Making Soap

“Water and oil don’t mix.”
Polar is immiscible with nonpolar

How is soap made?

- Soaps are made by a chemical reaction between fats/oils and sodium hydroxide ("lye").
- Chemical Reaction:

  Fat or Oil + NaOH → Soap

  Hydrophobic + Hydrophilic → amphiphilic

- Because soap is made by this reaction, the reaction is sometimes called "saponification"

https://www.youtube.com/watch?v=Fuu1ZCg5byg

Soap – Ingredients

Oil or Fats - Almost any natural oil or animal fat can be turned into soap.

Lye (NaOH - Sodium Hydroxide) - The ingredient that converts the oil or fat to soap.

Water - Preferably distilled water or bottled water. Minerals in hard tap water aren't good for soapmaking.

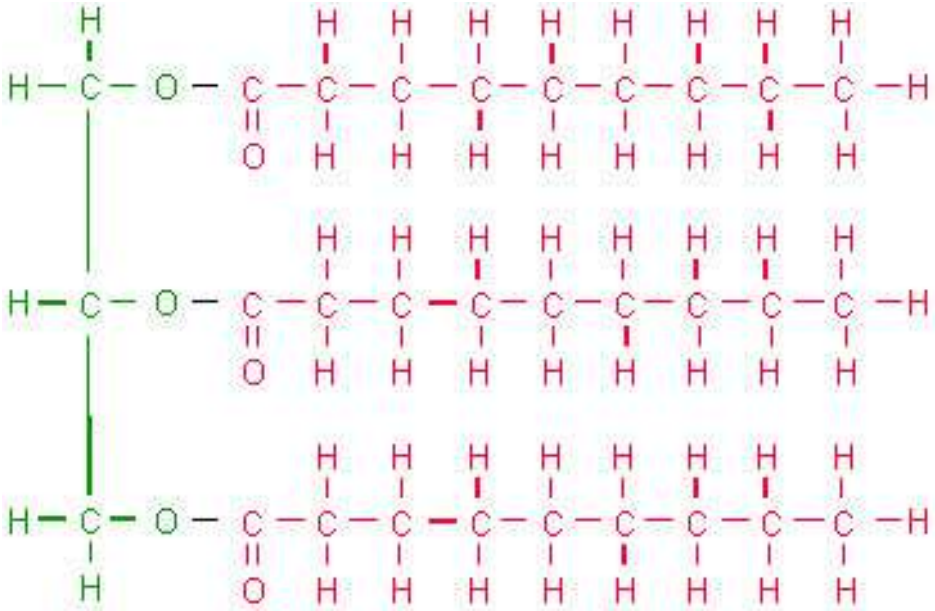
Essential and Fragrance Oils - These are not required, but can add a nice fragrance to your soap.

Soap Colorants – To color the soap.

Other additives - Oatmeal, spices, herbs etc. can also be added to add texture or for exfoliation.

The Structure of Soap

- You start with a fat molecule, which contains:
  - H – hydrogen
  - C – carbon
  - O – oxygen
- Fat molecules are also called “triglycerides”. They have three identical arms, which is where the “tri” comes from

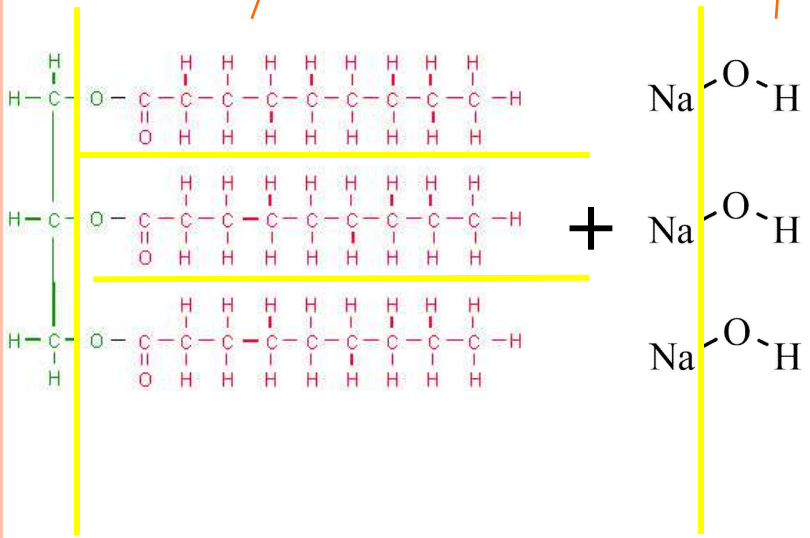


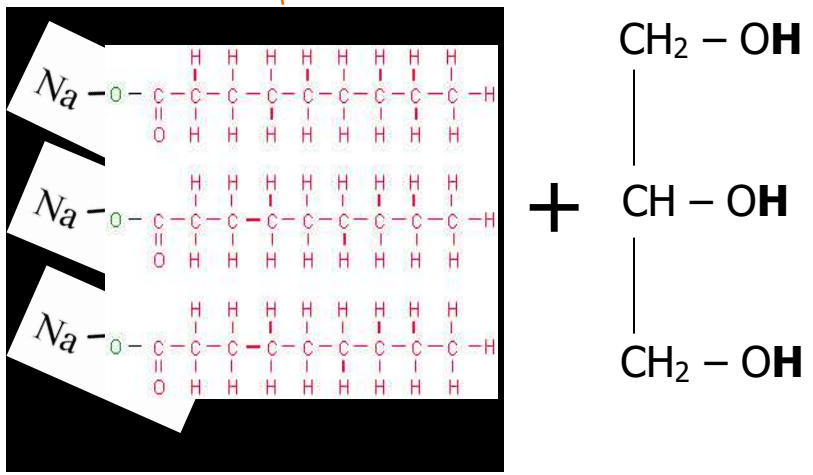
A fat molecule (a.k.a. a triglyceride)

- The various fats & oils that can be used in soapmaking all have this basic structure.

