Driving Balance of Properties at Lower VOCs in Waterborne Industrial Maintenance Coatings

WCS 2015

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Agenda

- Innovation Drivers in Coatings
- National VOC Restrictions
- Balance of Properties in Waterborne Industrial Coatings
- Hardness/Block/Corrosion Performance Survey
- Polymer Design/Monomer Toolbox
- Next Generation Technology

Innovation Drivers

- All about EHS – many examples driving technology changes
  - VOC reduction
    - Reduction/elimination of coalescing solvents
    - Low maximum incremental reactivity (MIR)
    - Low hazardous air pollutants (HAPs)
    - 100% solids epoxies
    - Conversion to water – 2k epoxies, 2k urethanes, alkyds
  - APEO-free
  - Chromate-free
  - Isocyanate-free
  - BPA-free can/bottle coatings

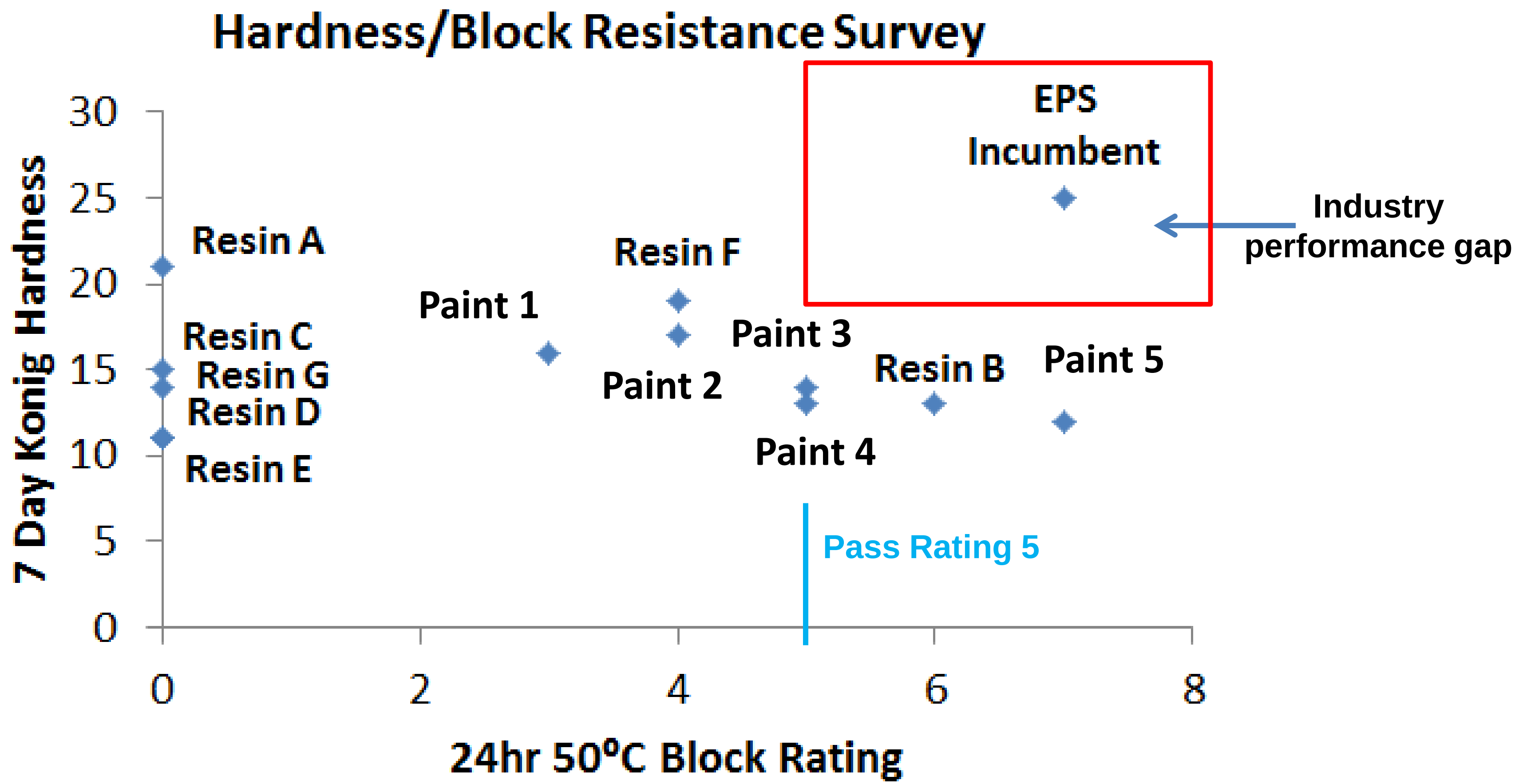
VOC Restrictions

Regulatory Body	IM VOC Limit (g/L)	Rust Preventive Limit (g/L)
EPA	450	400
CARB	250	150
South Coast (SCAQMD)	100	100
OTC	250	250
Canada	340	400
LADCO	340	400

