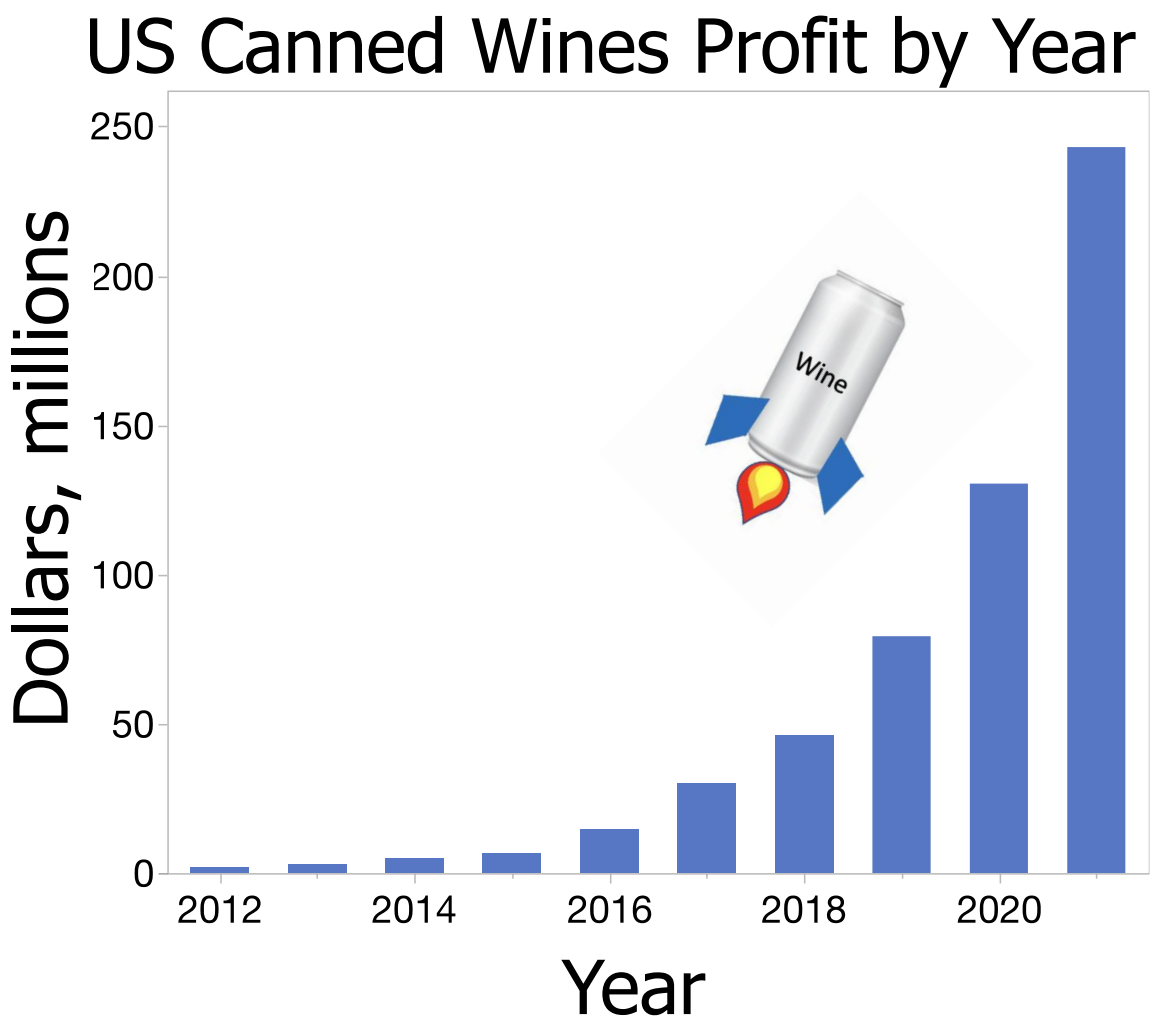
How Wine/Cider Components Affect Shelf Life in Cans

Congrès cidres, vins et alcools d'ici 2024

Austin Montgomery

Canned wine – trendy packaging

- Fastest growing packaging type

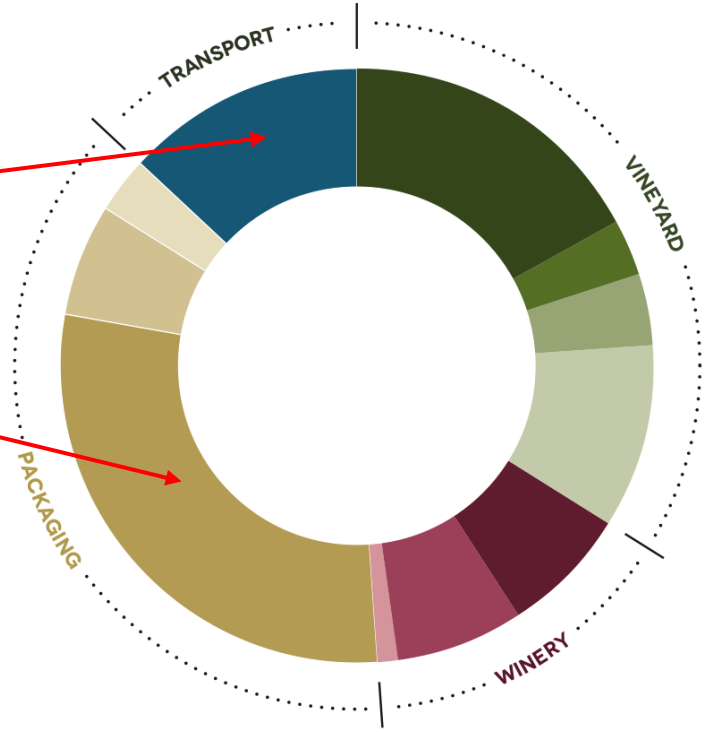


(Compiled from Nielsen IQ reports 2012-2021)

Canned wine – trendy packaging

- Fastest growing packaging type
- Less carbon footprint

Relative impact for carbon footprint of wines



(From sustainablewinegrowing.org)

Canned wine – trendy packaging

- Fastest growing packaging type
- Less carbon footprint
- Convenient Packaging

Can Specific Problems

Problem	Description
Staling	*Accelerated oxidation (if air in headspace; or, following **corrosion** and loss of hermetic seal)*

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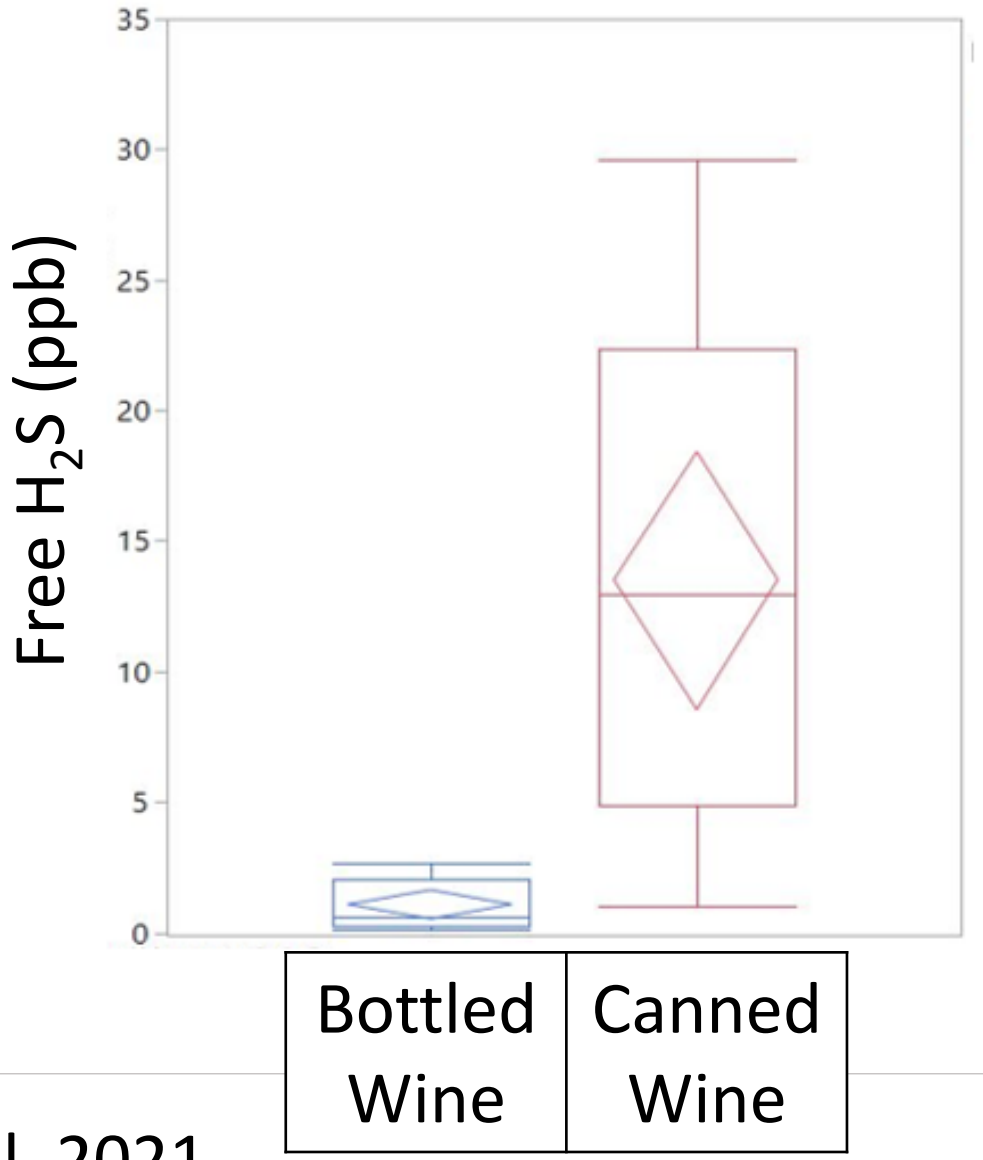
Scalping	*Absorption of odorants by polymeric **liner** (possibly an issue for hop aroma/cannabis compounds)*
Tainting	*Haze or off-flavor formation from aluminum or other components following **corrosion***

Canned wines typically have higher H_2S than glass

- Average H_2S of canned wines (~13 ppb)



Allison et al, 2021.

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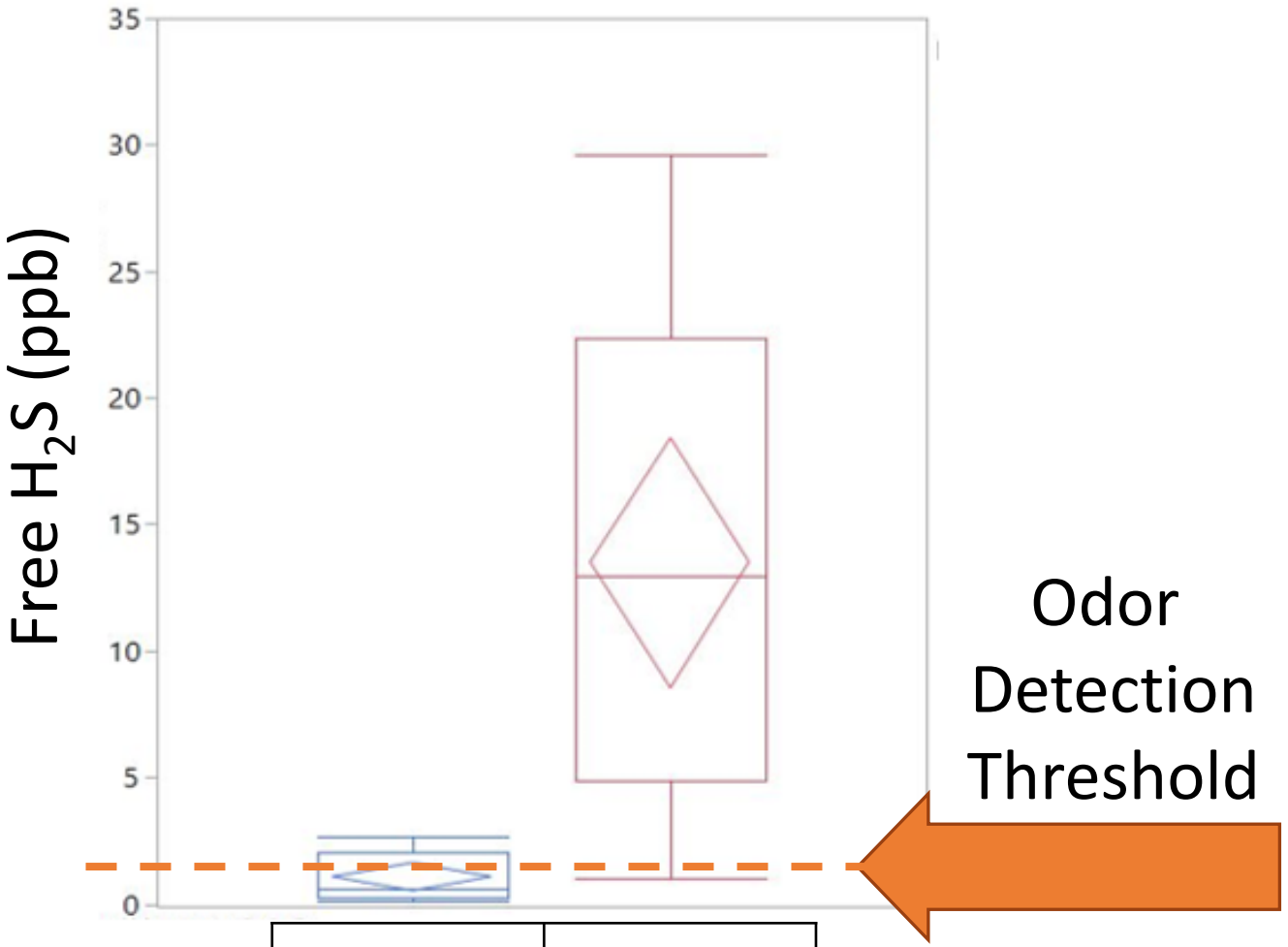
- H_2S odor detection threshold: 1.6 ppb (Siebert el al.)

