Choosing the Right Grease Polymer for Water-Resistant Industrial Greases

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FUNCTIONAL PRODUCTS INC.
Innovative Chemistry for Lubricants

Outline

- Our goal: teach fundamental material science of polymer selection
  - What is a “grease polymer”?
  - Interpenetrating Network Theory
  - Examples of use – water resistance
  - Key Points

What makes a “grease polymer”?

Polymers in Grease

- Many polymers found in grease – soluble or insoluble

Co-Base Stocks	Viscosity Modifiers	Thickeners / Solid Lubricants
• Polybutene • Polyalphaolefin & Related	• Olefin Copolymers • Styrene Copolymers	• PE, PP • PTFE

Very **Soluble** in Base Oil, Amorphous

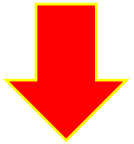
Insoluble, Crystalline

Micronized particle

But “Grease Polymers”…

Semi-Soluble

and Functionalized



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Grease Polymer Technology

- We want a **composite** between thickener and polymer networks

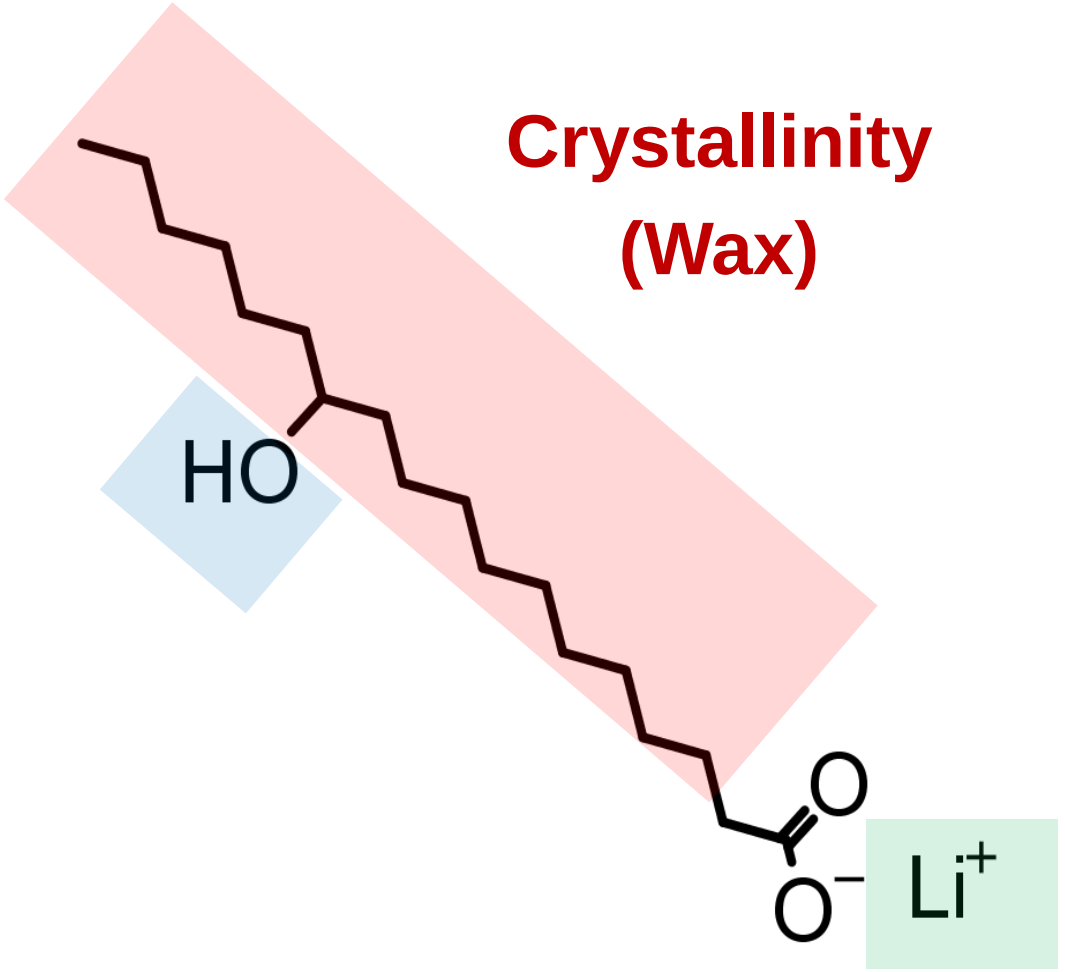
- Three types of cohesive interactions to bind the networks together:

