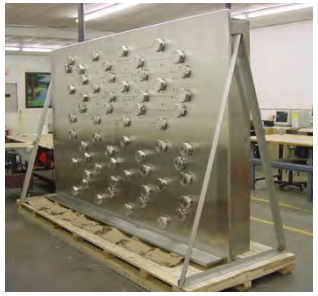
Solubility of Riboflavin for Coverage Testing

by Chris Bautz

CIP Summit

September 18, 2019

Proud to be an employee owned company

Riboflavin Spray Coverage Testing

- Establishes that all vessel process surfaces are contacted
- Riboflavin fluoresces under UV light for visual confirmation
- No visible fluorescence after test required for passing
- Not a cleaning test – evaluates coverage only!
- Sounds simple, but it’s a bit more complicated than that

Riboflavin Testing – False Failures

- A failed coverage test can be caused by factors other than flaws in the design of the spray devices or patterns
  - Trapping riboflavin in manway gasket or other seal and releasing back into vessel after opening
  - Contaminants or soils on the surface may prevent proper rinsing
- Incompletely dissolved riboflavin can give false results also!
- Unpredictability of results can be frustrating

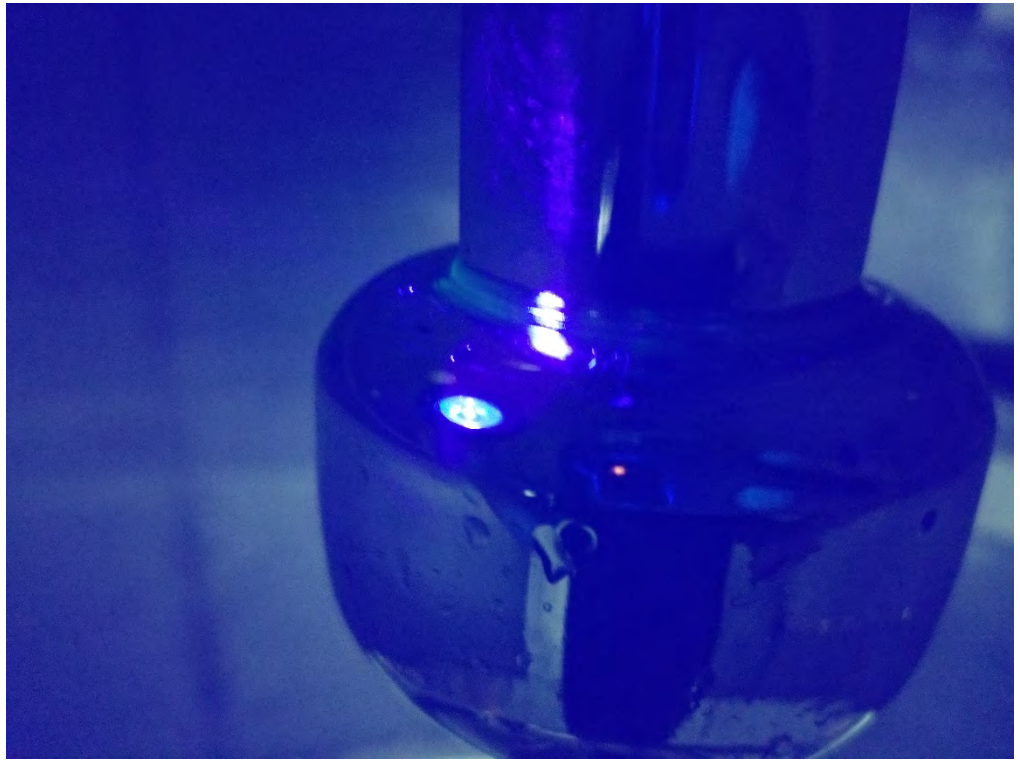
Clouding the Solution

Riboflavin *Mixture* vs Riboflavin *Solution*

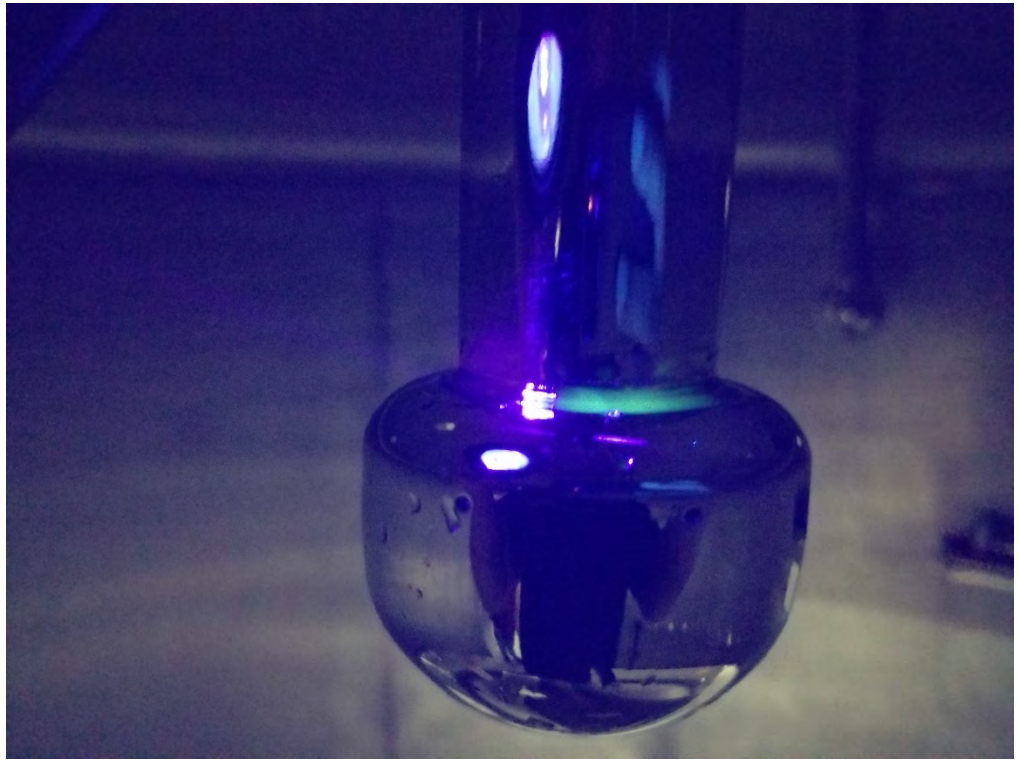
Riboflavin Testing – False Failures

- Undissolved riboflavin powder can stick to interior tank surfaces and prevent proper rinsing
- Droplets “reconcentrate” as remaining riboflavin dissolves
- Riboflavin on the spray devices themselves?!?
  - Not unheard of
  - High likelihood of being a false failure
  - Especially with straight spray devices

False Failure Illustrated on Sprayball



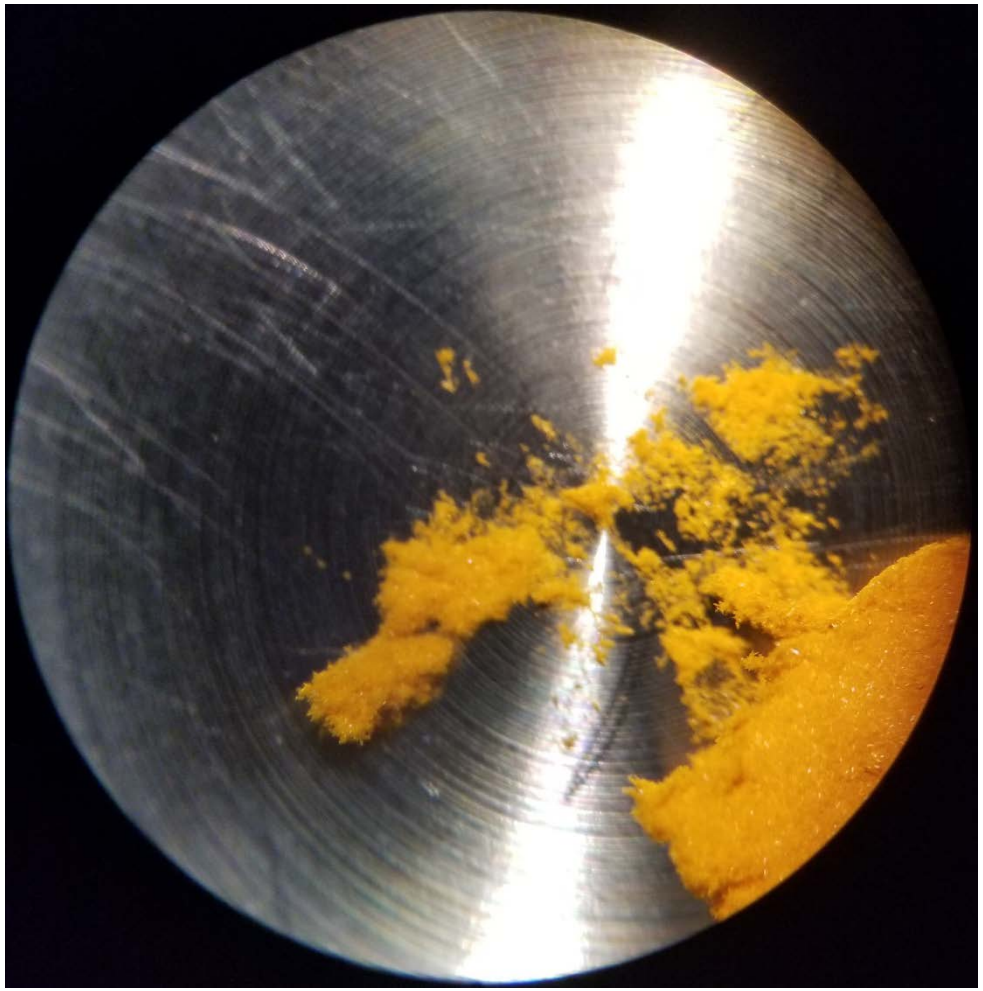
Initial inspection after 3 x 60 sec rinse bursts: Pass!