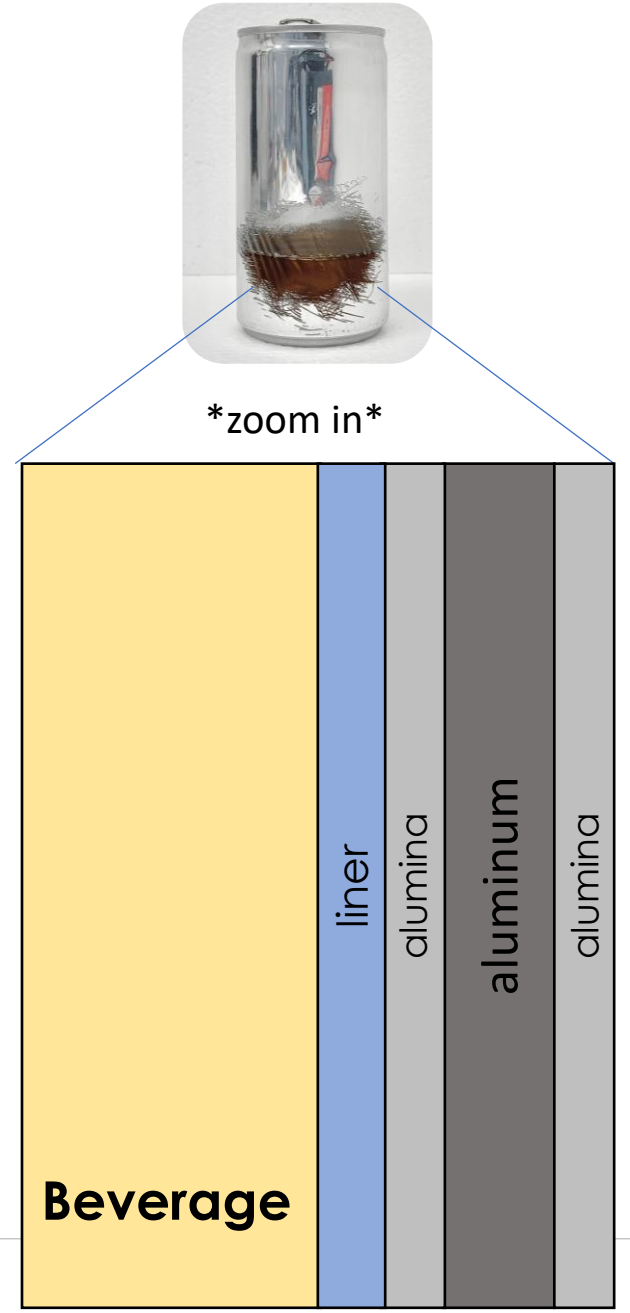


Allison et al, 2021.

Anatomy of a can

- A can is basically a thin plastic bottle with an aluminum shell.

- Typical liners we have studied:
  - BPA-epoxy
  - BPA-NI alternatives
    - Acrylic
    - Polyester
    - BPF epoxy
    - aTULC



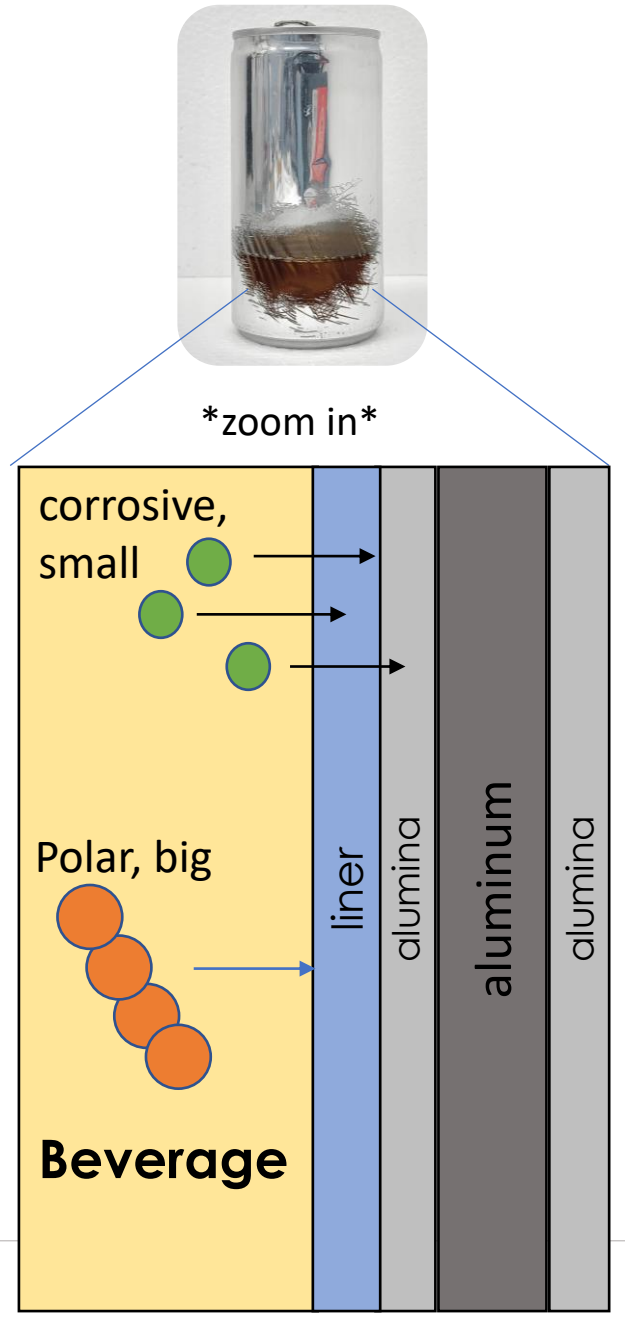
Anatomy of a can

- A can is basically a thin plastic bottle with an aluminum shell.

- Two places to focus on corrosion:
  1) **Liner x beverage interactions**
  2) Aluminum x beverage interactions

  ”How fast does a compound diffuse through the polymer?”

  “How do beverage components affect diffusion?”



Anatomy of a can

- A can is basically a thin plastic bottle with an aluminum shell.

- Two places to focus on corrosion:
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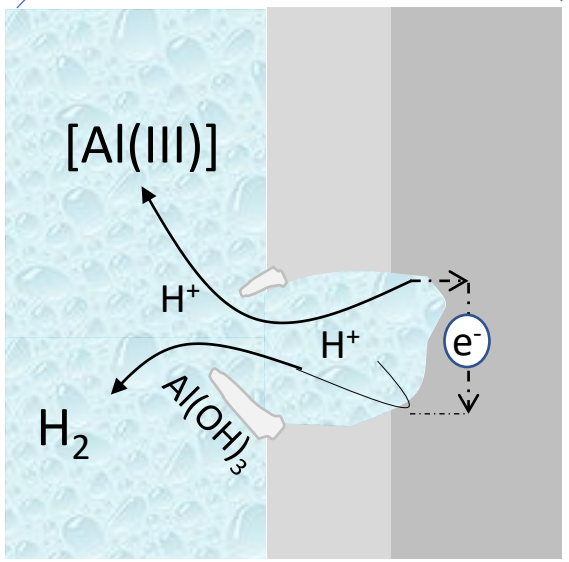
  "What reaction occurs between beverage components and aluminum?"

  "What can we measure to quantify this reaction?"

zoom in

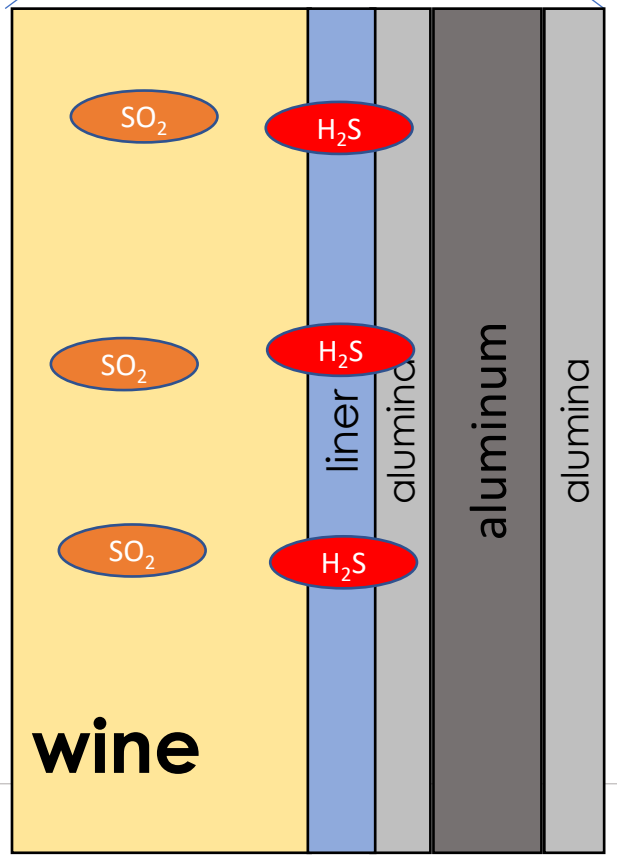


H_2S formation

Store @ 20 ° C

4-8 months

zoom in



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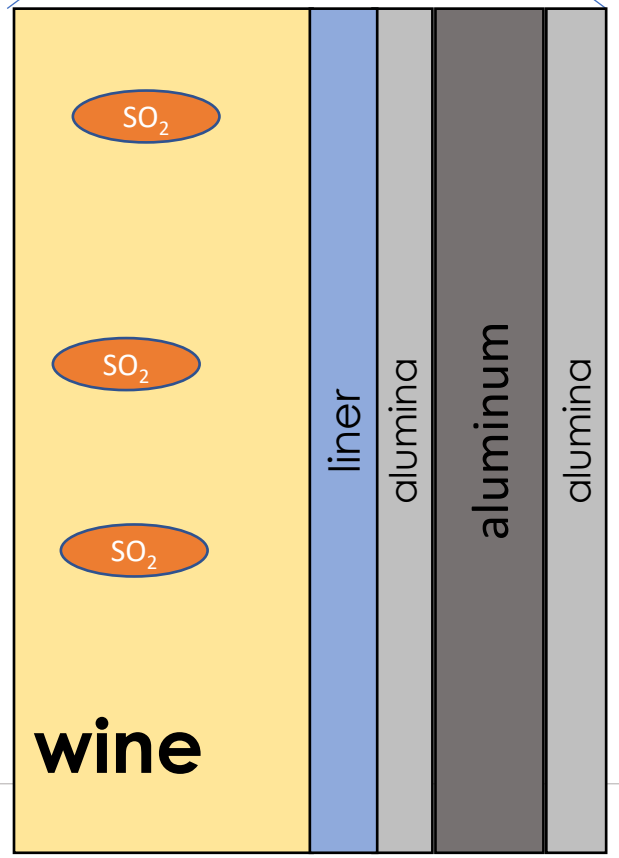


$3Al_{(s)} + SO_{2\,(aq)} + 6H^+ \rightarrow 3Al^{3+}_{(aq)} + H_2S_{(aq)} + 2H_2O$

Or, SO_2 facilitates reduction of other sources of sulphur

Review of SO_2 in wine: free vs. molecular

"Free SO_2" = molecular + bisulfite

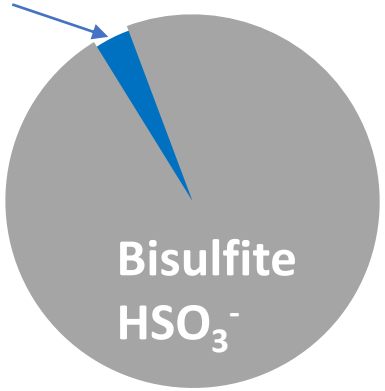
molecular SO_2	***Bisulfite***
SO_2	$\rightleftharpoons$ HSO_3^-

Ratio depends on pH

Molecular SO_2 is a minor component of free SO_2, typically <5%
Higher molecular SO_2 proportions at lower pH

