

Partial Saponification in Cold-Process Soap

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Spring 2013

\$Revision: 1.1 \$

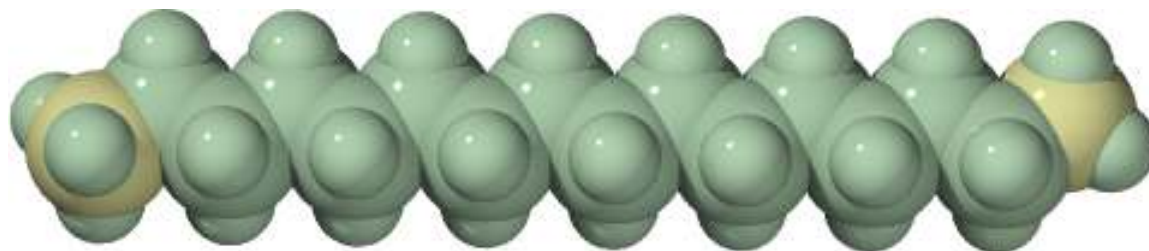
Acknowledgements

- Mike Lawson/Columbus Foods
- Hampden-Sydney College
 - Meade Edmunds
 - John Dekarske
 - Caleb Watkins
 - Andrew McLeod
 - Robert O'Cain
 - Jay Rawles

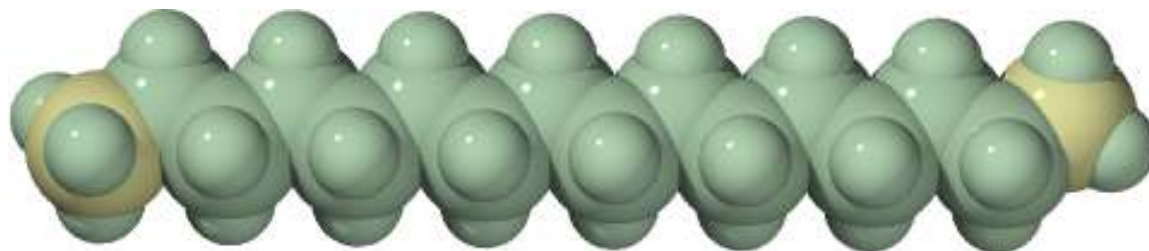
Background Chemistry

Oil and water don't mix.