5 Minutes Later: Wait, it failed!?

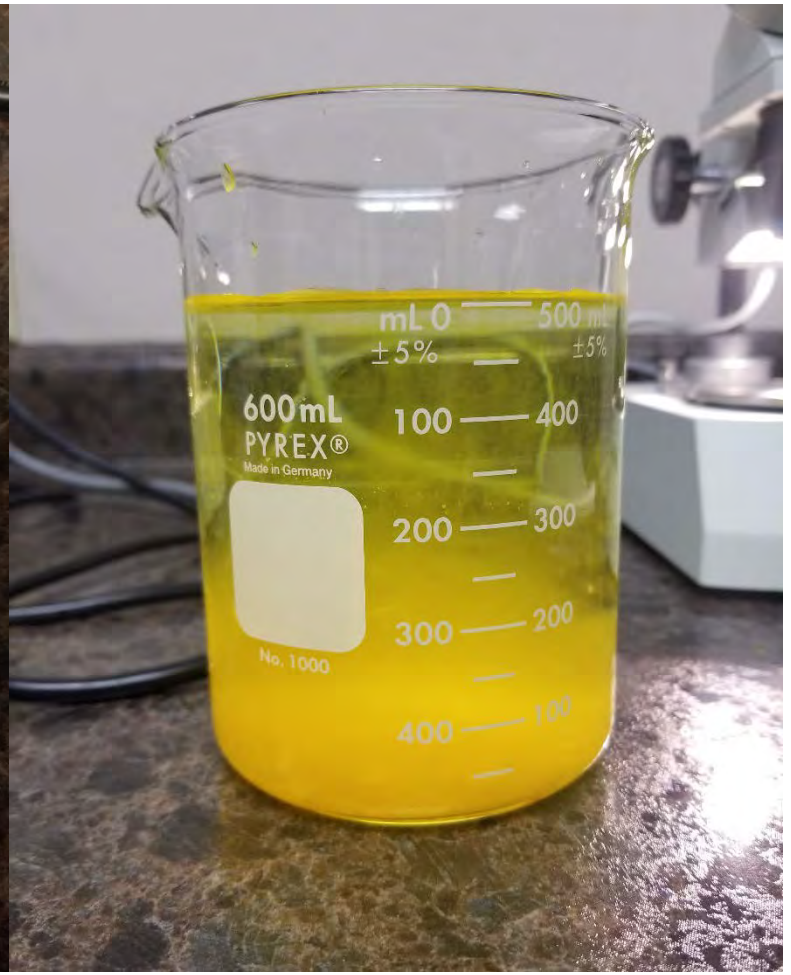
Riboflavin Solution Preparation

- Preparation is Important
  - BPE specifies a riboflavin ***solution***, not *mixture*
  - Riboflavin is harder to dissolve in water than you may think
  - “Slightly soluble in water” according to riboflavin manufacturer literature
- Heating the water helps



Dissolving Riboflavin at Different Temps

- 0.2 g/L riboflavin aqueous solution
- Solubility tested at range of temps
  - ≈ 25° C (77° F)
  - ≈ 40° C (104° F)
  - ≈ 50° C (122° F)
  - ≈ 60° C (140° F)
  - ≈ 70° C (158° F)



Dissolving Riboflavin at Different Temps

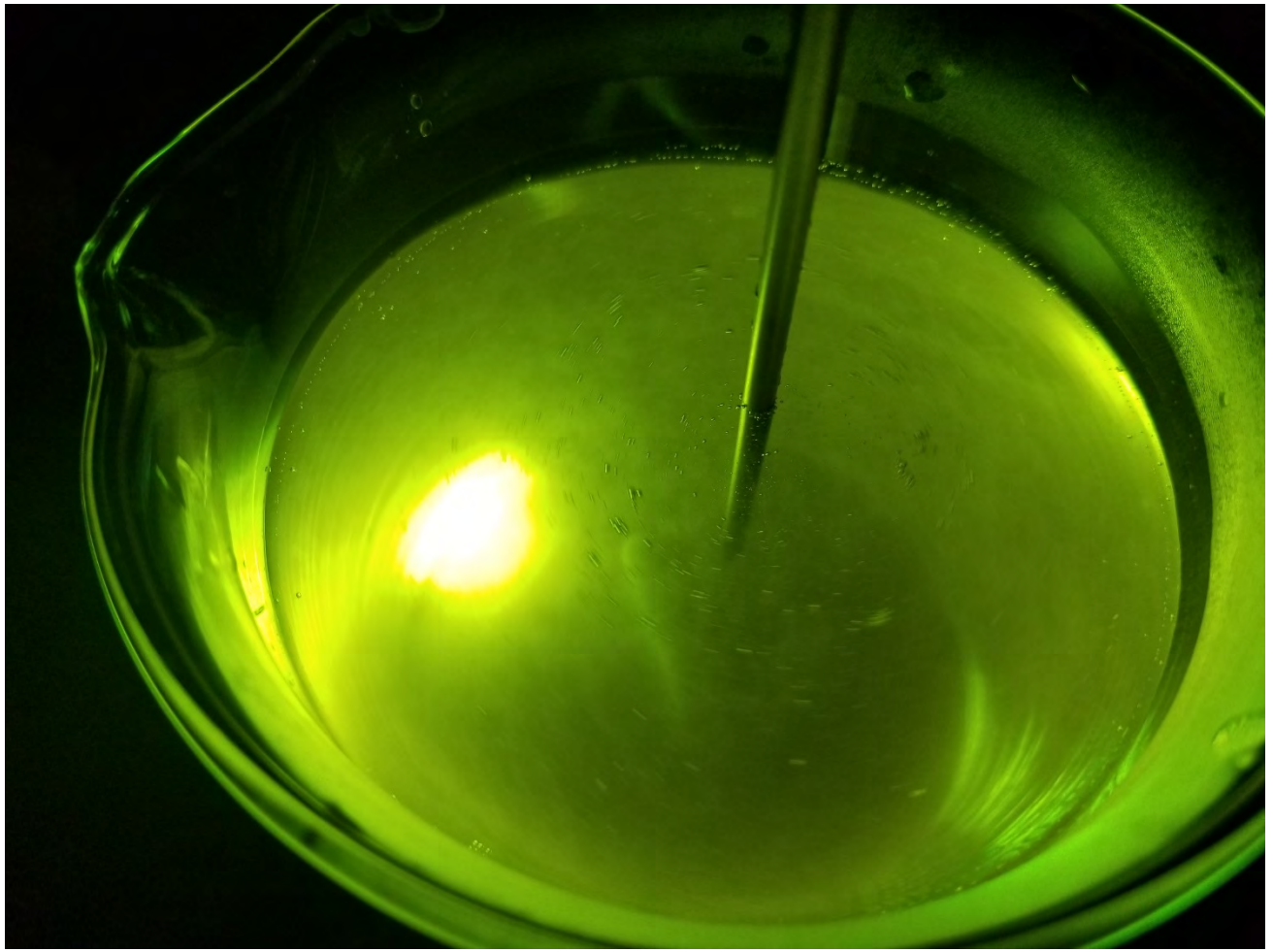
- Riboflavin in RO water at 25° C
- Mixed for 5 minutes on high setting of magnetic lab mixer
- Obvious cloudiness due to incompletely dissolved granules

