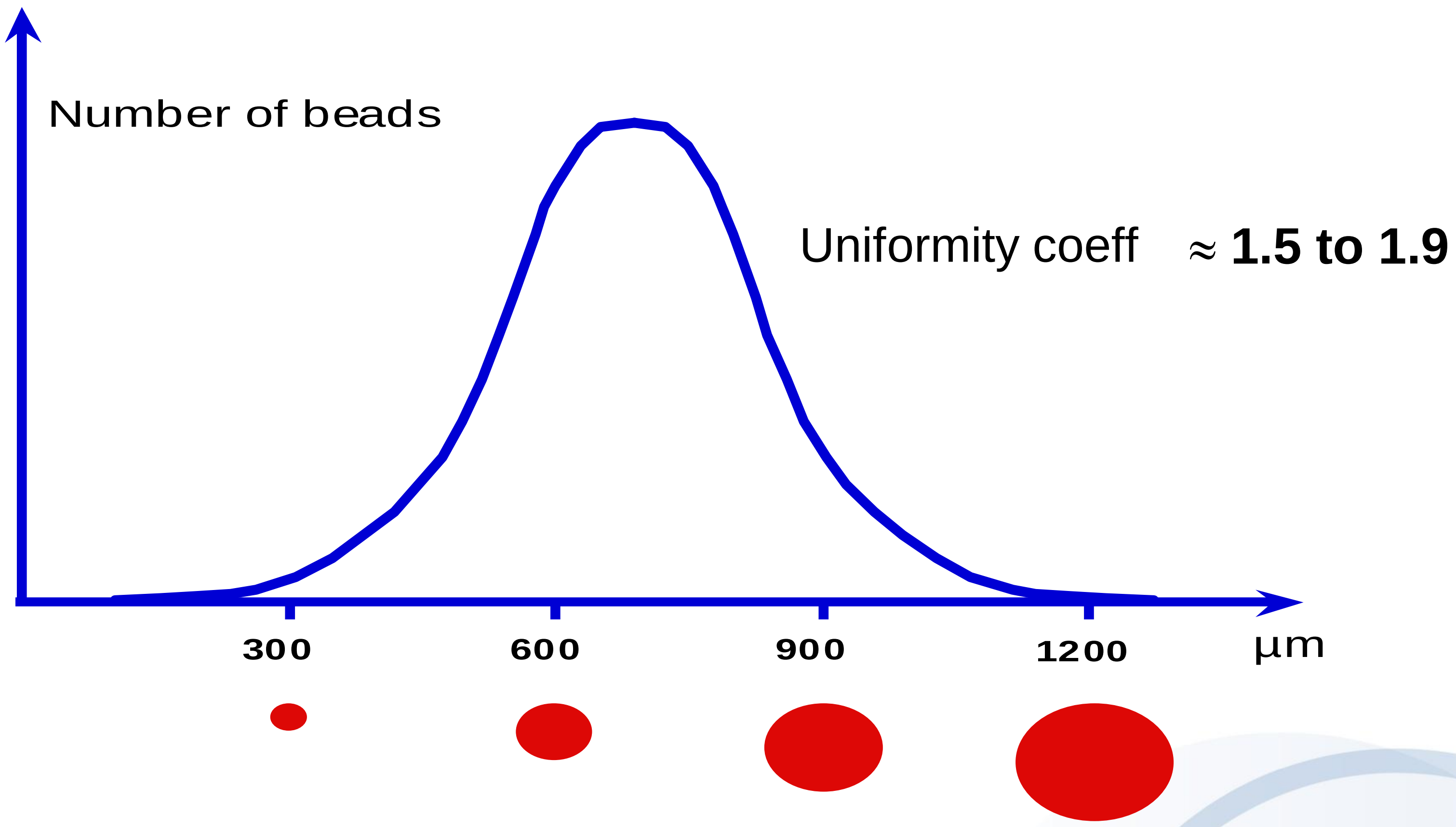
Degradation of Anion Resins



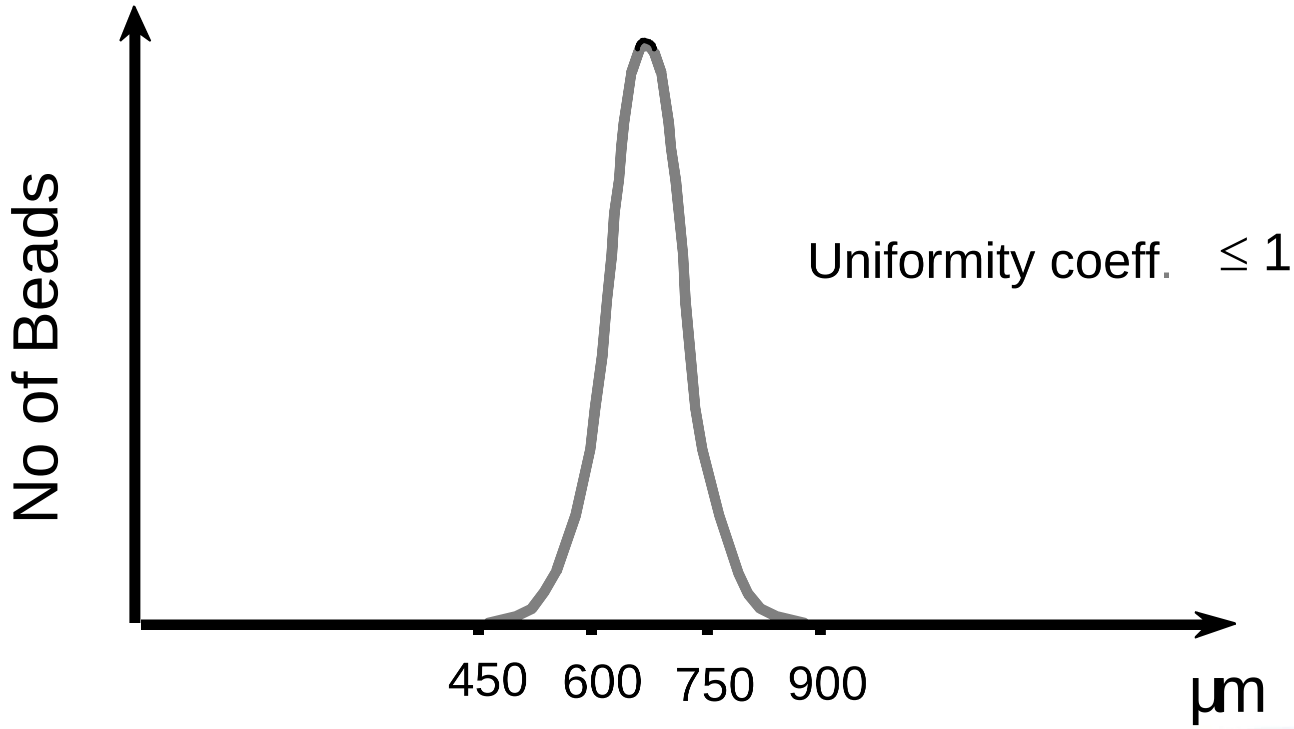
Particle Size

- Standard Mesh (wet or dry)
- Visible Light or Laser
- Optical Cell
- Parallel light
- Gel resins
- Macroporous resins

