

Demystifying Anti-Mist Agents and Their Testing

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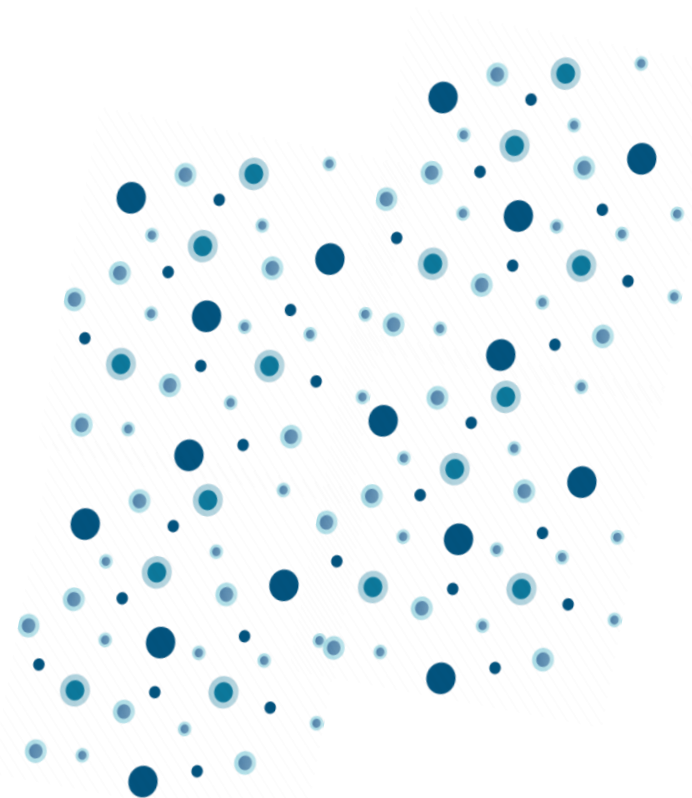
November 11th 2022

STLE Houston Chapter



Agenda

1. Backstory
2. Technical Need
3. New Approach to Quantify Misting
4. Benchmarking Base Oils & Anti-mist Agents
5. Summary & Future Work

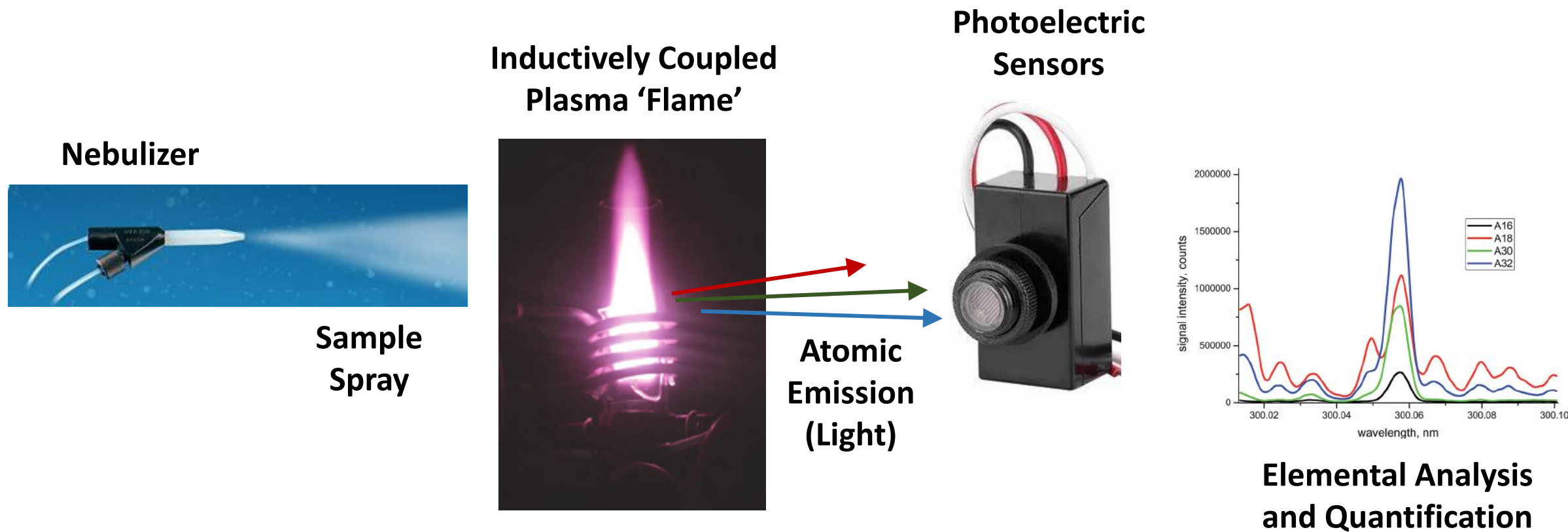


Backstory

- About 6 years ago:
- “We’re **adding** 2wt% of your viscosity modifier and it’s **removing** phosphorus from the formula.”