Oil and Water



Nerds and Cheerleaders

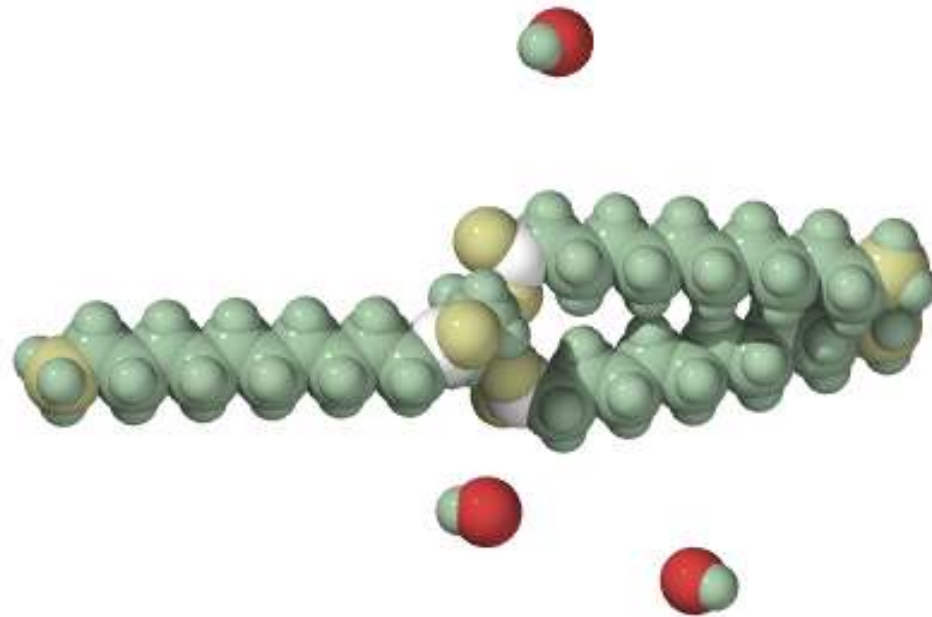


Lipophilic

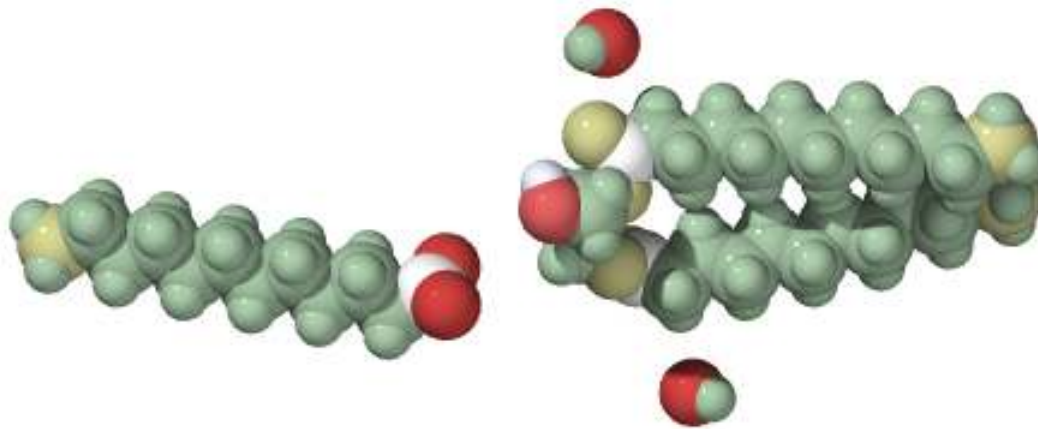


Hydrophilic

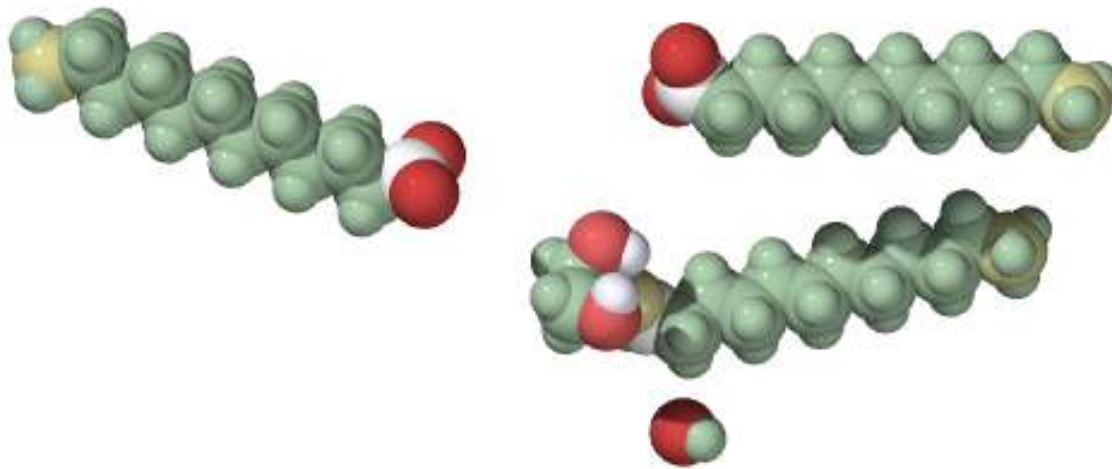
Oil and Lye



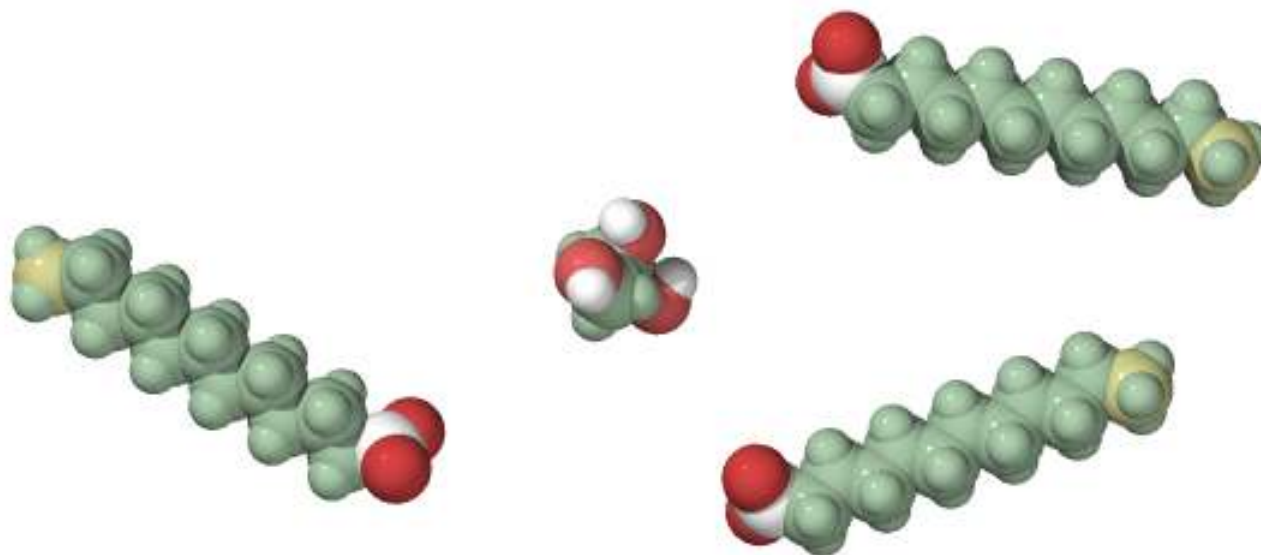
One Soap



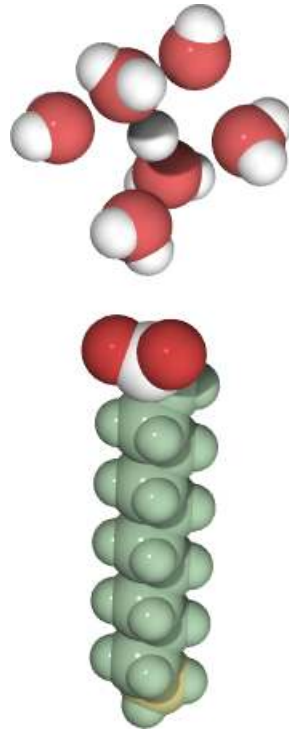
Two Soaps



Three Soaps and a Glycerin

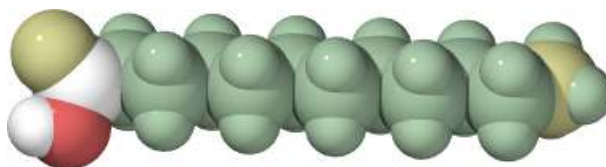
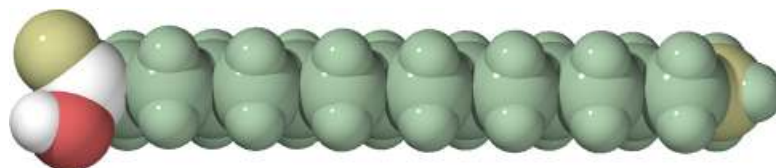
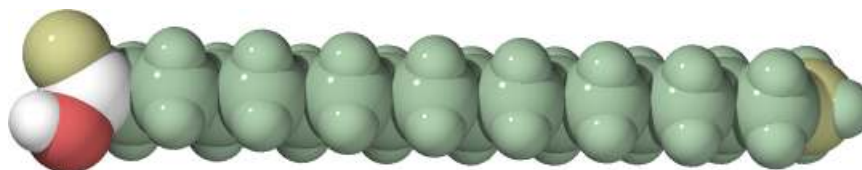