1. Crystalline/waxy interactions
2. Ionic interactions
3. Hydrogen bonding

Three Interactions

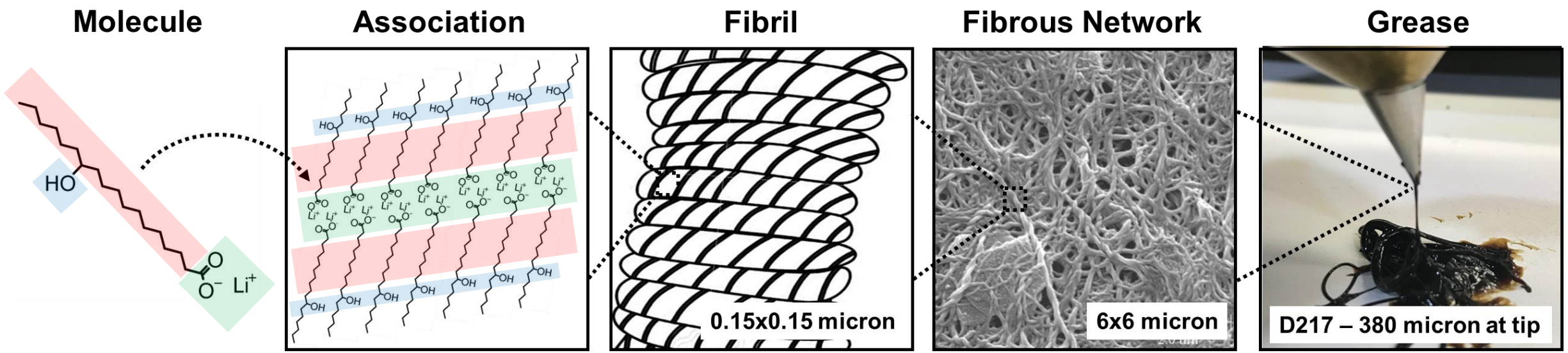
Crystallinity
(Wax)

Hydrogen
Bonding
(-OH,-NH)