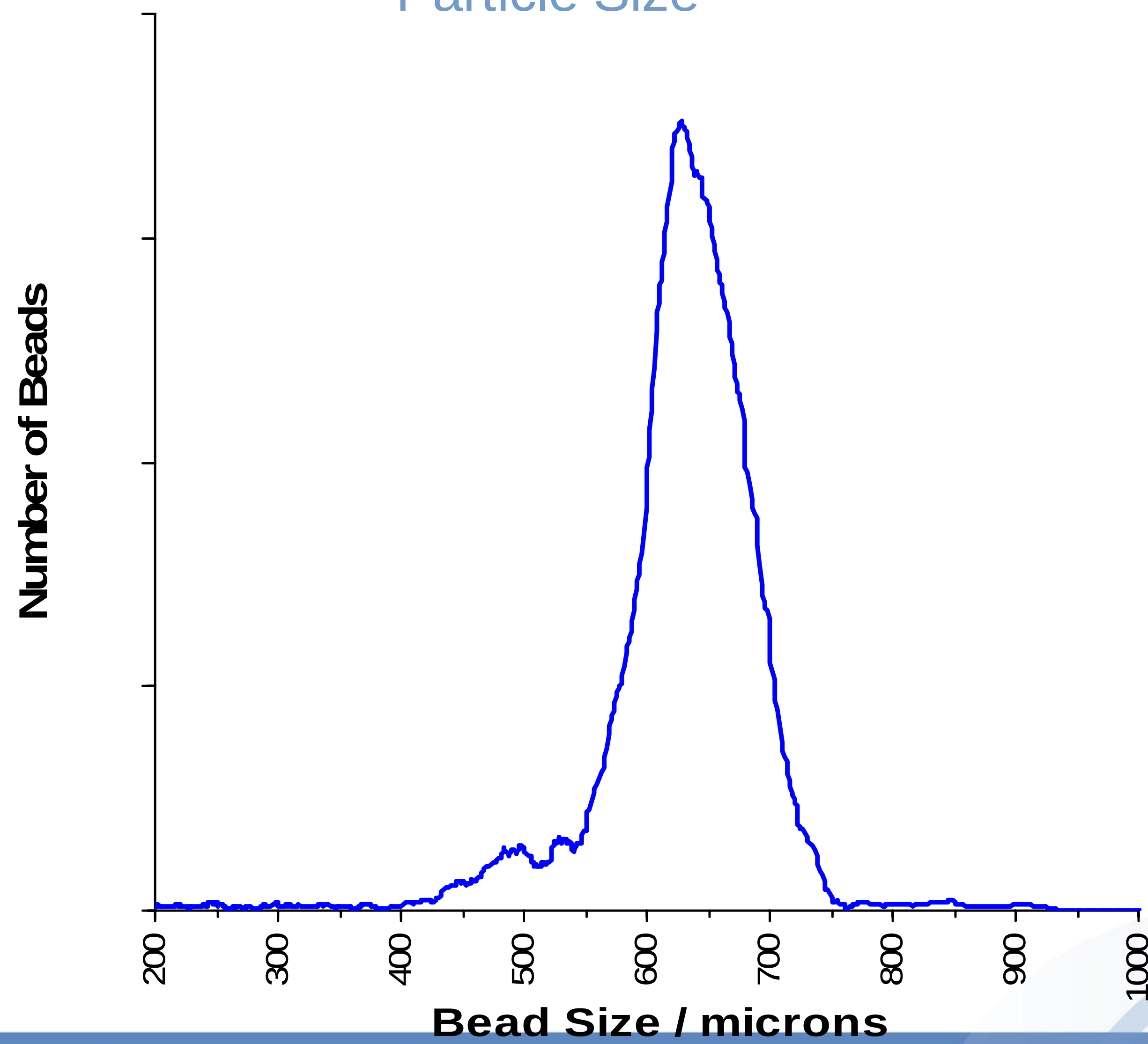
Resin Bead Size Distribution



Uniform Beads



Particle Size