Soap: A Nerdy Cheerleader

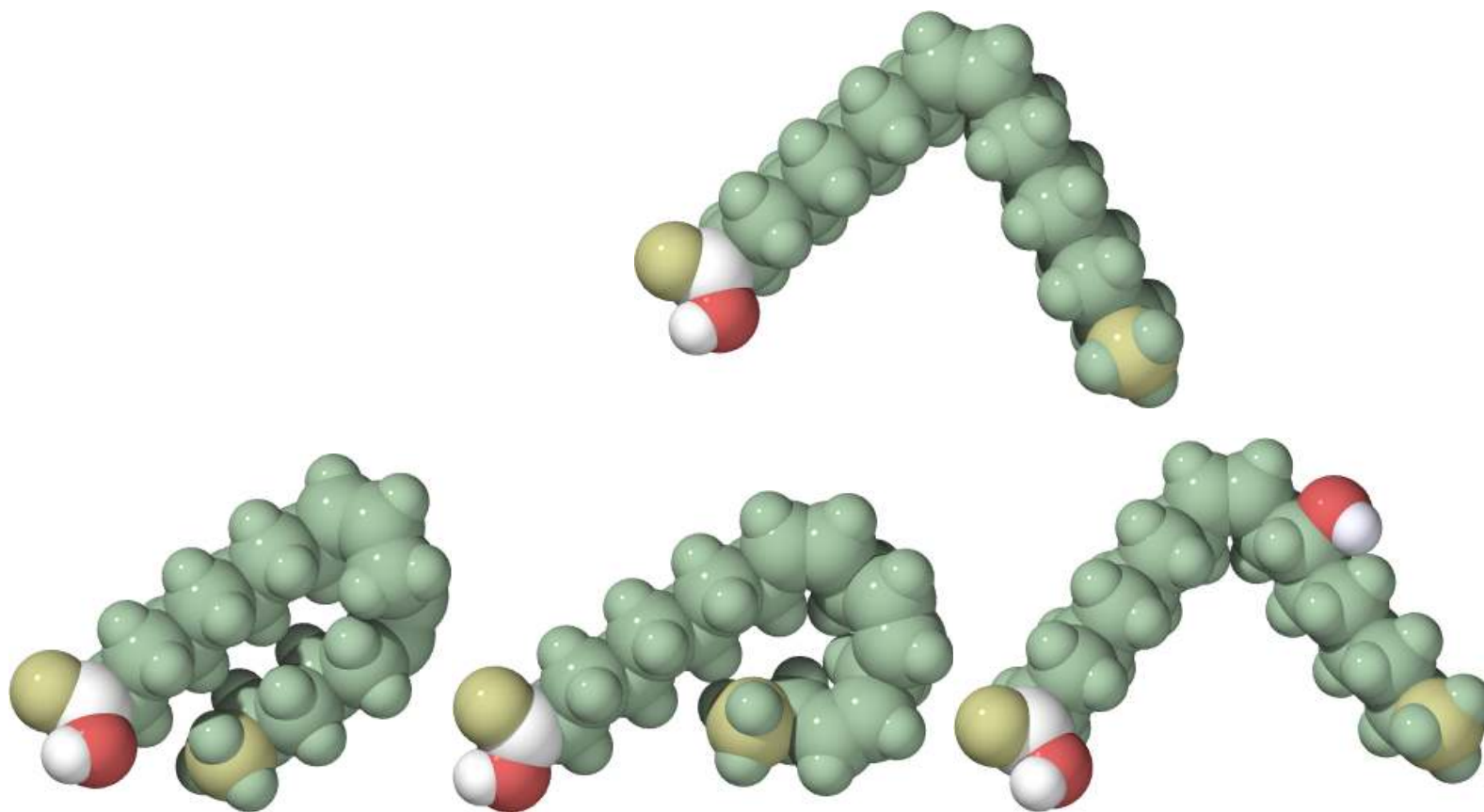


Amphiphilic

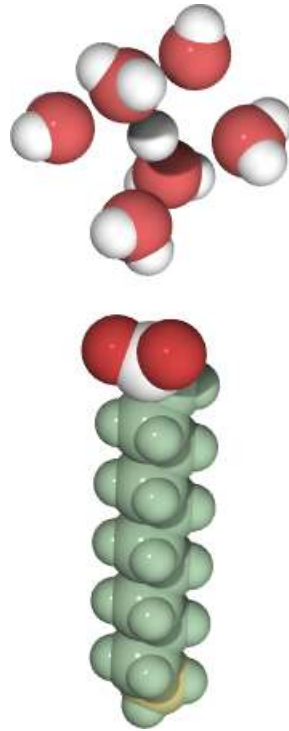
Saturated Fatty Acids

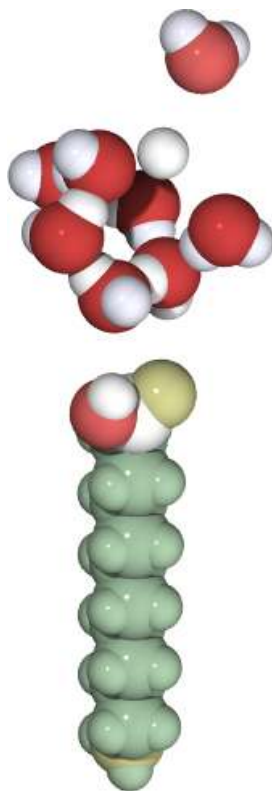
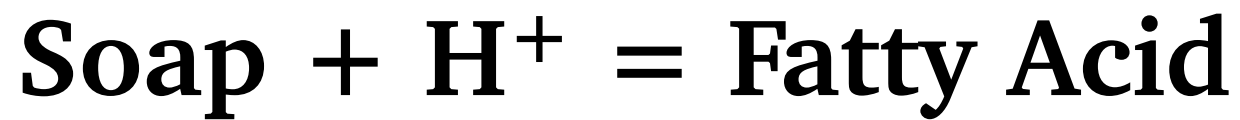