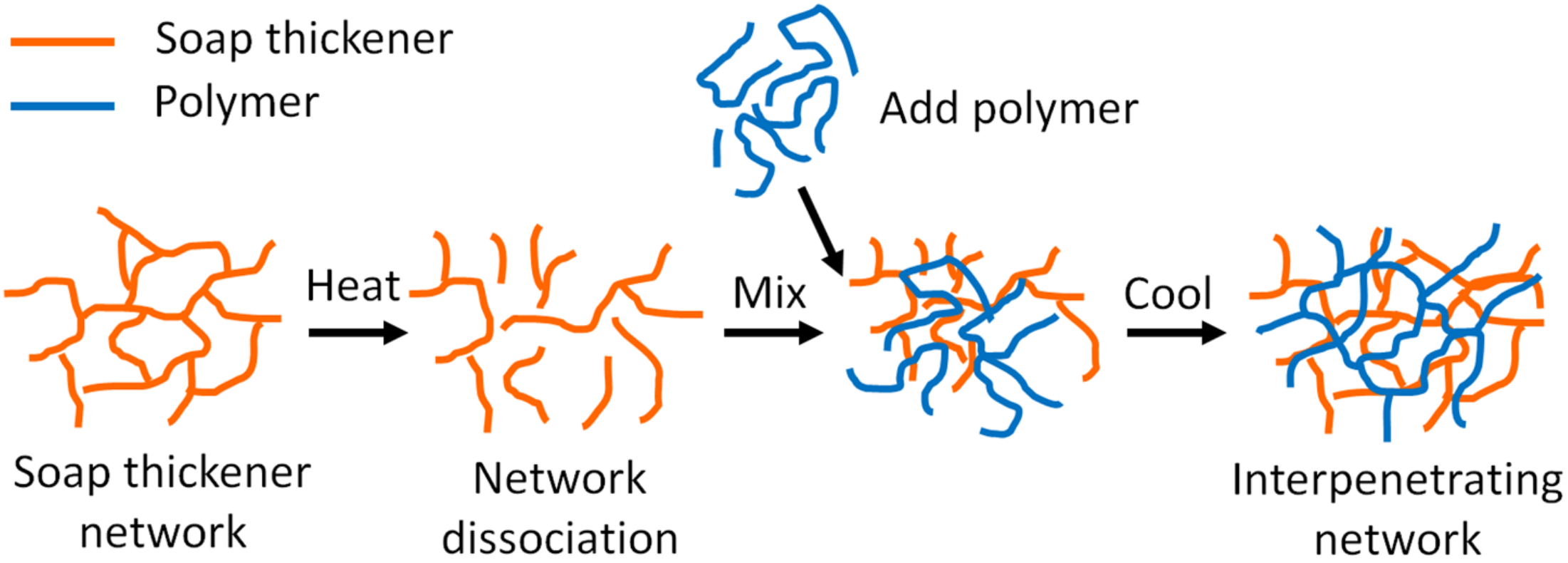


Ionic
C^+A^-

Self Assembly of Grease



Interpenetrating Network (IPN) Structure



Three Functionalities of Grease Polymers

1. Crystalline/Waxy

think ‘hook and loop’ tape

2. Reactive

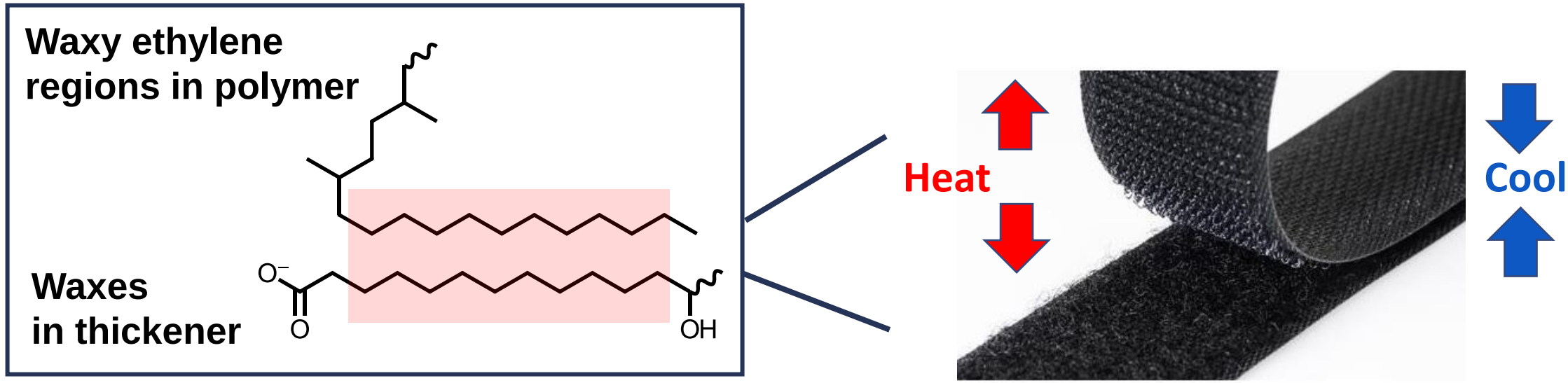
think super glue

3. Hydrogen Bonding

think polar attraction

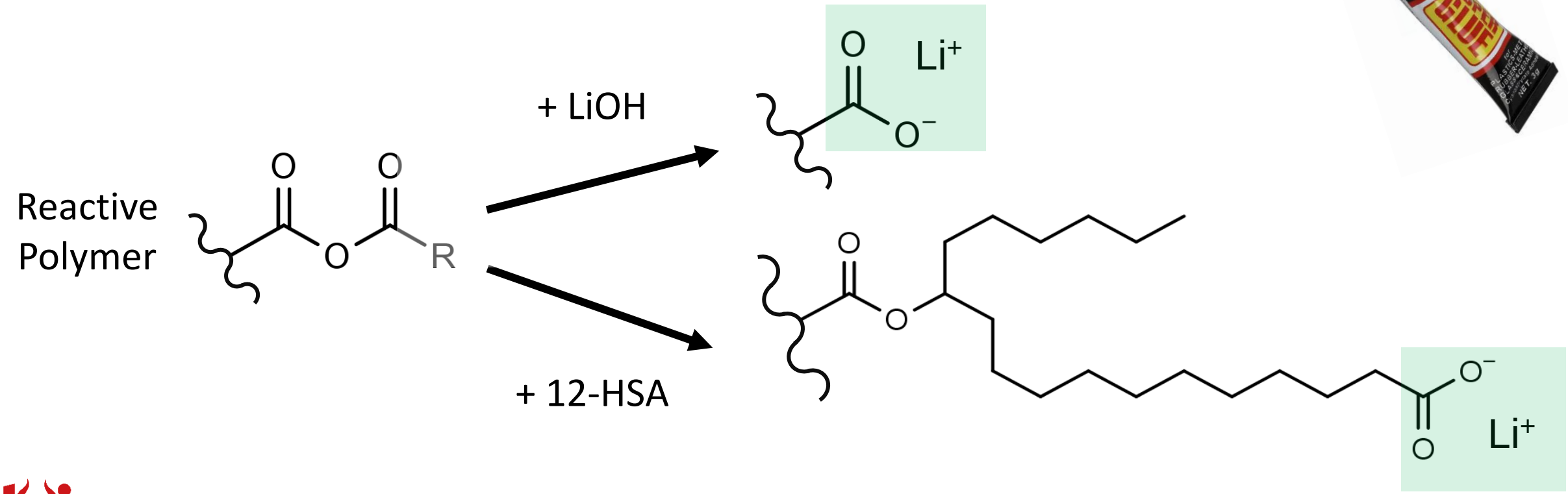