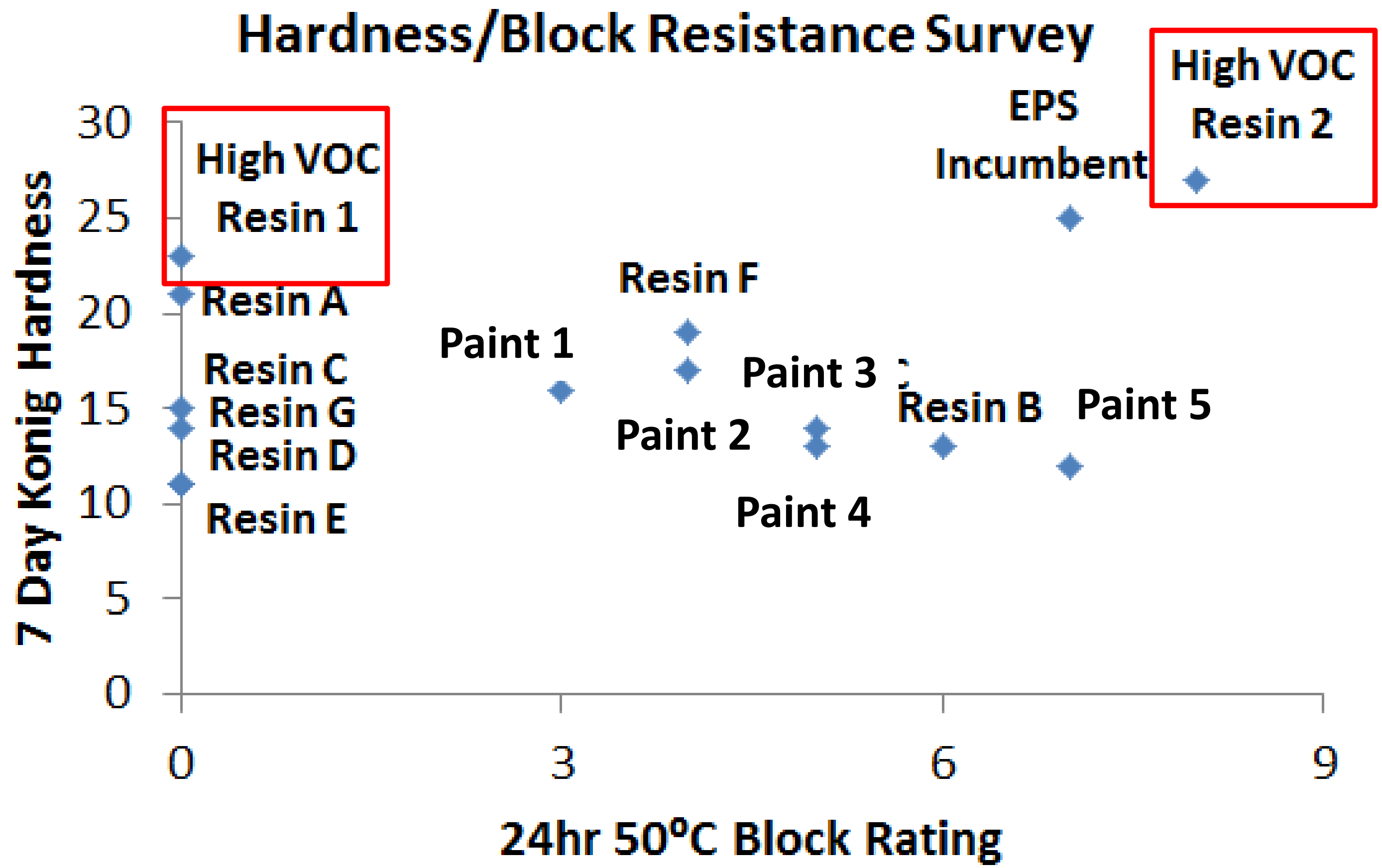
Elimination of quart exemption will force compliance with 100g/L in South Coast – may drive 100g/L adoption across country for national suppliers to minimize SKUs

Balance of Properties

- For DTM coatings, customers may specify a variety of performance attributes:
  - VOC, application, corrosion resistance, adhesion, block resistance, gloss, hardness, chemical resistance, early water resistance, etc
- Typically two strategies employed to hit lower VOC water-based formulations
  - Lower MFFT through T_g reduction
  - Formulation with low VOC plasticizer
- Properties such as hardness and block resistance are most often sacrificed
  - Can be addressed through formulation but usually have tradeoffs
- Polymer design strategies can overcome some of these limitations to retain a balanced polymer



- Survey of commercially available, <100g/L capable resins and paints
- Resins formulated into 100g/L high gloss formulations
- Konig oscillations @ 3-3.5mil DFT, 24hr block @ 3mil wet
- Significant performance gap for good block and hardness



- High VOC resins more likely to hit performance balance
- Early hot block resistance can still be occasionally troublesome