Unsaturated Fatty Acids

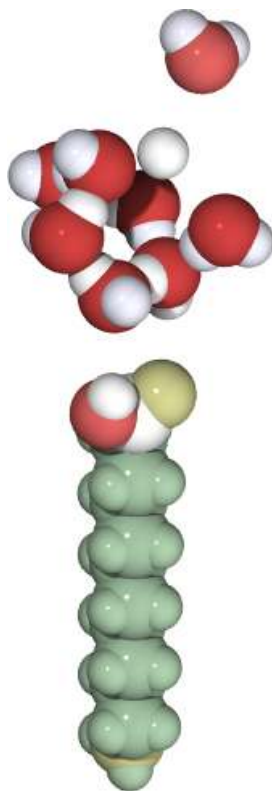


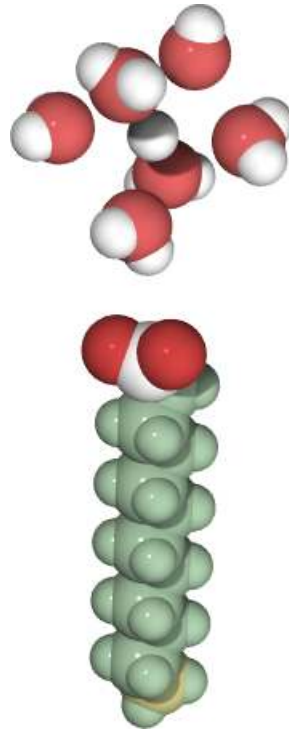
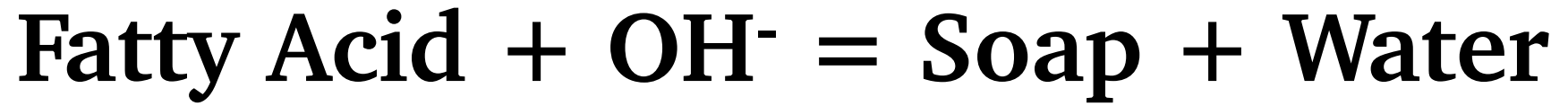
Soap + H⁺





Fatty Acid + OH⁻





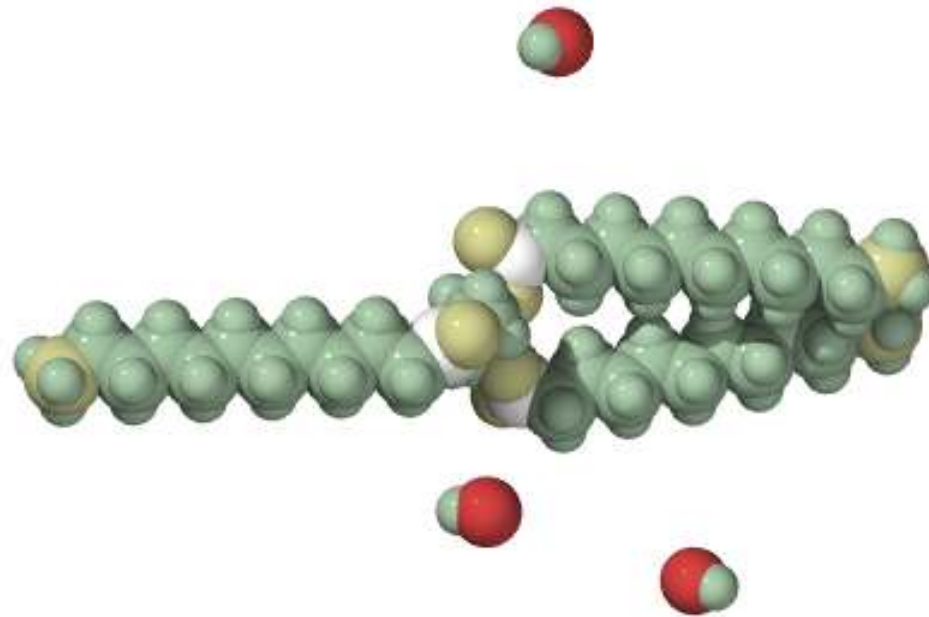
Soap/Fatty Acid Equilibrium

- Soap (pH 10, universal indicator blue)
- Soap + Fatty Acid (pH 7, universal indicator green)
- Fatty Acid + Soap (pH 6, universal indicator yellow)
- Fatty Acid (pH 5, universal indicator orange)

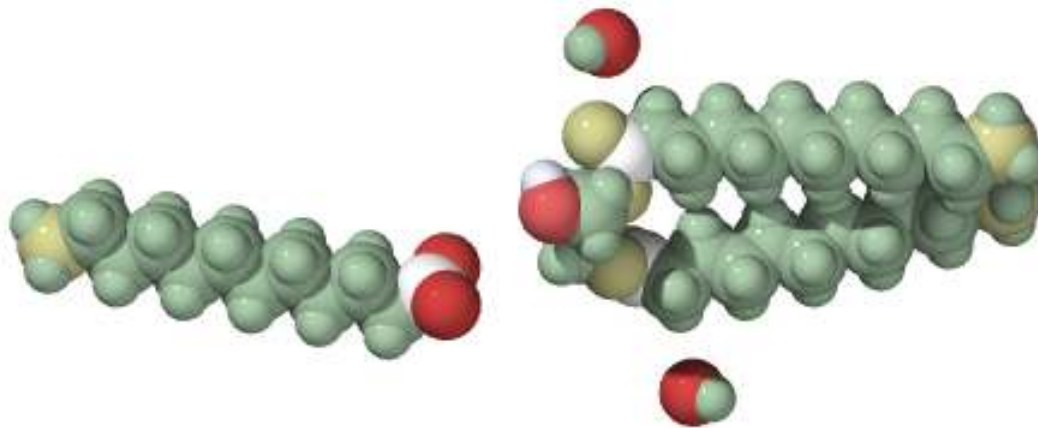
Soap/Fatty Acid Equilibrium

- 5 mL of saturated soap solution in half bottle of water
- A few drops of universal indicator shows pH
- Make sure cap is on bottle before shaking
- Add vinegar (red pipet) a few drops at a time to lower pH
- Add ammonia (blue pipet) a few drops at a time to raise pH
- Note the quality of suds after each addition