2 - Waxy Grease Polymers

- Lock in and interact with waxy segments of thickener
- Ethylene, alpha-olefins, styrene, etc.



2 - Reactive Grease Polymers

- Complex-like (diacid, borate ester) effect



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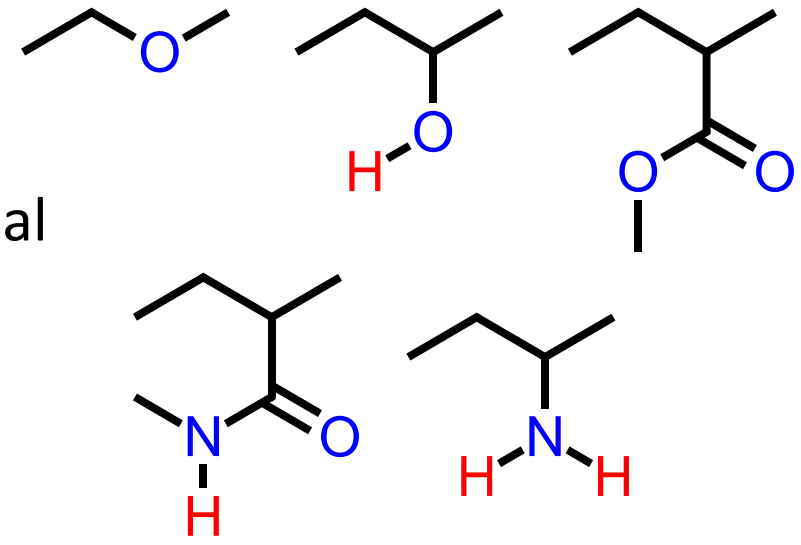
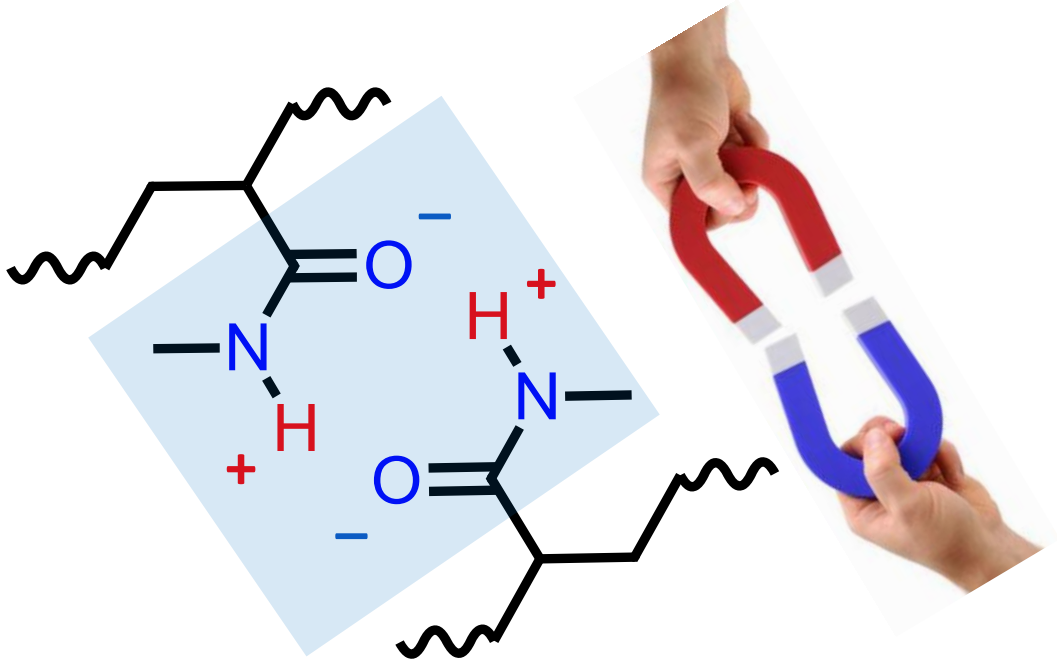
3 - Hydrogen Bonding Grease Polymers