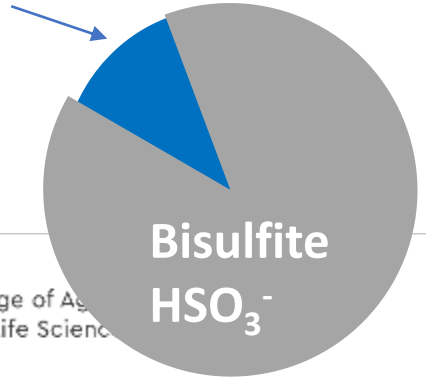
Lower proportion molecular SO_2

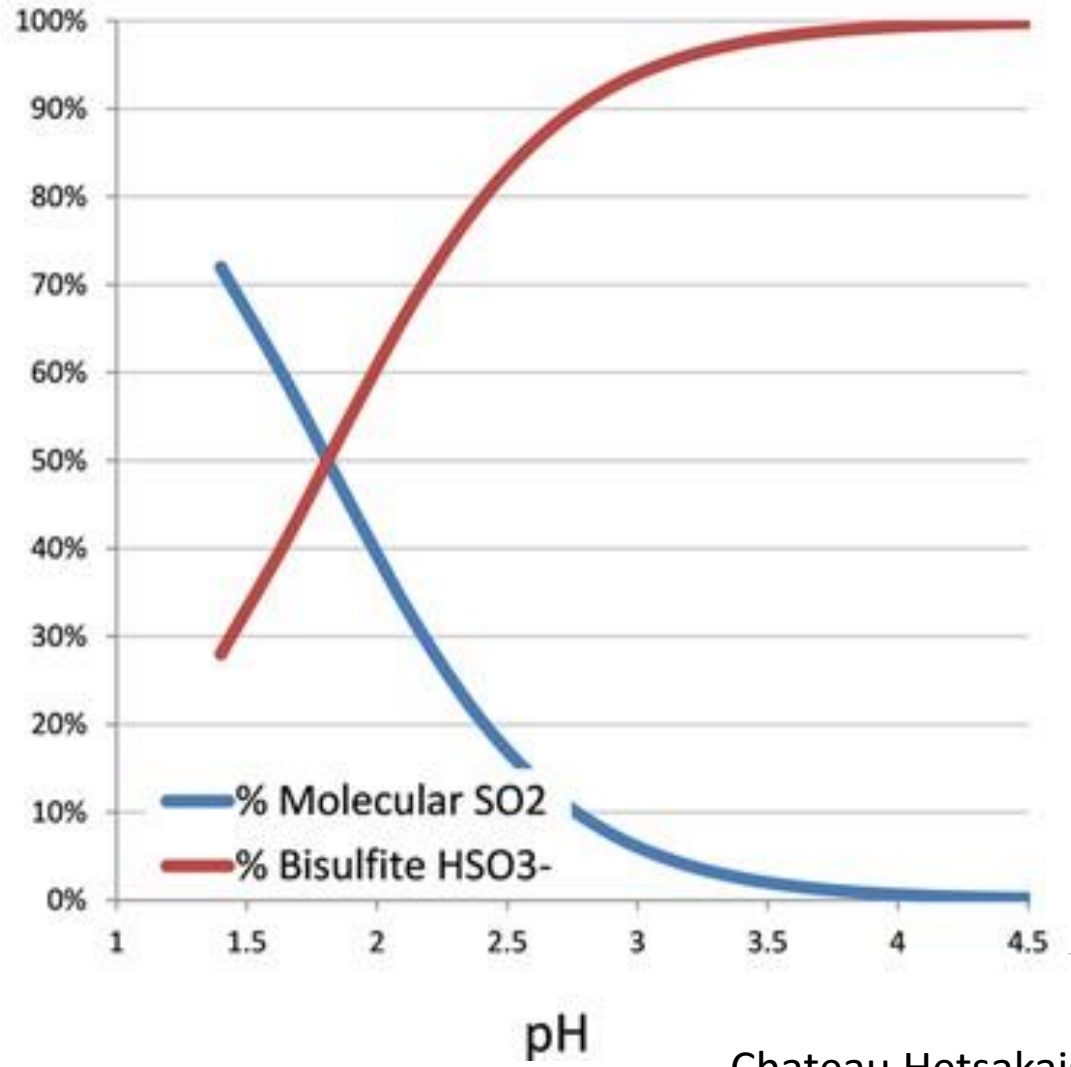
Higher pH = 3.4



Higher proportion molecular SO_2

Lower pH = 2.8



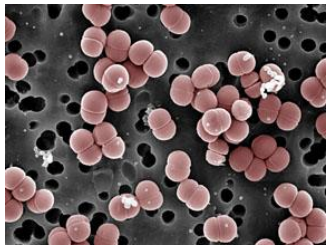


Chateau Hetsakais, 2023

Review: we have two complementary targets with SO_2

1) Molecular SO_2 is an **antimicrobial**

Typically, **~0.6 mg/L molecular** SO_2 recommended to prevent spoilage, with higher amounts recommended for wines with residual sugar
At higher concentrations, concerns about sensory effects



2) Free SO_2 (as bisulfite) is an **antioxidant**

~30 mg/L **free** SO_2 common recommendation for glass packaging
Reacts with oxidation products (e.g. hydrogen peroxide, quinones)
Typically, at **<10 mg/L free** SO_2, oxidized aromas appear

SO_2 should be limited in cans

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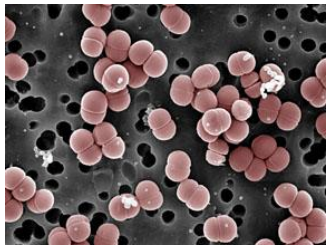

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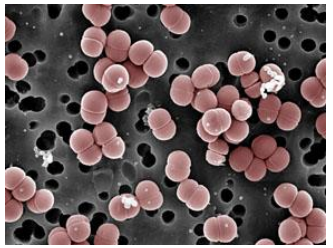

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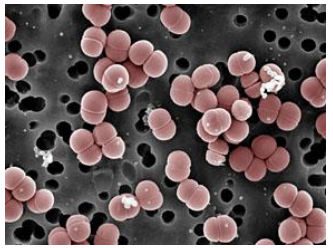

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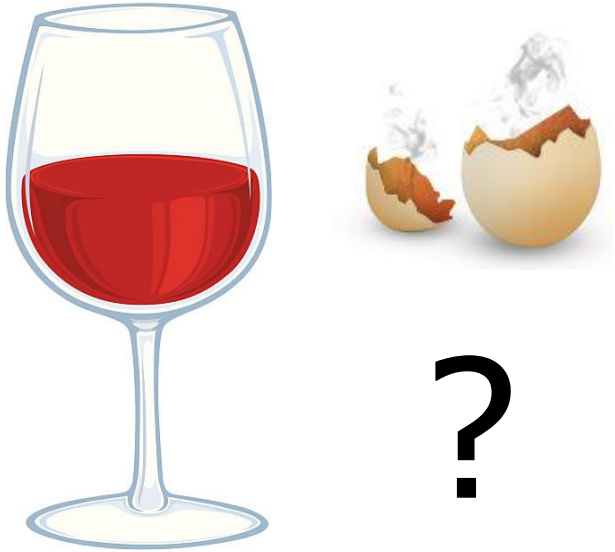
What factors affect H_2S production?



?

Do any wine components predict H_2S production?

How does liner choice affect H_2S production following storage?

Experimental design

10 wines (2 rosés, 2 reds, 6 whites)

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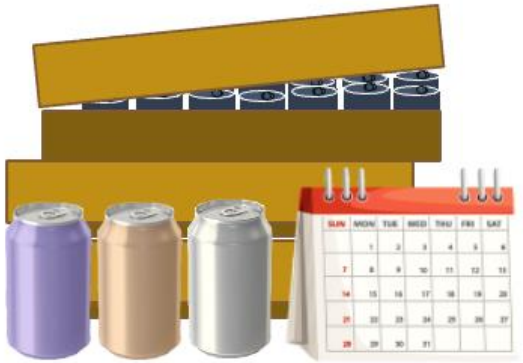

Canned with..
N = 3 Liners
N = 4 Timepoints
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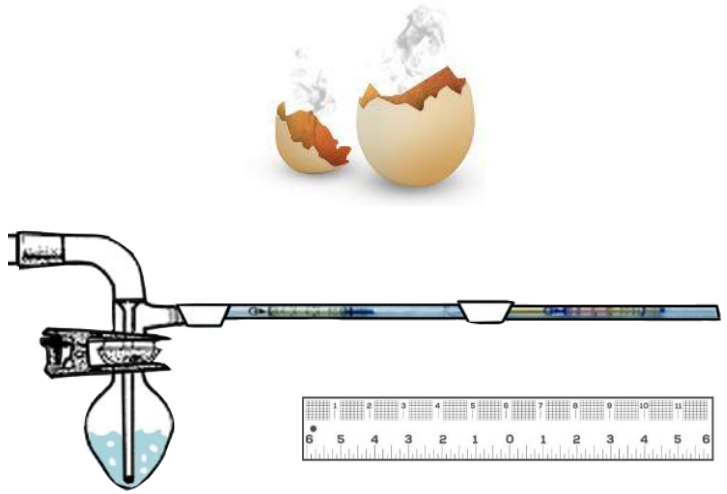
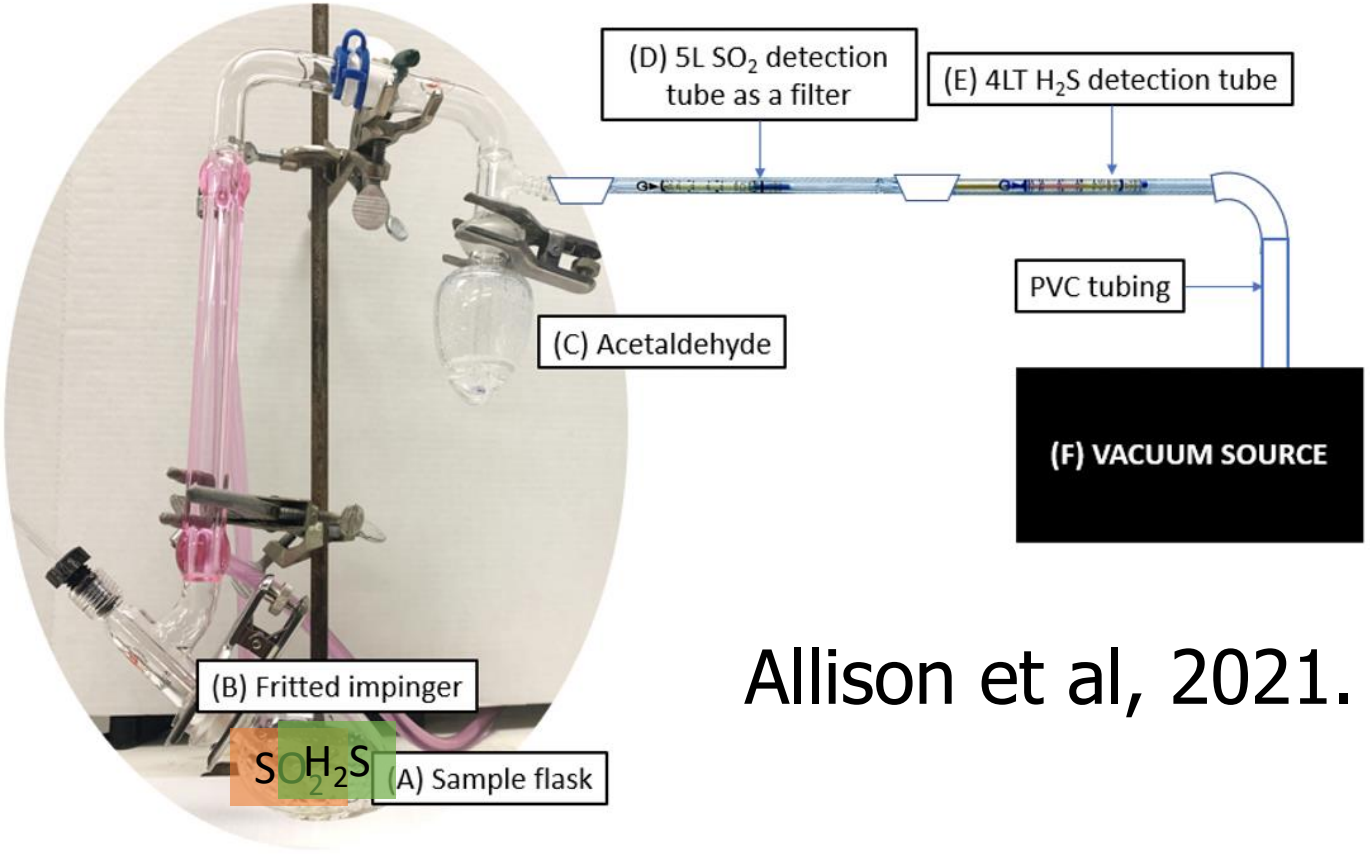


Measure H_2S
Visible degradation
Measure Al^{3+}

Measuring H_2S with gas detection tubes

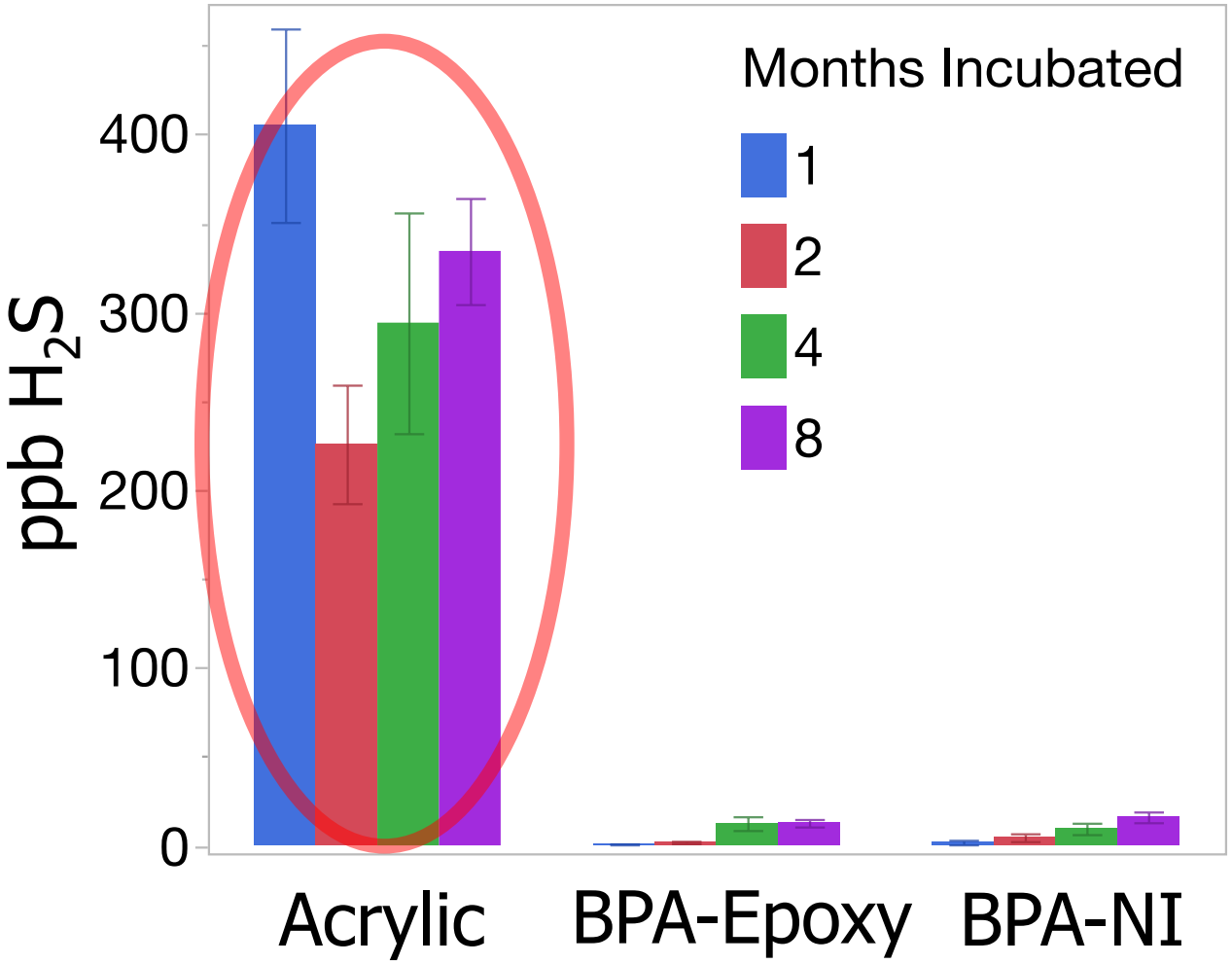
- Wineries can adapt A-O setup to measure H_2S <10 minutes
- Excellent reproducibility within standard solutions



Allison et al, 2021.