Dissolving Riboflavin at Different Temps

- Riboflavin in RO water at 40° C
- Mixed for 5 minutes on high setting of magnetic lab mixer
- Less cloudy, but ribo obviously still not completely dissolved

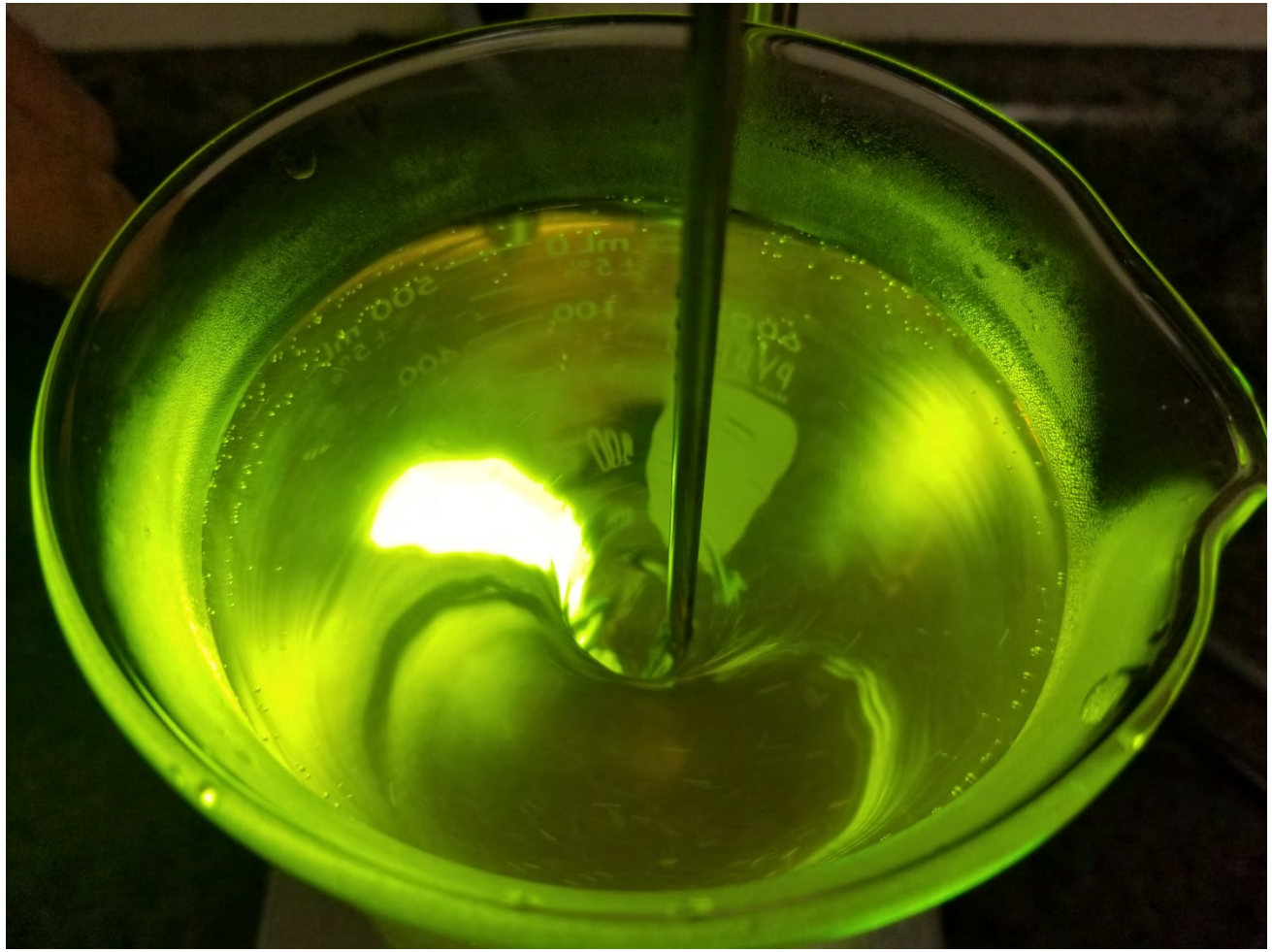
Dissolving Riboflavin at Different Temps

- Riboflavin in RO water at 50° C
- Mixed for 5 minutes on high setting of magnetic lab mixer
- Less cloudy still
- Stir bar becoming visible, but undissolved powder still present