Corrosion Performance – B117

R-Series Q Panel, 2-2.5mil DFT

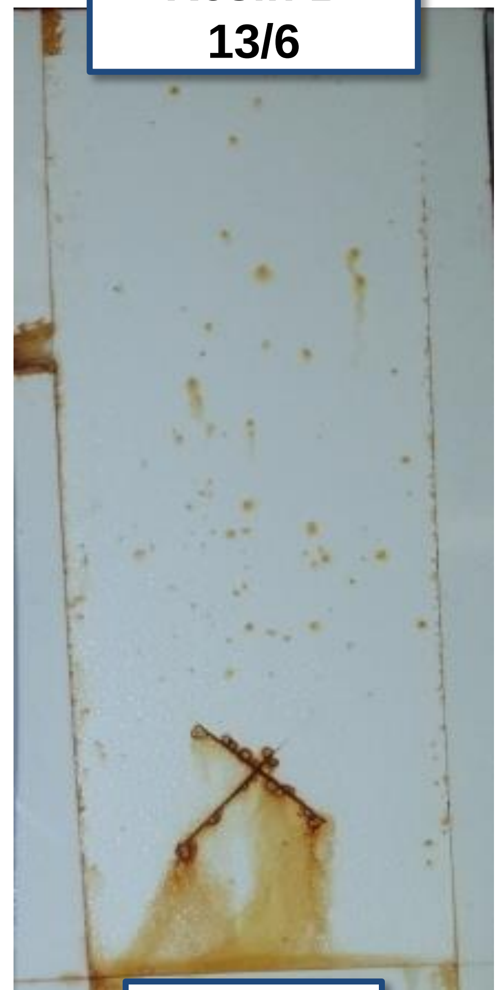
EPS Incumbent
Hardness/Block - 25/7

150 hrs

Resin A
21/0

100 hrs

Resin B
13/6



48 hrs

Corrosion Performance – B117

Corrosion Performance – B117

Resin F
19/4

200 hrs

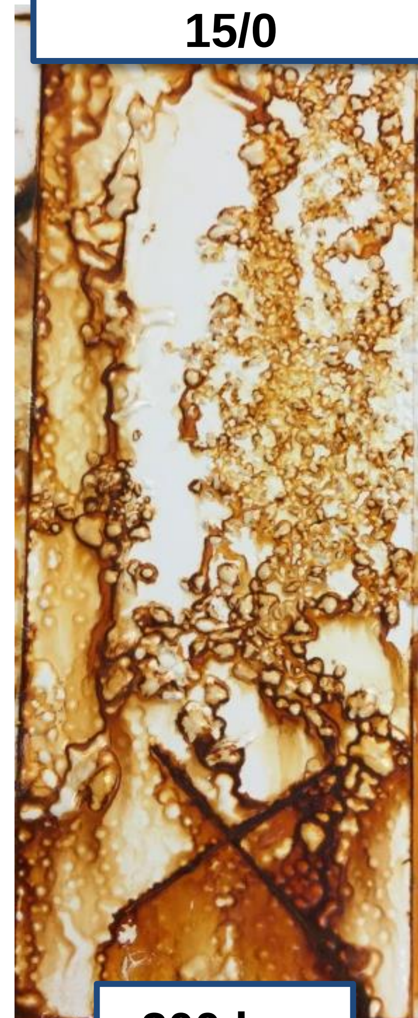
Resin G
14/0

500 hrs

High VOC Resin 1
23/0

500 hrs

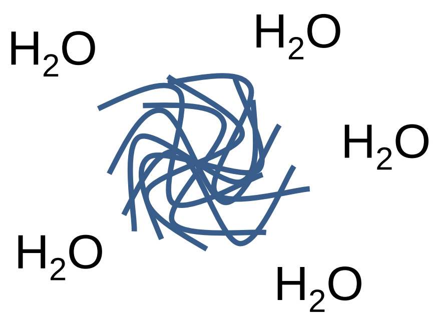
Corrosion Performance – B117

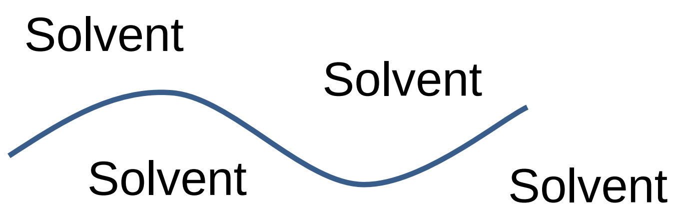


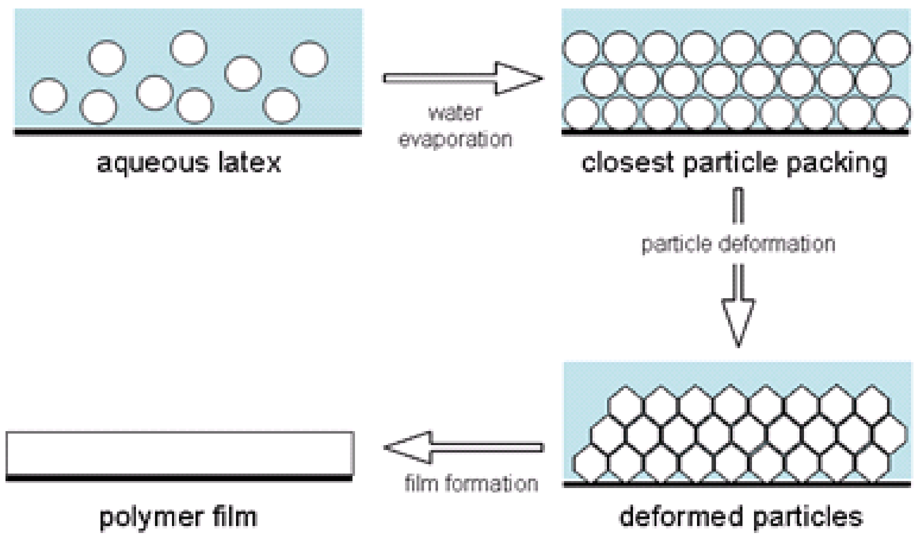
How to Tune Performance

- Statistical design approach optimizing all important factors of polymer development
  - Monomer composition
  - Surfactant choice
  - Feed ratios, times
  - Polymer morphology
  - Crosslinker type
  - Particle size
  - MW?
  - etc