ICP (ASTM D5185) Process

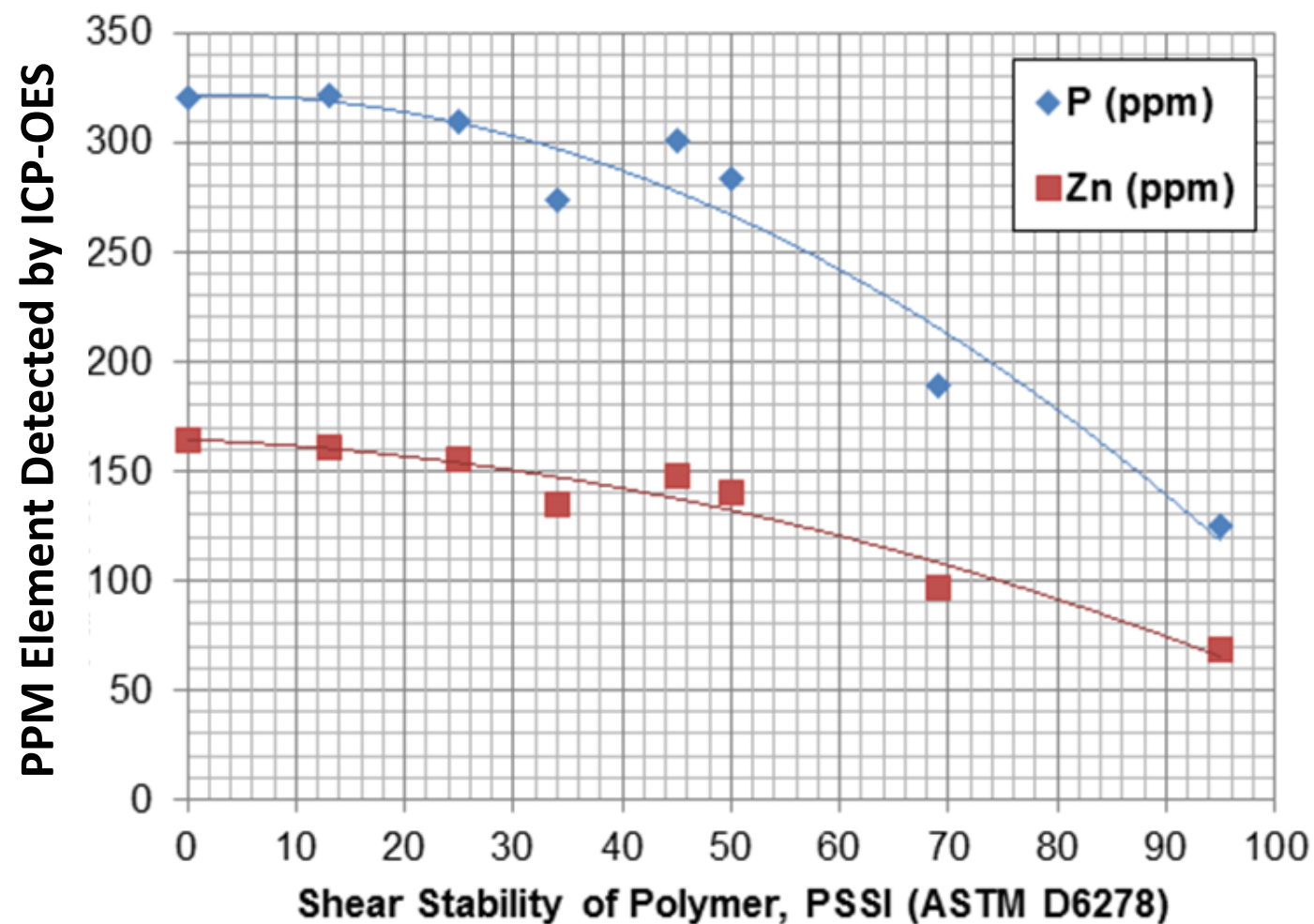


- Do you see a failure point?

Test method is ASTM D5185 - Standard Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

Capturing the Effect with ICP Experiment

- 2wt% VMs, different PSSI
- Constant loading:
 - 320 ppm P
 - 160 ppm Zn
- ICP result varies with PSSI
 - Anti-mist effect



Molecular Weight of VM →

Troubleshooting



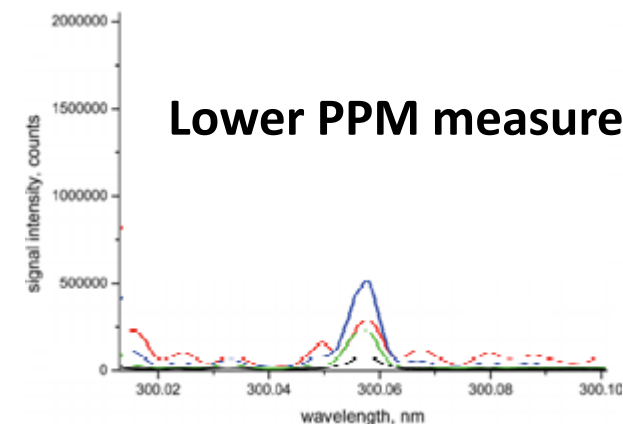
**Reduced
Mist
Due to
Polymer**

**Less elements
delivered to ICP**



**Reduced
light
emissions**

**Weak
photoelectric
signal to computer**

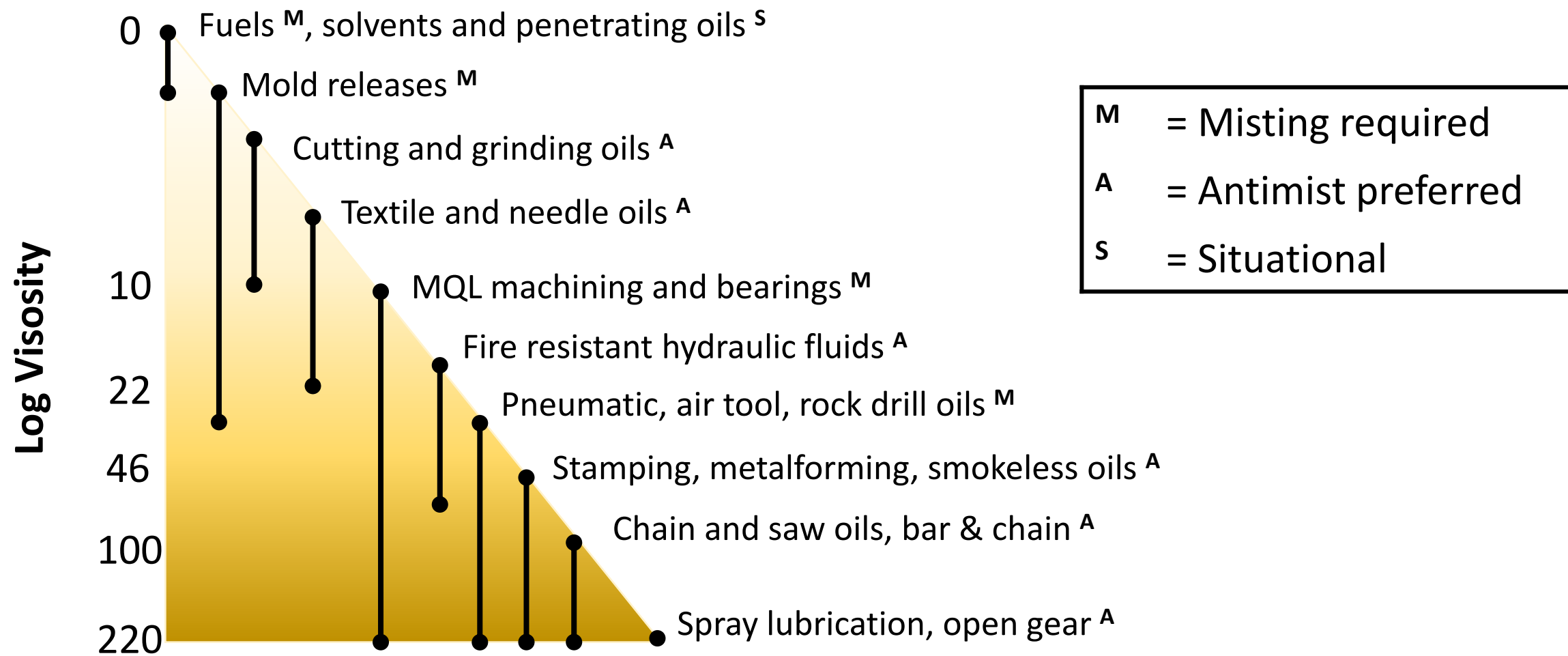


- Use XRF for formulations with high tack / VM or recalibrate!