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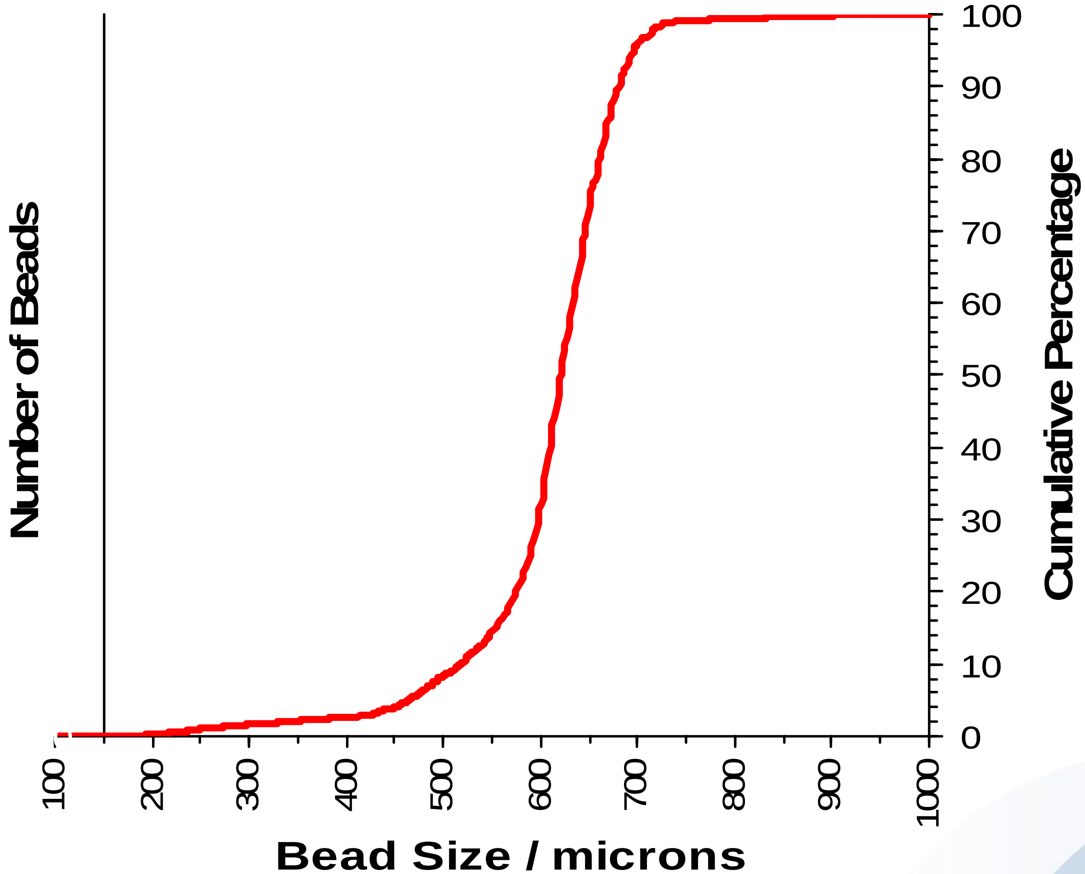
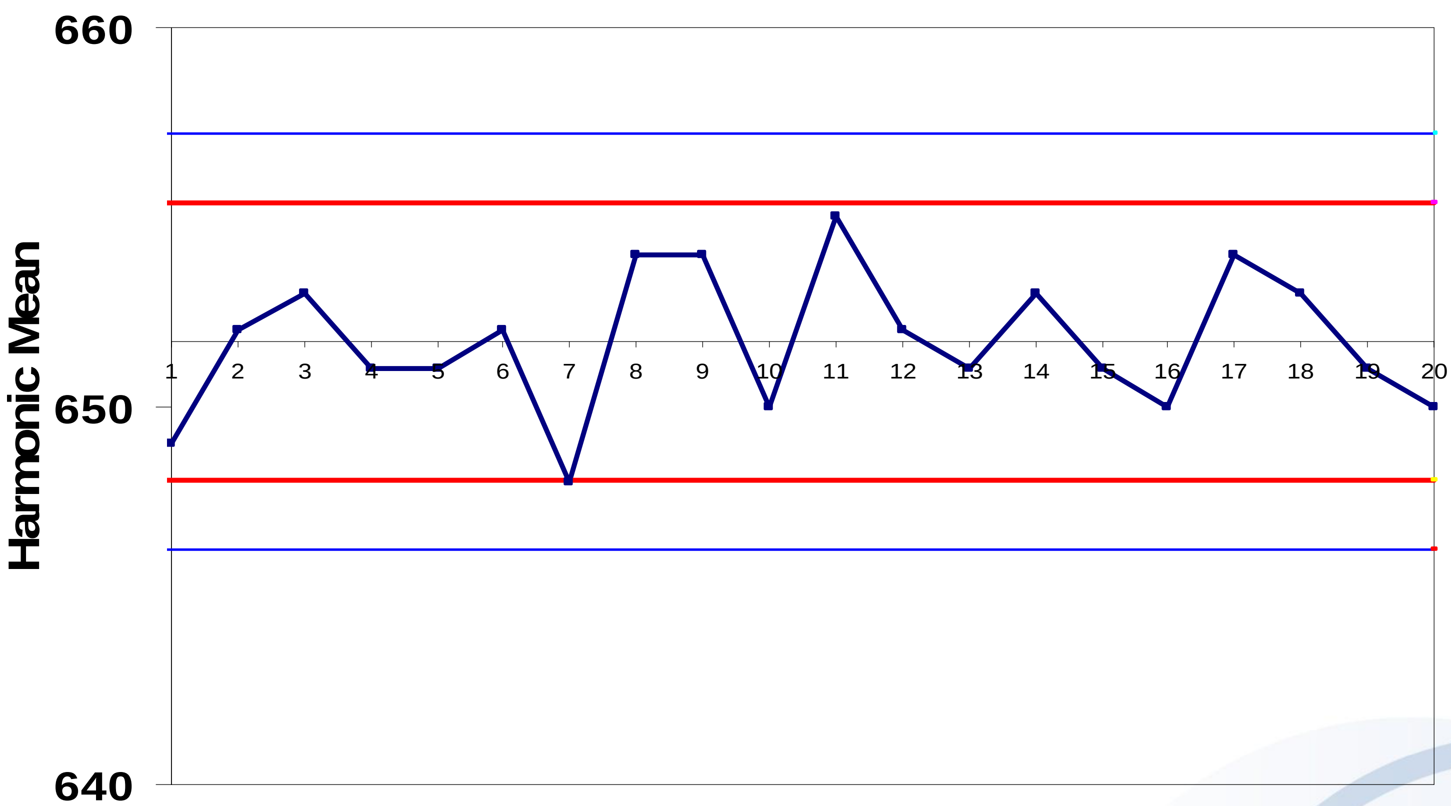
Particle Size



