

Case Studies in Sustainable Collection Care

Solvents, Scents and Sensibility

Part I

Swapping: Solvent Substitution Strategies

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Case Studies in Sustainable Collection Care

Please Note: This slideshow was originally presented in the Health & Safety Committee Session, *Sustaining the Conservator*, at the American Institute for Conservation's 42nd Annual Meeting on May 31st, 2014.

**Questions or comments, please contact:
HealthandSafety@conservation-us.org**

Sustainability...

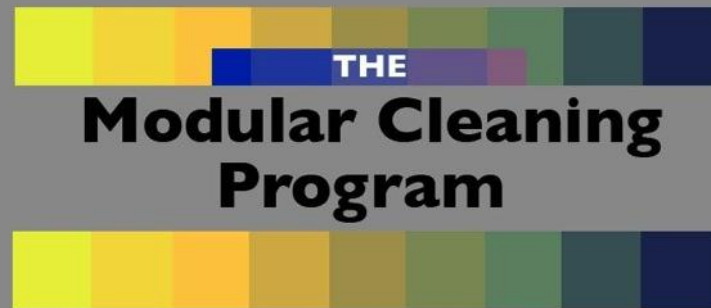
- As the topic is sustainability I'll be discussing sustaining the conservator and environment more than the title "Swapping – Solvent Substitution Strategies" implies.
- Please come to the Health and Safety session on Saturday @11:00 for Part II, "Sequestering and Minimizing" which is more the topic here...

Lessons Learned from Developing the MCP

(Modular Cleaning Program)

- I hope you all know the MCP – at least by name if not from direct experience
- If not, it started as a system for rapidly prototyping aqueous cleaning systems (for paintings) based on combining concentrated stock solutions.

The MCP in Use



Concentrated stock solutions



Mixing small amounts of stock solutions



Lazy and Cheap

- Stock solutions took time to make and materials are pricey
- Didn't want to waste solutions or money (or, in hindsight, I wanted to be more sustainable)
- New technique – new tools

$$1\text{mL} + 1\text{mL} + 1\text{mL} + 1\text{mL} + 1\text{mL} = 5\text{mL}$$



Mixing solvents or resin solutions: Not this...



... not even this ...



... but this.



Recyclable? Yes!

But better to wash and reuse indefinitely!

Testing?

- 25% Isopropanol : 75% Mineral Spirits
 - 1mL isopropanol and 3mL mineral spirits
- ~10% Regalrez 1094 in ShellSol D-38
 - 5mL 33% stock Regalrez solution and 10mL ShellSol
- Work from concentrated stock solutions with long shelf life and dilute small amounts as necessary for use.
- Avoids bottles at different dilutions on shelf

A short digression

Sustainability is often regarded as kind of a “hippie” issue.

Okay, so let's roll our own...

- Rather than use pre-rolled cotton swabs on hardwood sticks
- Toothpicks to bamboo skewers
 - Different sized handles
 - Different sized cotton bit on top
 - Different shapes

Variety



Skewer too long? Hmm.



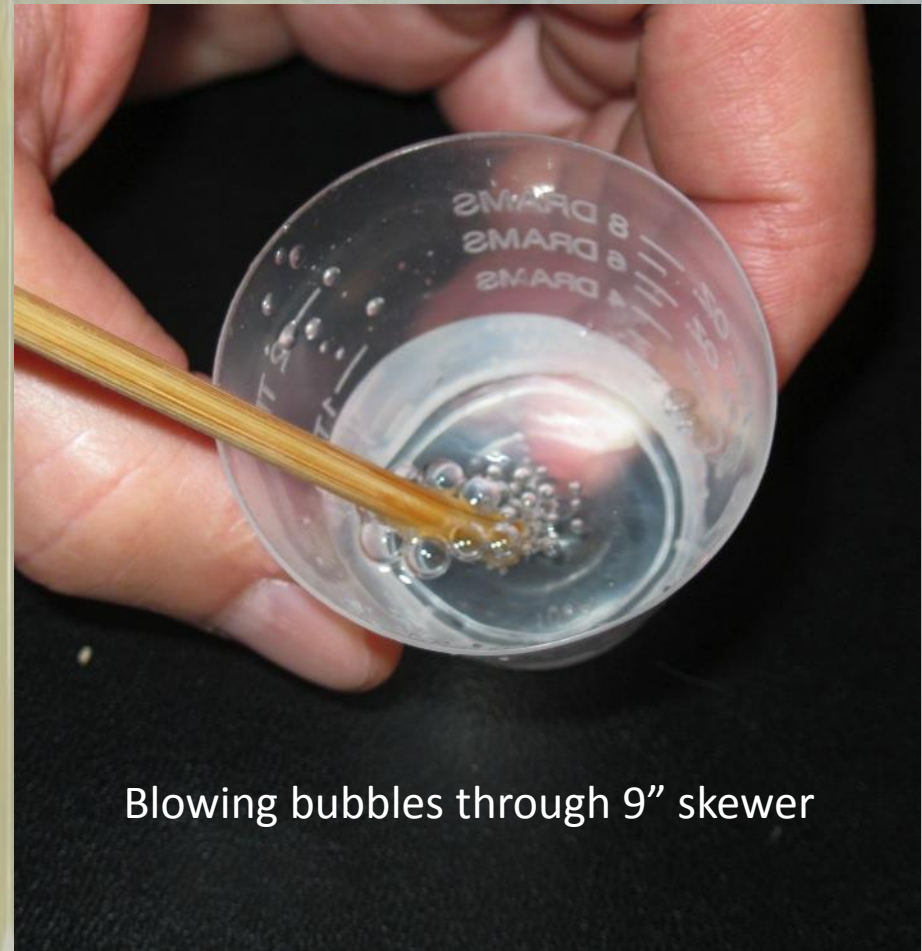
Bamboo

- Super “green” material
- Grows fast
- Sustainable



The Problem with Bamboo

- Vessels in bamboo can easily transport solvent from the tip to your hand.
- My first attempt to mollify the problem was to dip the hand-end in shellac. When I used alcohol on the swab, my whole hand got sticky.
- Surprising how much solvent passes through bamboo so easily and quickly.