Many Years Later...

- Polymers vs. misting
- Still no good / easy test method for rapidly iterating on formulas and hypotheses
- Still important to many corners of the lubricant market
 - And consumer goods, sprays, etc.

Key Areas for Misting or Antimist Lubes



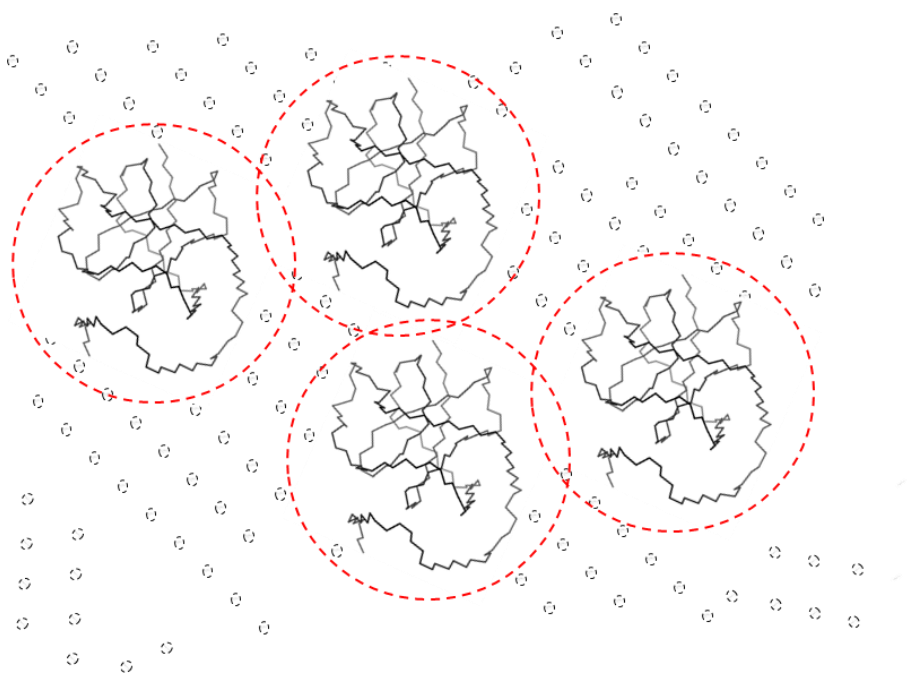
Petroleum EHS

- Aspiration Toxicity – < 20.5 cSt @ 40°C
 - 100 SUS oils including 4 cSt Group III, PAO4, etc.
- Acute Inhalation Toxicity
 - Low visc PAO i.e. PAO2
- Carcinogenicity
 - Naphthenic oils, process oils, kerosene
 - IP 346 – $>3\%$ DMSO extractable content
- Oil Mist Exposure Limit (OSHA/NIOSH) – 5 mg/m^3 average, 8-hours



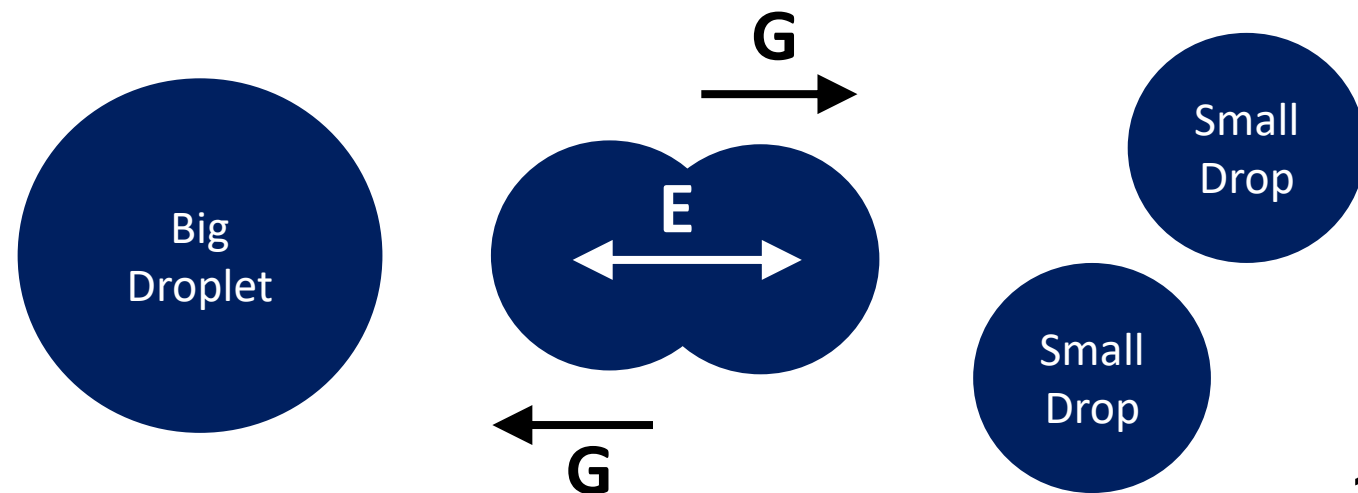
Use of Antimist Agents

- High MW polymers that add a slight **viscoelastic** behavior
 - Non-Newtonian
- Cohesion from viscoelasticity prevents droplets from splitting
 - Can even affect ICP mass spec nebulizers