Saponification Reaction:

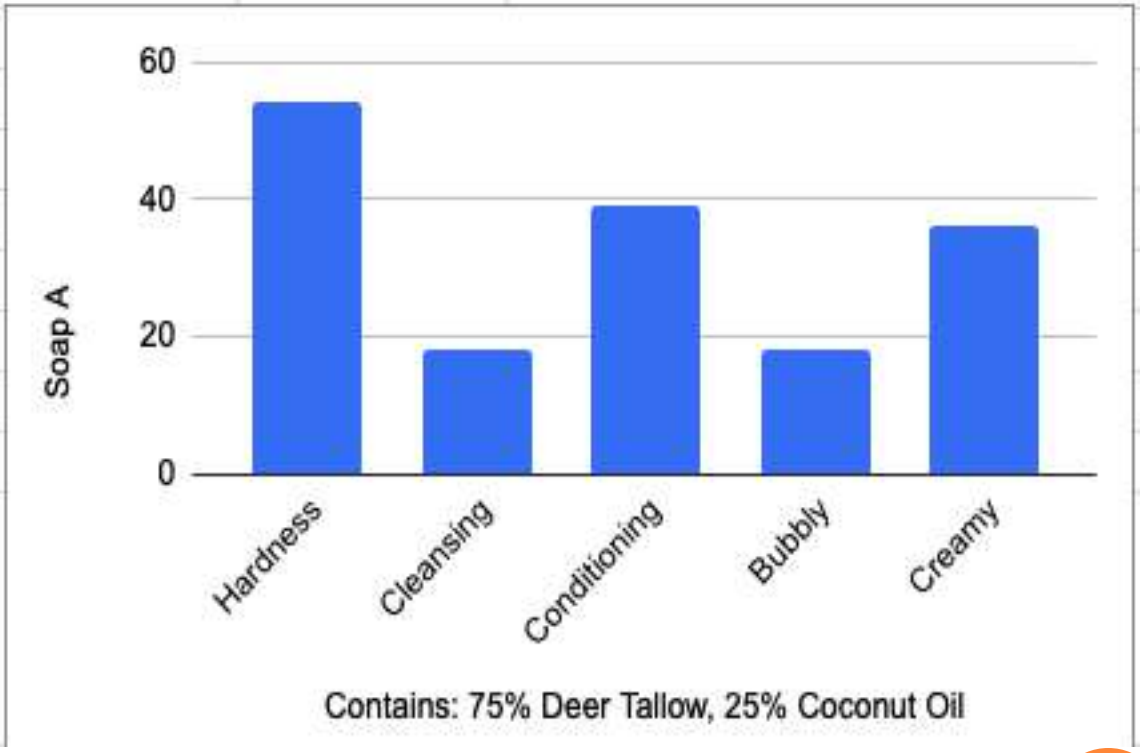
ACID		BASE		SALT		
Fat or Oil	+	NaOH	→	Soap	+	Glycerol
(Triglyceride)		(lye or sodium hydroxide)				