- Lewis acid/base electron donor or receptor
  - :O: or N:

CHON Functional Groups





Thickener/Polymer Composite Effect

- Successful grease polymer selection meets two key criteria:

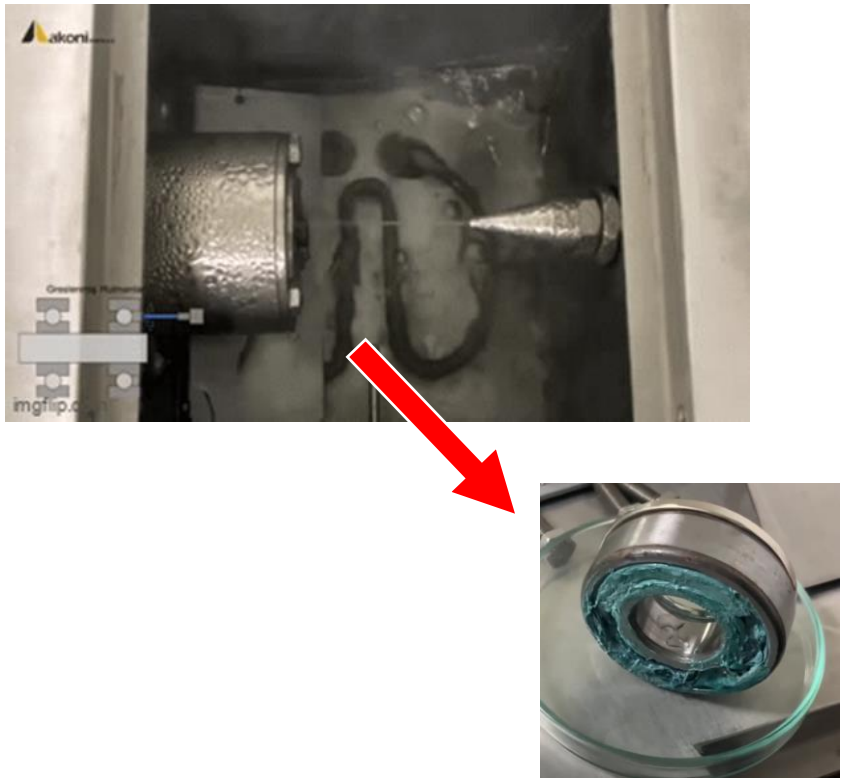
1. Significant modification of physical properties…
   - Water resistance
   - Oil retention
   - Mechanical stability
   - Tackiness/adhesion