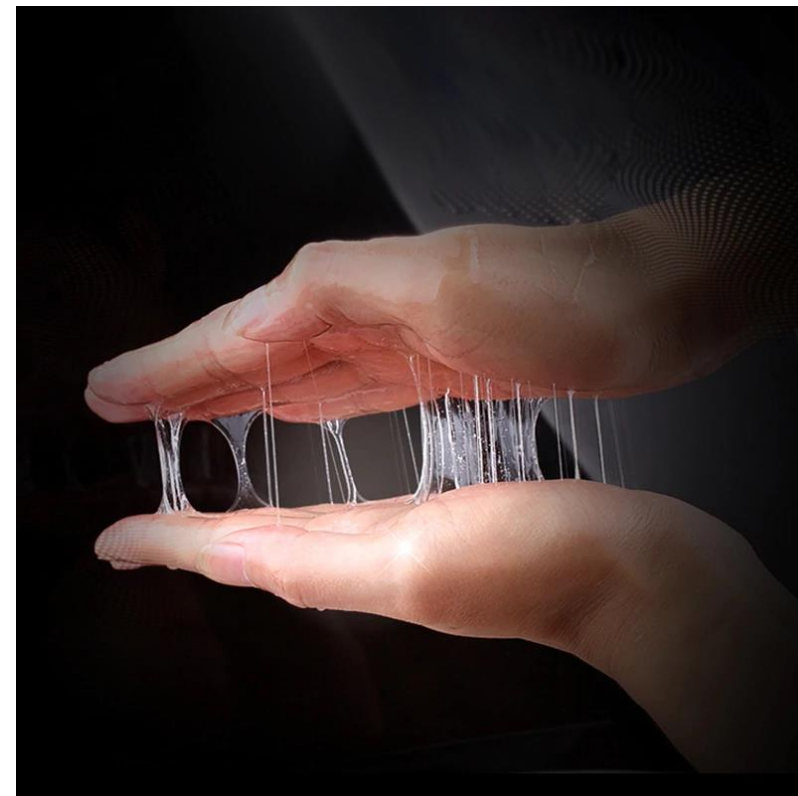
Why? Poisson Ratio Effect

- “Elongational viscosity” in some texts – what does this mean?
- Bulk Modulus (Compressibility) – solids and liquids
- Elastic Modulus, E – solids only
- Shear Modulus, G – solids only
- Viscoelasticity from polymer provides a non-zero E and G to droplets



Putting It Visually

- Viscoelasticity breaks some rules on what it means to be solid or liquid
- High shear (misting / spraying) activates a viscous response – anti-mist



Current Mist Testing

- ASTM D3705 (\$\$\$) aka 'oil mist reclassification'
 - Few test labs; complex
- Field trials (\$\$\$\$)
 - Trial & error; antimist additives can be added tankside
- Factory Mutual (\$\$\$\$\$)
 - Spray combustion test; typically after all testing has been done

A More Convenient Mist Test?

- Wish list for testing
 - Fast results for formulators
 - Easy to interpret
 - Low cost
 - Portable for use in the field
- Won't be all things to all people

Spray Bottle Test

- Low cost: ~\$1/each
- Repeatable: 0.44 grams per spray (+/- 2.2%)
- Portable: *Yes*
- Simple to operate: *Yes*
- Simple to interpret: ??