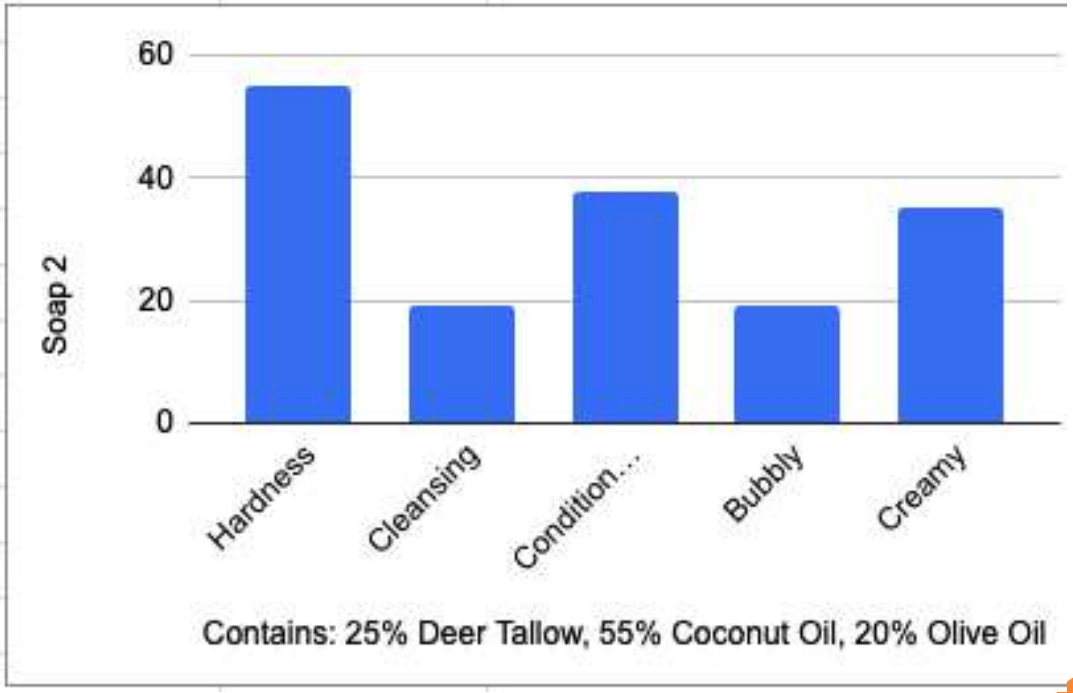
Testing Soap: Recipe A

Soap A	
Contains: 75% Lard, 25% Coconut Oil	
Hardness	54
Cleansing	18
Conditioning	39
Bubbly	18
Creamy	36



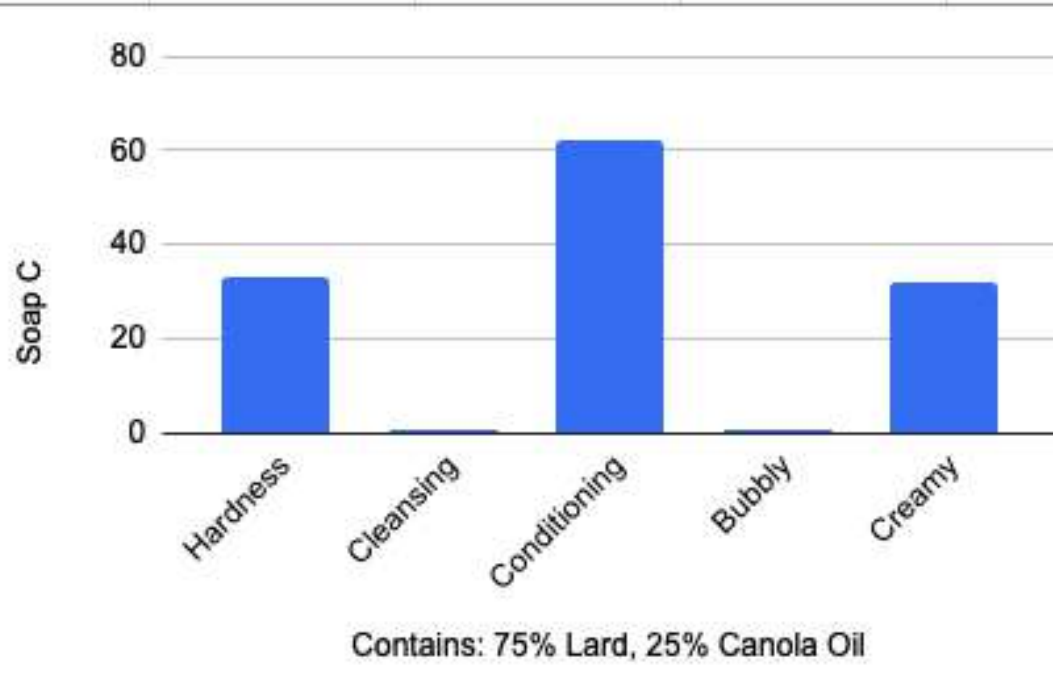
Testing Soap: Recipe B

Soap B	
Contains 75% Deer tallow, 20% Coconut Oil, 5% Myristic Acid	
Hardness	55
Cleansing	19
Conditioning	38
Bubbly	19
Creamy	35