Blowing bubbles through 9" skewer

Make Friends with an Objects Conservator

(if you are not an objects conservator yourself)

Extra Hxtyl epoxy left over from a treatment

- Color code end with marker
- Dip/coat 2/3 of skewer into epoxy – handle end
- Leave front 1/3 of skewer uncoated to grip cotton
- Let cure



But enough fluff



What you really came here for:

- Is there a perfect, safe substitute for xylene?

Nope

(Damn)

But we will talk about solvent substitution strategies in Part II in the Health and Safety Session, Saturday @ 11:00 – 11:30

A gooey future for conservation

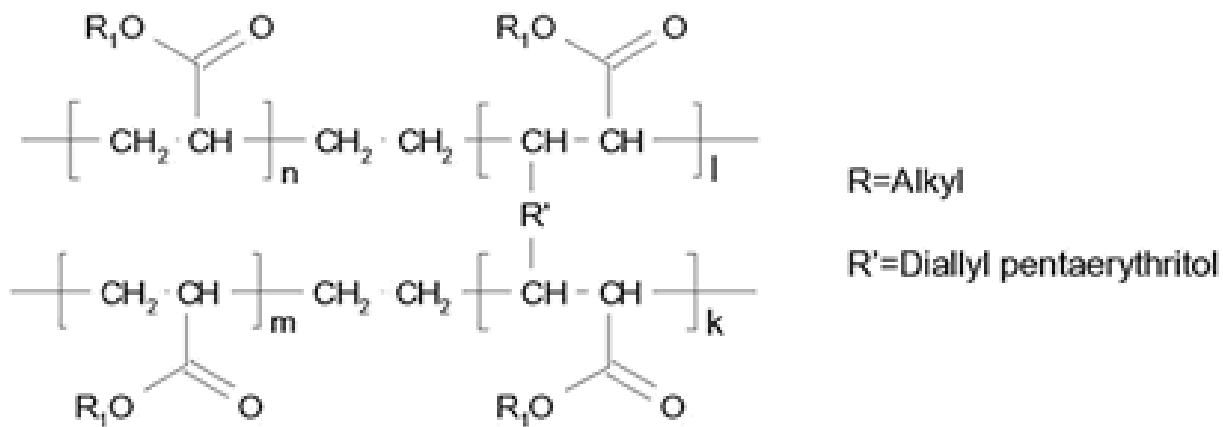
Whenever possible, replace solvents with Pemulen TR-2 emulsion.

- Still figuring it out
- Seems simple, and it is, but details are bedeviling
- Aspects are counterintuitive
- Many dimensions to think about
- Countless permutations

Pemulen TR-2

- It is a copolymer – poly(acrylic acid) with C10-C30 alkyl acrylate. The C10-C30 groups are interspersed with the acid groups that we find in Carbopol.
- So, within the same polymer molecule, there are domains of polar, Carbopol-like poly(acrylic acid) and non-polar regions areas of C10-C30 hydrocarbons.
- C10-C30 hydrocarbons work as virtual surfactant micelles
- Introduced to conservation by Richard Wolbers
- Basis for sunscreens formulated without irritating surfactants