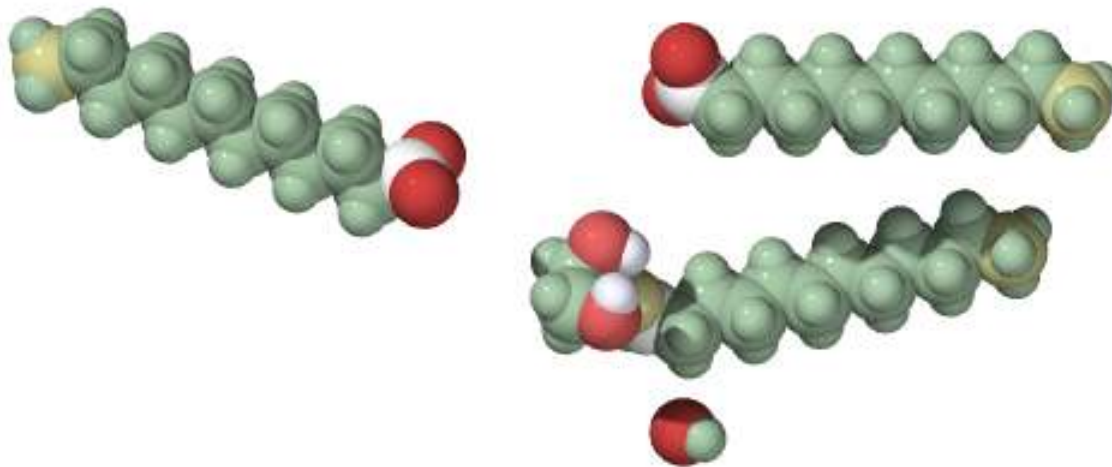
Triacylglyceride (AAAG)



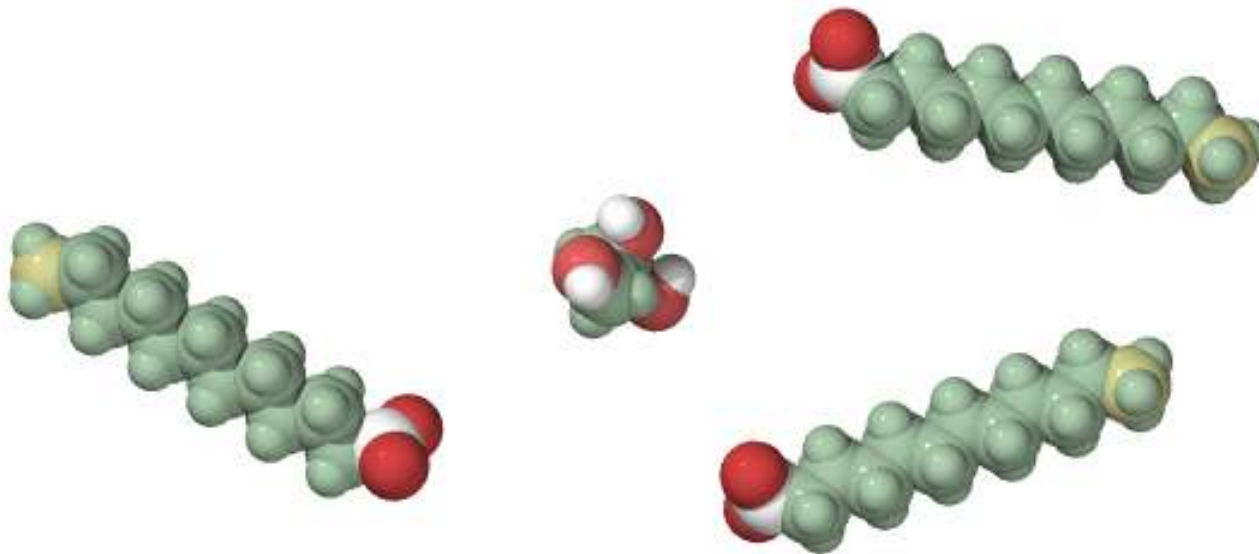
Diacylglyceride (AAG)



Monoacylglyceride (AG)



Glycerol (G)



The Stoichiometric Hypothesis

- $AAAG + 1 NaOH = AAG + 1 NaA \text{ (Soap)} + 1 H_2O$

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- $AAAG + 2 NaOH = AG + 2 NaA \text{ (Soap)} + 2 H_2O$