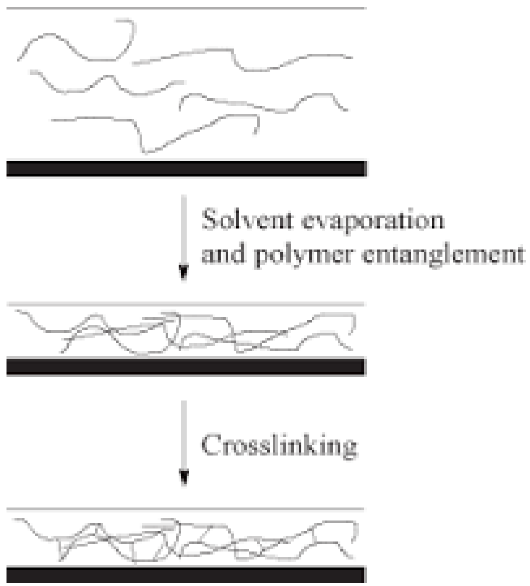
Waterborne vs. Solventborne







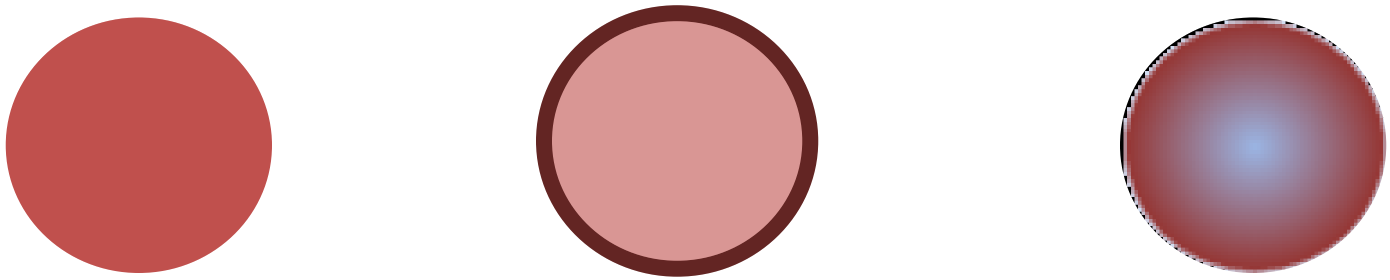
www.bauchemie-tum.de

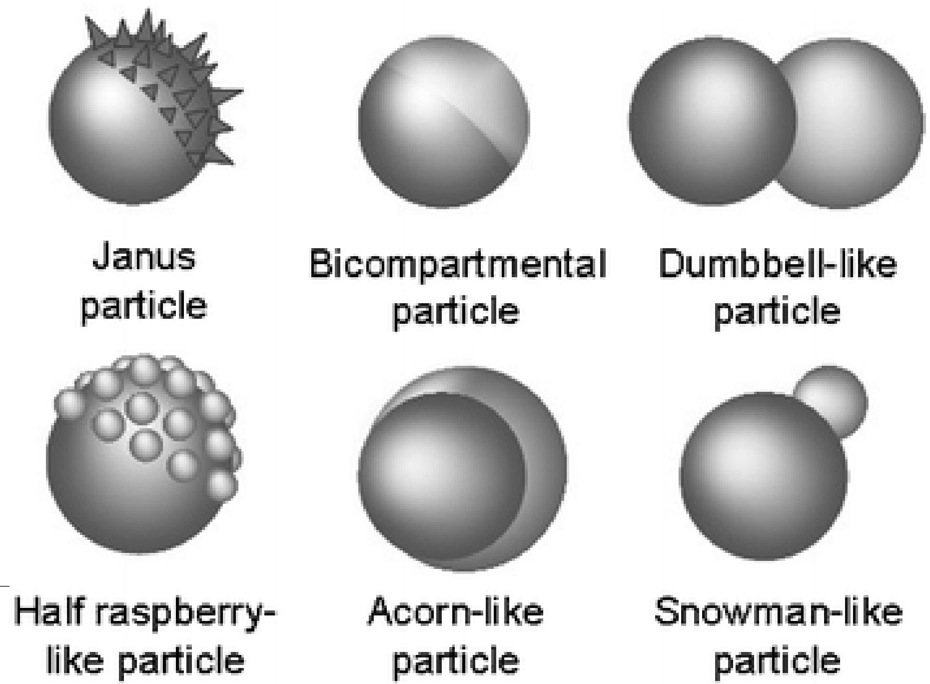


www.industrialpaintquality.com

Polymer Morphologies

Single Feed | Core/Shell | Gradient

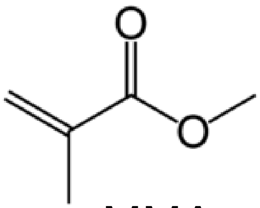




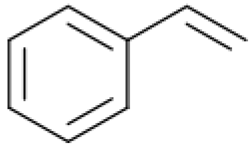
J. Mater. Chem., 2005, 15, 3745-3760

Tuning Monomer Composition

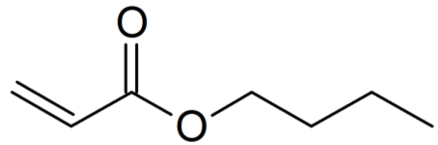
Bulk, low cost Monomers



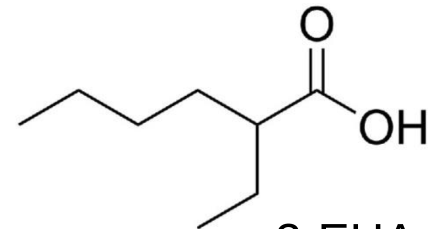
MMA



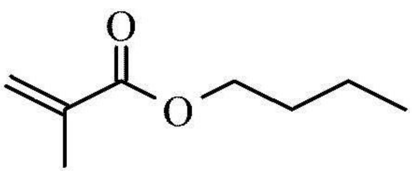
Styrene



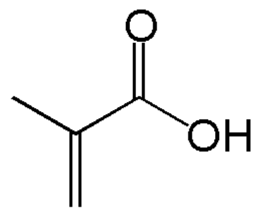