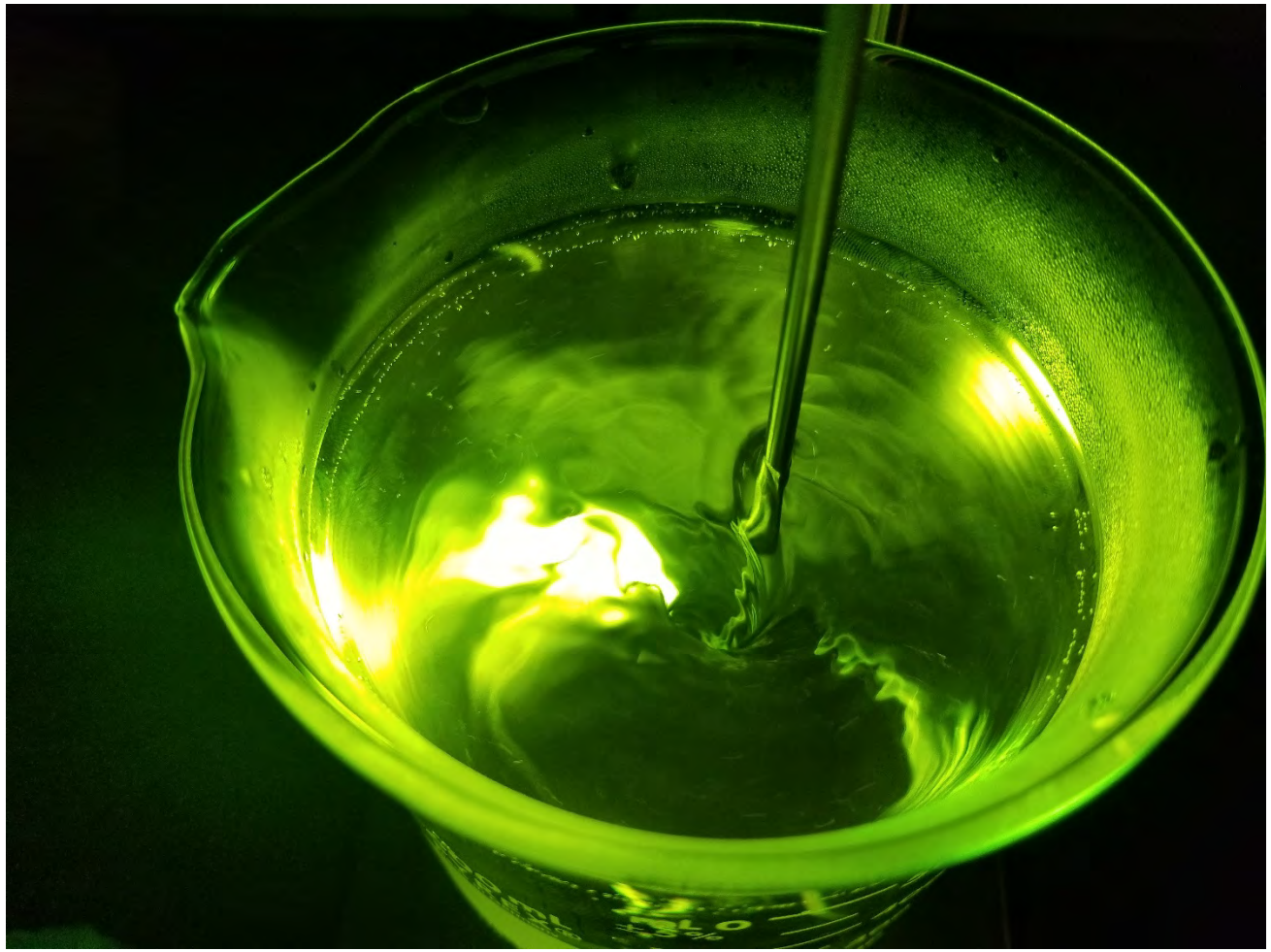
Dissolving Riboflavin at Different Temps

- Riboflavin in RO water at 60° C
- Mixed for 5 minutes on high setting of magnetic lab mixer
- Small amount of riboflavin powder still visible when mixing stopped



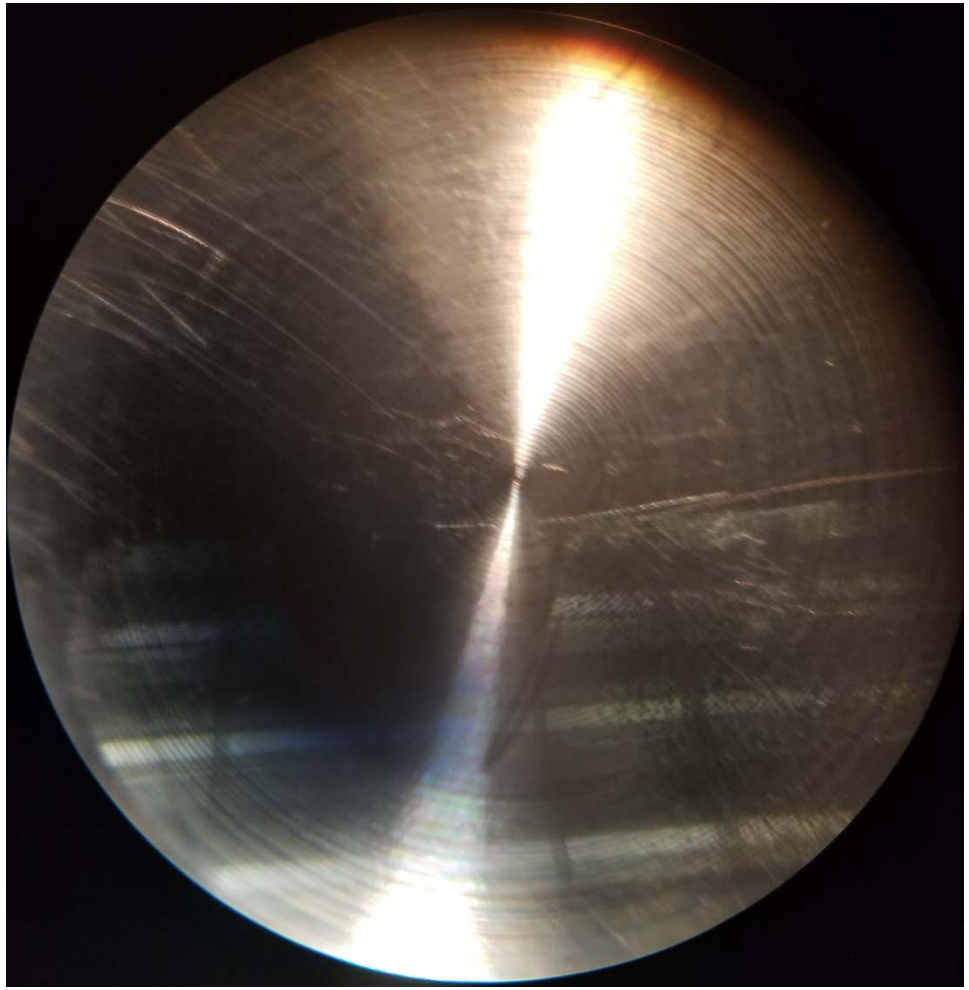
Dissolving Riboflavin at Different Temps