Effect of liner type – long term aging

- Acrylic is not a suitable liner for wine.



N = 30, Error Bars = Standard Error

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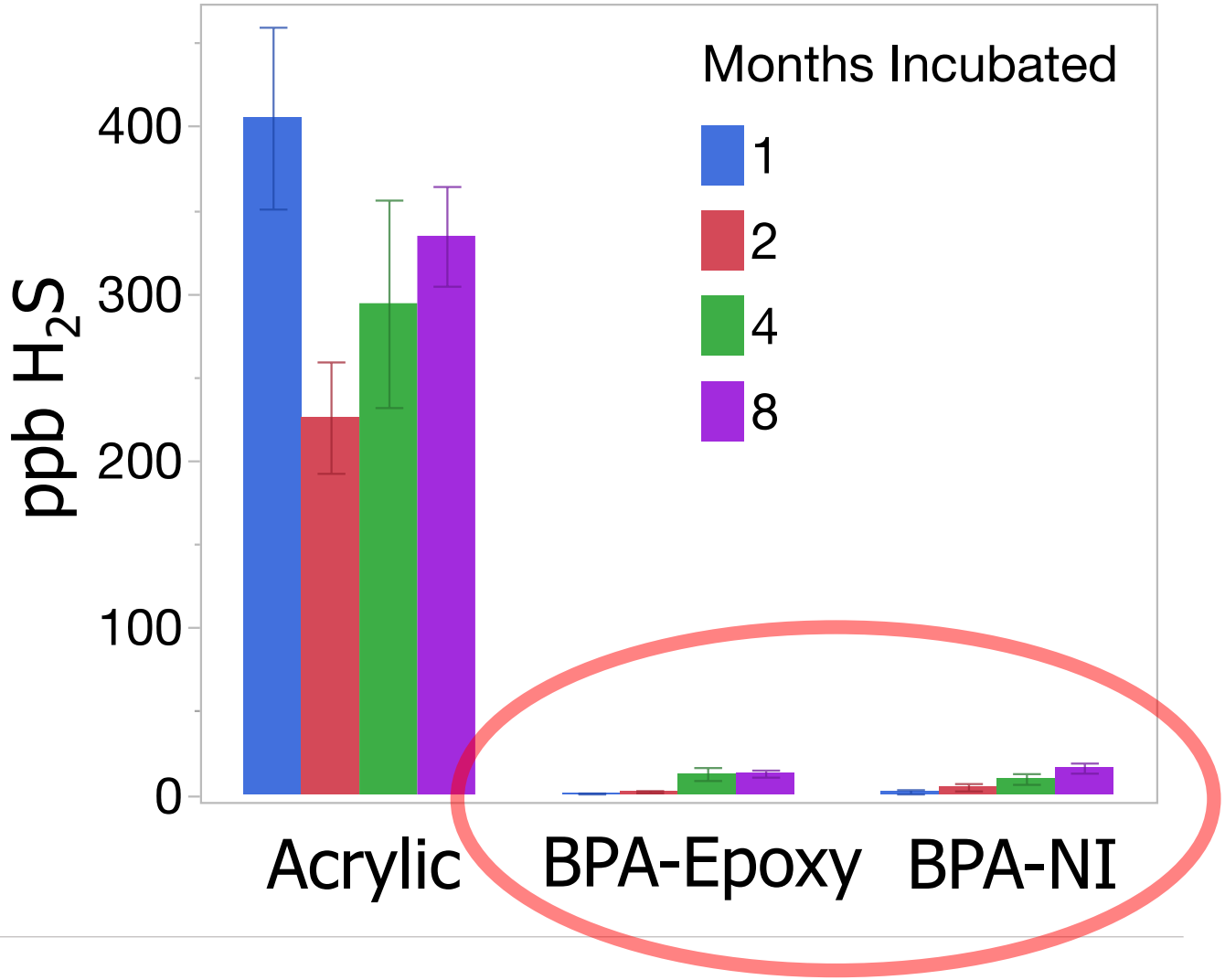

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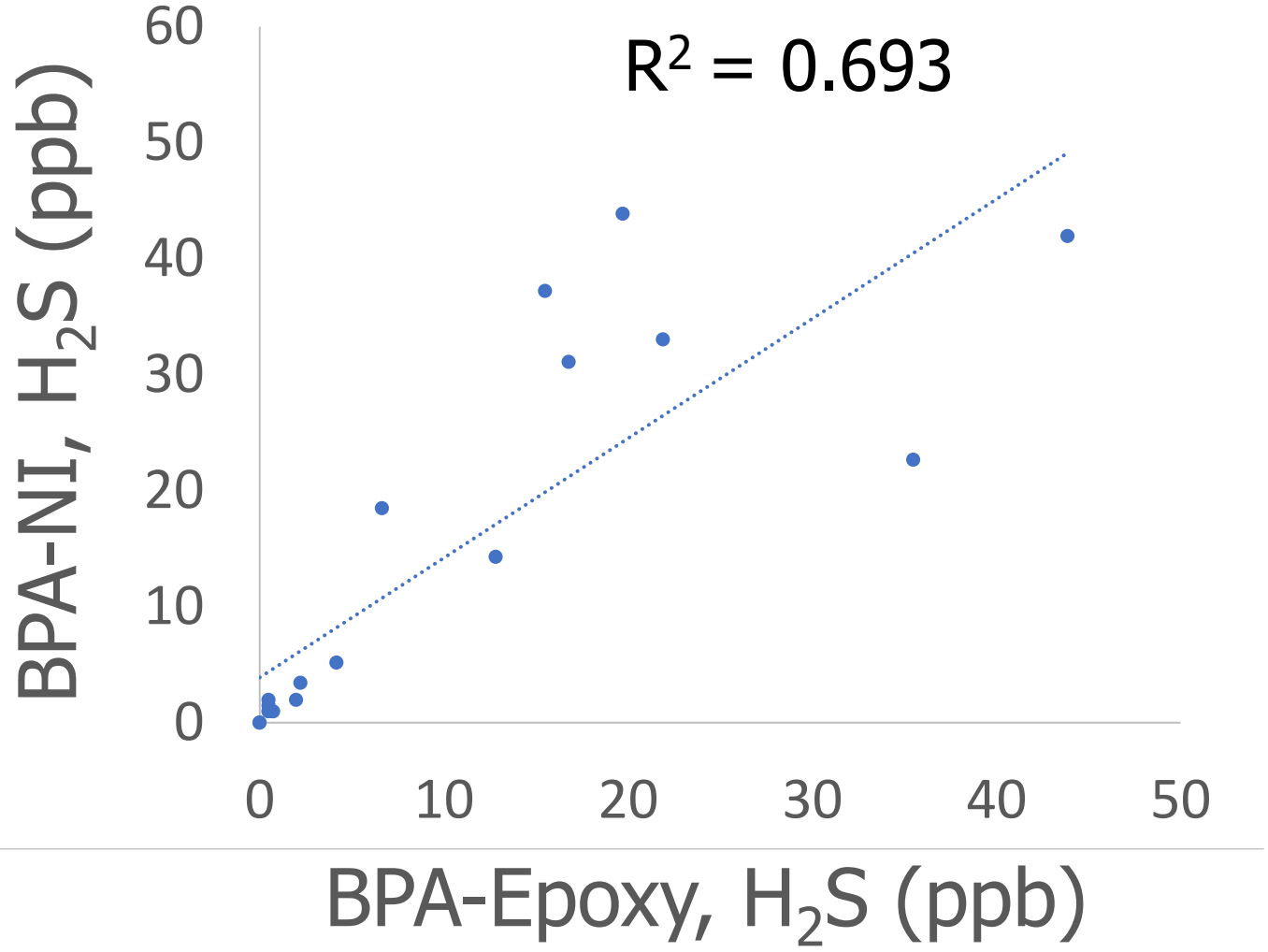
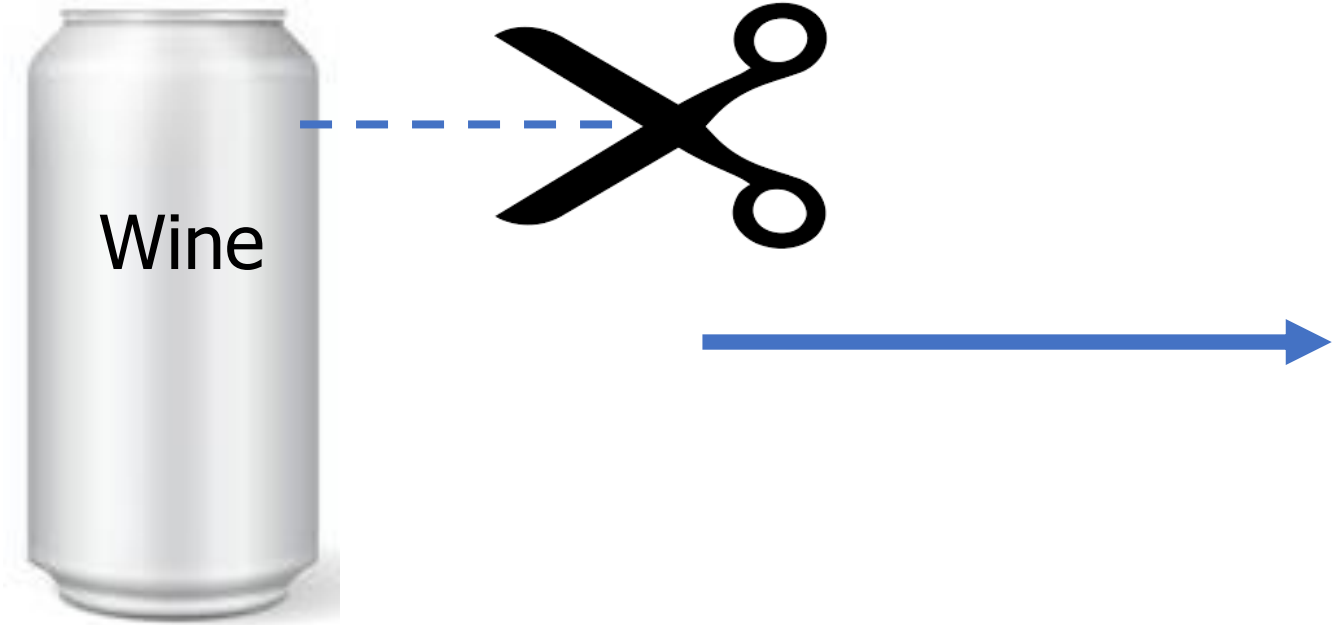


Visible degradation correlates to H_2S production



BPA/BPA-NI

No H_2S Production

Visible degradation correlates to H_2S production

- Acrylic looked… scary.