BA



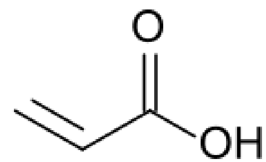
2-EHA



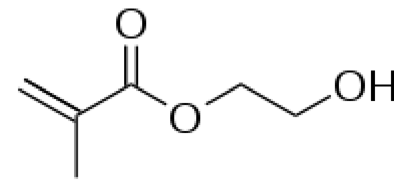
BMA



Acrylic acid

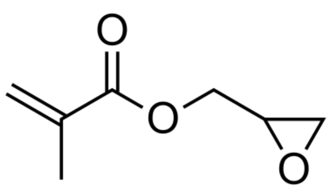


Methacrylic acid

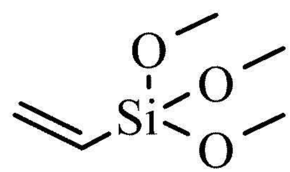


HEMA

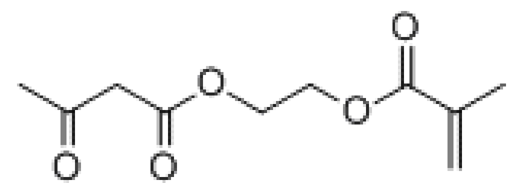
Example specialty monomers



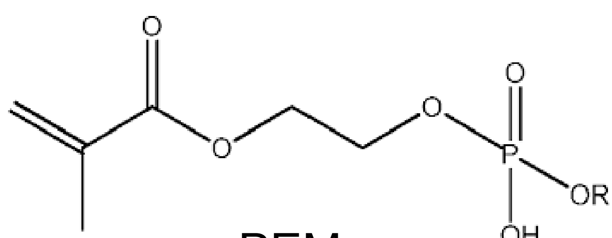
GMA



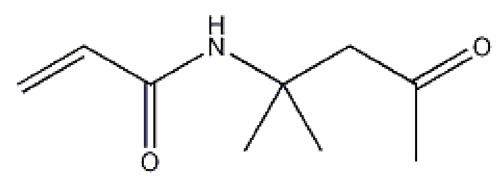
VTMS



AAEM



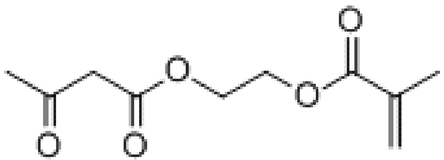
PEM



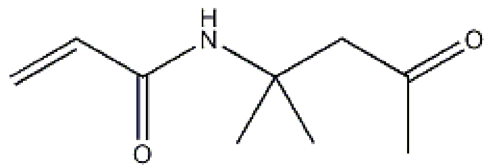
DAA

Crosslinker Types

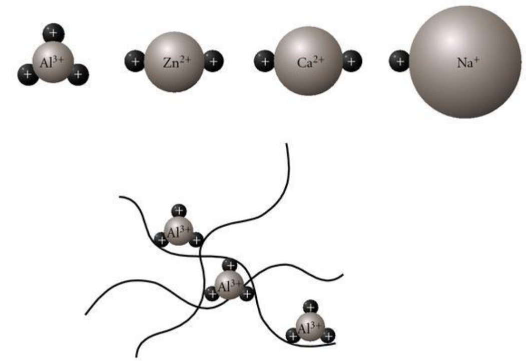
Build hardness back into the polymer prior to, during or after film formation