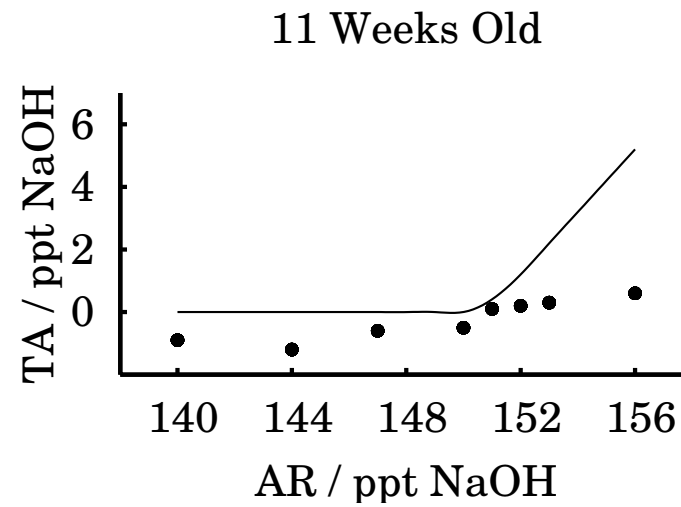
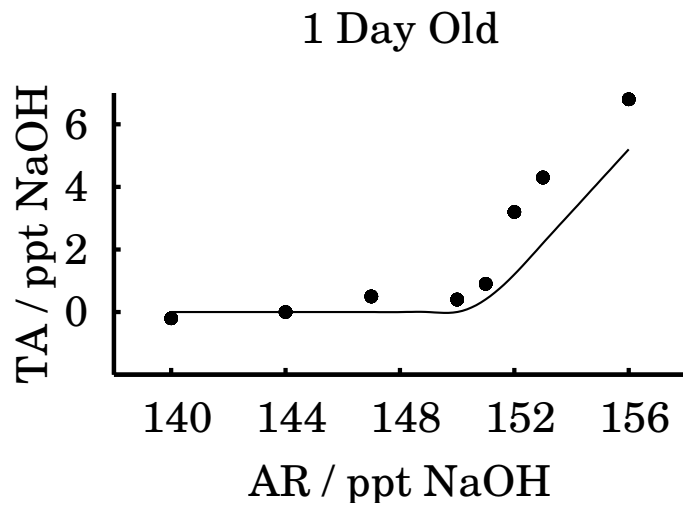
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- $AAAG + 3 NaOH = G + 3 NaA \text{ (Soap)} + 3 H_2O$

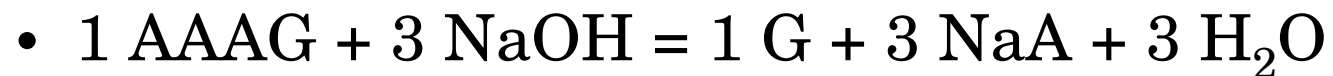
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- $AAAG + 2 NaOH = AG + 2 NaA \text{ (Soap)} + 2 H_2O$
- $AAAG + 3 NaOH = G + 3 NaA \text{ (Soap)} + 3 H_2O$
- $AAAG + 4 NaOH = G + 3 NaA \text{ (Soap)} + 3 H_2O + 1 NaOH$

The Stoichiometric Hypothesis



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The Stoichiometric Hypothesis

- $1 \text{ AAAG} + 3 \text{ NaOH} = 1 \text{ G} + 3 \text{ NaA} + 3 \text{ H}_2\text{O}$
- $2 \text{ AAAG} + 6 \text{ NaOH} = 2 \text{ G} + 6 \text{ NaA} + 6 \text{ H}_2\text{O}$

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- $4 \text{ AAAG} + 12 \text{ NaOH} = 4 \text{ G} + 12 \text{ NaA} + 12 \text{ H}_2\text{O}$

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- $4 \text{ AAAG} + 12 \text{ NaOH} = 4 \text{ G} + 12 \text{ NaA} + 12 \text{ H}_2\text{O}$
- $10 \text{ AAAG} + 30 \text{ NaOH} = ?$

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- $4 \text{ AAAG} + 12 \text{ NaOH} = 4 \text{ G} + 12 \text{ NaA} + 12 \text{ H}_2\text{O}$
- $10 \text{ AAAG} + 30 \text{ NaOH} = 10 \text{ G} + 30 \text{ NaA} + 30 \text{ H}_2\text{O}$

10% Lye Discount

- $10 \text{ AAAG} + 27 \text{ NaOH} = ?$

10% Lye Discount

- $10 \text{ AAAG} + 27 \text{ NaOH} = 9 \text{ G} + 1 \text{ AAAG} + 27 \text{ NaA} + 27 \text{ H}_2\text{O}$

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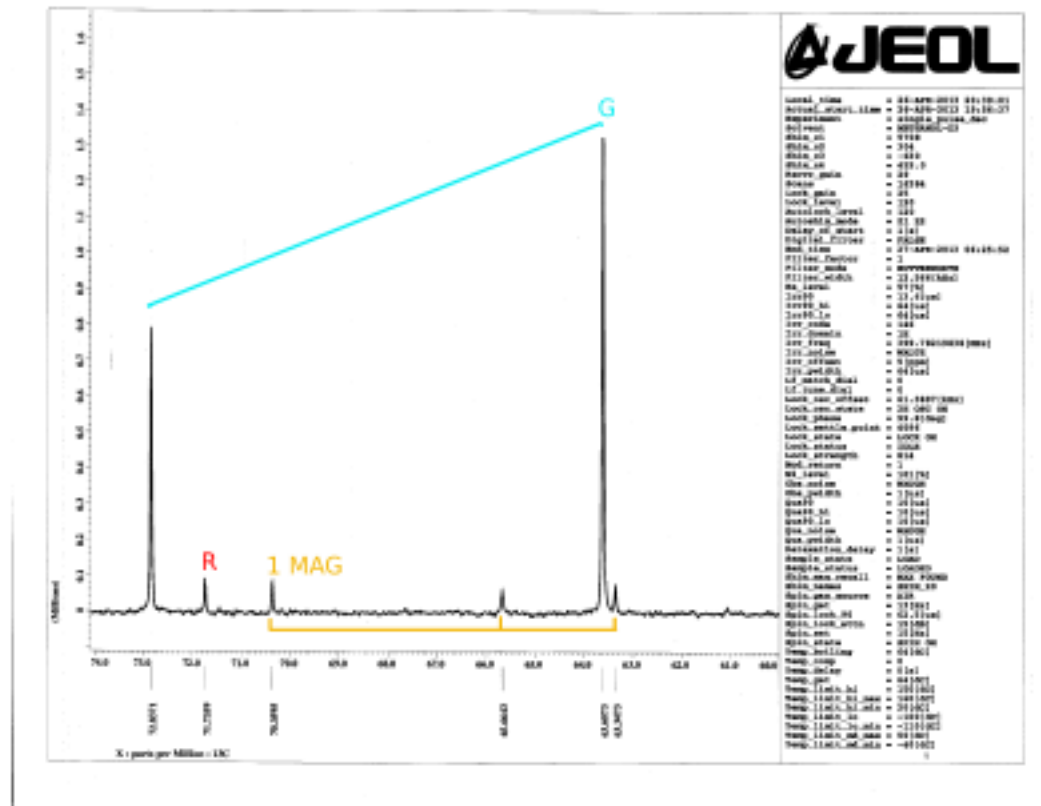
10% Lye Discount