Pemulen



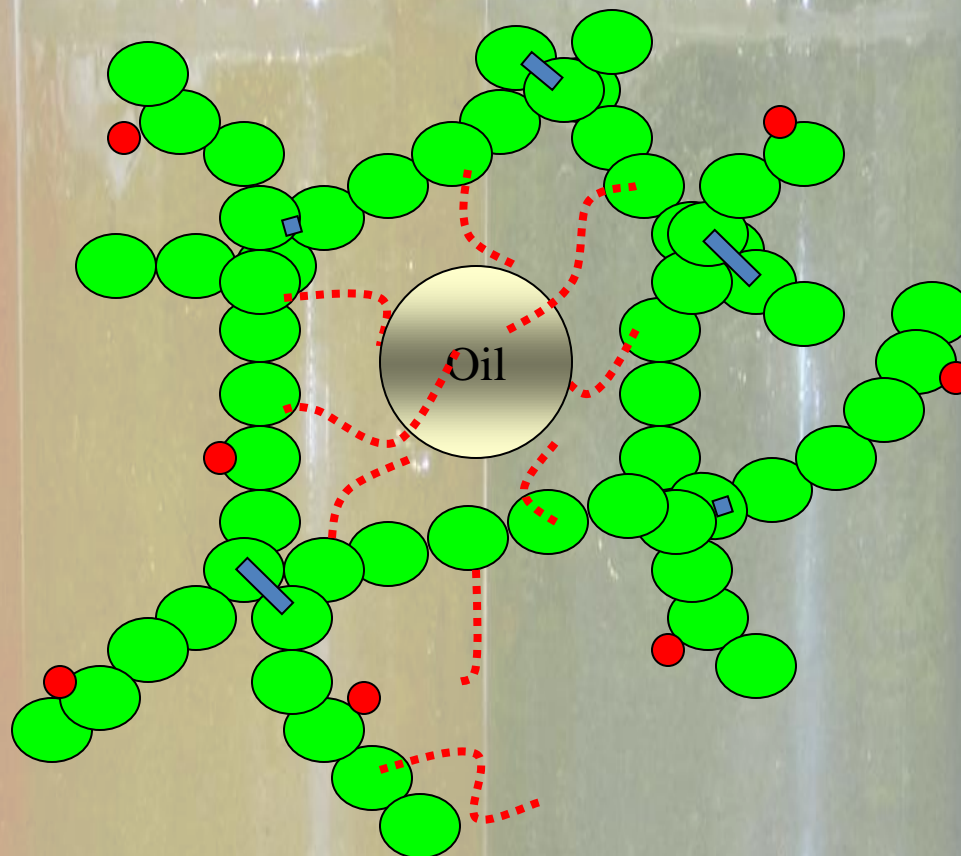
R=Alkyl

R'=Diallyl pentaerythritol

Acrylates/C10-30 Alkyl Acrylate Crosspolymer

"Oil in Water" Surfactant-Free Emulsion

Water



Water

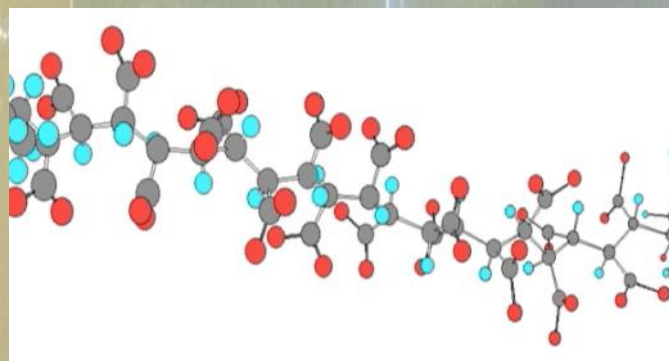
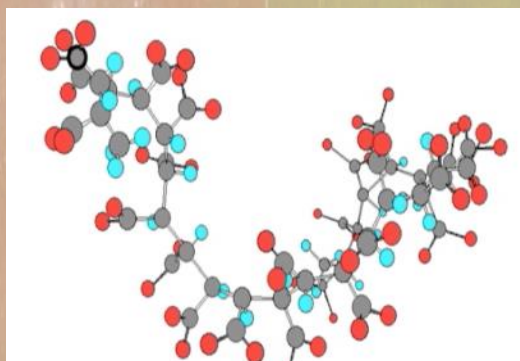
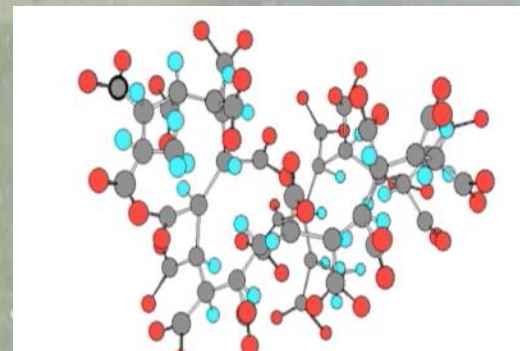
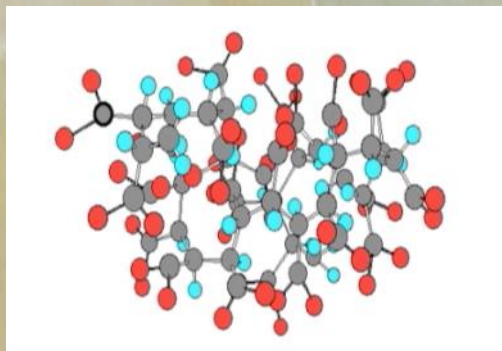
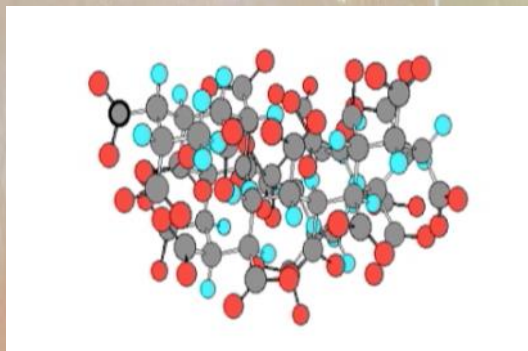
C15-30 Alkyl Acrylate Cross Polymer

Diagram by Richard Wolbers

Using Pemulen

- Gelled water
 - Typically used at 1% Pemulen (1 gram in 100mL)
- Base added to “relax” polyacrylic acid backbone
 - TEA (triethanolamine) or TEA + NaOH for pH 8.0 and 8.5 most commonly used

Base deprotonates acrylic acid groups in Pemulen



Tightly wound Pemulen relaxes and extends into water to gel solution.

Base also sets pH of Pemulen Gel

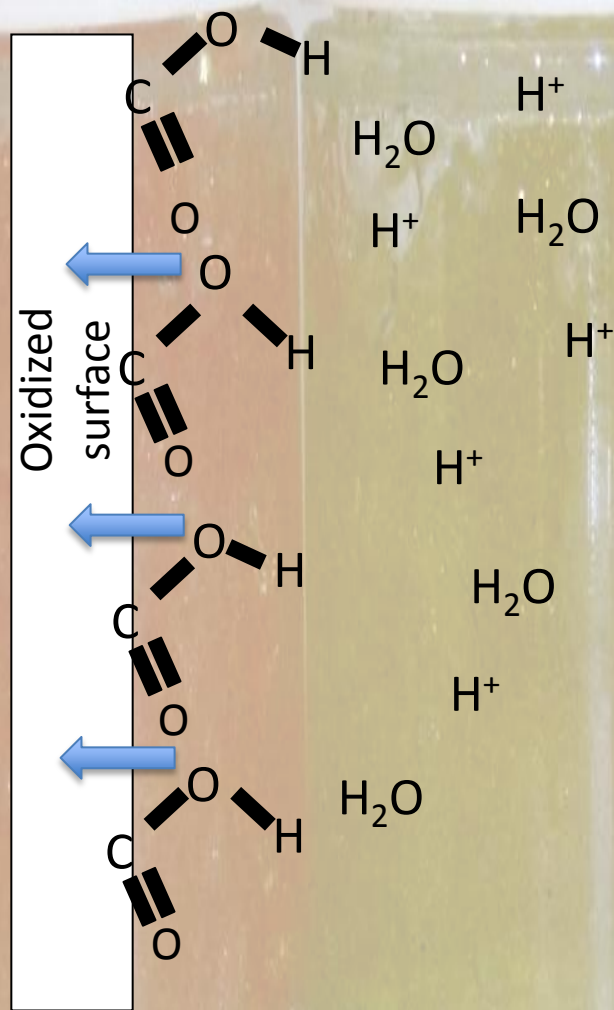
Pemulen usable from about pH 6.0 to pH 8.5