Acrylic
High H_2S Producer

BPA/BPA-NI
No H_2S Production

Visible degradation correlates to H_2S production

- Acrylic looked… scary

- BPA/BPA-NI showed blistering in headspace + body damage

BPA/BPA-NI
High H_2S Producer

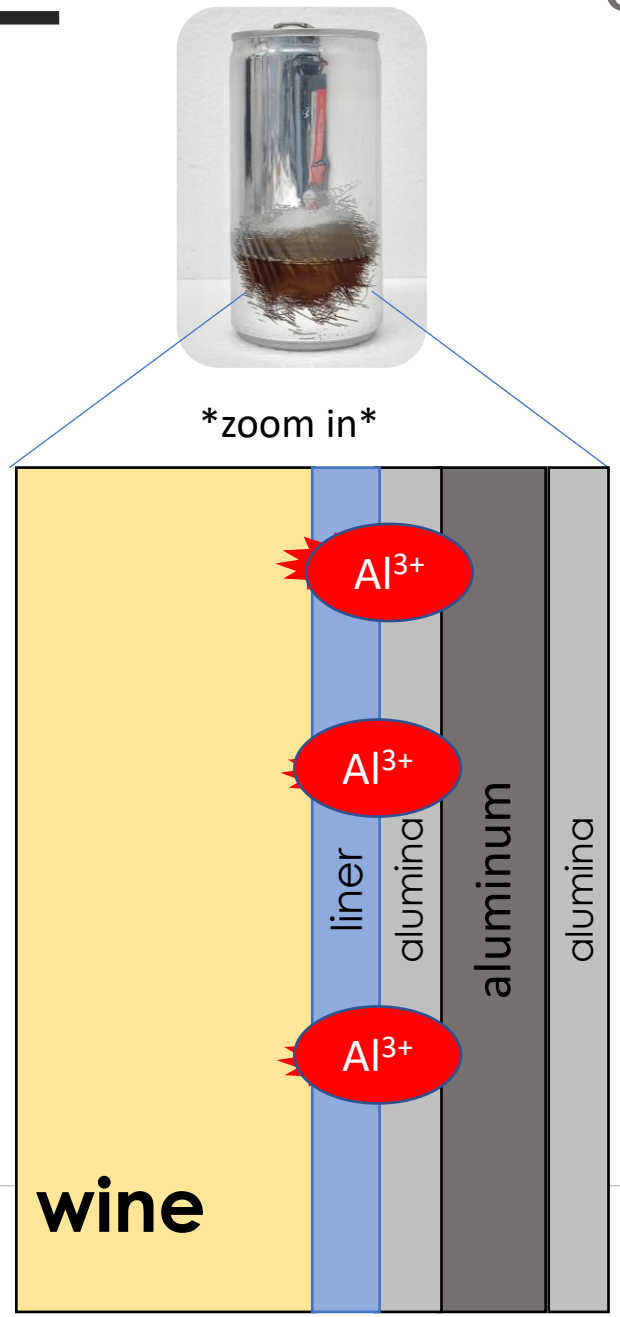
BPA/BPA-NI
No H_2S Production

Expectation: Visual degradation = dissolved Al^{3+}

- Visible liner damage should lead to the exposure of bare aluminum

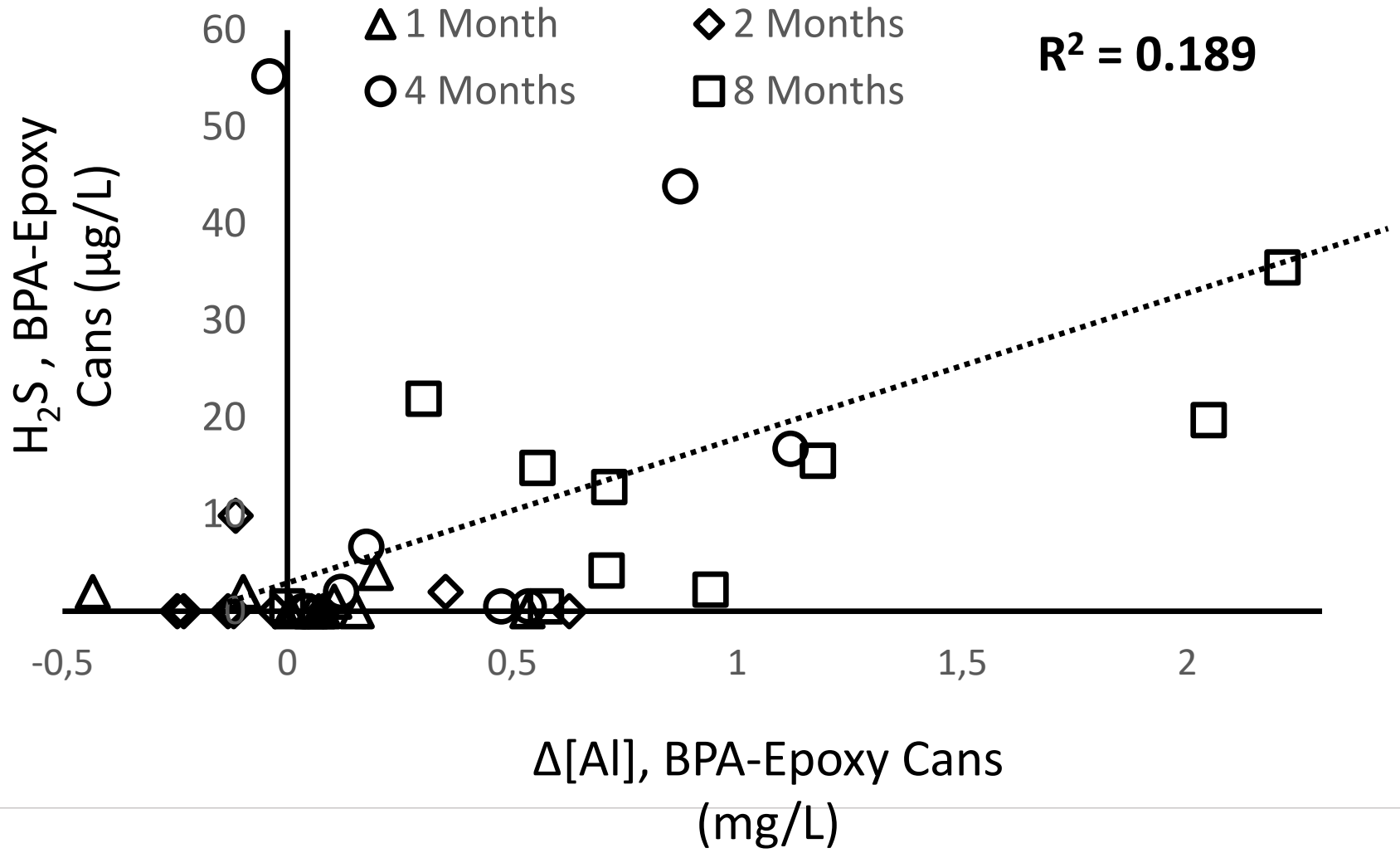
- This should result in dissolved aluminum:

$$2Al^{0}_{(s)} + 6H^{+} \rightarrow 2Al^{3+}_{(aq)} + 6H_{2(g)}$$



… but Al^{3+} is poorly correlated to H_2S production

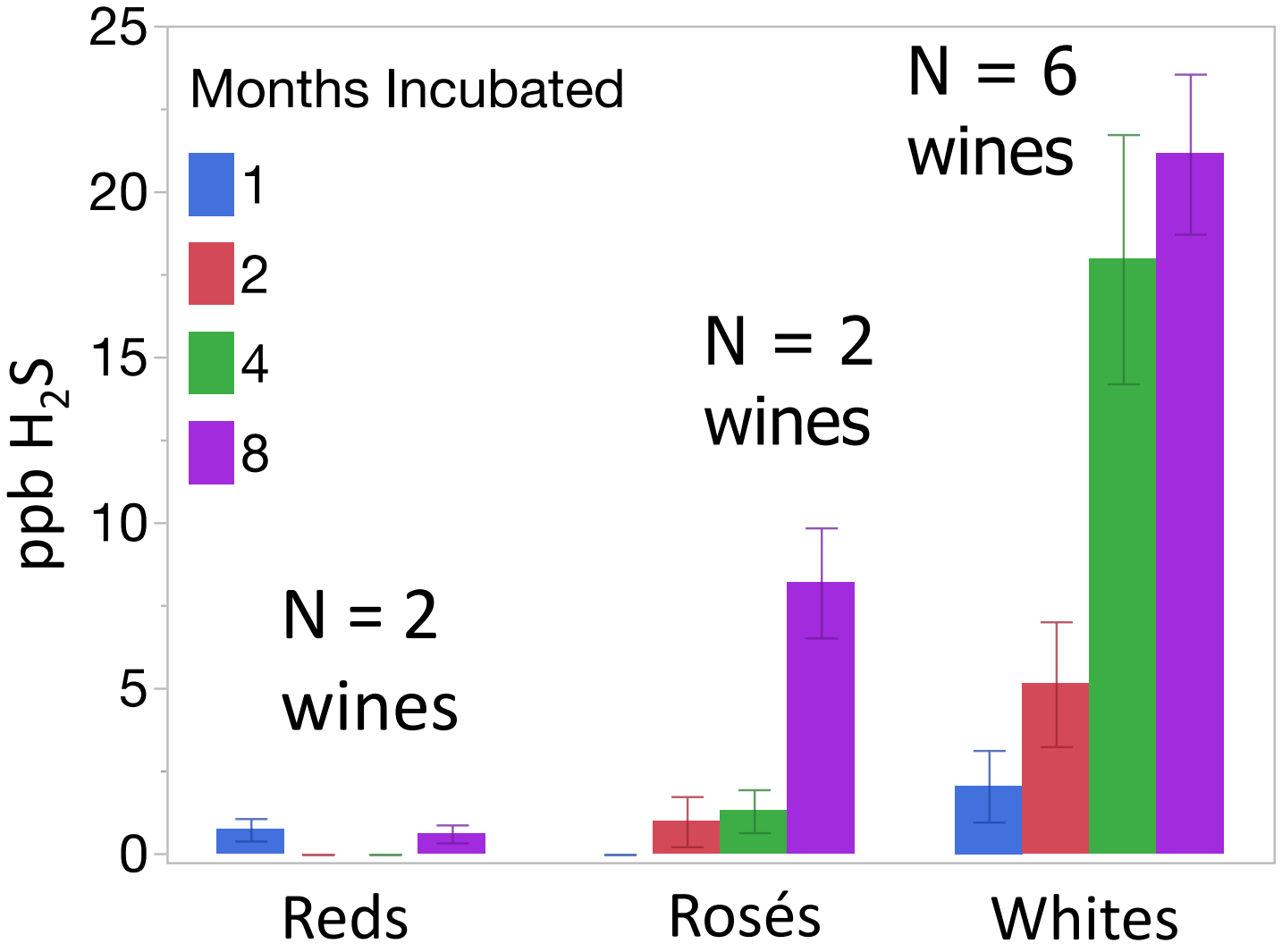
- Negligible Al^{3+} signal until somewhere between 4 and 8 months.



Montgomery and Allison, Goddard, Sacks. AJEV 2023

Effect of wine type – long term aging

- Significant H_2S formation can happen as soon as 4 months



Acrylic samples excluded. Each point is n=3 reps

Chemical composition of wines studied

- Wines possessed typical table wine chemistry with these ranges:

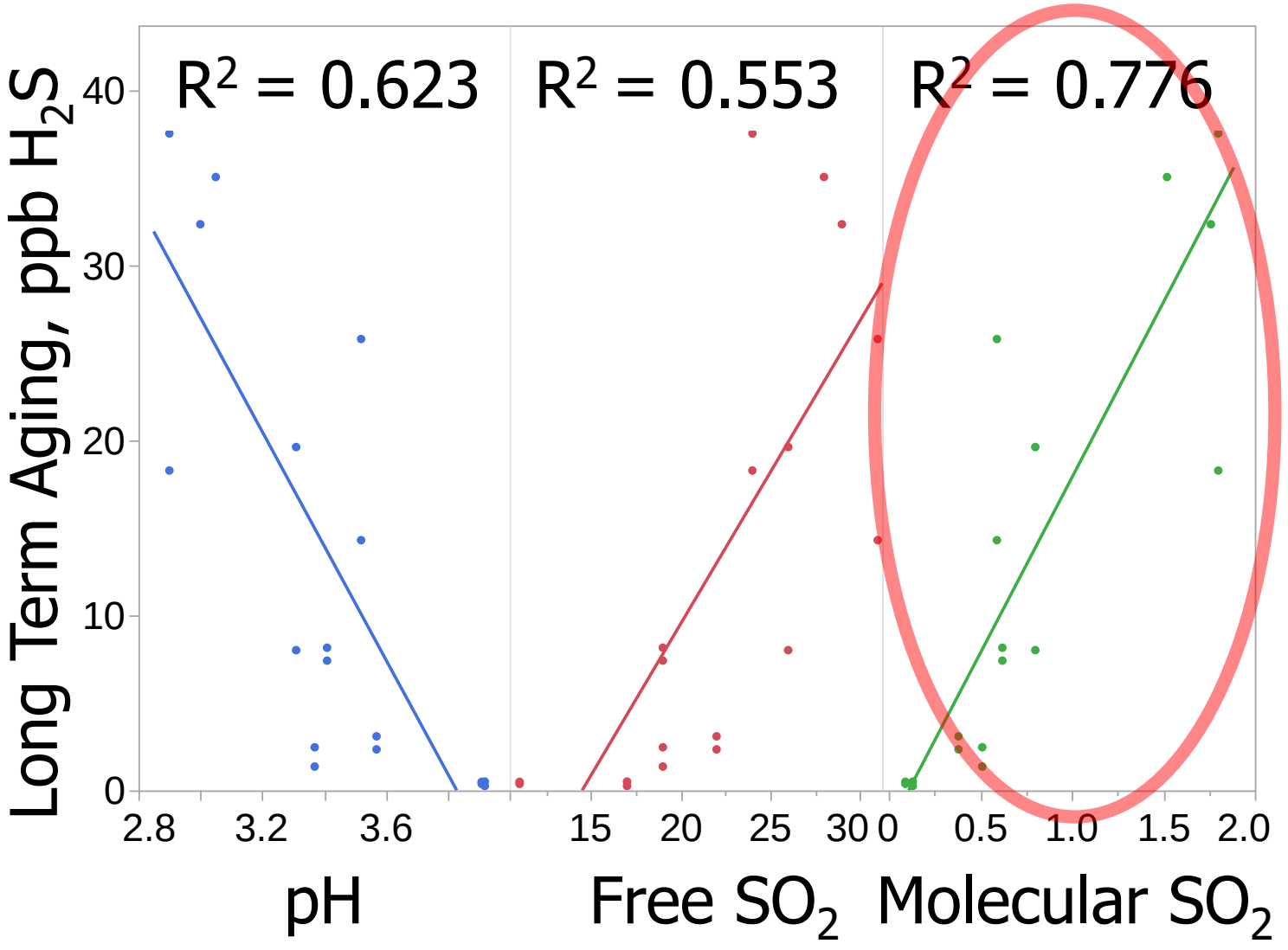
Range	pH	TA g/L	ABV v/v	SO_2 mg/L			Sugar g/L	Cu mg/L	Cl- mg/L
				Free	Total	Mol.			
Low	2.9	5.5	8.6	11	36	0.1	0.9	0.05	32.1
High	3.9	9.1	13.2	31	142	1.8	65.33	0.39	442