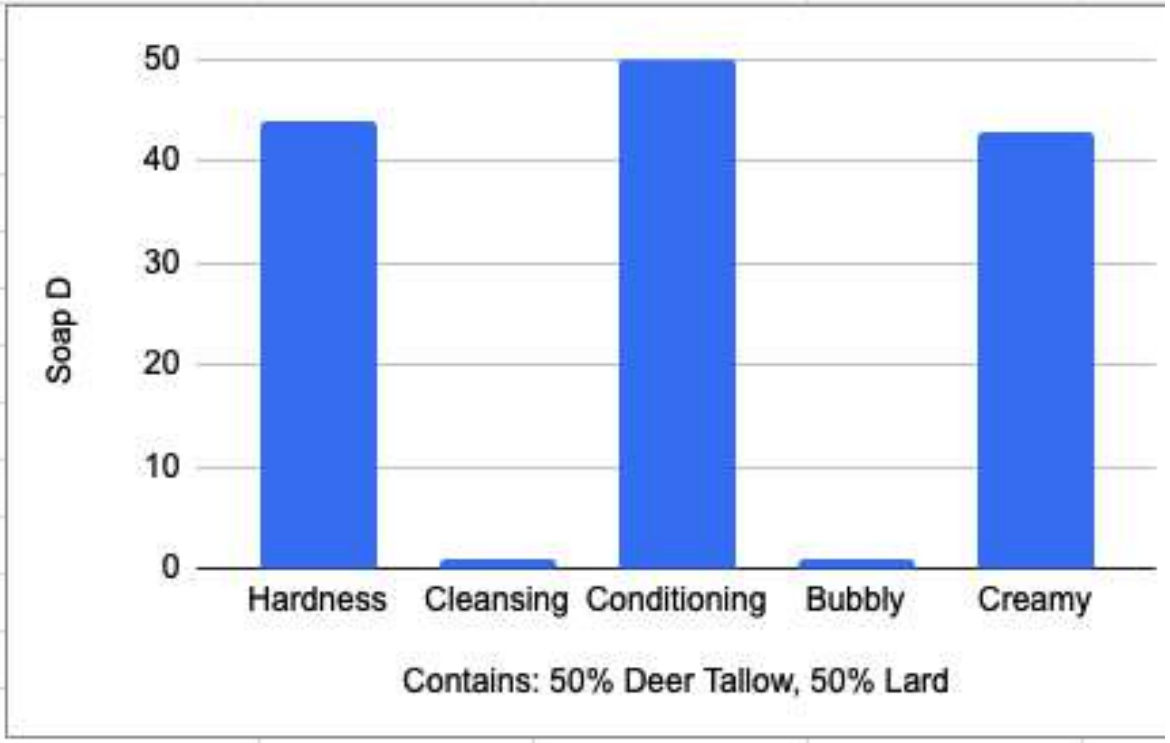
Testing Soap: Recipe C

Soap C	
Contains: 75% Lard, 25% Canola Oil	
Hardness	33
Cleansing	1
Conditioning	62
Bubbly	1
Creamy	32



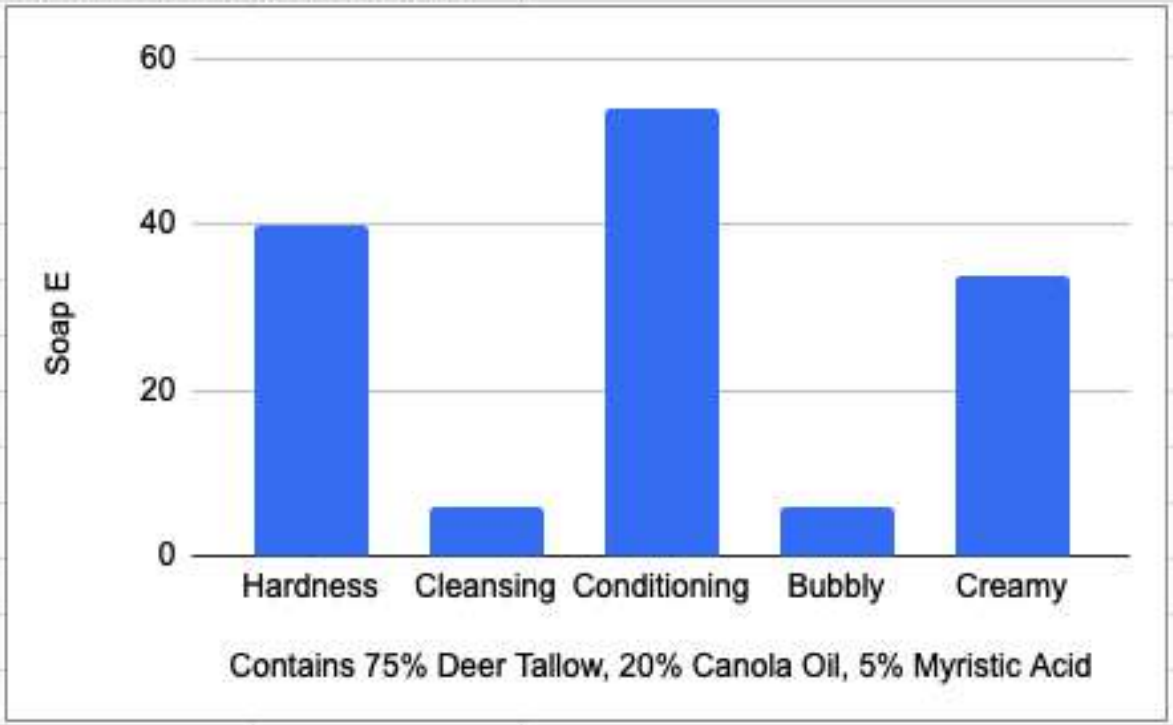
Testing Soap: Recipe D

Soap D	
Contains: 50% Deer Tallow, 50% Lard	
Hardness	44
Cleansing	1
Conditioning	50
Bubbly	1
Creamy	43