- Use TEA as base up to pH 7.5
 - pKa of TEA is 7.76
- Use TEA and NaOH solution above pH 7.5

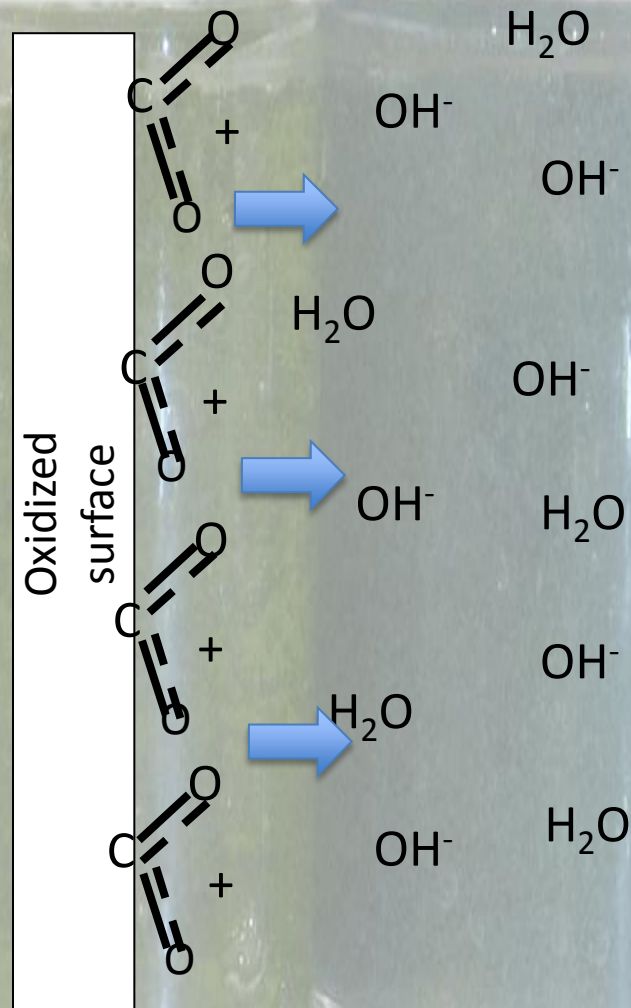
Choose pH

- Smart choice of pH of Pemulen
- Higher pH will tend to pickup oxidized material
- Low pH will tend to hold oxidized material onto surface

Low pH



High pH



Be Clever

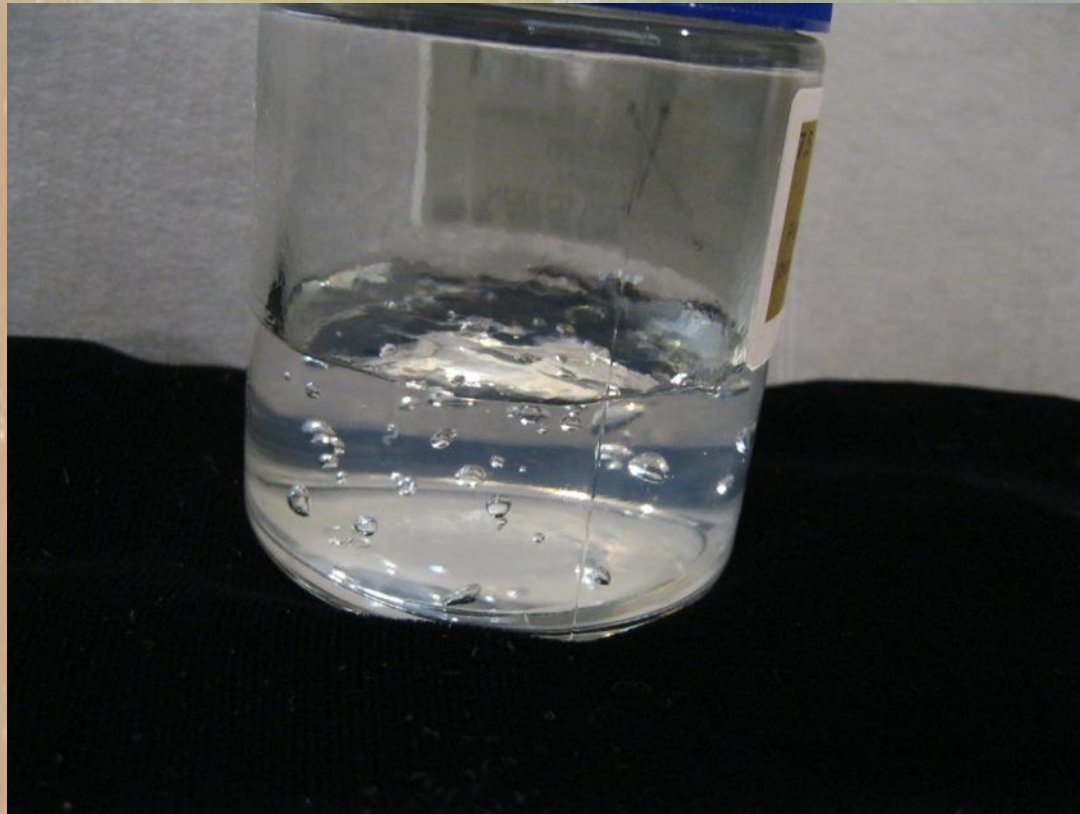
- Add other things to aqueous Pemulen gel
- Chelating Agent
 - Citrate
 - EDTA
- Control ionic strength (aka conductivity)