2. …at very low treat rates
   - 0.25 – 1.0wt%

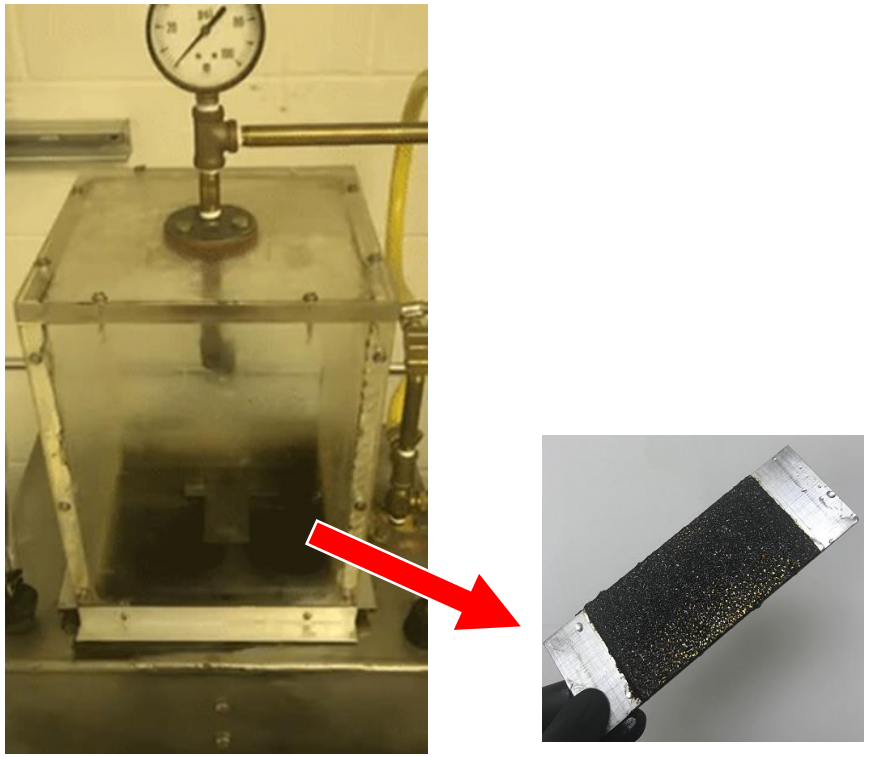
Examples of use – water resistance

Water Resistance Testing

- Water Washout (D1264)
  - Favors adhesive grease



- Water Spray Off (D4049)
  - Favors cohesive grease

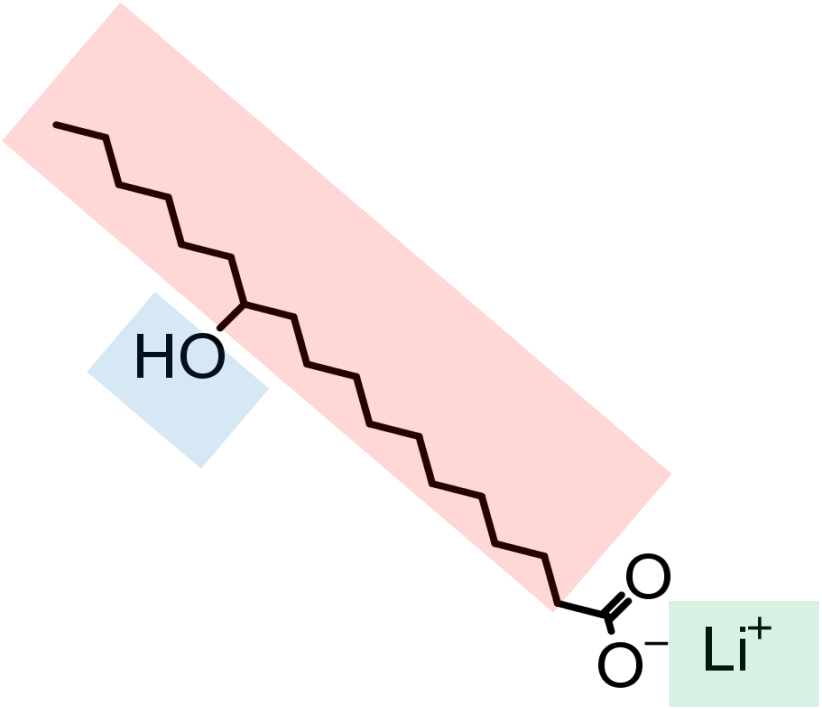


Examples of WSO / WWO Effect

Treat	WSO (D4049)	WWO (D1264)
NLGI #2 Lithium Complex (base)	**52%**	**26%**
+0.25% reactive olefin copolymer pellet	26%	25%
+1% semi-crystalline copolymer flake	24%	11%
+1% styrene copolymer flake	9%	12%
+4% proprietary *blend* liquid	7%	2.0%
NLGI #2 Calcium Sulfonate (base)	**72%**	**4.8%**
+0.25% reactive olefin copolymer pellet	47%	3.9%
+0.5% reactive olefin copolymer pellet	4%	3.3%
+0.5% semi-crystalline copolymer flake	16%	4.2%
+1.0% styrene copolymer flake	7%	4.4%
NLGI #2 Clay Grease (base)	**49%**	**0.0%**
+5% concentrated olefin copolymer, liquid	48%	1.3%
+4% reactive olefin copolymer pellet, liquid	12%	-2%
+1% emulsion polymer	10%	29%