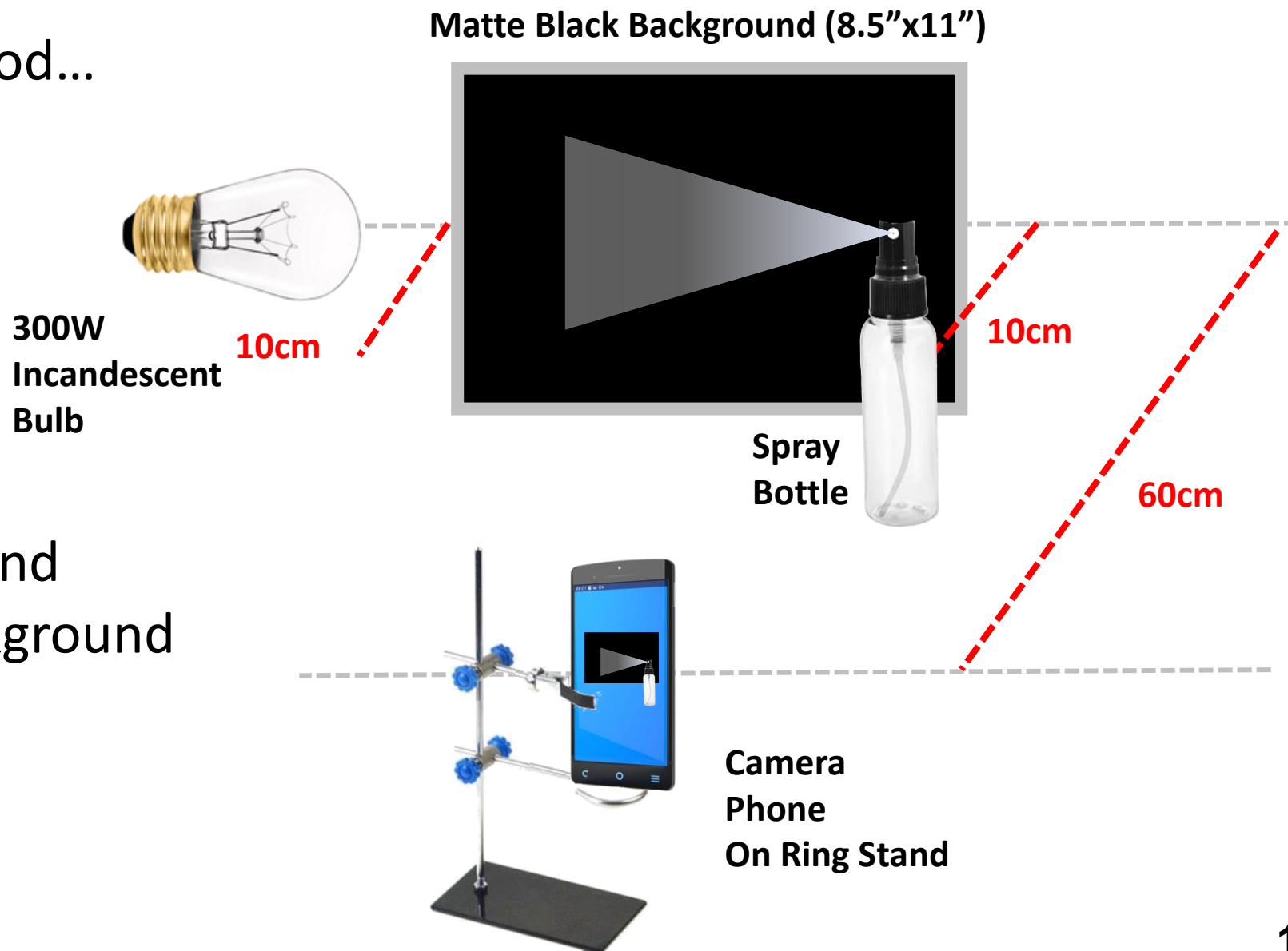


Final Setup

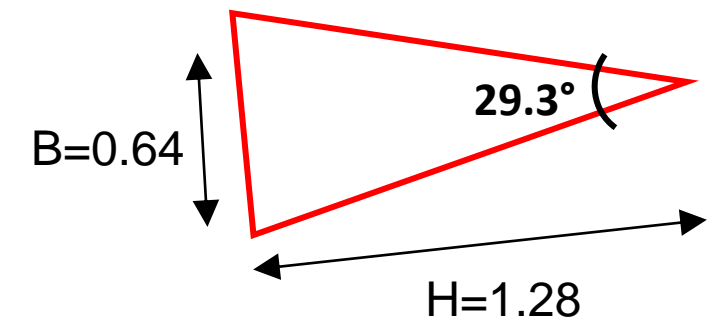
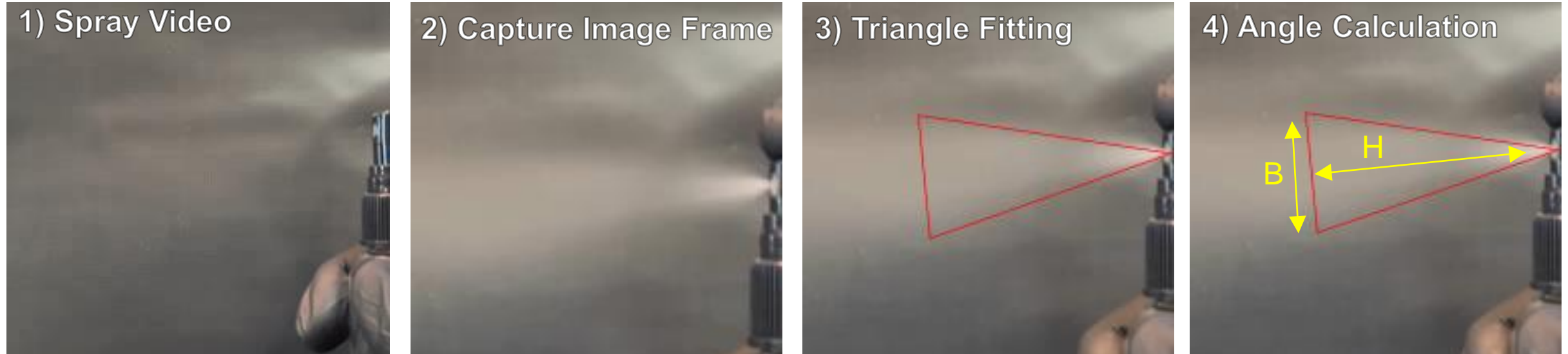
- In fully open fume hood...

Fine Points:

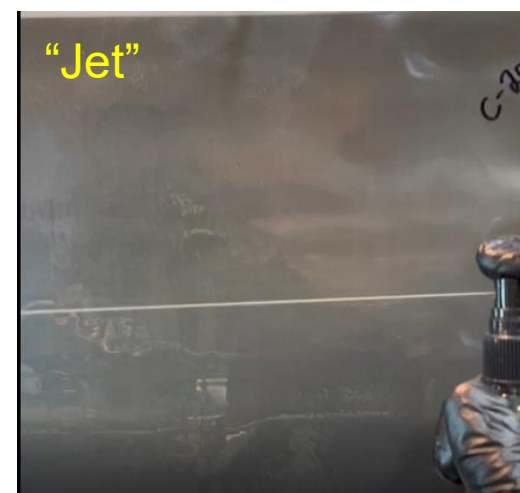
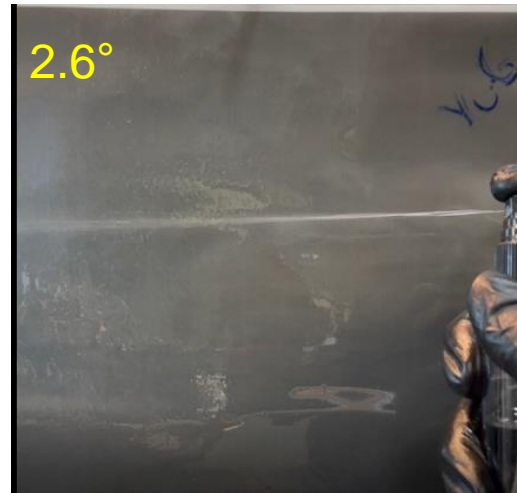
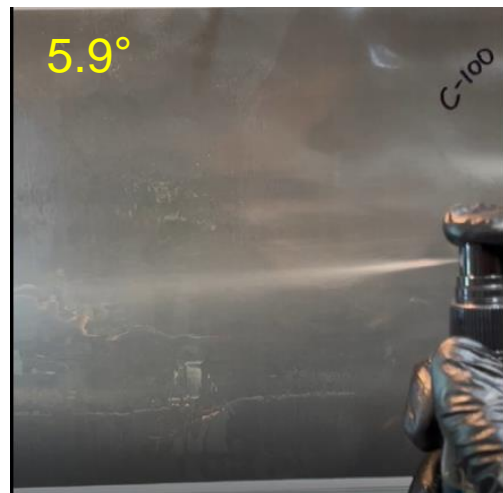
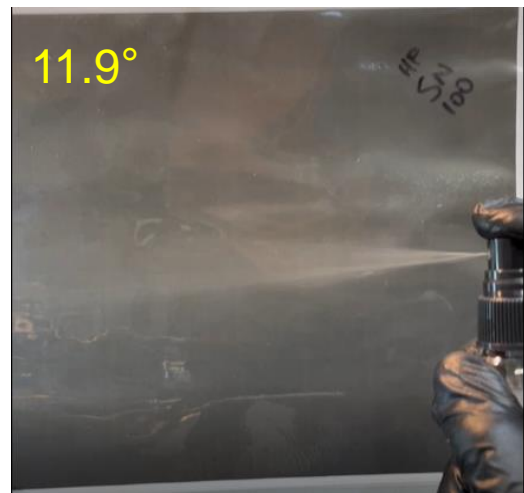
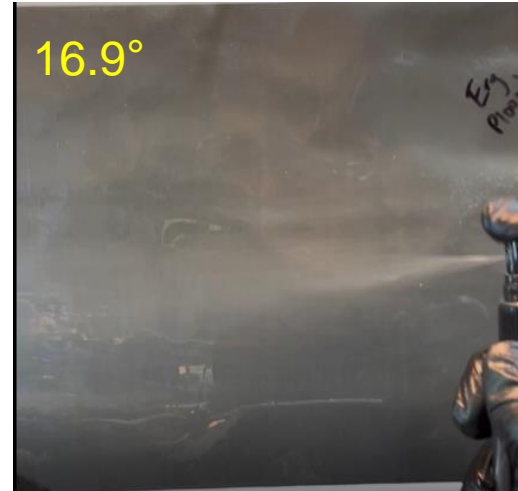
- Matte black background
- Bottle in front of background
- Spray into bright light
- Distances are relative