Add solvent to make emulsion

Any non-water miscible solvent

- Benzyl alcohol
 - Best – very safe
 - Alcoholic functionality
 - Aromatic functionality
- Xylene or Toluene (pick your poison)
- Mineral spirits

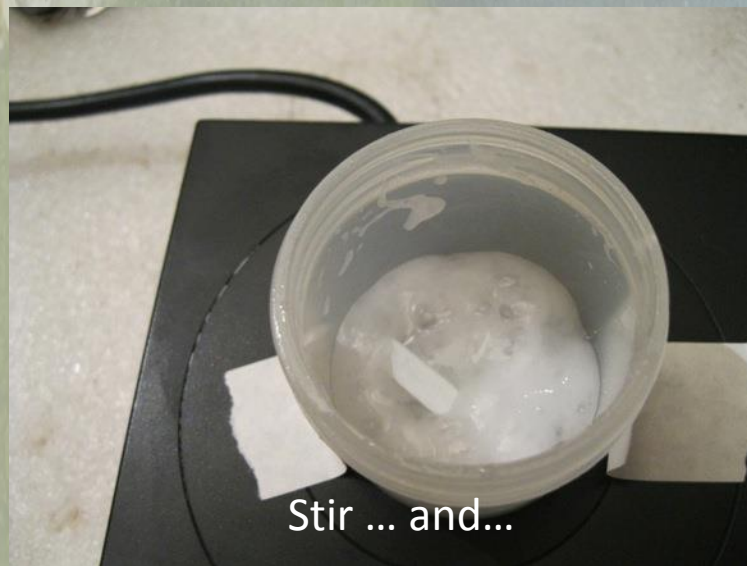
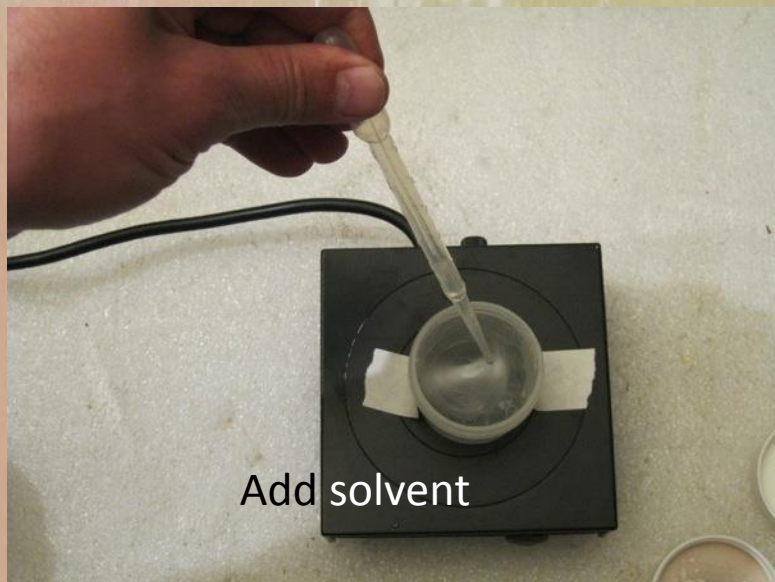
2% Pemulen (MCP Stock Gel)