What best predicts H_2S? Molecular SO_2

- Molecular SO_2 = best predictor of H_2S

$$SO_2 \leftrightarrow HSO_3^- \leftrightarrow SO_3^{2-}$$

Free SO_2



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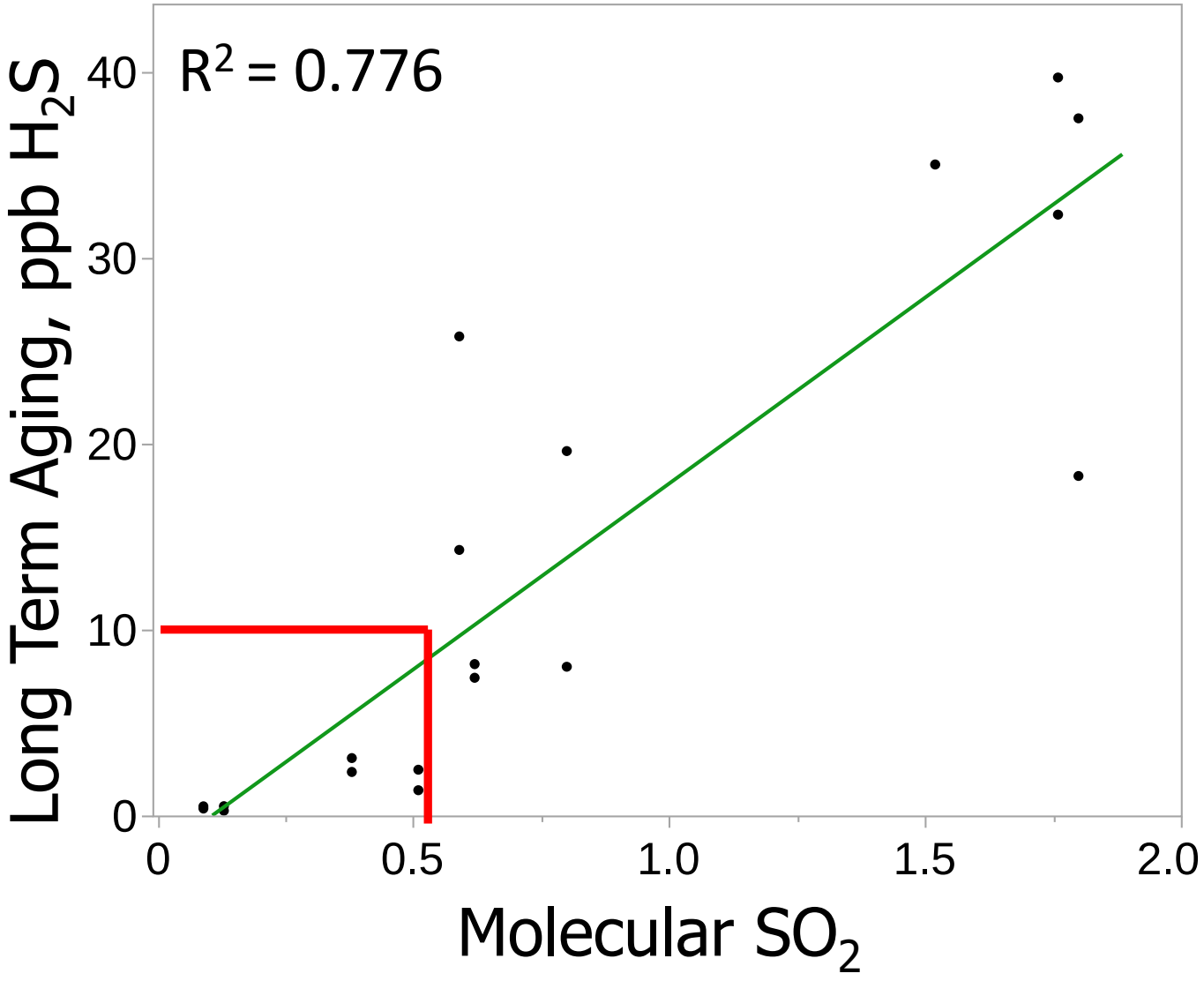
- ~ 0.5 ppm target Molecular SO_2



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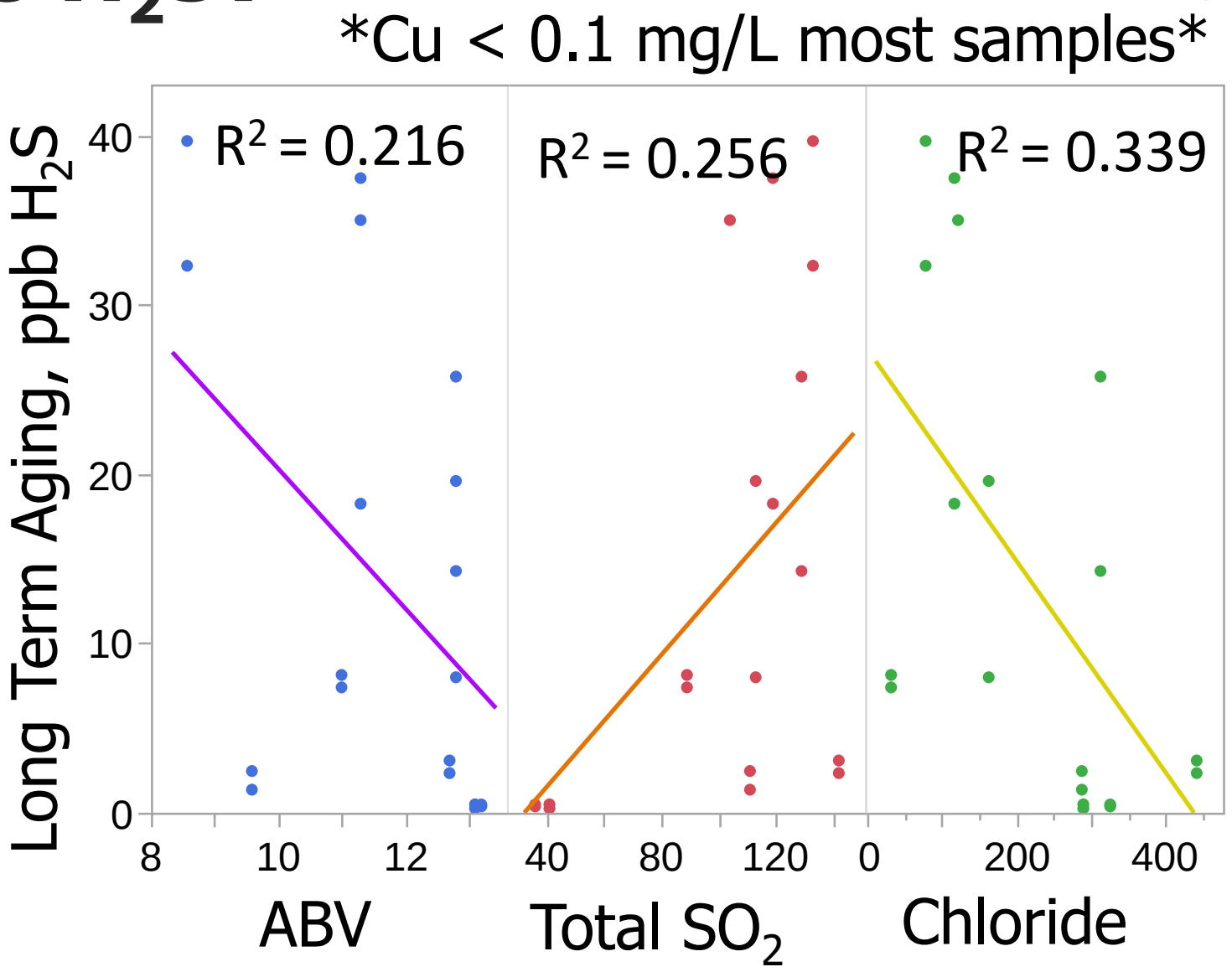
What best predicts H_2S? Molecular SO_2

- Molecular SO_2 = best predictor of H_2S
- ~ 0.5 ppm target Molecular SO_2
- ABV, Total SO_2, Cl^- uncorrelated



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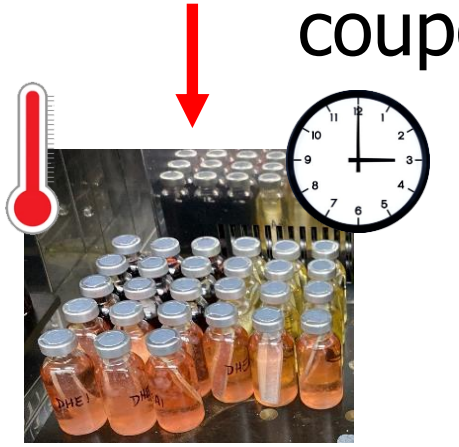
Can accelerated aging conditions predict H_2S formation?

Same 10 wines

+

"Coated coupon"

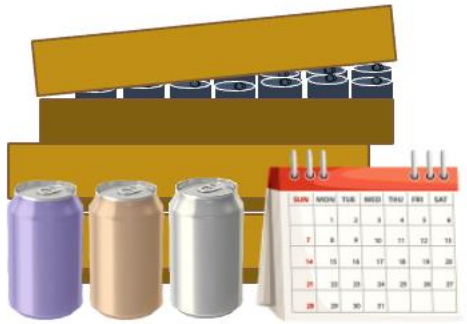


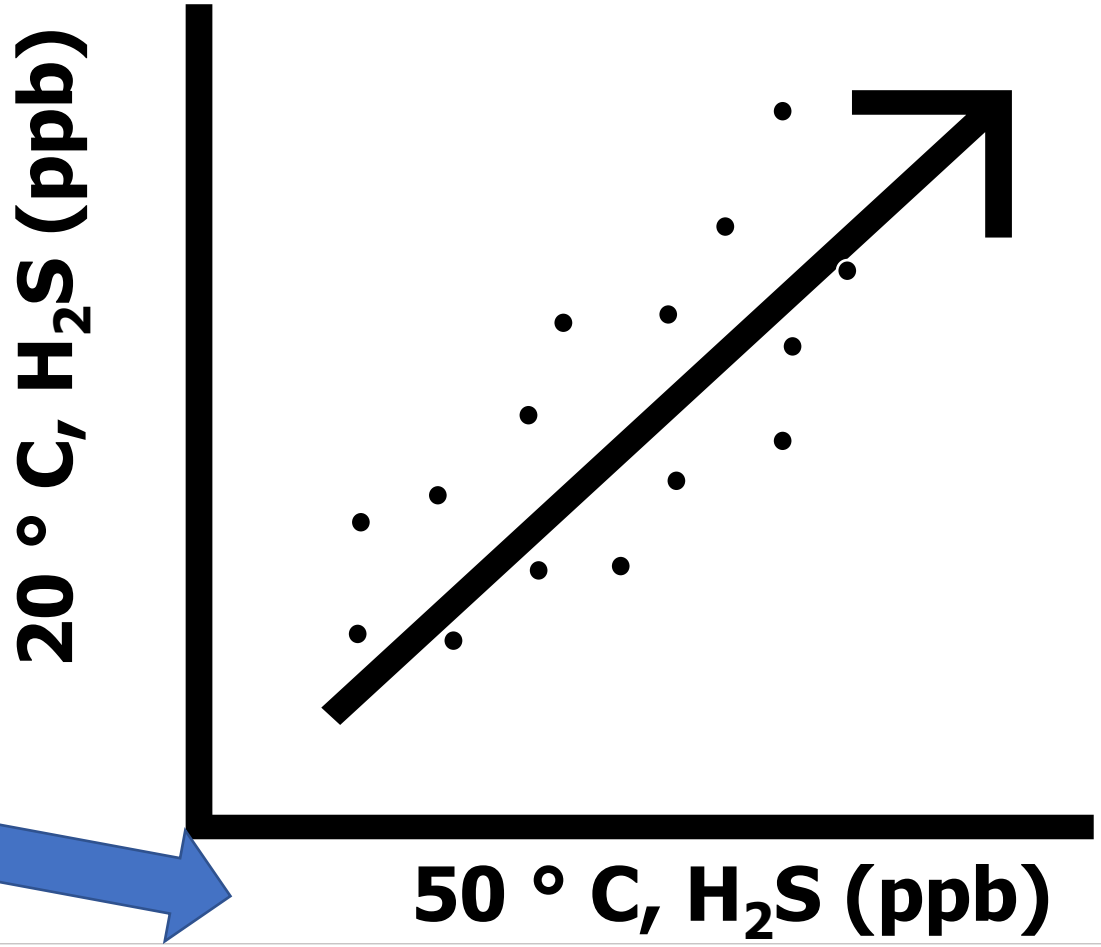
Store in 27 mL glass vials at 50 ° C, < 14 d

Advantages

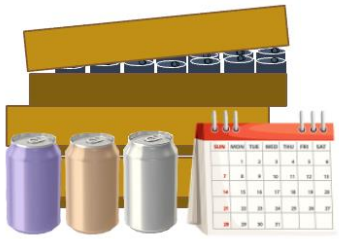
1. Increase sample throughput
2. Save $$ on cost of materials
3. Measure model systems easily

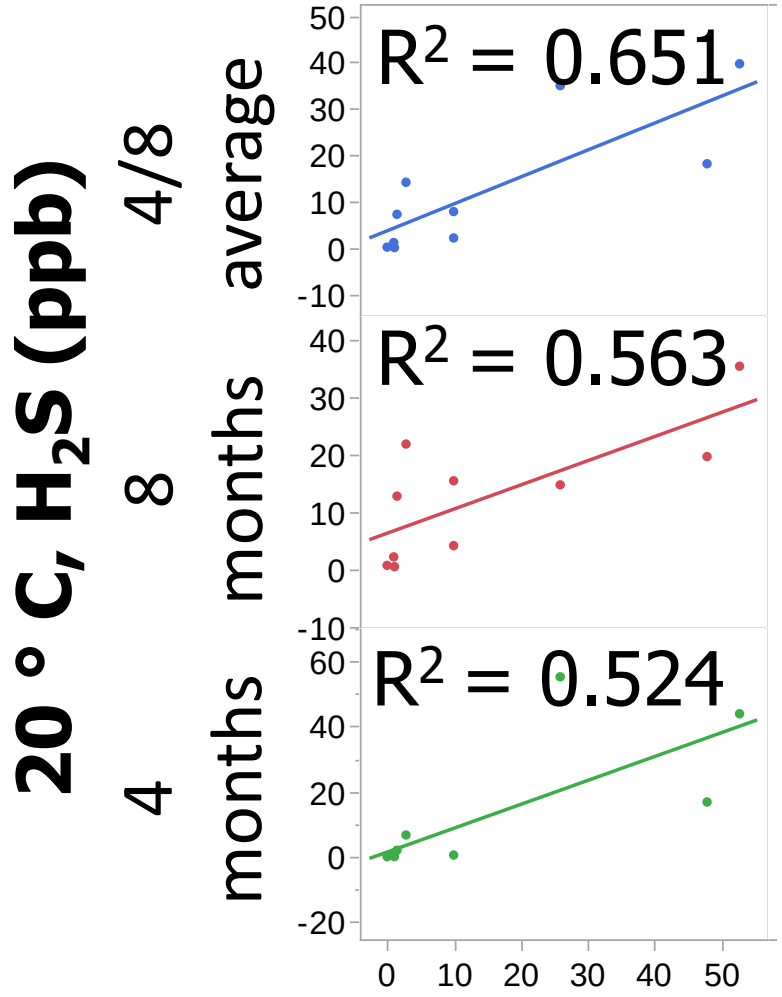
How can we validate accelerated aging?