Data Collection

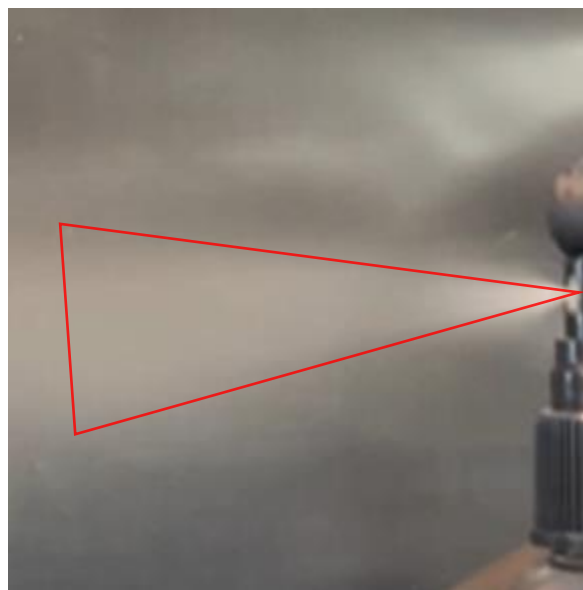


Spray Angles from 45 to 0°

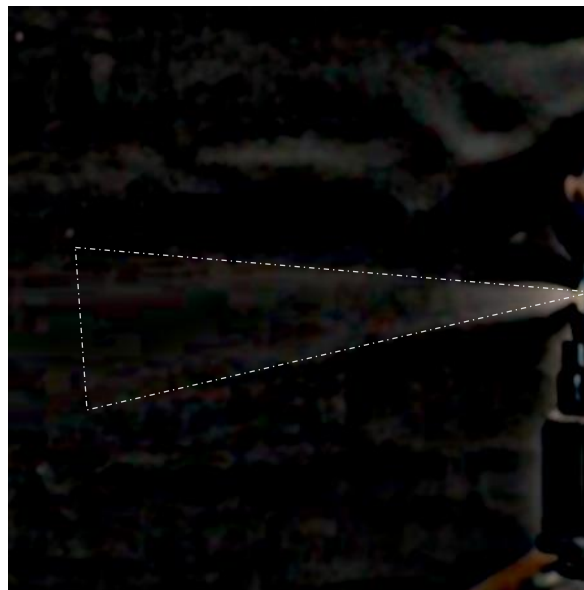


Removing Human Error

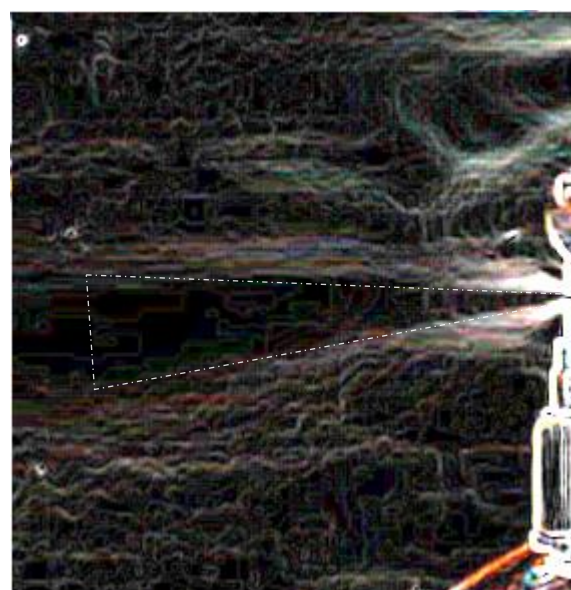
- Image processing to make spray angle calculation more repeatable
- Different post-processing methods don't agree