Aqueous 1% Pemulen pH adjusted when prepared as stock other components added

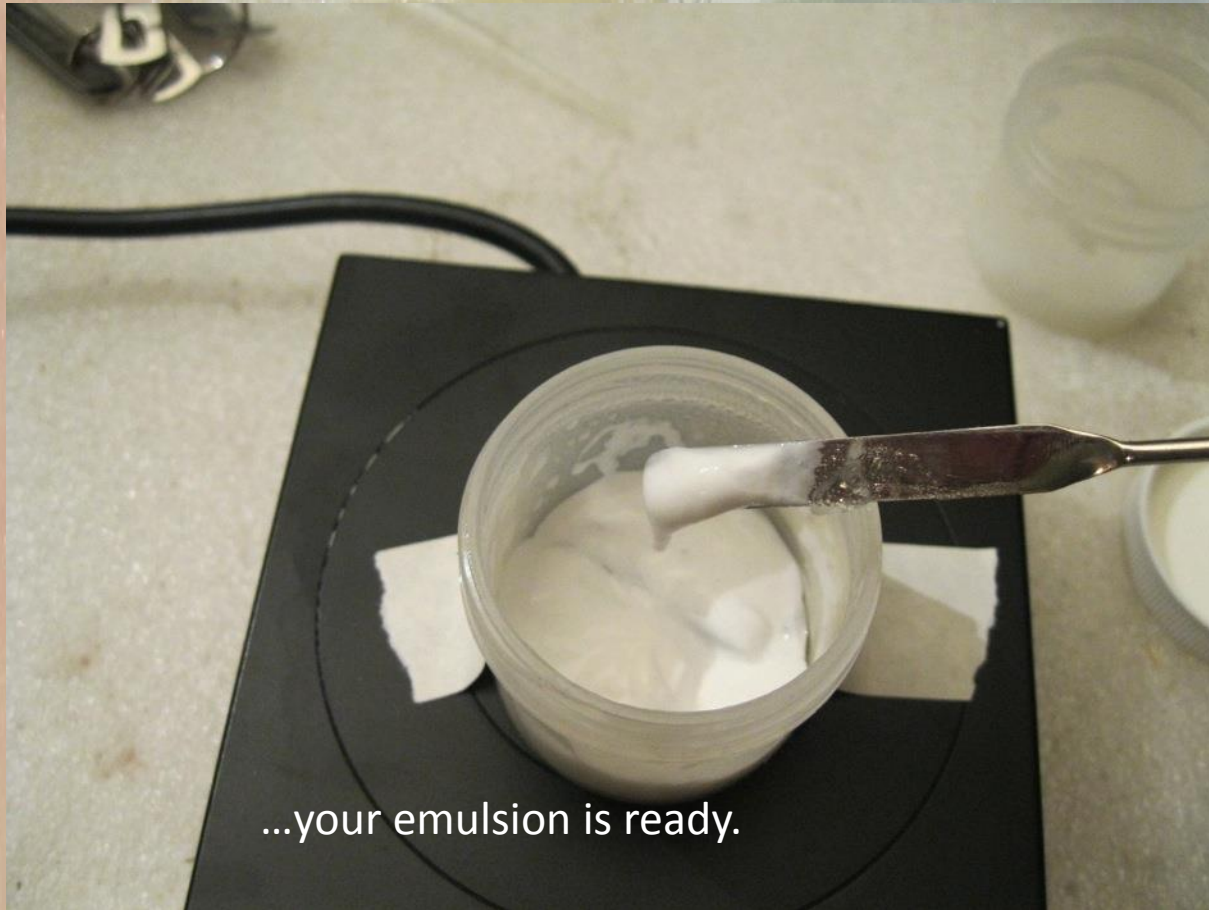


Add Solvent



Again, working in small quantities from stock solutions.

Instant Emulsion First Time – Every Time



...your emulsion is ready.

Solvent Phase

- Surprisingly little solvent is required
 - 5% - 10% is often sufficient
 - Up to about 30%
- O/W (oil in water) emulsion
 - Still water-based (water is continuous phase)
 - Clears with water
- Must be cleared!

Look Ma, no smell!

- Solvent is suspended in virtual micelles
- Very difficult for it to evaporate from gel
- Even with the maximum amount of solvent the Pemulen can hold, it's still only 30-40% and usually much less

New system, new tools

- Best to use brush of appropriate size to apply and work gel
 - White nylon bristles
- Can see color of material being removed in contrast with the white of the bristles
- Very satisfying feel
- Be generous with gel (not like photo)
- Never let gel dry on surface – It's not a poultice!!!



Clearing (rinsing)

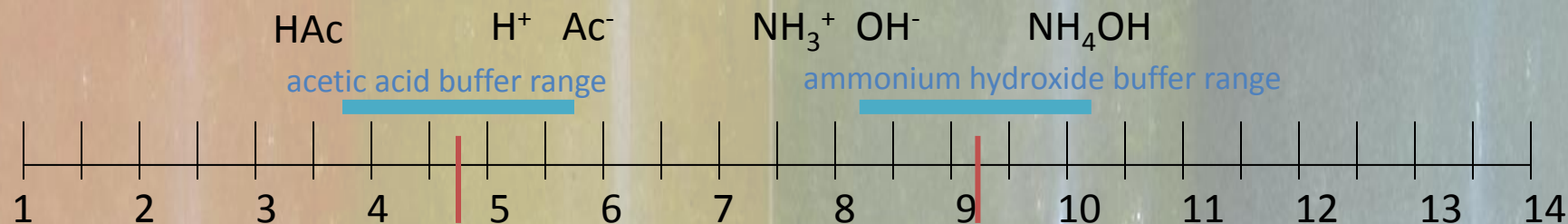
pH Adjusted Water

a dilute mixture of

- ammonium hydroxide
- acetic acid

(acid neutralizes base / base neutralizes acid)

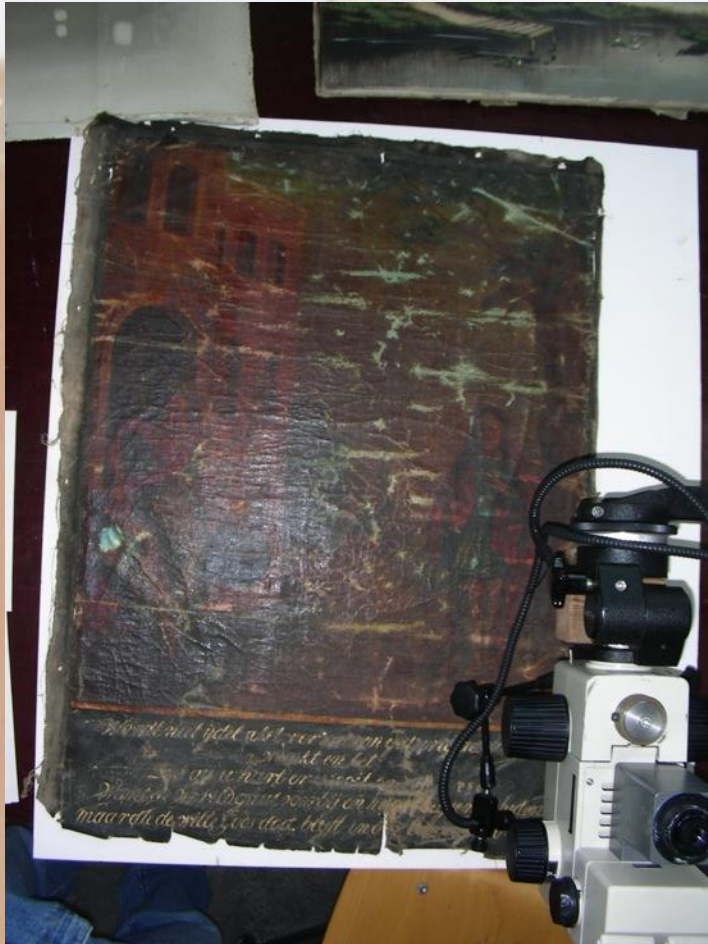
(1000 $\mu\text{S}/\text{cm}$ \sim 0.05% -- 1ml acetic acid in 2 L water)