Statistics of Measurement



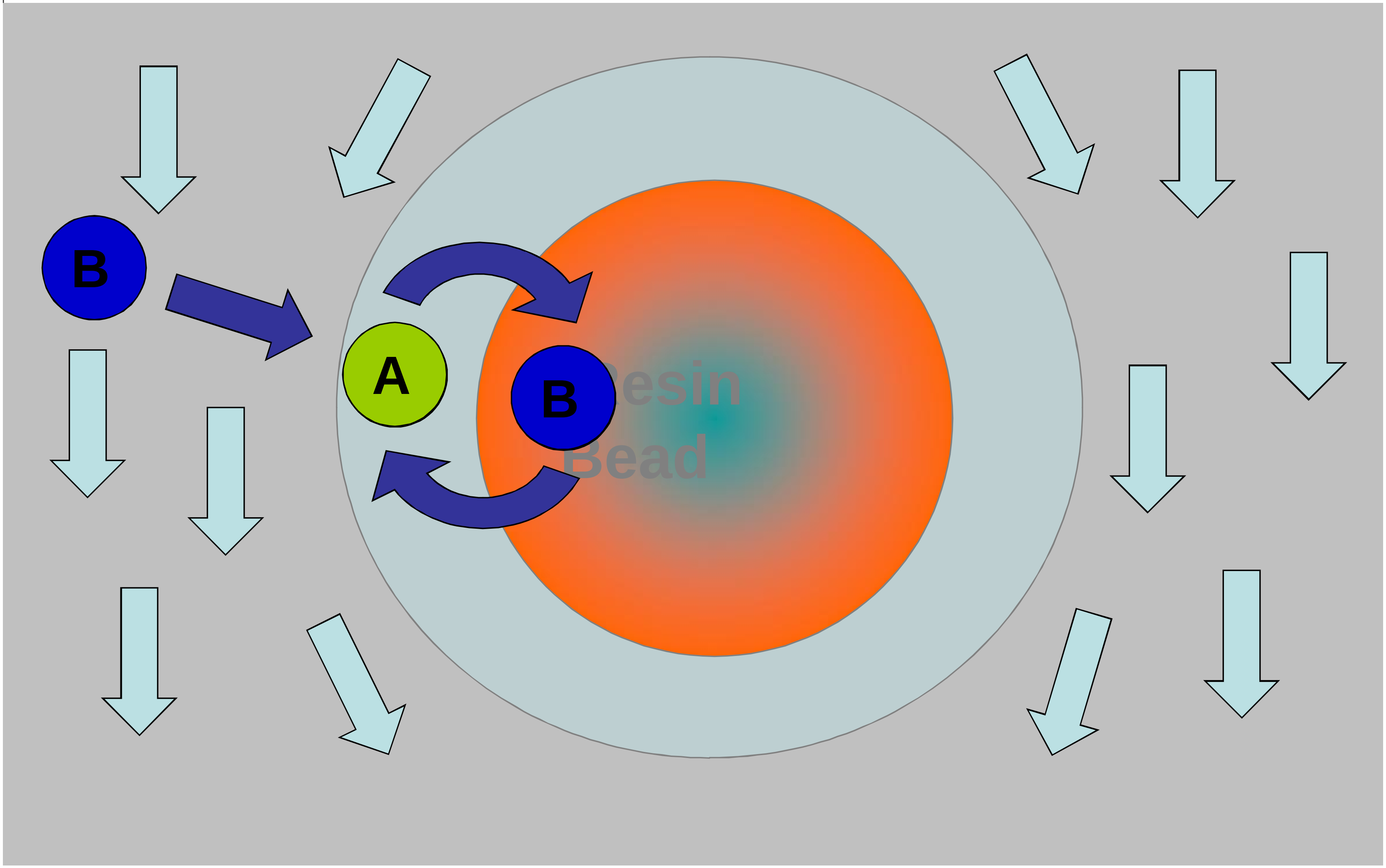
Anion Kinetics

- Condensate Polishing Plants (CPP)
- High Flow

Anion Kinetics

- Chloride
- Sulphate
- Carbon Dioxide

Exchange Kinetics



$$MTC = \frac{V \ln(C/C_0)}{SZA}$$

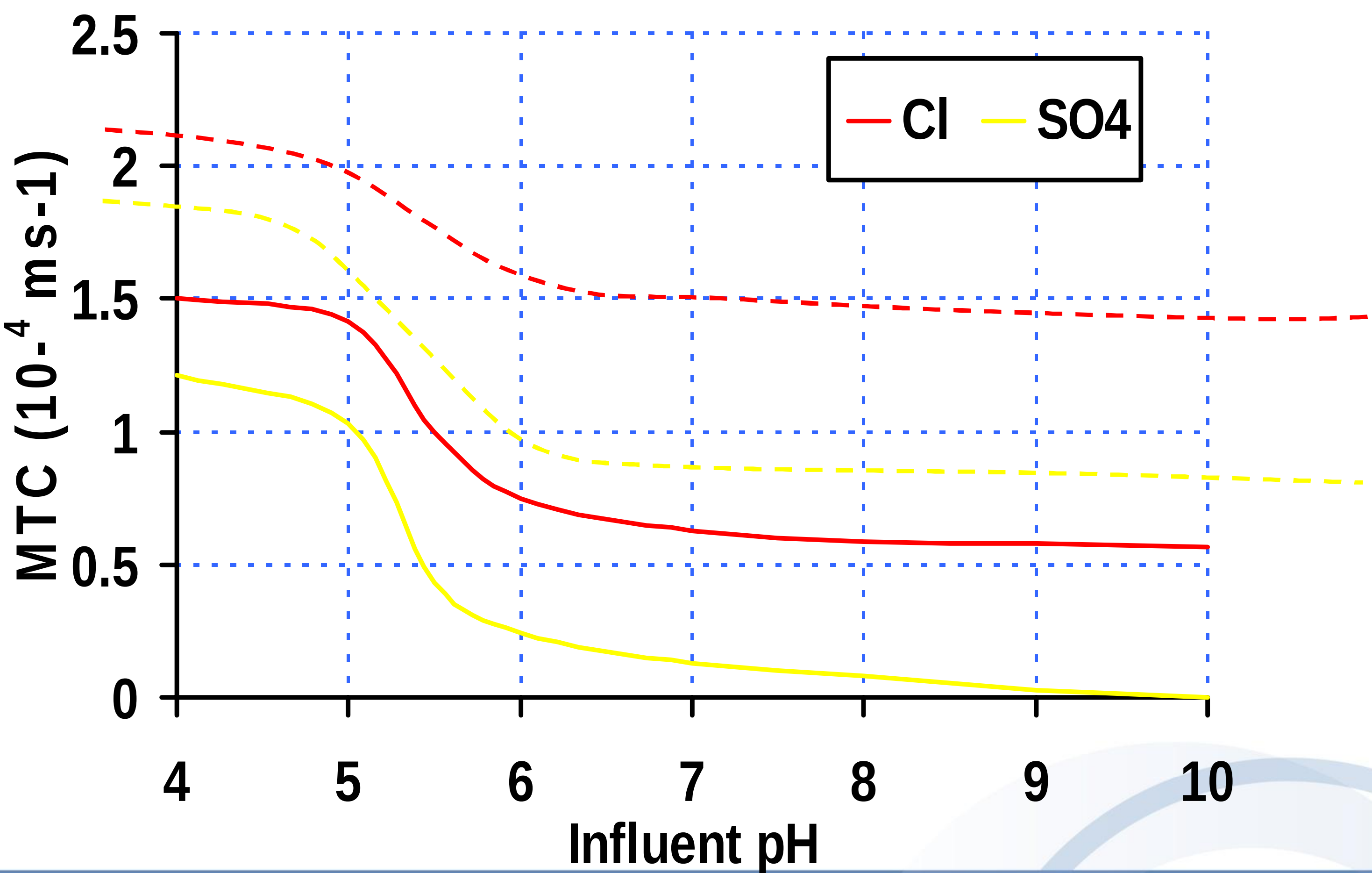
- MTC = Mass Transfer Coefficient (m/s)
- C_0 = inlet anion concentration (mg/l)
- C = outlet anion concentration (mg/l)
- V = volumetric flow rate (m^3/s)
- S = specific surface area of anion resin (m^2/m^3)
- Z = depth of resin bed (m)
- A = cross section of resin bed (m^2)

Specific Surface Area

- $\mathbf{S = \frac{3.9}{d_{HMS}}}$
- d_{HMS} = harmonic mean diameter (m)

MTC = Constant x d_{HMS} ln(C/C_0)