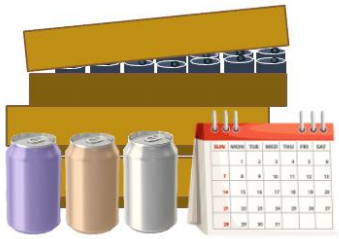
3 days 50 ° C predicts H_2S formation well



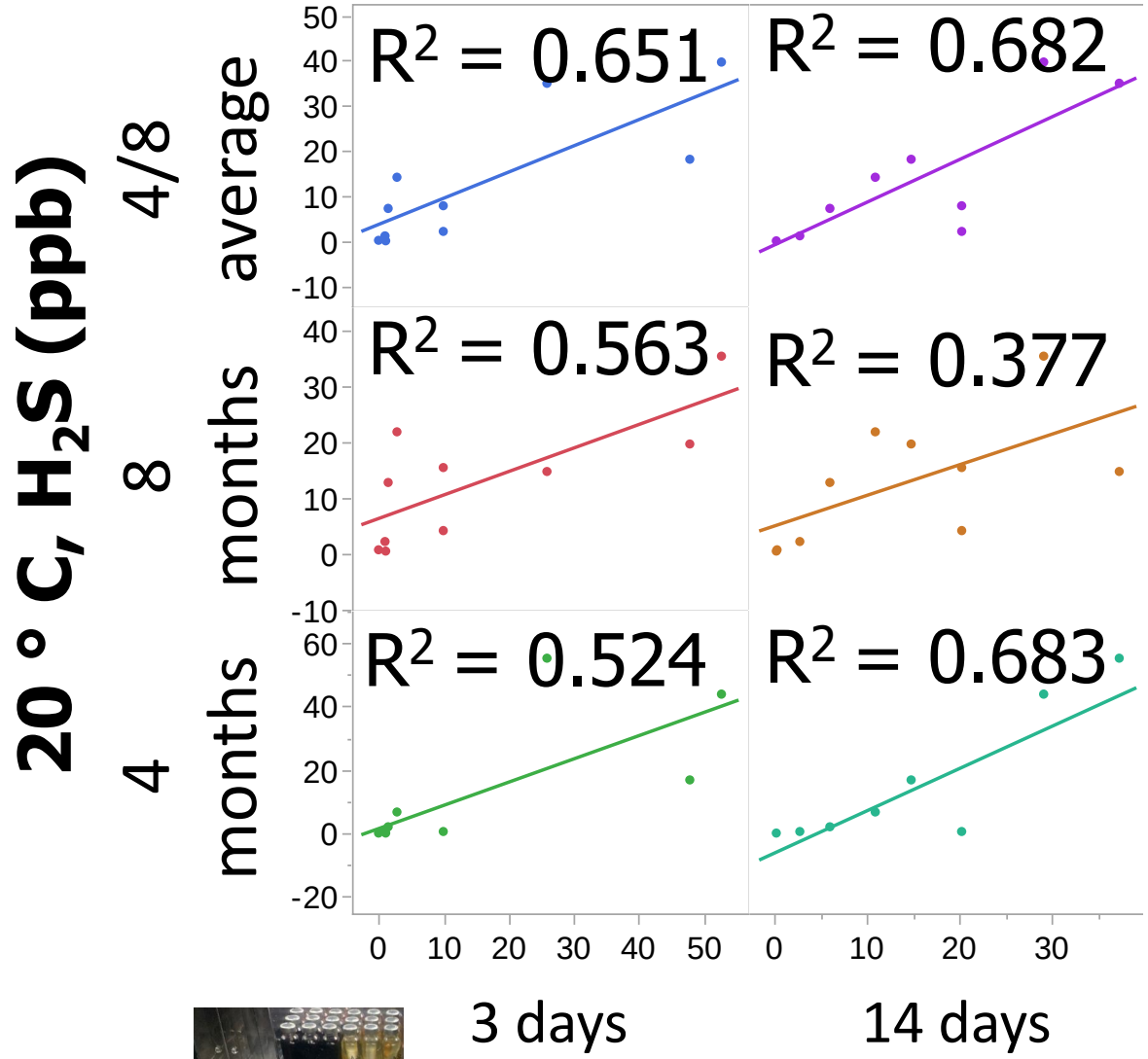


50 ° C, H_2S (ppb)

14 days also predicts H_2S formation well

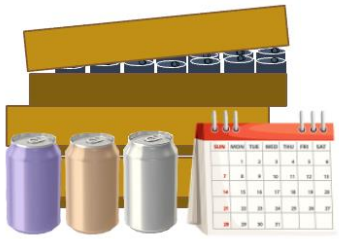


20 ° C, H_2S (ppb)



50 ° C, H_2S (ppb)

But, the average of 3 and 14 d predicts H_2S best



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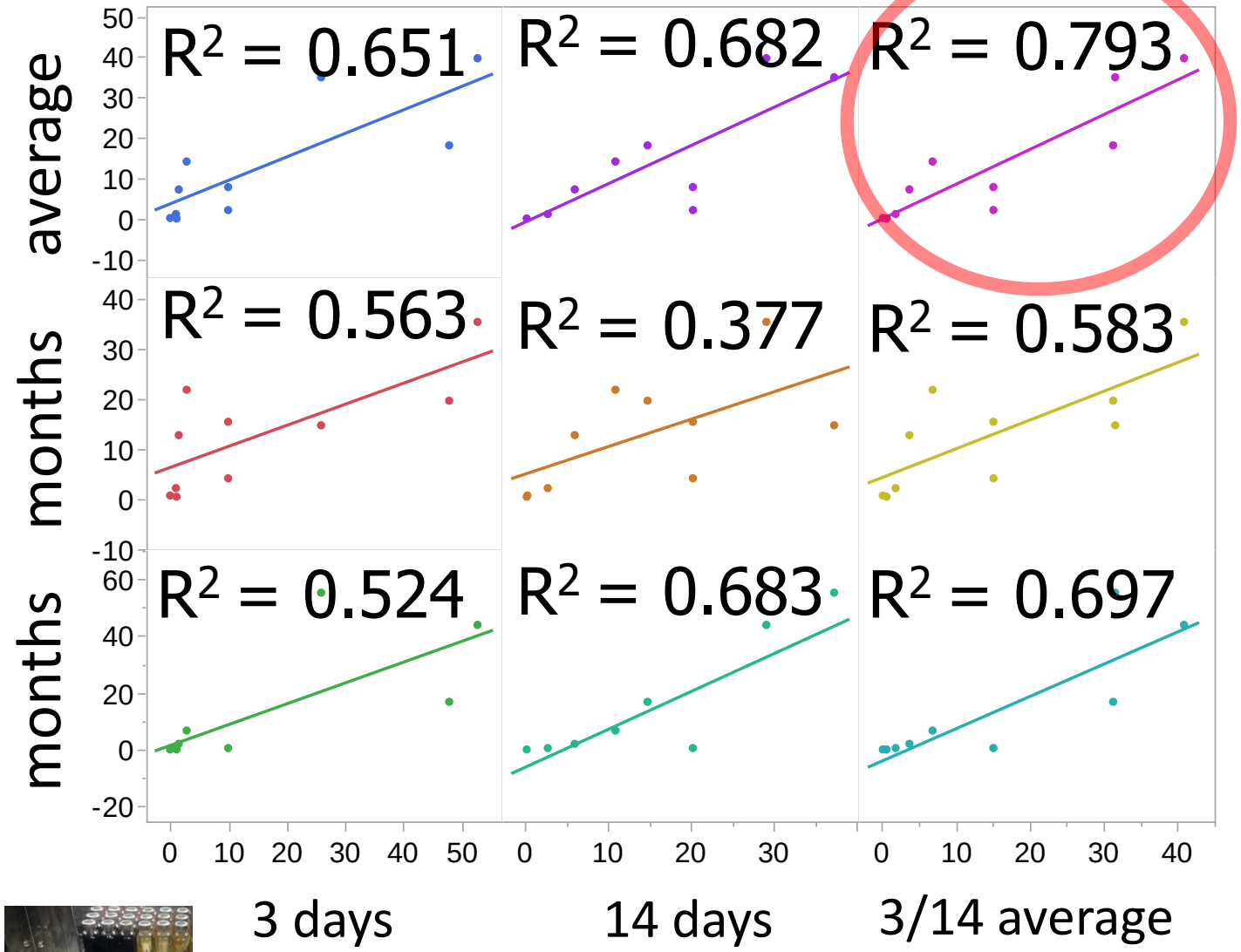


50 ° C, H_2S (ppb)

Putting accelerated aging test to work

Now that we have a valid test,
we can use it to address
specific wine-systems!