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- $10 \text{ AAAG} + 27 \text{ NaOH} = 7 \text{ G} + 3 \text{ AG} + 27 \text{ NaA} + 27 \text{ H}_2\text{O}$
- $10 \text{ AAAG} + 27 \text{ NaOH} = 8 \text{ G} + 1 \text{ AAG} + 1 \text{ AG} + 27 \text{ NaA} + 27 \text{ H}_2\text{O}$

Glycerol



Glycerol and MAGs in Duckbar's Delight Soap



Lye Discounting vs Superfatting

Lye Discounting

- We don't want excess lye in our soap.
- So we add less lye than the SAP indicates.

Superfatting

- We want an excess of a “desirable” oil in our soap.
- So we add more oil than the SAP indicates.
- And we add the desirable oil at trace.

The Superfatting Hypothesis

The later an oil is added during the soapmaking process, the more likely it is to remain unreacted in the finished soap. Thus desirable superfatting oils should be added at the last possible moment.

This is the conventional wisdom, but is it possible to test this hypothesis?

The Superfatting Experiment

- Two soaps were made, both containing 91% coconut oil and 9% olive oil.
- Both soaps were made using a 5% lye discount.
- For soap A, olive oil was added to the coconut oil at the beginning. (Discounting 5%)
- For soap B, olive oil was added to the coconut oil at trace. (Superfatting 5%)

Extracting the Unreacted Oil

- Both soaps contain unsaponified or partially saponified oil.
- Oil was extracted from each soap using ether.
- The extracted oils were analysed for percent oleic acid.

Superfatting Results

- The oil used was 9% olive oil / 91% coconut oil.
- Oils were mixed at the beginning for Soap A.
- Olive oil was added at trace for Soap B.
- The original oil contained 7% oleic acid.
- The oil extracted from Soap A contained 22% oleic acid.
- The oil extracted from Soap B contained 22% oleic acid.

Superfatting Results

- The test was repeated using 10% castor oil / 90% palm oil.
- A 10% lye discount was used.
- The original oil contained 9% ricinoleic acid.
- The oil extracted from Soap A contained 4% ricinoleic acid.
- The oil extracted from Soap B contained 4% ricinoleic acid.

Superfatting Results

- The test was repeated using 10% grapeseed oil / 90% palm oil.
- A 10% lye discount was used.
- The original oil contained 9% linoleic acid.
- The oil extracted from Soap A contained 19% linoleic acid.
- The oil extracted from Soap B contained 17% linoleic acid.

Superfatting Conclusions

- For the oils studied, it did not matter whether the superfatting oil was added before or at trace.
- The "superfatting" oil may react more or less quickly than the base oil.
- The unreacted oil in soap is mostly base oil but may contain the "superfatting" oil if it reacts more slowly than the base oil.
- The "superfatting" oil may be beneficial because of the soap produced rather than the oil remaining unreacted.
- For the oil combinations studied, there is no difference between superfatting and discounting.

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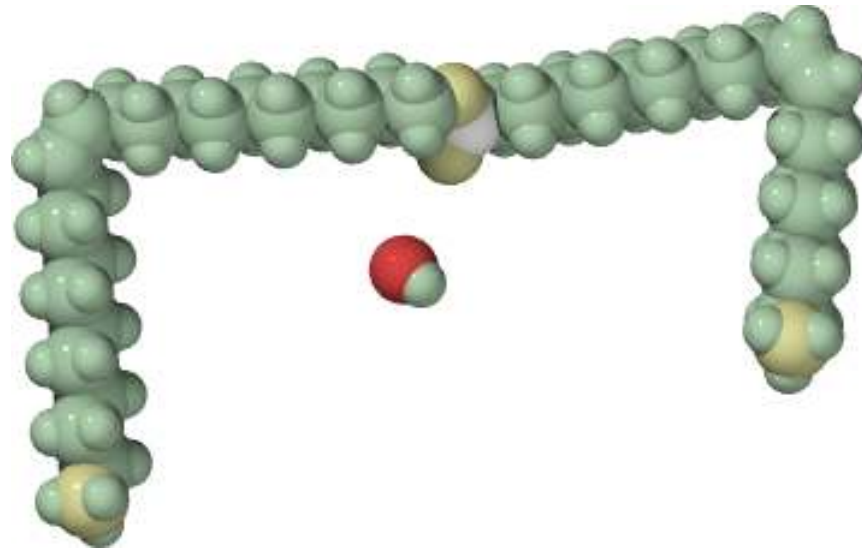
Jojoba "Oil": A Special Case

- Jojoba has been in short supply (2010-2012).
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- Jojoba is not a triacylglyceride--it is a wax ester.

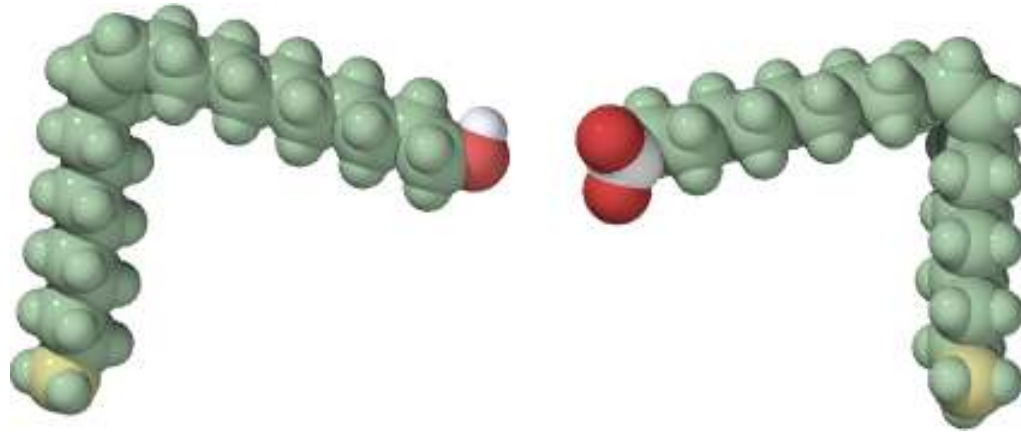
Jojoba "Oil": A Special Case

- Jojoba has been in short supply (2010-2012).
- Jojoba is still expensive.
- Jojoba is not a triacylglyceride--it is a wax ester.
- How does Jojoba saponify?