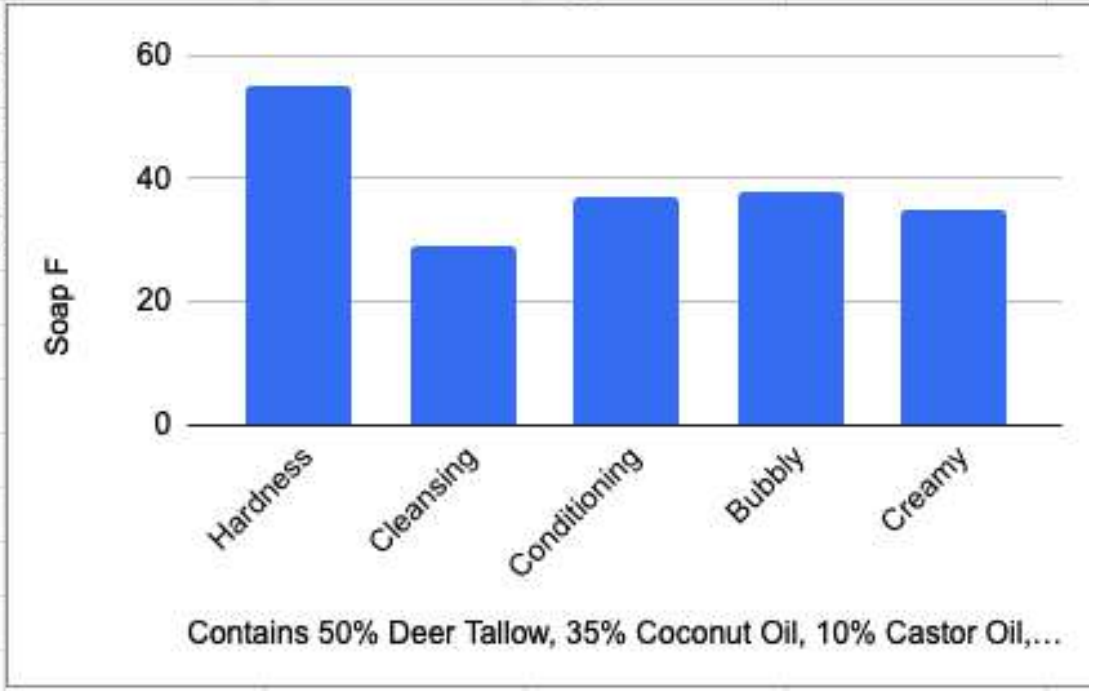
Testing Soap: Recipe E

Soap E	
Contains 75% Deer Tallow, 20% Canola Oil, 5% Myristic Acid	
Hardness	40
Cleansing	6
Conditioning	54
Bubbly	6
Creamy	34