- Riboflavin in RO water at 70° C
- Mixed for 5 minutes on high setting of magnetic lab mixer
- Riboflavin particles finally appear to be completely dissolved



Dissolving Riboflavin at Different Temps

- RO water on 16AMP solid end cap
- <20 Ra mechanical
- 10x magnification



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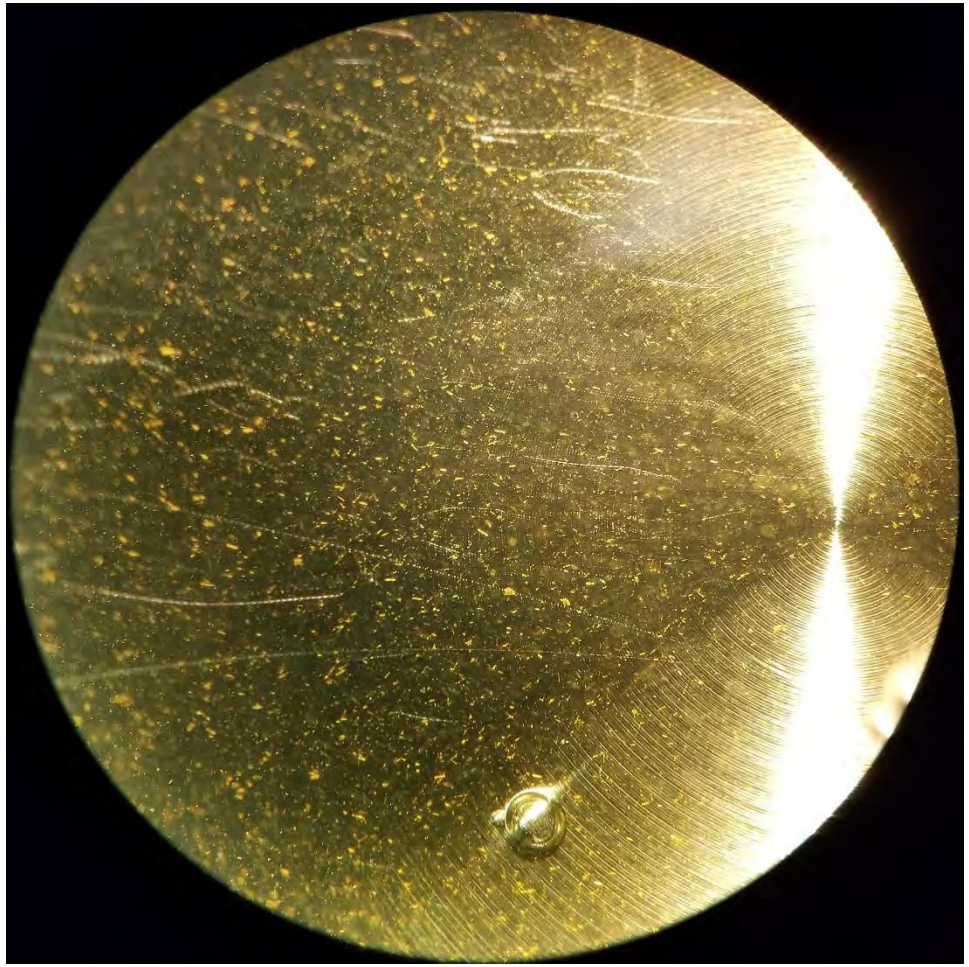