Putting accelerated aging test to work: role of ethanol

Non-alcoholic wines
Red, Rosé, White

BevZero
BEVERAGE INNOVATION

Ethanol, SO_2
Tartaric Acid

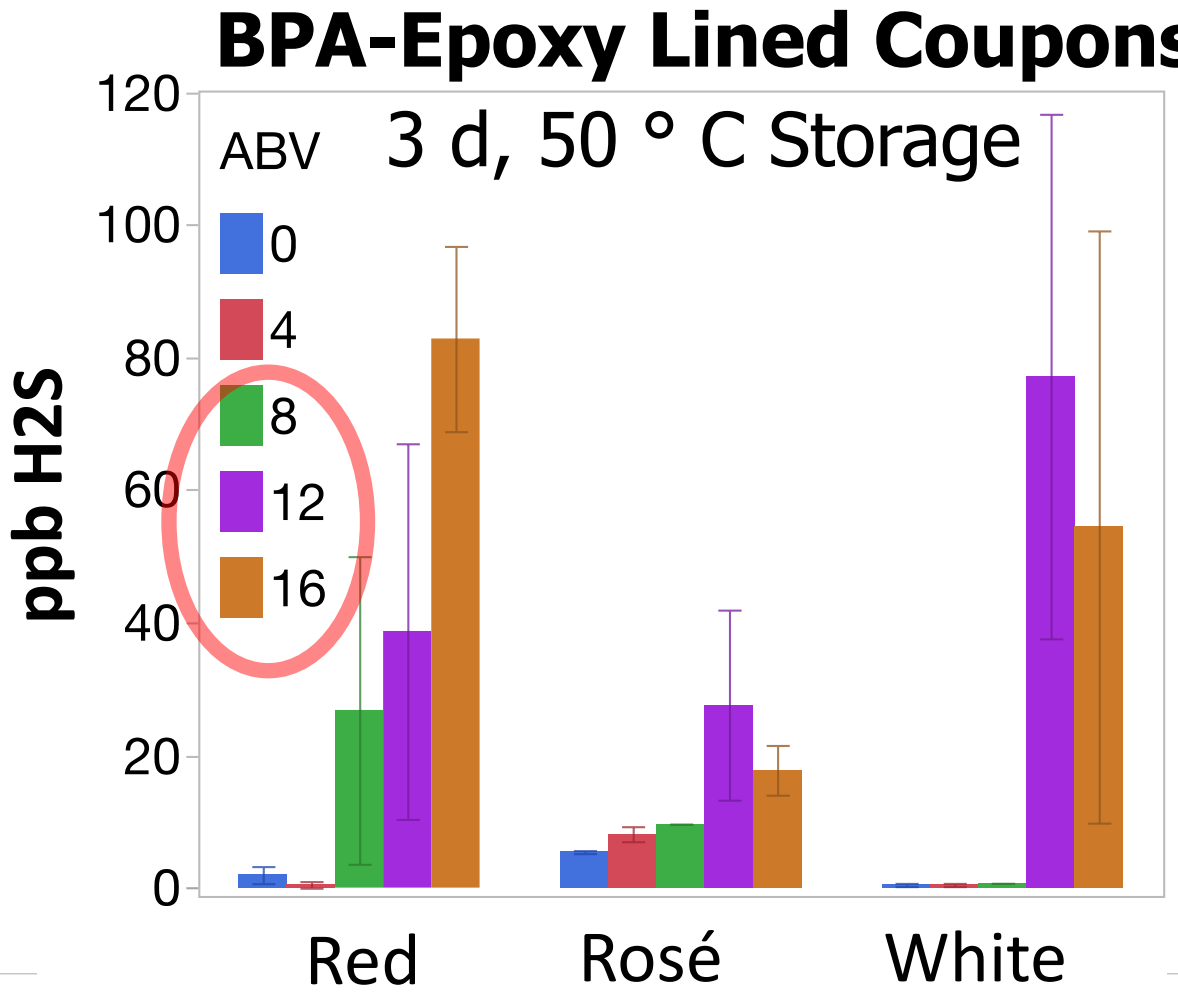
+ BPA-Epoxy Coupon

Challenge solutions with specific wine chemistry

pH	3
Free SO_2	50 ppm
EtOH	0, 4, 8, 12, 16 %

Putting accelerated aging test to work: role of ethanol

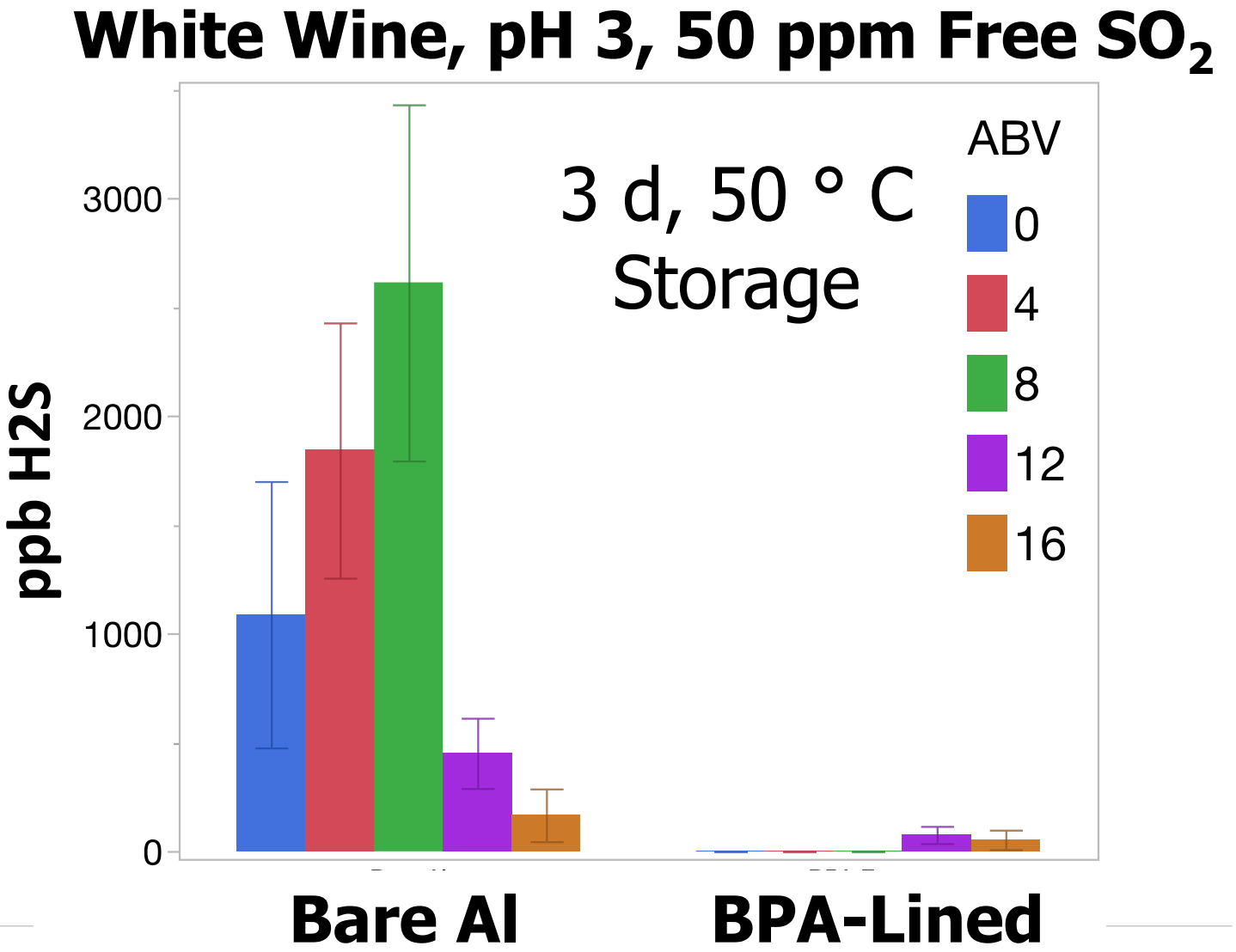
- ~8% ethanol "threshold" to observe H_2S production
- Ethanol shows a weak effect over the range of typical table wines



N = 3 for each bar, error bars are standard error.

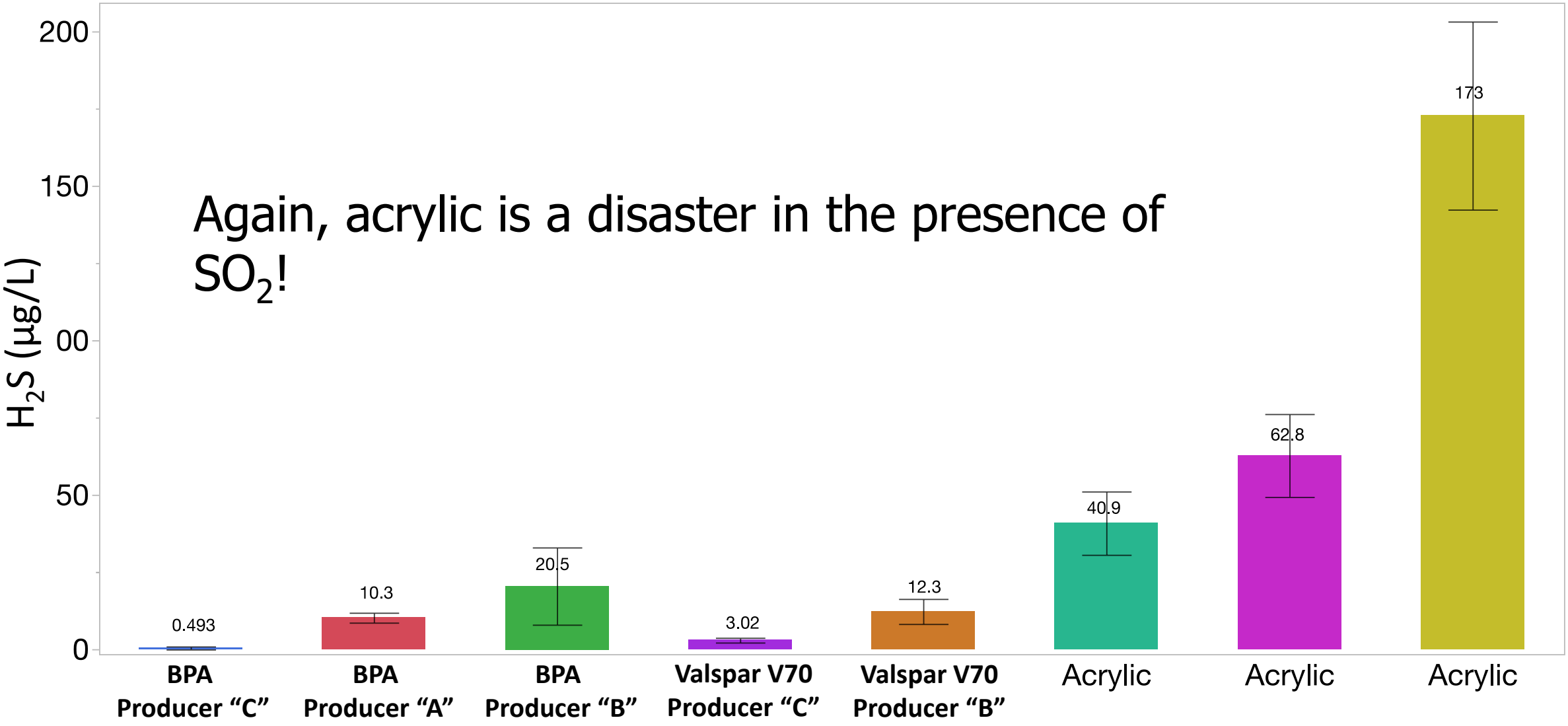
Bare aluminum – Poor Predictor of H_2S

- Bare aluminum shows opposite ABV effect, with a peak at 8%.
- Don't use bare aluminum as a metric for H_2S potential!



N = 3 for each bar, error bars are standard error.

Comparison of various liner performance



Sheehan, Montgomery, Goddard, and Sacks, *in review*

Accelerated tests allow us to isolate parts of the can

- Highest and most variable corrosion is in the headspace!
- Further suggests that neutral, volatile acids are correlated with corrosion.

Sheehan, Montgomery, Goddard, and Sacks, *in review*

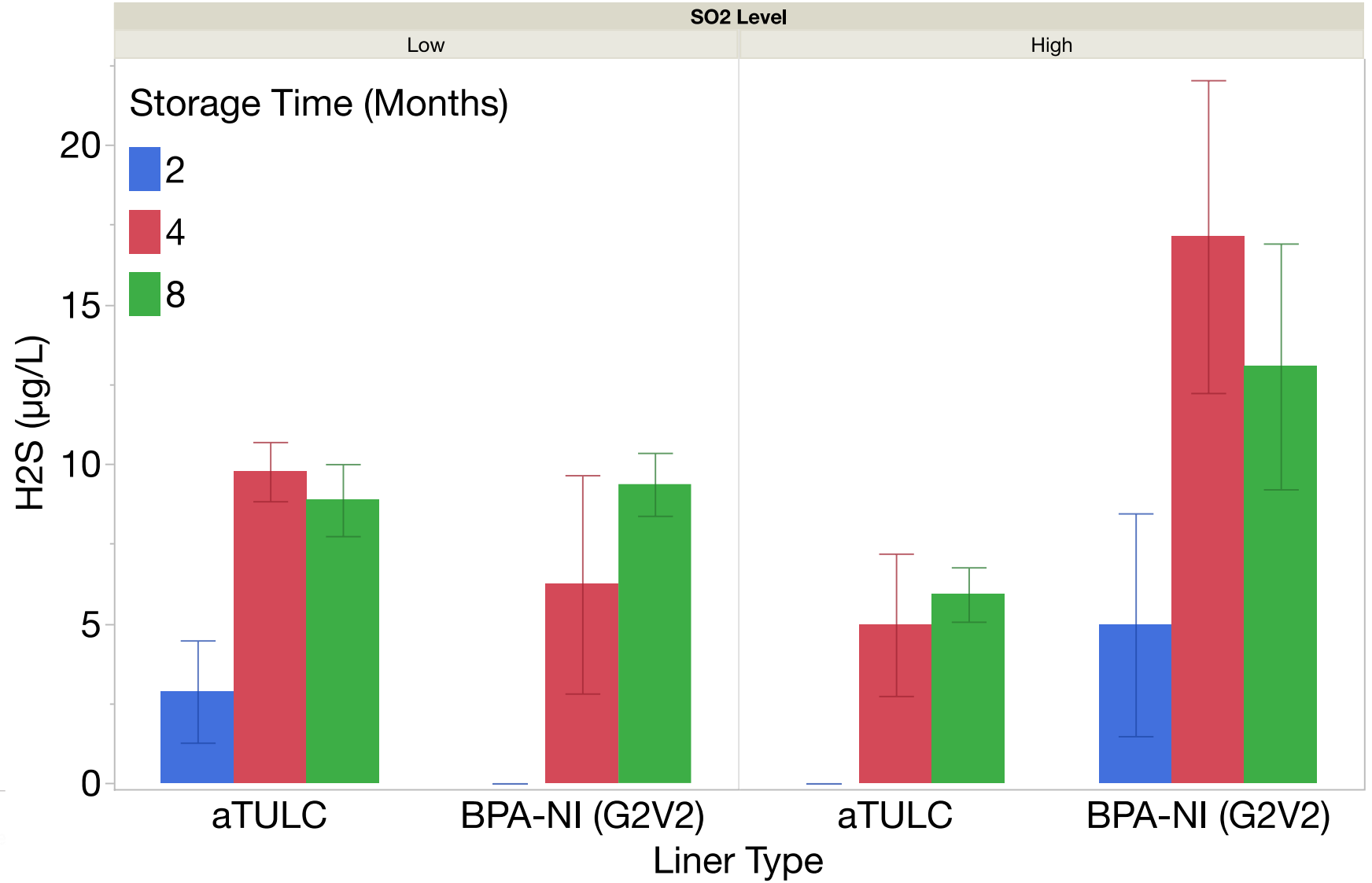
aTULC cans are a promising new liner

- aTULC cans are formed from extra thick PET-coated aluminum
  - More consistent application compared to spray on coatings.
  - Internal data (American Canning) suggests minimal scalping.

American Canning, 2022

Preliminary data suggests aTULC is good

- aTULC performed better than G2V2 at 4 and 8 months for a high SO_2 wine.
- Need more trials to confirm effect.



For Wines/Ciders

- Keep molecular SO_2 under 0.5 mg/L.
  - If high residual sugar, in-bulk HPP and velcorin are options.

- Try to stay away from acrylic liners whenever possible – BPA and BPA-NI are comparable in performance.
  - Get in contact w/ me if interested about accelerated aging protocol to test.

- Preliminary results suggest that aTULC is "good"!
  - More trials need to be conducted

General Takeaways

- When conducting shelf-life tests, the brand and type of liner matters!
  - Bare aluminum should not be used under any circumstance.
  - Producer A liner ≠ Producer B liner even if same polymer

- Be sure to use as many replicates as possible – these systems are highly variable… yet one bad sample can ruin a whole pallet!

- We don't fully understand this system! We are currently working on finding new metrics that can predict corrosion more completely than simply Al^{3+} or H_2S.

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