**Nutrition & Neutrons**

**The Effect of Citrate on Casein Micelles**

**Benjamin Brooks** – Teacher at Magruder High School

---

**Why Study Calcium in Citrate?**

*I'm a Cheese Guy!*

**How to Make a Better Cheese Mix for Mac & Cheese?**

- Heat 11g sodium citrate in 265g of skim milk (160 mM sodium citrate)

- When hot and citrate dissolved, add 2% G cheese

- But something happened while stirring... transparent flashes in the liquid!

- He used this to model the inquiry process for his students

---

**Casein Micelles**

- Majority of milk protein (82%)
- Colloidal structure that scatters light

**Nanocluster Model of a Casein Micelle**

- Different Models!

**Calcium Phosphate Nanocluster**

- β-casein cross-linker
- α-casein shell 1.6 nm

**Experimental Approach**

- Use simulated milk ultra filtrate (SNUF)
- Dissolve NIST SRM1549a whole milk powder in SNUF
- Skim the milk via ultracentrifuge
- Re-suspend in SNUF
- Alter SNUF with citrate
- Analyze with DLS, SANS, USANS

**Opacity Changed with Increasing Sodium Citrate Conc**

---

**Conclusions**

- Both citrate & contrast matching have same effect on SANS profile → calcium phosphate clusters

- Citrate doesn’t change $R_g$

- Citrate increases $R_h$

- Not likely disassociation of casein in presence of calcium chelators (as discussed in literature)

**Are Protein Concentrations Too High?**

- Future experiments should use more concentrated citrate; purify casein micelles; other techniques sensitive to larger particles

---

**Table:**

<table>
<thead>
<tr>
<th>Citrate Conc (mM)</th>
<th>$R_g$ (USANS)</th>
<th>$R_h$ (DLS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>2.18±14 nm</td>
<td>15±4± 8 nm</td>
</tr>
<tr>
<td>20</td>
<td>2.14±22 nm</td>
<td>20±4±11 nm</td>
</tr>
<tr>
<td>30</td>
<td>2.14±16 nm</td>
<td>2.19±16 nm</td>
</tr>
<tr>
<td>60</td>
<td>2.12±19 nm</td>
<td>2.19±9 nm</td>
</tr>
</tbody>
</table>

---

**Sketchnotes:** Rob Dine (rob_dine)