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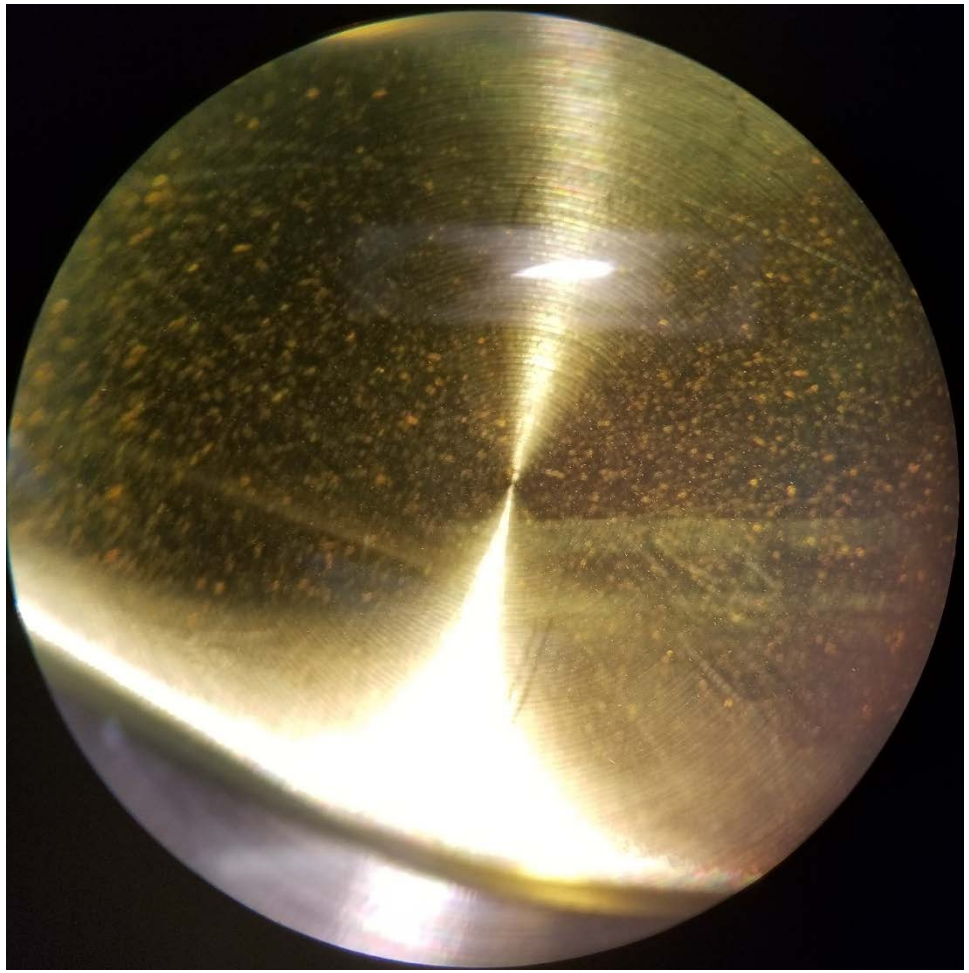

Dissolving Riboflavin at Different Temps

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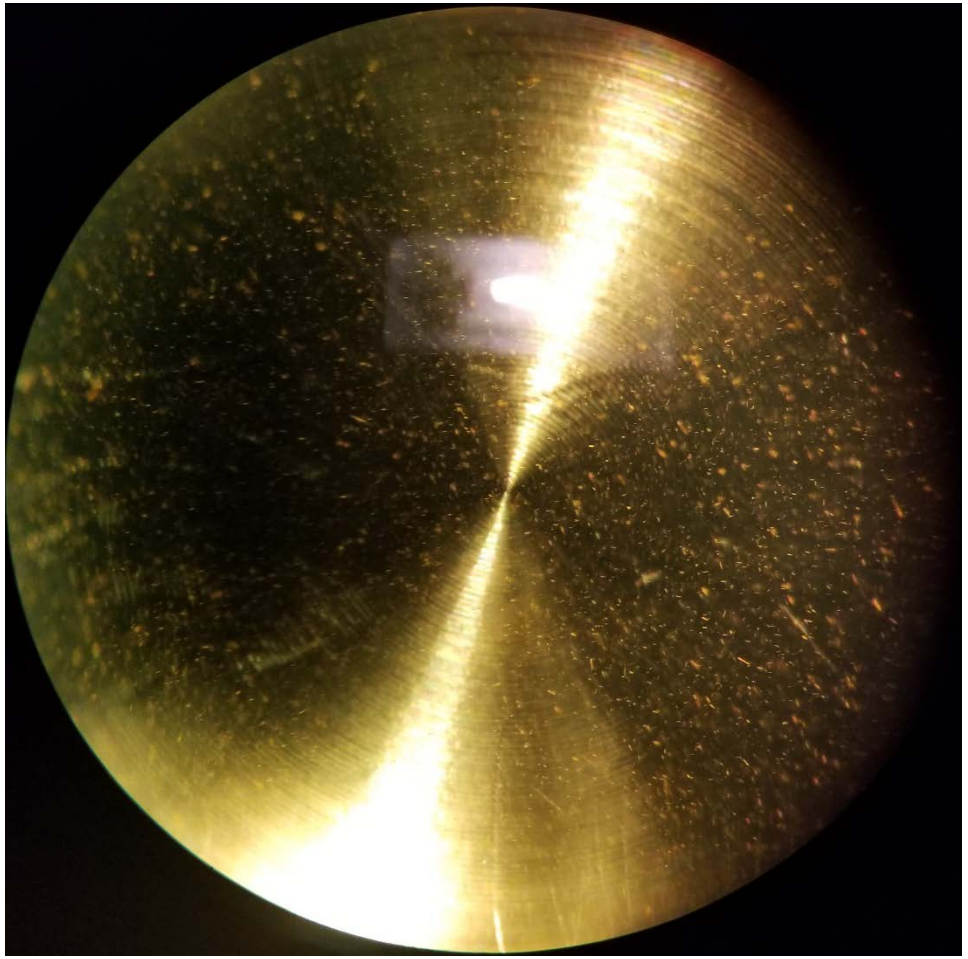
- Mixed for 5 minutes on high setting of magnetic lab mixer
- Less cloudy still
- Stir bar becoming visible, but undissolved powder still present