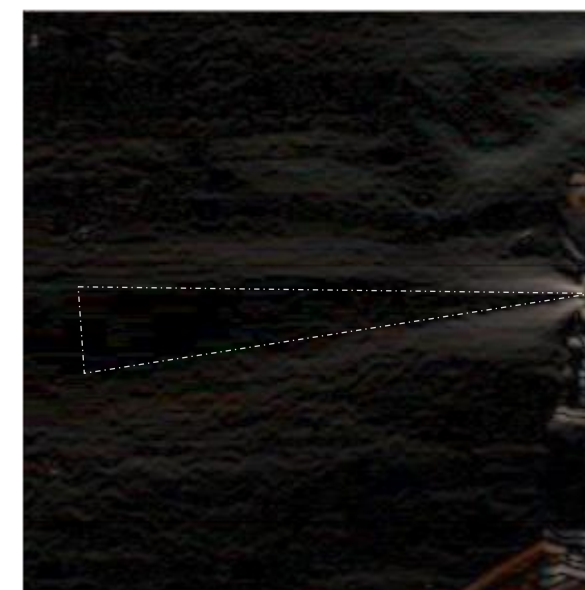
Full Color: 28.1°



'Difference of Gaussians'
Edge Detection: 18.1°

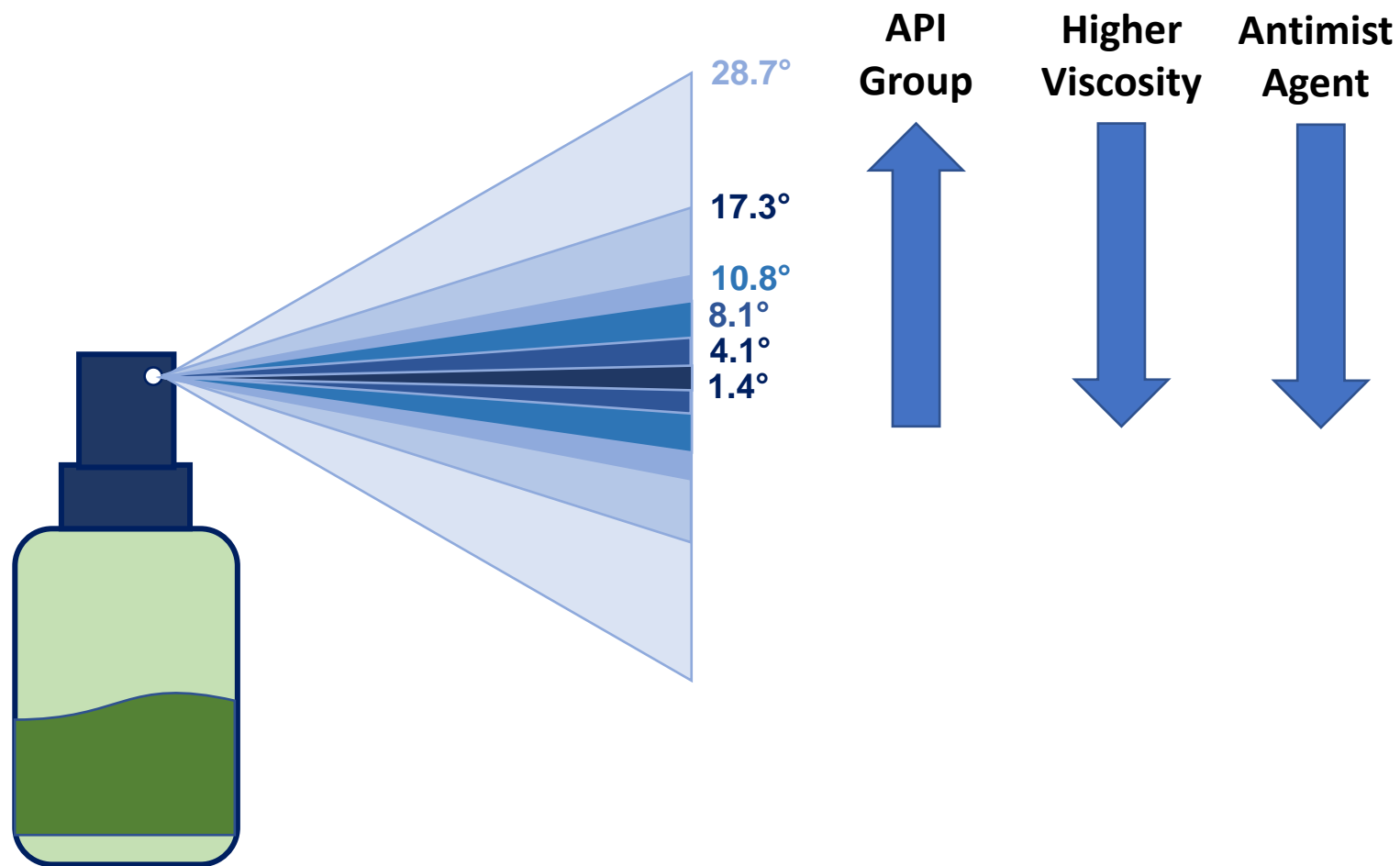


'Prewitt compass'
Edge Detection: 12.8°

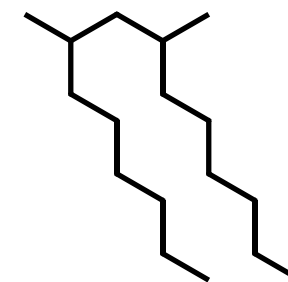
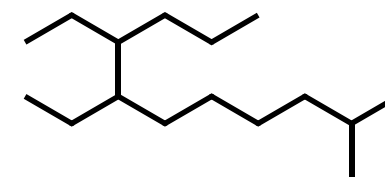
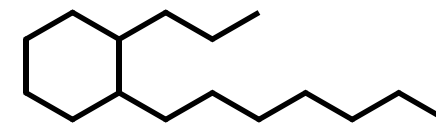
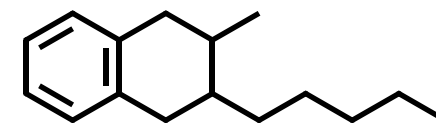
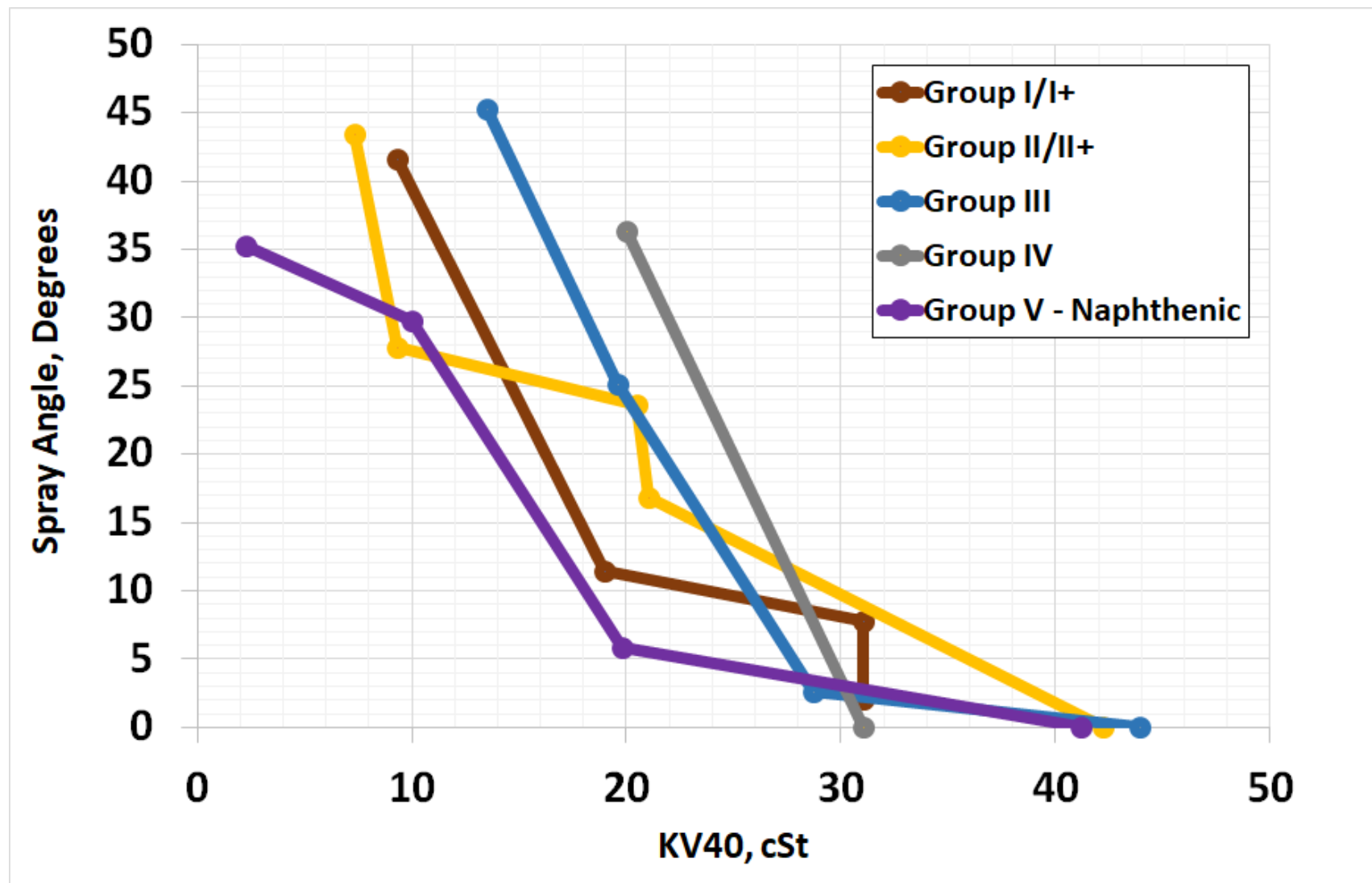