Effect of pH on MTC



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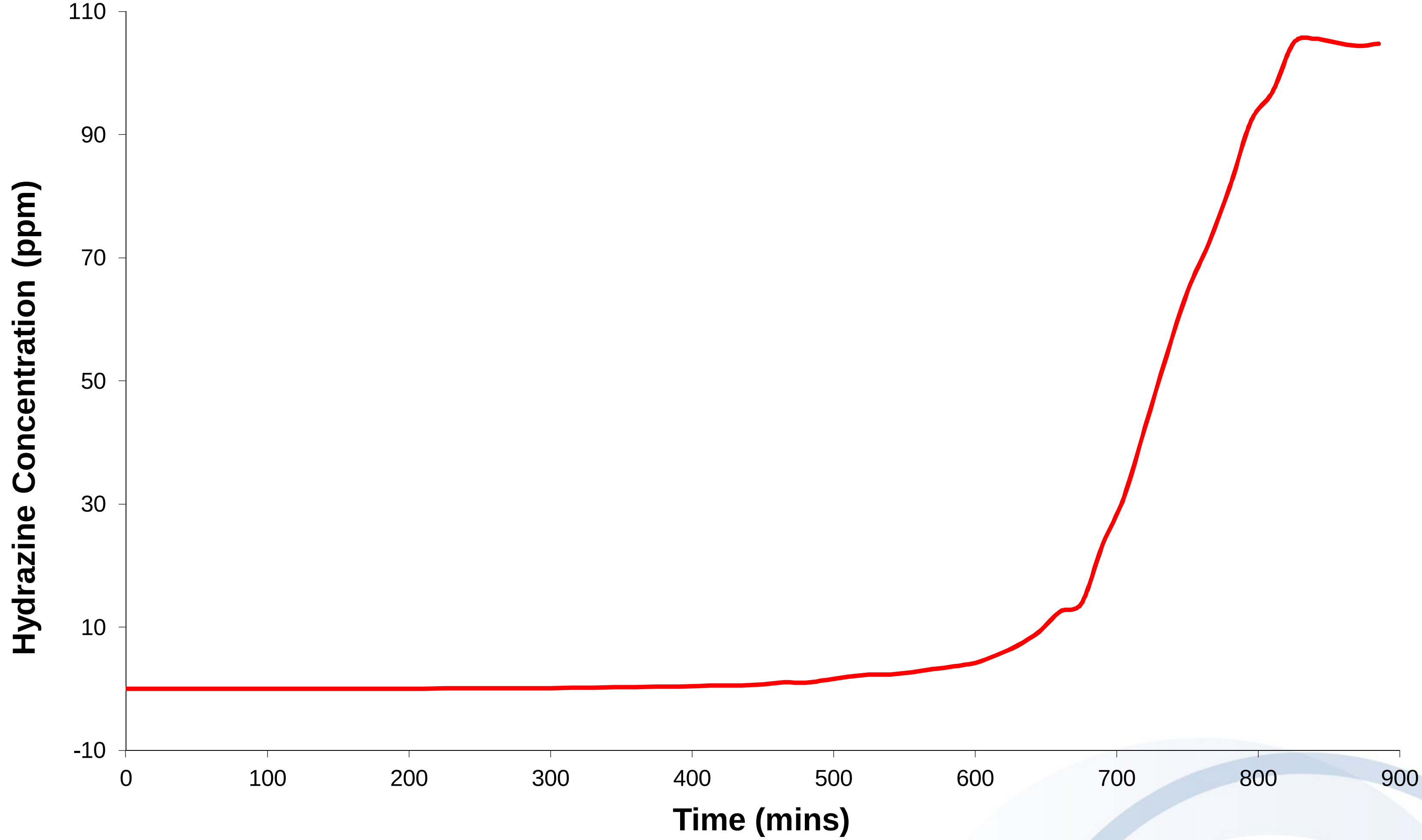
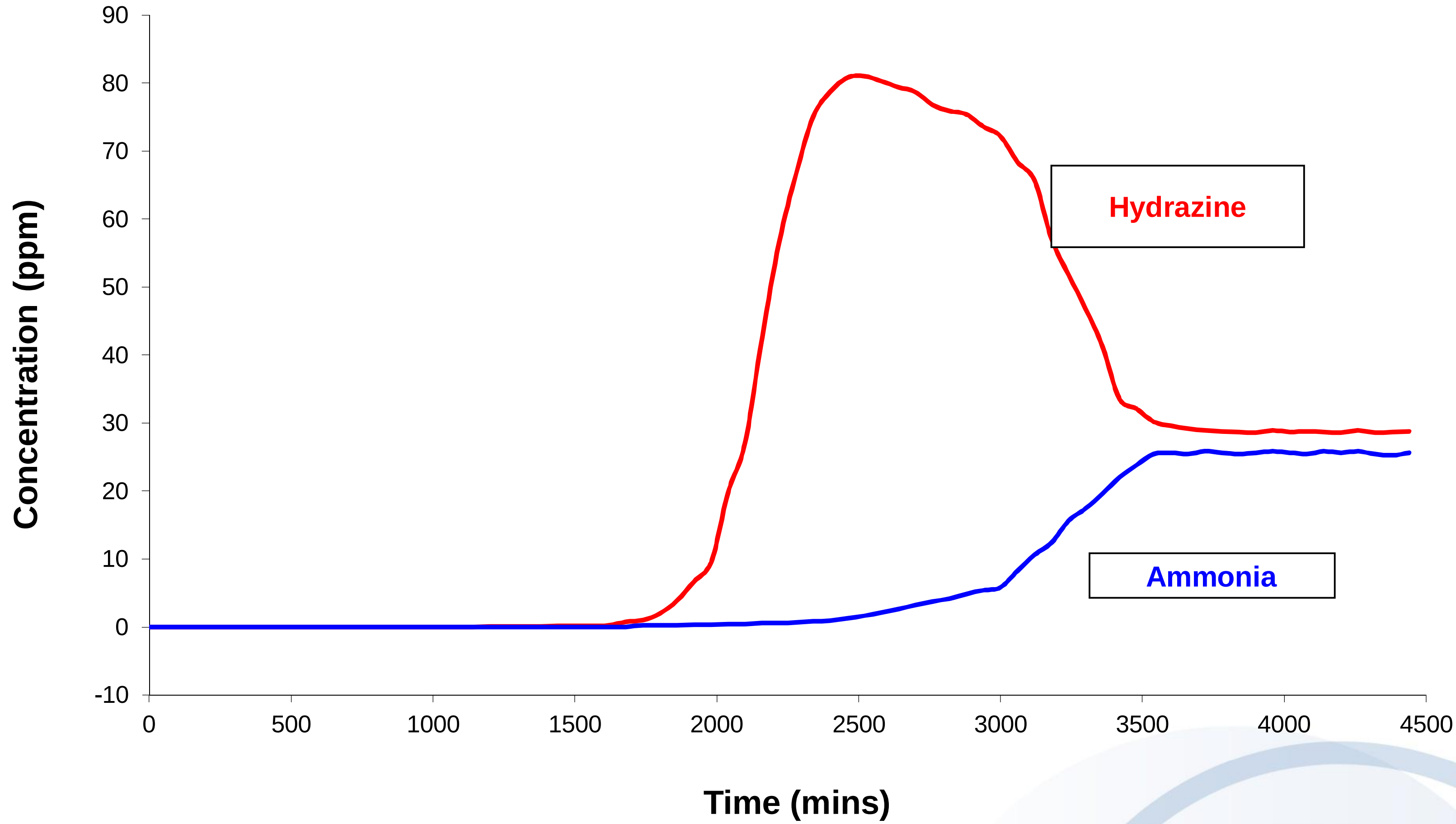
Column Tests