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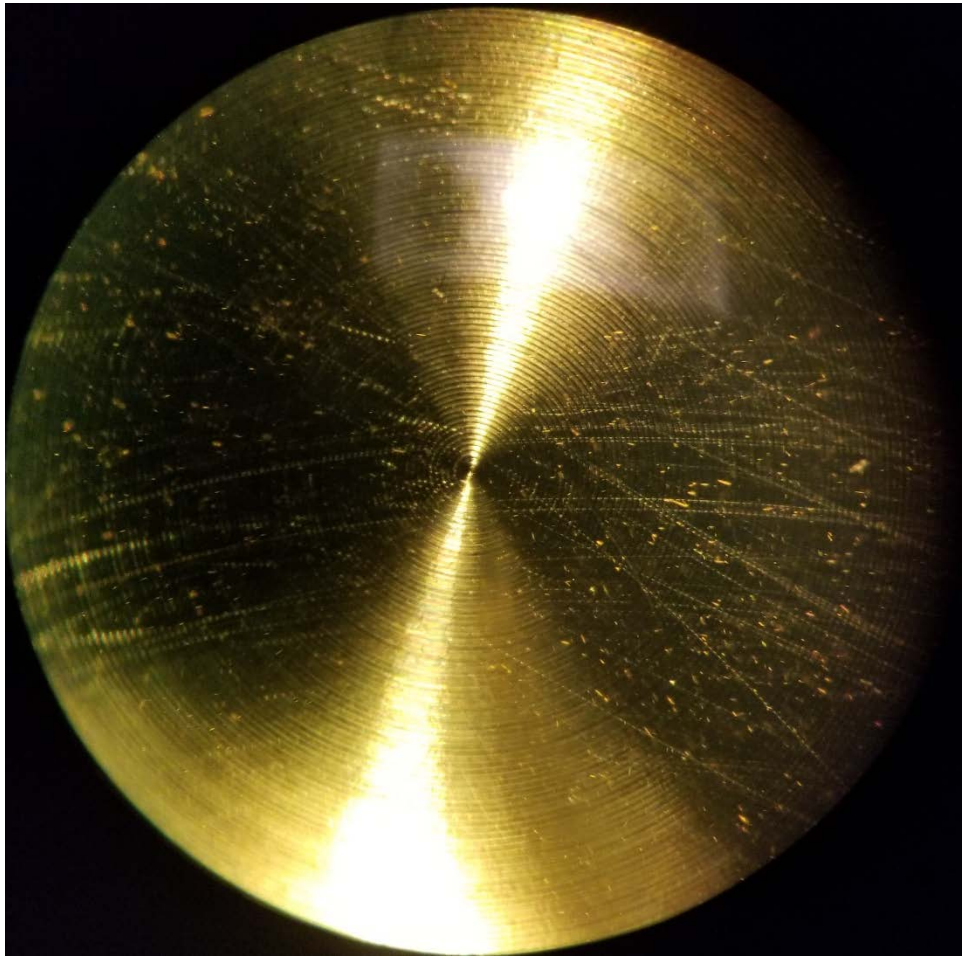

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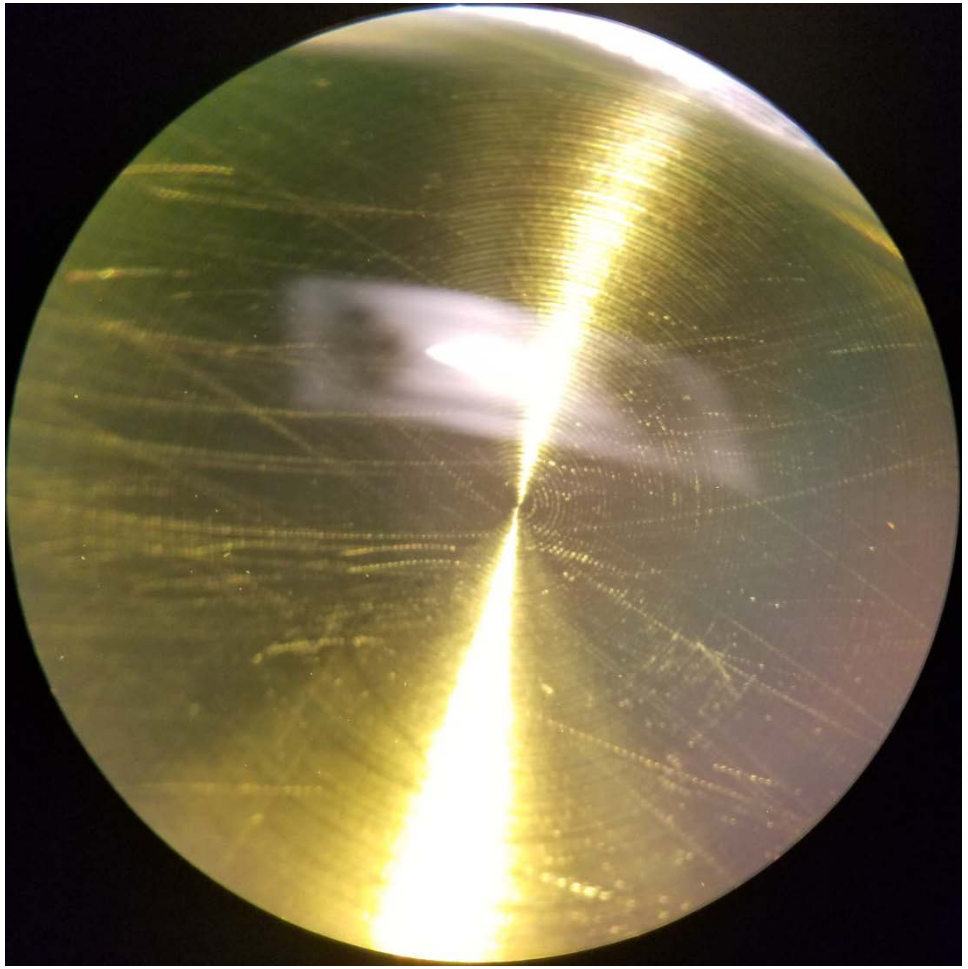

ESC Riboflavin Mixing Recommendations

- Heat at least 50% of final solution volume of water to 80°C
- Mix the riboflavin powder into the hot water with vigorous agitation until no undissolved powder remains
- Add the remaining water to the hot riboflavin solution to achieve final solution volume & concentration
- Mix vigorously and allow to cool before use