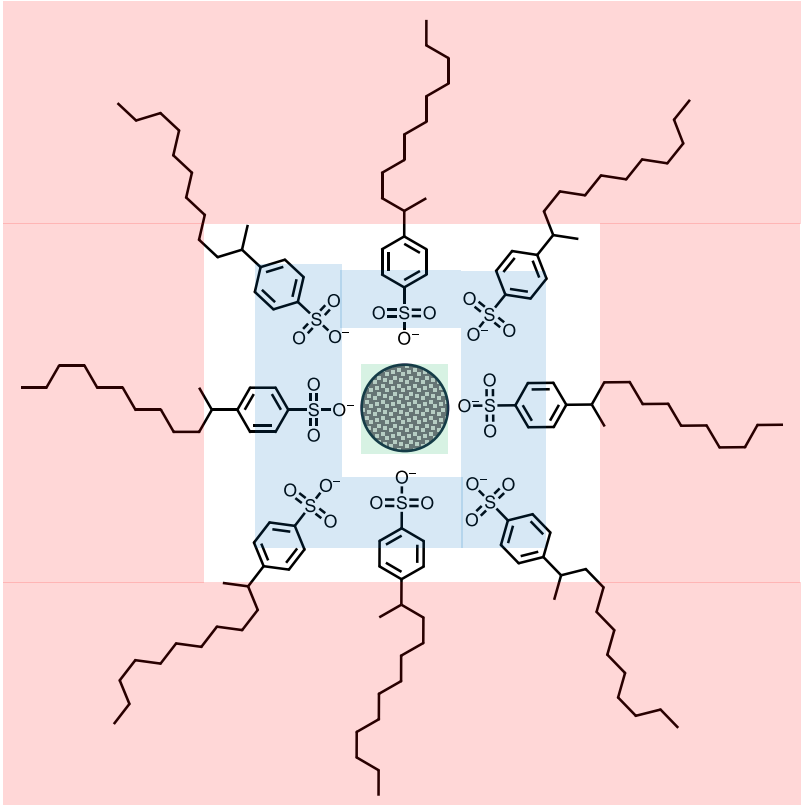
Lithium and Lithium Complex

- Work best with reactive type polymer
  - Can add +0.5 or +1.0 NLGI grade
  - Less soap per kg of grease, save $$
- Waxy polymers tend to give bad texture



Calcium Sulfonate (Complex)

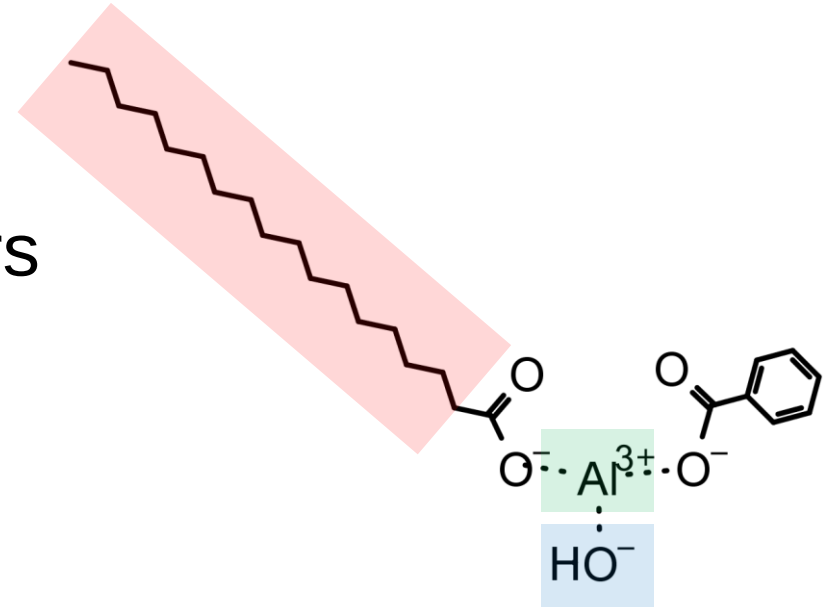
- Good inherent water washout resistance
- Poor **water sprayoff** resistance