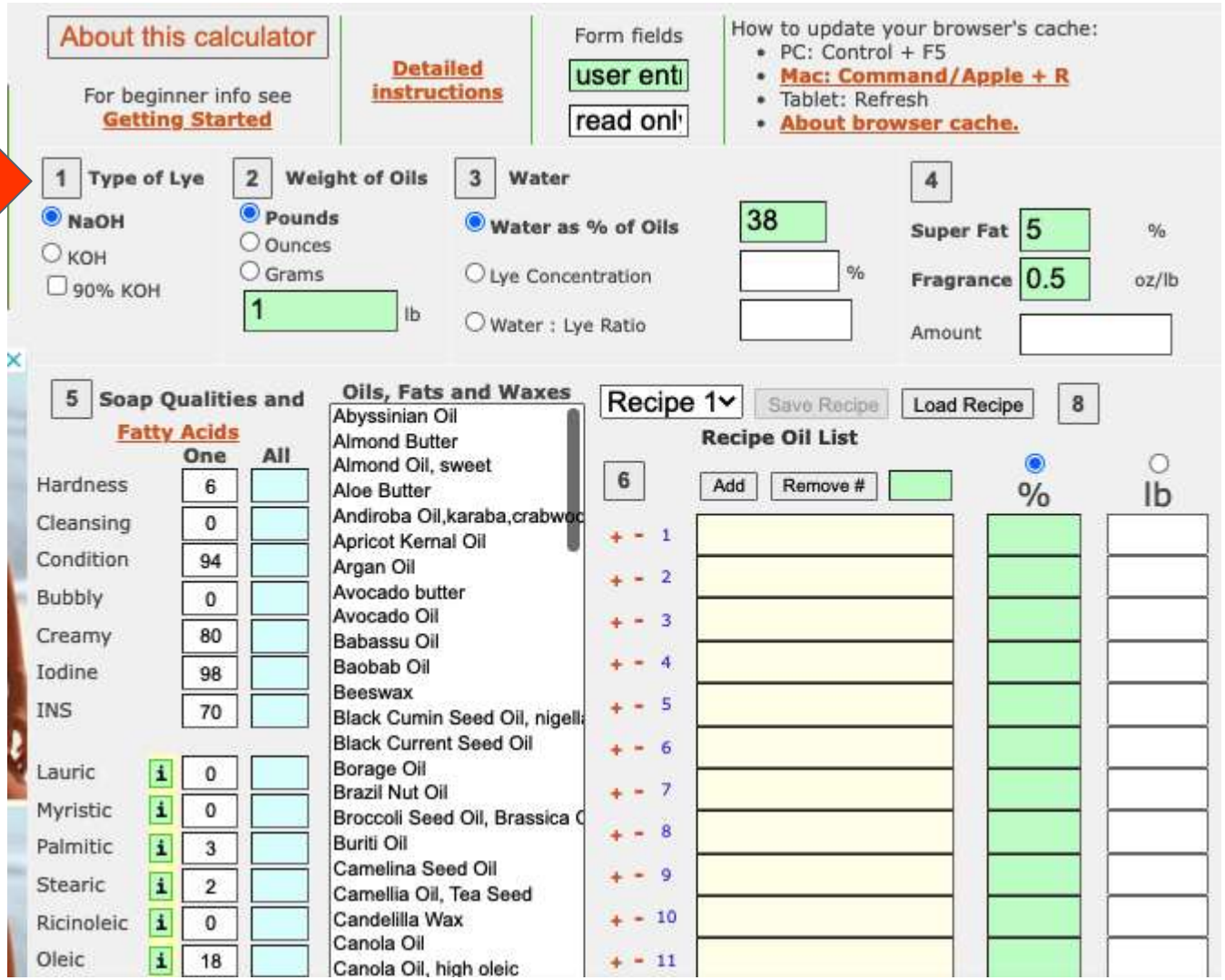
Testing Soap: Recipe F

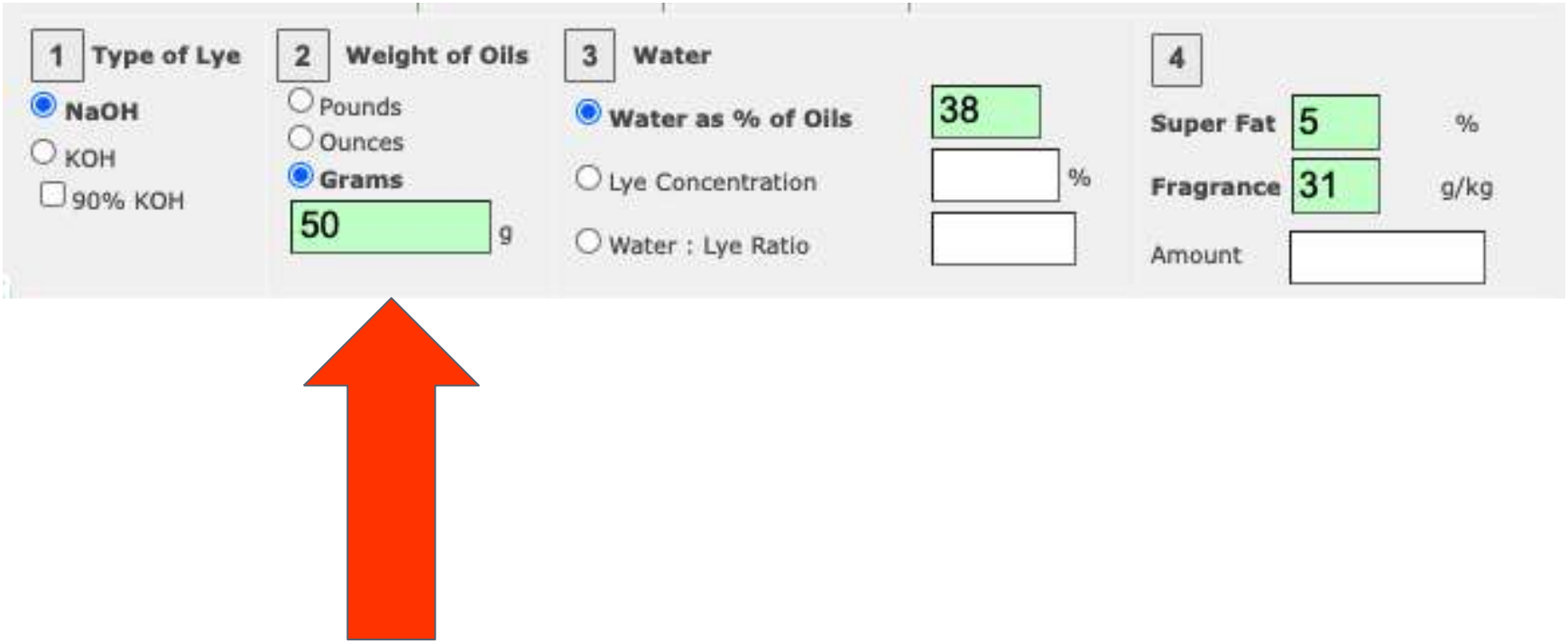
Soap F	
Contains 50% Deer Tallow, 35% Coconut Oil, 10% Castor Oil, 5% Myristic Acid	
Hardness	55
Cleansing	29
Conditioning	37
Bubbly	38
Creamy	35