Acetic Acid: $\text{pK}_a = 4.756$; buffer range approximately 3.8 – 5.6

Ammonium Hydroxide: $\text{pK}_a = 9.25$; buffer range approximately 8.3 – 10.1

An Example

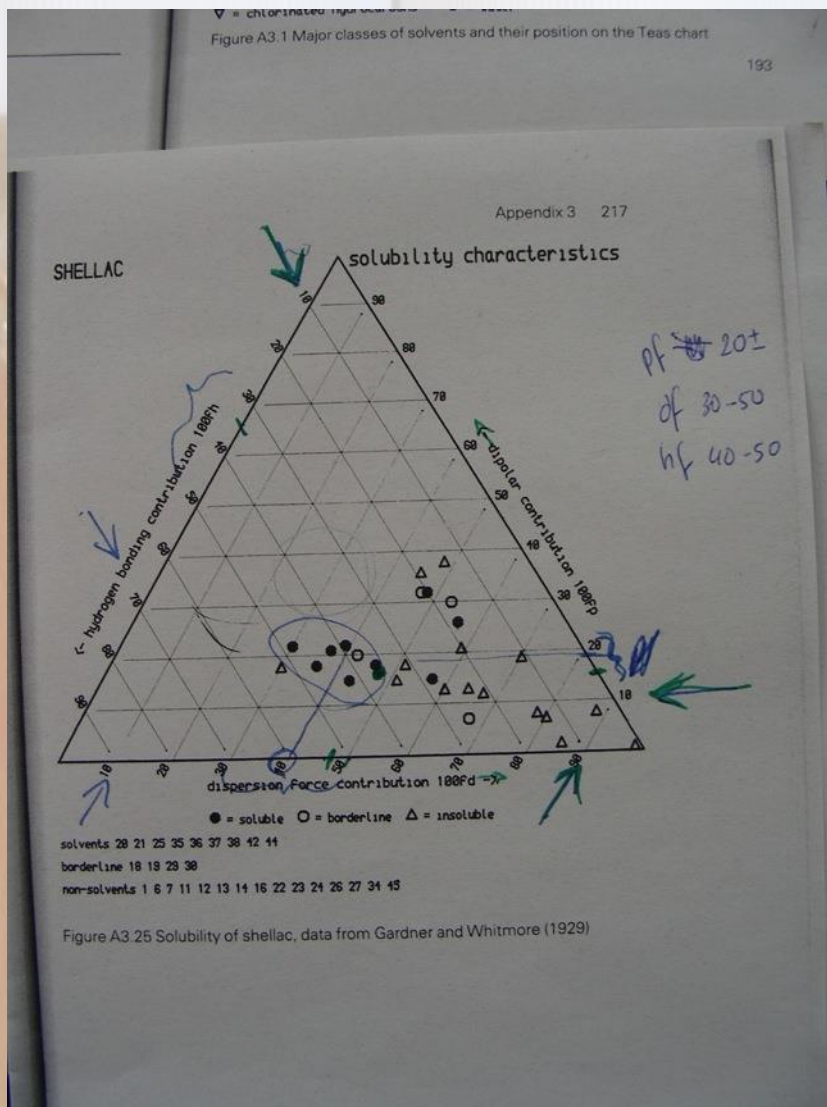


A sample painting from a workshop at SRAL in Maastricht.

Test painting had defied cleaning – thick, old, oxidized shellac

A solution by two very clever participants that I would not have thought of.