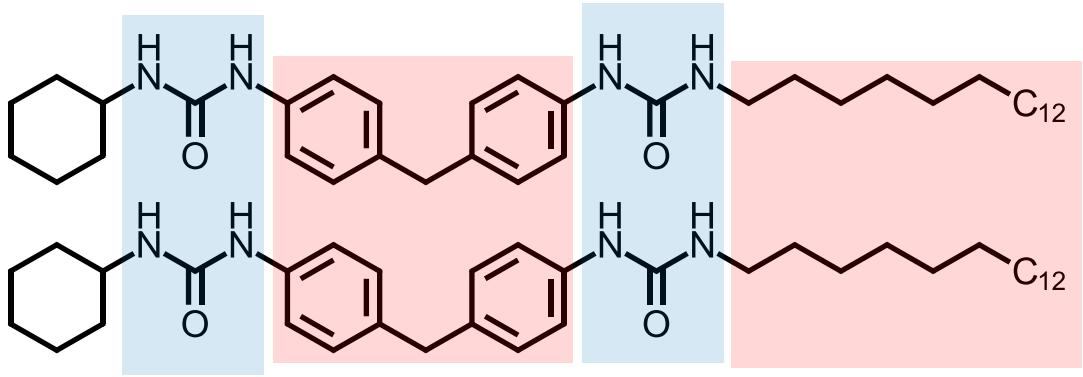
- Work best with crystalline/waxy type polymer
  - Polar functionality can disrupt micelle structure

Aluminum Complex

- Can have difficulty with water resistance
- Works well with waxy and reactive polymers
  - Reactive
    - Generally not HX-1
  - Waxy
    - HX-1 available



Polyurea



- Strongly dominated by
  Hydrogen bonding
  Crystalline interactions (C18 + rings)

- Styrene copolymers have been most successful
- Hydrogen bonding can be antagonistic and disrupt thickener

Difficulty with Full Synthetic Greases

- Polymer base oils are poor solvents for additives and very poor solvents for polymer additives

- Conventional polymers insoluble with high wt% mPAO or PB/PIB

Improper Selection Effects

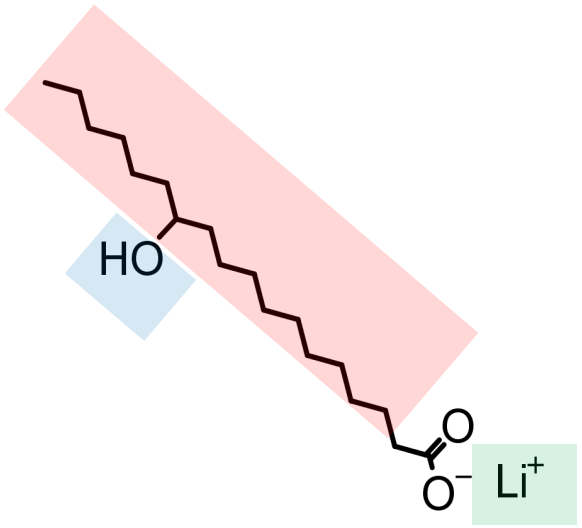
- Disruption of grease thickener network
  - Loss of consistency (low yield)

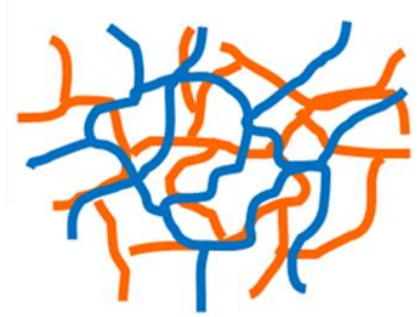
- Dispersant-like effect
  - Increase in WSO or WWO %

- Excessive tackiness or a ‘rubber-like’ texture
  - Often occurs in naphthenic-based greases

Conclusions

Three Things to Remember





Interpenetrating network

1. Crystalline/Waxy

2. Reactive

3. Hydrogen Bonding

More to Talk About in the Future

- How to add these grease polymers?
- What can grease polymers do for wet roll stability (D8022)?
- How does polymer affect low temperature, mechanical stability, and oil bleed?
- *Let's chat!*

Key Points

- Grease polymers form composite with grease thickener
  - Small wt% treat, big effect
- The right polymer varies with thickener, base oil, viscosity
  - Polymer should have features similar to the interactions that bind the grease thickener network together

Thank you for your attention