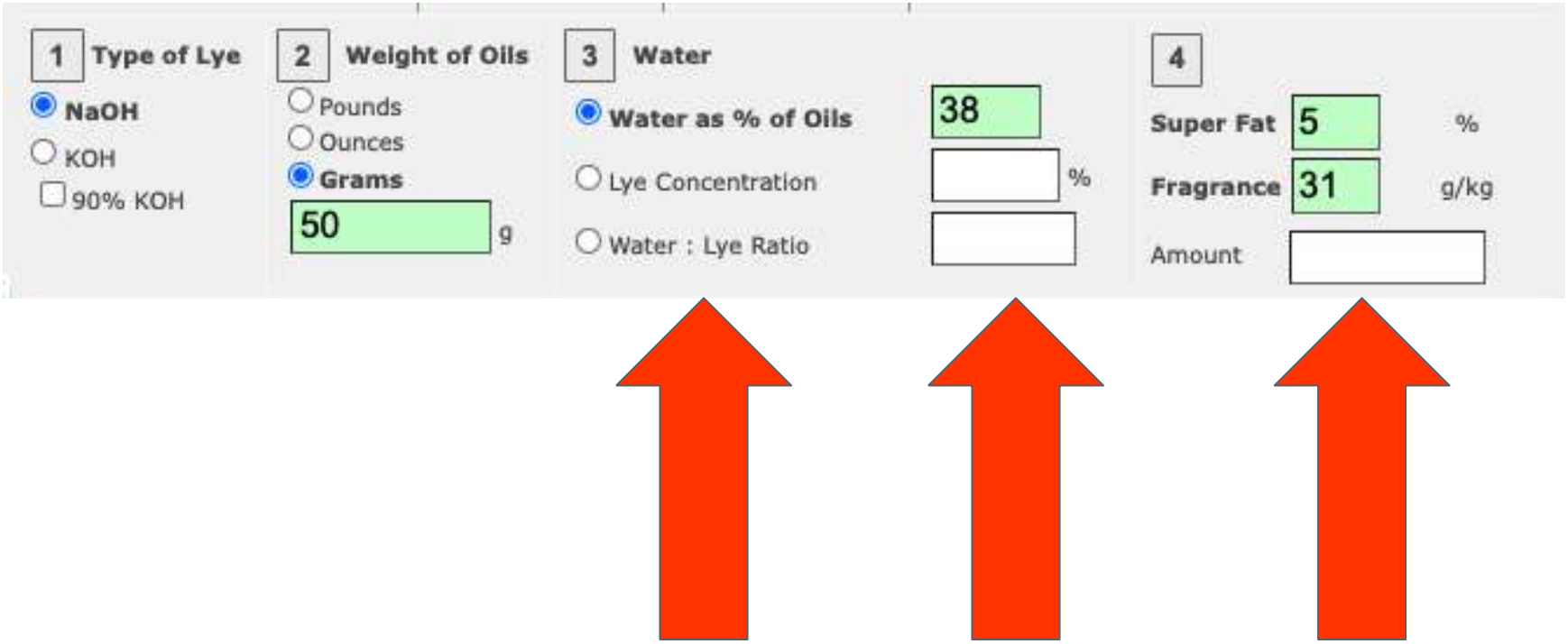
How to use the Soap Calculator

Leave type of Lye on NaOH, Sodium Hydroxide