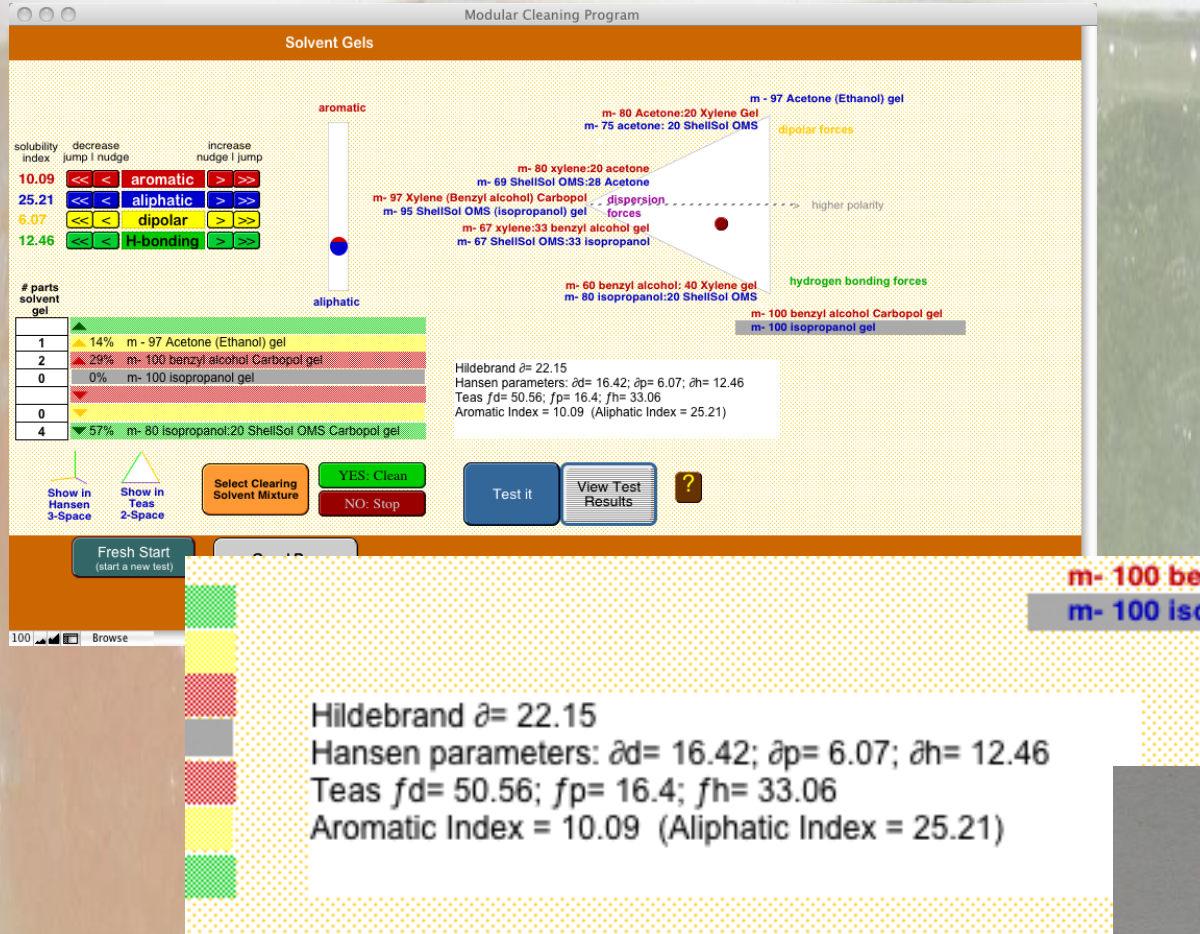
An Example



Suspecting that the coating was shellac based on solubility and UV fluorescence, they began trying solvent gel mixtures.

They went to the library and got a Teas diagram for shellac and determined the Teas parameters for optimum solubility.

Formulated a Solvent Gel with the MCP



They then manipulated the MCP gel calculator to find a solvent gel mixture with Teas parameters as close as they could to those read from the diagram.

*pf 20±
df 30-50
hf 40-50*

And...



They noted in the record for the testing that: “...the varnish is really dissolving with two applications of the gel and rinsing but little fragments of varnish left on surface; with three applications the result is wonderful”

They felt that the varnish layer below the shellac remained intact.

And then...



Richard Wolbers went to teach his workshop the following year.

Mixed up a Pemulen emulsion with 10% Benzyl alcohol.

Worked just as well if not better.

Cleared with water.

Disposal of Excess Emulsion

- Spread out on toweling and allow solvent to evaporate
 - Dispose of as common waste after solvent has evaporated
 - Doesn't sound particularly good, green, sustainable or even legal in some areas
- Don't want emulsion contaminating waste solvent stream
 - Can rust out steel drums and swell plastic liners over time
- pH adjusted water – down the drain

How I mix Pemulen

- 2% Stock gel – can be diluted with water or MCP components to allow chelators, etc. to be added
- To make 200 mL of stock gel
 - 4 grams Pemulen onto 100mL of distilled (or deionized) water in screw-top jar.
 - Cap and shake like crazy
 - Let stand for ½ - 1 hour, shaking occasionally

How I mix Pemulen (part II)

- stock gel (continued)
 - Add specified amount of TEA to 100mL distilled (or deionized) water
 - Swirl to mix TEA and add to swollen Pemulen paste
 - Cap and shake like crazy
 - Let stand a while longer, shaking occasionally

How Much TEA to Add

- Amount of TEA determines gel's pH
- I've published three (3!) different sets of recipes – so far all have been wrong.
- Difficulty of measuring pH accurately
- pH meter gives very bad reading (reference junction clogged?)
- pH strips better – not that accurate and hard to read (problems of gel wetting paper)

pH Measurement (cont.)

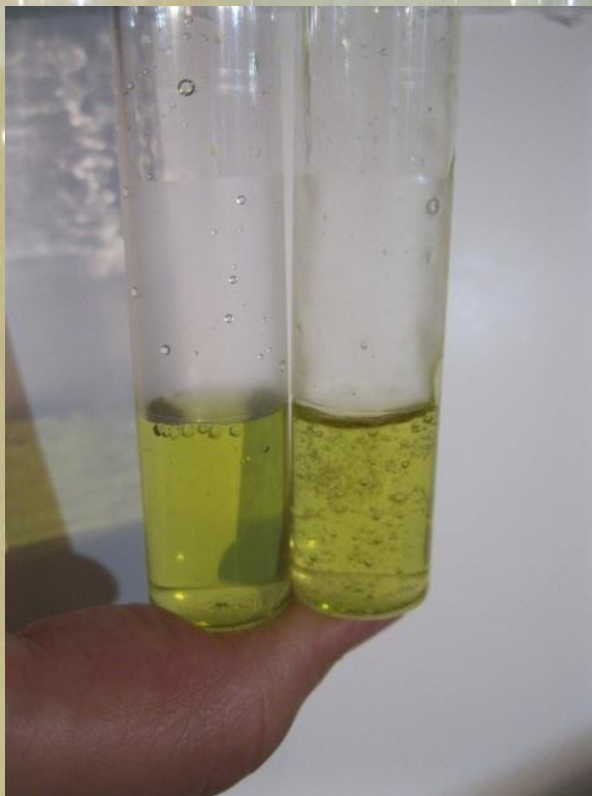
- Started using poor-person's spectrometer: pH indicator dye and color comparator.



Very Pretty



Compare with Buffer Solution



pH reference buffer | 1% Pemulen Gel

New Recipes

(I sure hope these are right)

- For 4 grams Pemulen TR2, add:
 - pH 6.0 – 4.5 grams (4.0mL) TEA
 - pH 6.5 – 5.0 grams (4.5mL) TEA
 - pH 7.0 – 5.5 grams (4.9mL) TEA
 - pH 7.5 – 9.0 grams (8.0mL) TEA
 - pH 8.0 – ??? (will use TEA and NaOH)
 - pH 8.5 – 9.0 grams TEA (8.0 mL) + 6.2 grams (5.6mL) 10% NaOH solution

Maybe these are finally right