'Sobel'
Edge Detection: 9.6°

Misting Angle



Misting Angle by API Group and Viscosity



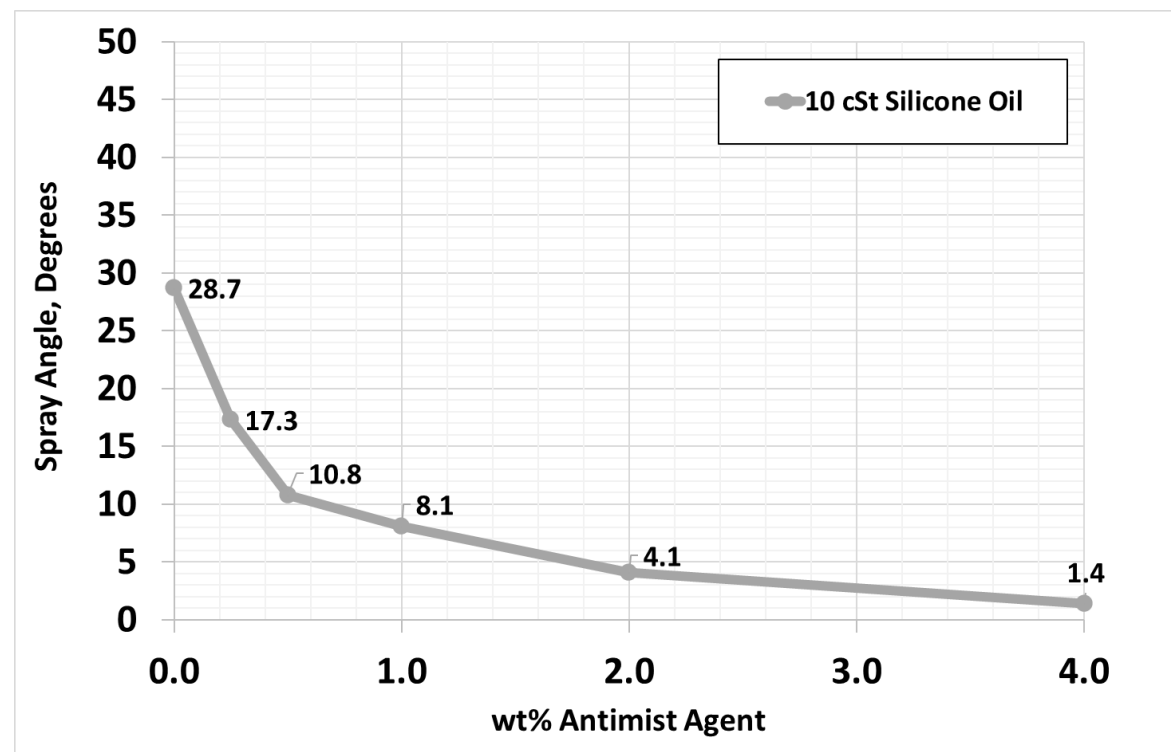
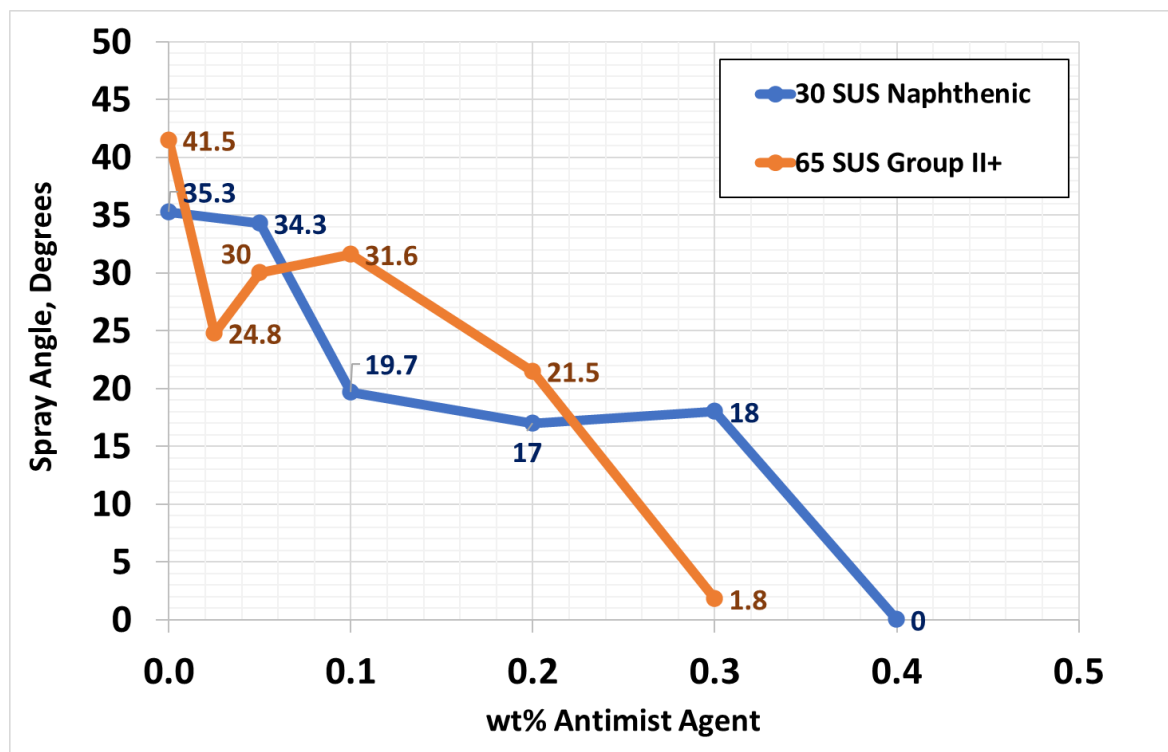
More
Refined

Lower
NOACK

More
Misting

Anti-mist Agents vs. Spray Angle

- High spray angle can be reduced by antimisting agents
- Spray bottle test captures this effect



Summary

Motivation

- Oil mist is performance parameter or hazard for different applications
- Very few test methods, tend to be complex
- An easy rapid test could allow us to control misting
 - Eliminate, or
 - Just enough misting without excessive exposure and overspray

Key Findings

- Use XRF elemental analysis (or non-spray test) for tacky elemental analysis
- ‘Spray bottle mist test’
 - Widely accessible, cheap, simple
 - Test is limited to 120-150 SUS oils with current bottle
- More refined oils mist more, but lower NOACK
- High molecular weight antimist agents reduce misting at low treat
 - Works for petroleum, silicone, etc.



Thank you for attending today's session!

Contact:

ewillett@functionalproducts.com



*Ask for a
spray bottle*