- Various Sizes
- Small Scale Laboratory
- Pilot Plant
- Follower Rigs on Plant

Hydrazine Breakthrough for Resin A



Breakthrough Curve for Resin A



ORGANICS

- Organic Extractables

- Organic Fouling

Organic Fouling Measurement($KMnO_4$ method)

- Principle
  - Oxidise with potassium permanganate
  - Boil in acidic conditions
  - Titrate excess $KMnO_4$

- Procedure
  - 100ml water + 2 ml 5 N H_2SO_4
  - Add 20 ml of 0.0125 N KMnO4
  - Boil for 10 minutes
  - Add 20 ml of 0.0125 N Mohr's salt $\{(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O\}$
  - Titrate the excess of Mohr's salt with 0.0125 N $KMnO_4$
  - Read volume required for titration = *y* ml
  - Organic matter = 4 *y* in mg/L as $KMnO_4$ or *y* in mg/L as O_2

There is no direct relation between KMnO4 and TOC measurement

Sampling

- Most Important left to the end!
- Should be Representative
- Representative of What?
- Whole Bed
- Top of the Bed
- Bottom of the Bed

Conclusions 1

- See Resin Testing as one part of the bigger picture
- Condition Monitoring – proactive
- Trouble shooting – reactive
- Trending

Conclusions 2

- Resin Testing is only one weapon in the armoury
- Best used in conjunction with other Plant Monitoring Tools
- Generally modern resins are strong and robust
- Causes of Plant Performance Problems frequently lie elsewhere

- QUESTIONS

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