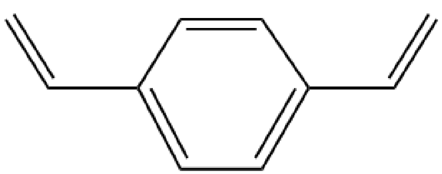
AAEM



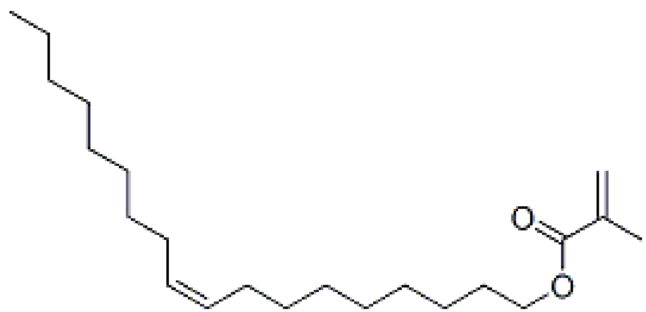
DAA



Ionic crosslinking



divinylbenzene

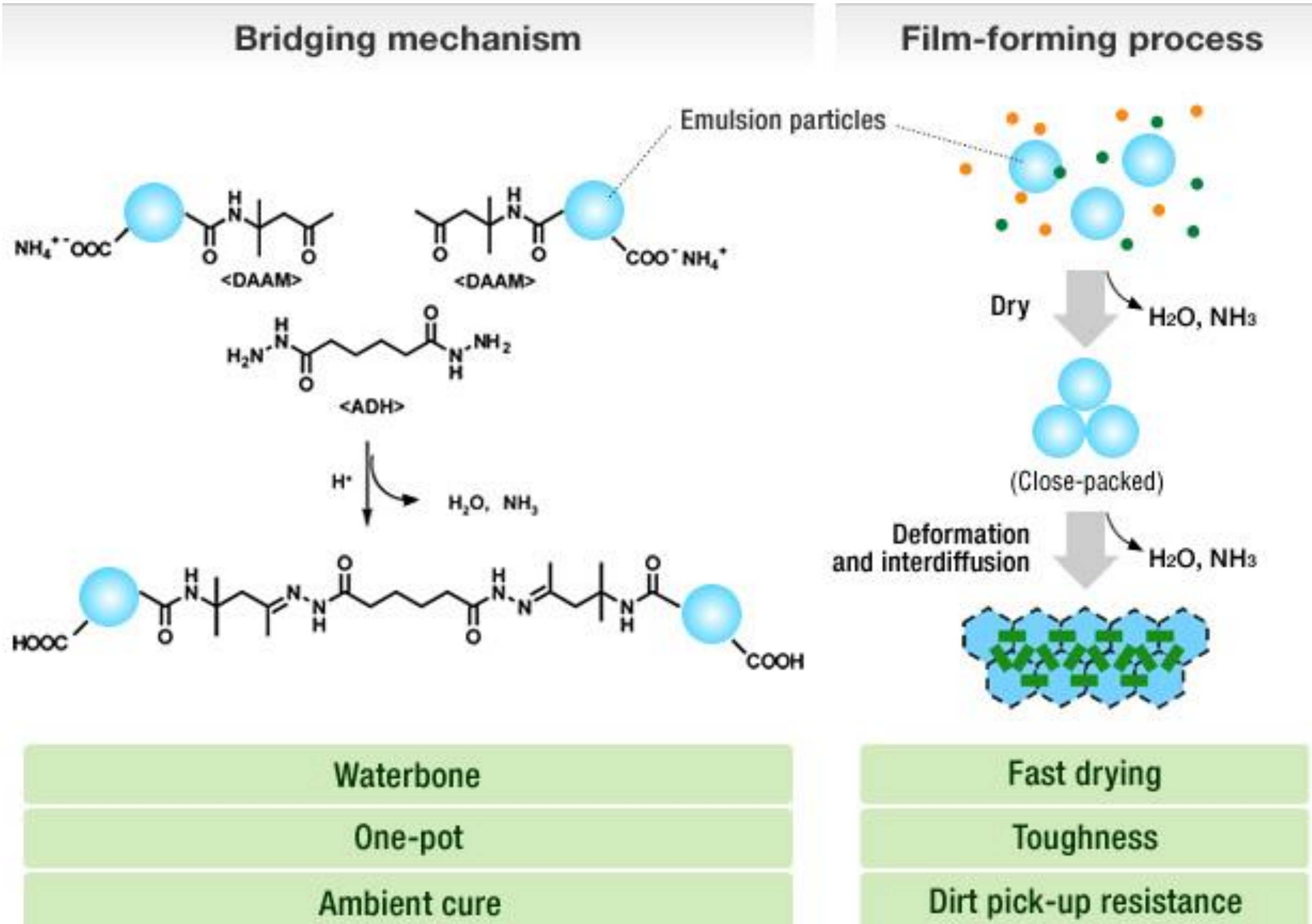


Unsaturated oil monomers?

Other secondary interactions:

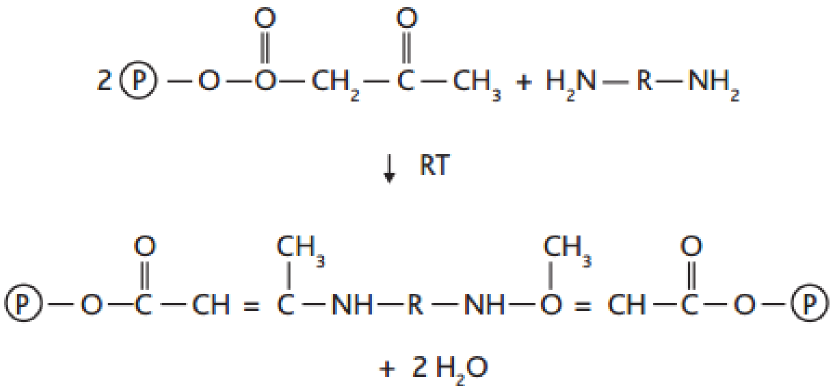
- Hydrogen bonding
- Pi-pi stacking

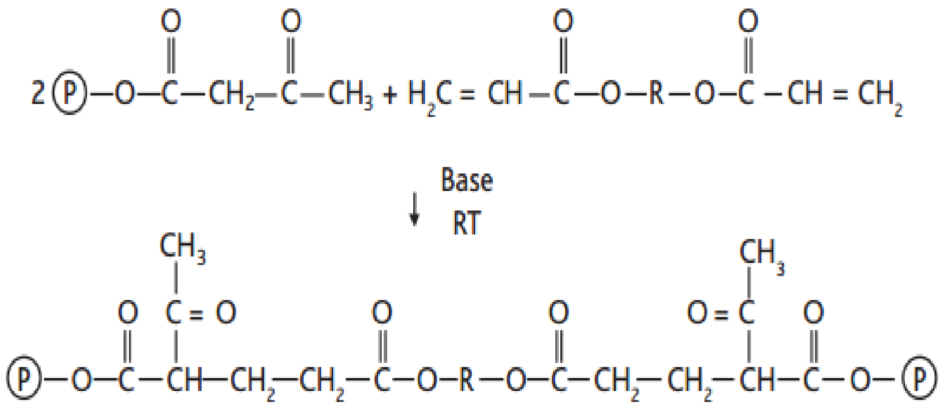
Crosslinking Mechanisms



http://www.khneochem.co.jp/en/rd/technology/daam/

Crosslinking Mechanisms





Eastman, http://www.eastman.com/Literature_Center/N/N319.pdf

Next Generation 100g/L

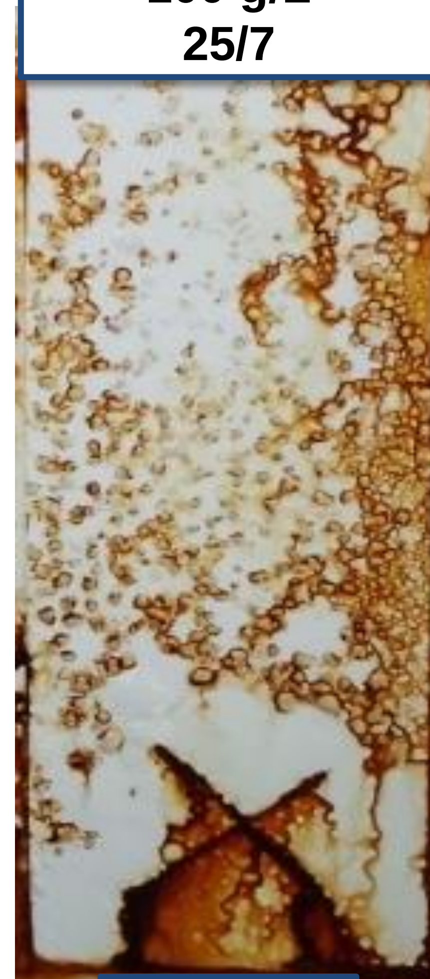
High VOC Resin 1
21/0

300 hrs

Prototype 5
100g/L
26/7

300 hrs

EPS Incumbent
100 g/L
25/7



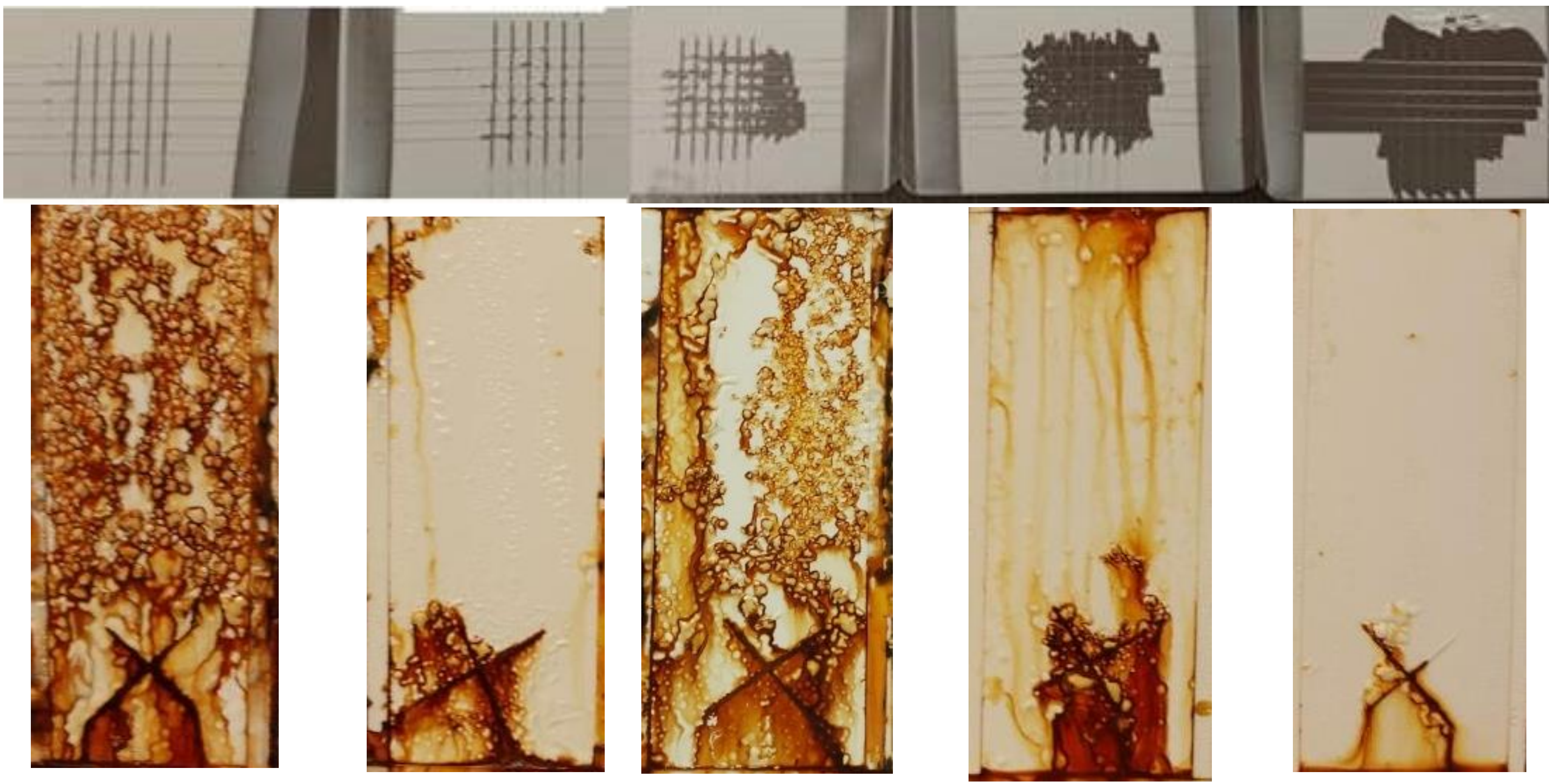
300 hrs

Adhesion vs. Corrosion Resistance

2-2.5mil DFT, 12PVC High Gloss, 400hr B117

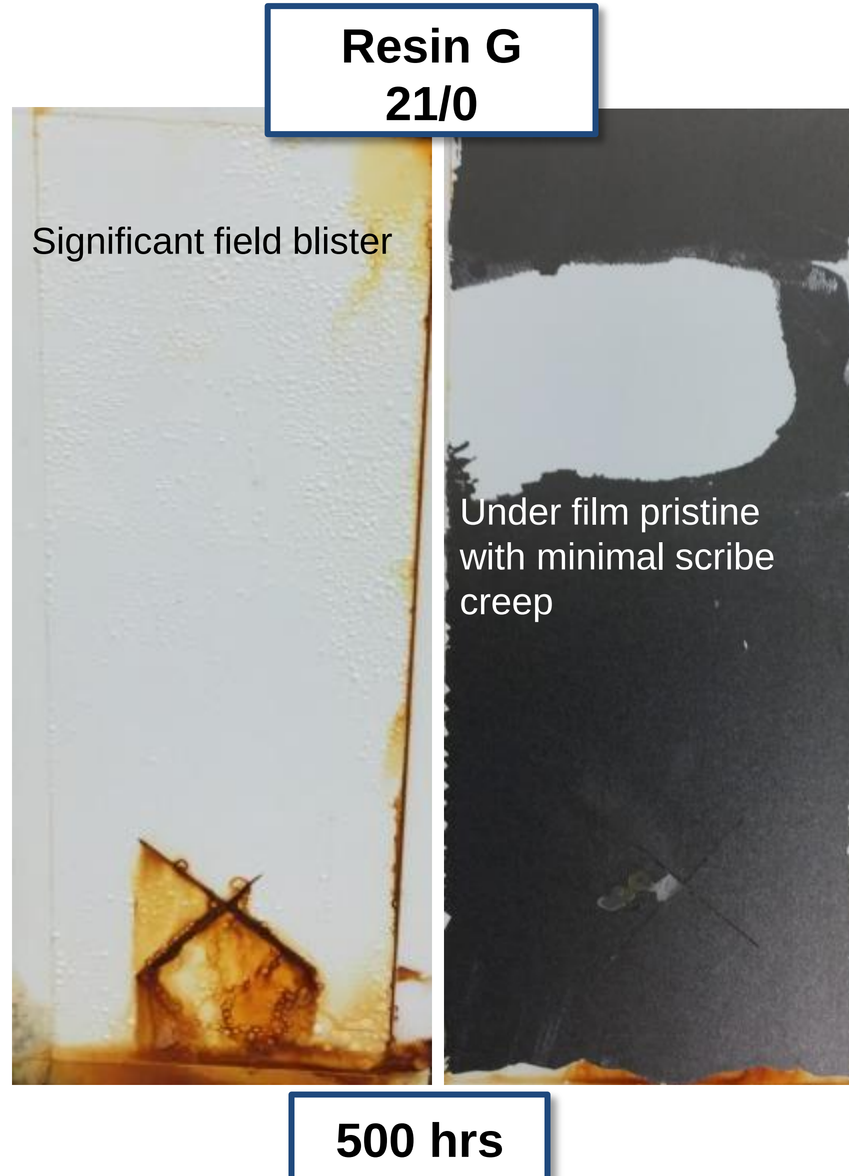
Decreasing adhesion properties

EPS Incumbent | **Prototype 1** | **Prototype 2** | **Prototype 3** | **Prototype 4**



Blistering in Salt Fog

Not all blistering created equally



Summary

- Low VOC trends place difficulties in resin selection and design yielding a performance gap in balancing hardness/block/ corrosion resistance
- Systematic polymer design can yield well-balanced, high performance waterborne systems
- Current experimental prototypes based on current state of the art polymer understanding are filling that performance gap
- Good adhesion not necessarily a requisite for good corrosion resistance
- Blistering can be caused by different mechanisms, some related to corrosion and others not
- Future work includes leveraging learnings to carry performance properties through 50g/L and lower

Acknowledgements

- Chris LeFever – Associate Chemist
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- Iain Harvey – Project/Process Director

Questions?