Jojoba: A Wax Ester



Saponified Jojoba



Jojoba Delight

- Jojoba Delight: 39% Olive, 28% Palm, 28% Coconut, 5% Jojoba

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- 3% lye discount

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- Jojoba Delight: 39% Olive, 28% Palm, 28% Coconut, 5% Jojoba
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- Fatty matter extracted with petroleum ether

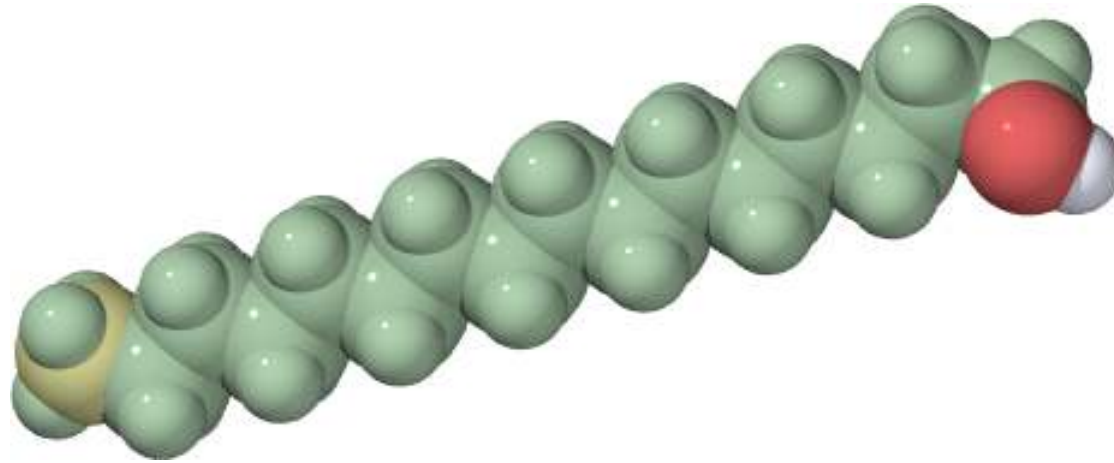
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- Extract contained mostly fatty alcohol

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- 3% lye discount
- Fatty matter extracted with petroleum ether
- Extract contained mostly fatty alcohol
- Extract contained no unsaponified ester

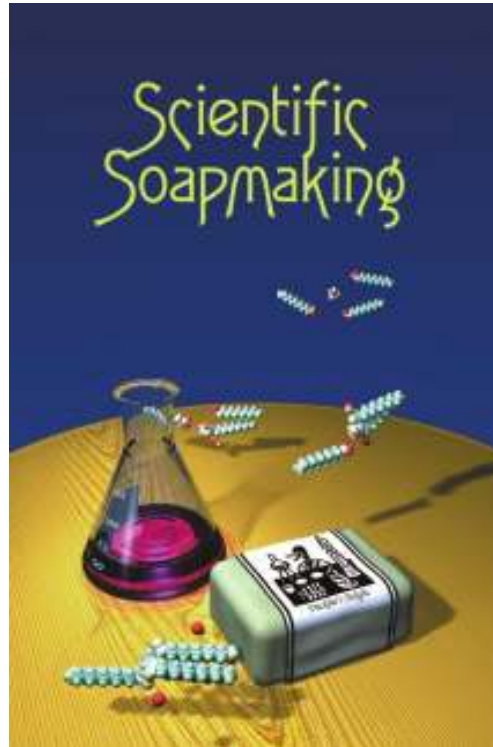
Cetyl Alcohol



Cetyl alcohol is an inexpensive fatty alcohol that can be substituted for jojoba in soap (not cosmetics). Substitute 2 oz of jojoba with 1 oz of cetyl alcohol.

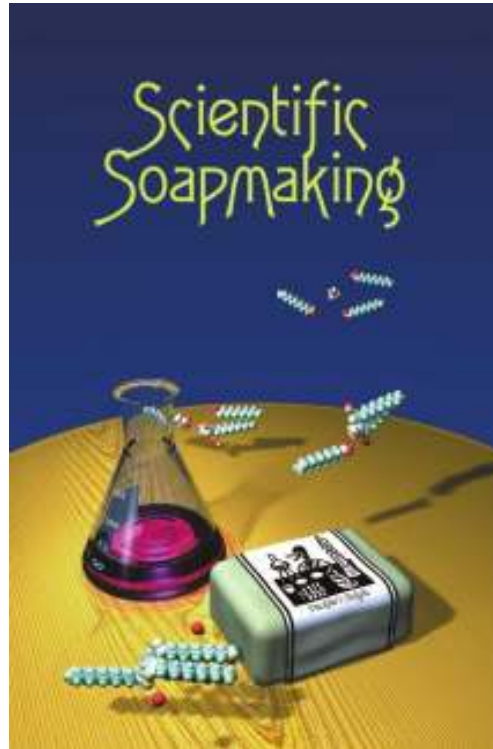
Questions

Scientific Soapmaking



Thanks to the HSCG for all the questions I could not have answered 8 years ago.

Scientific Soapmaking



Thanks to the HSCG for all the questions I may be able to answer in the coming years.