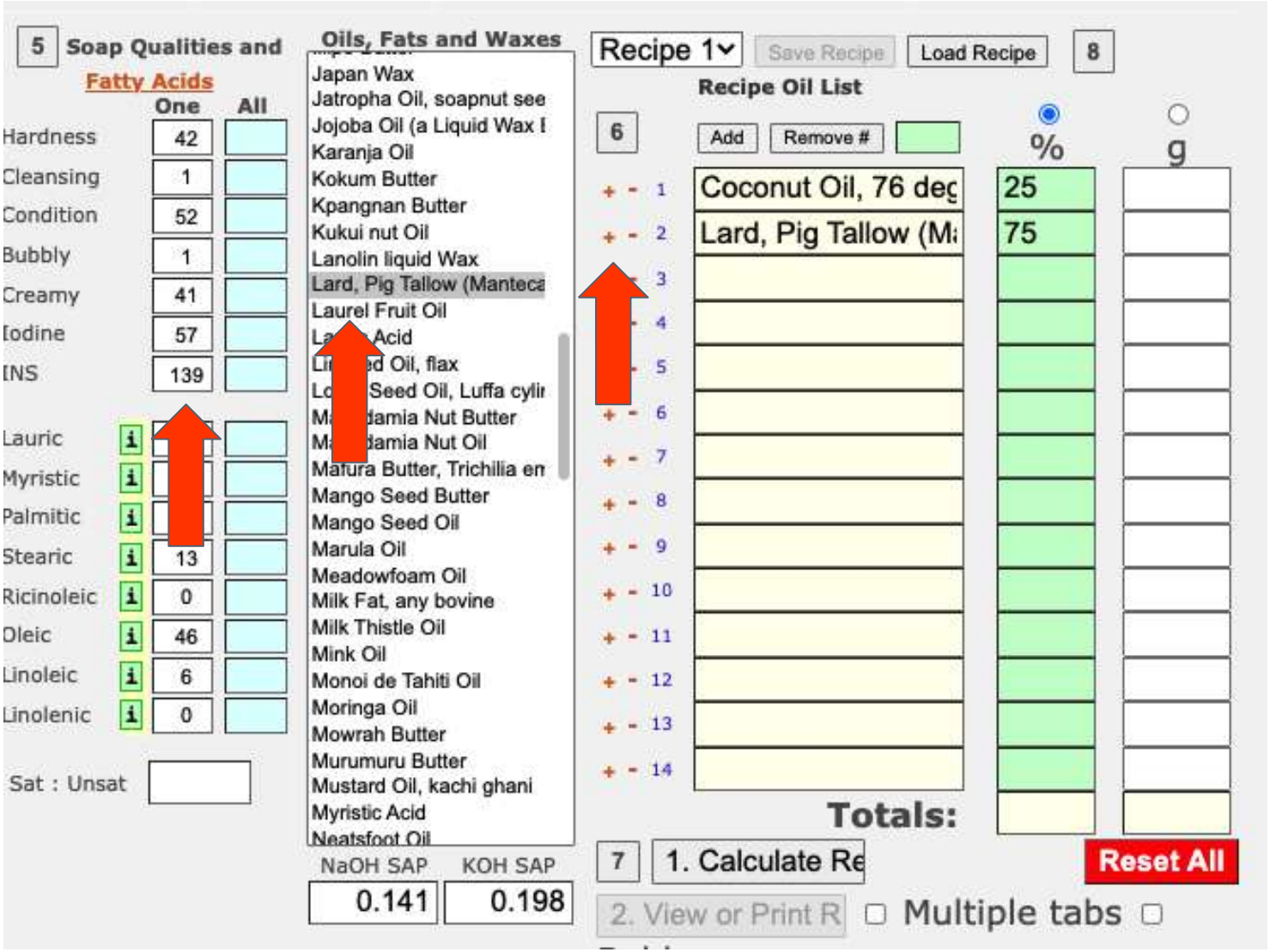




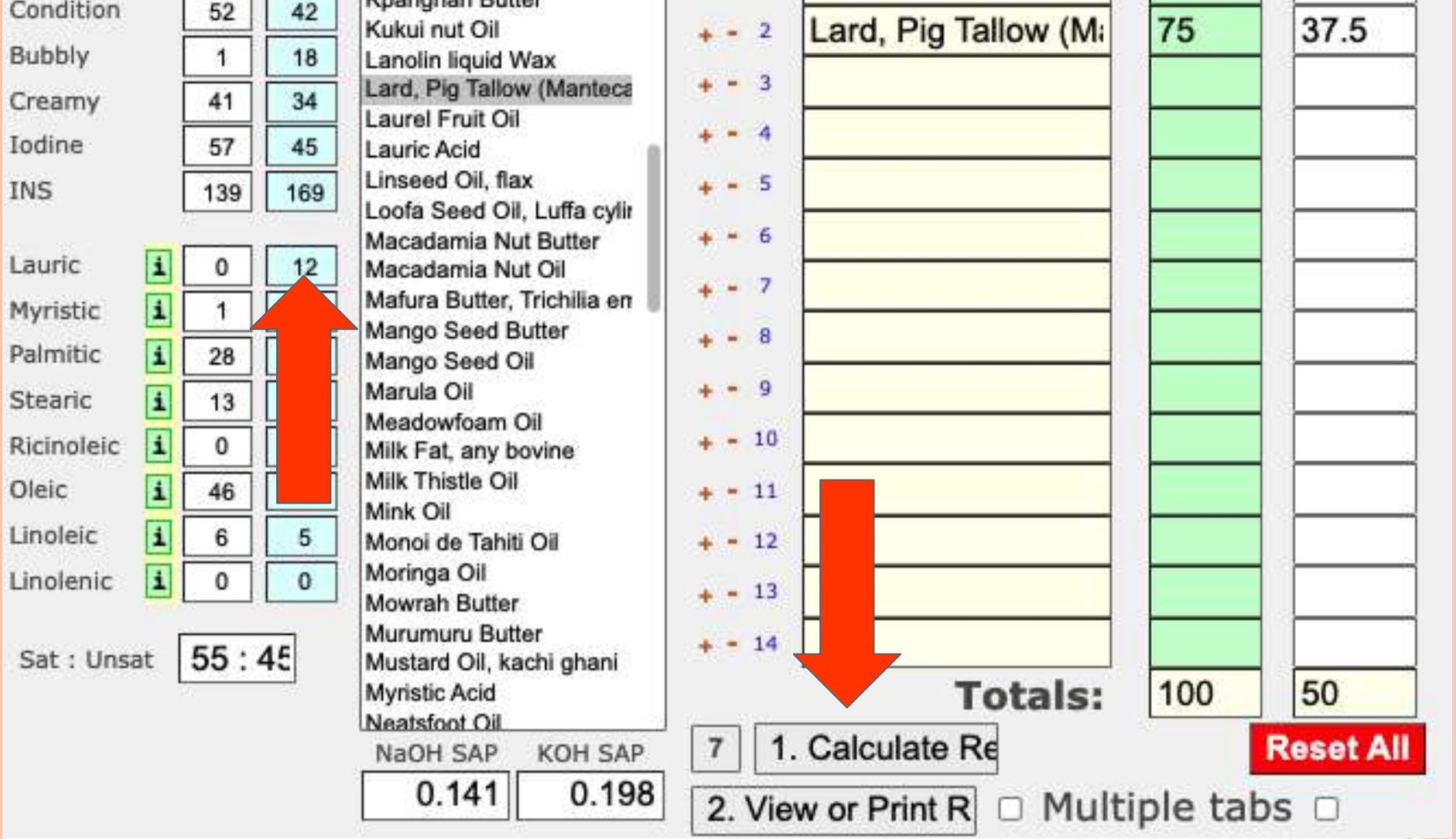
Change Weight of Oils to 50 Grams



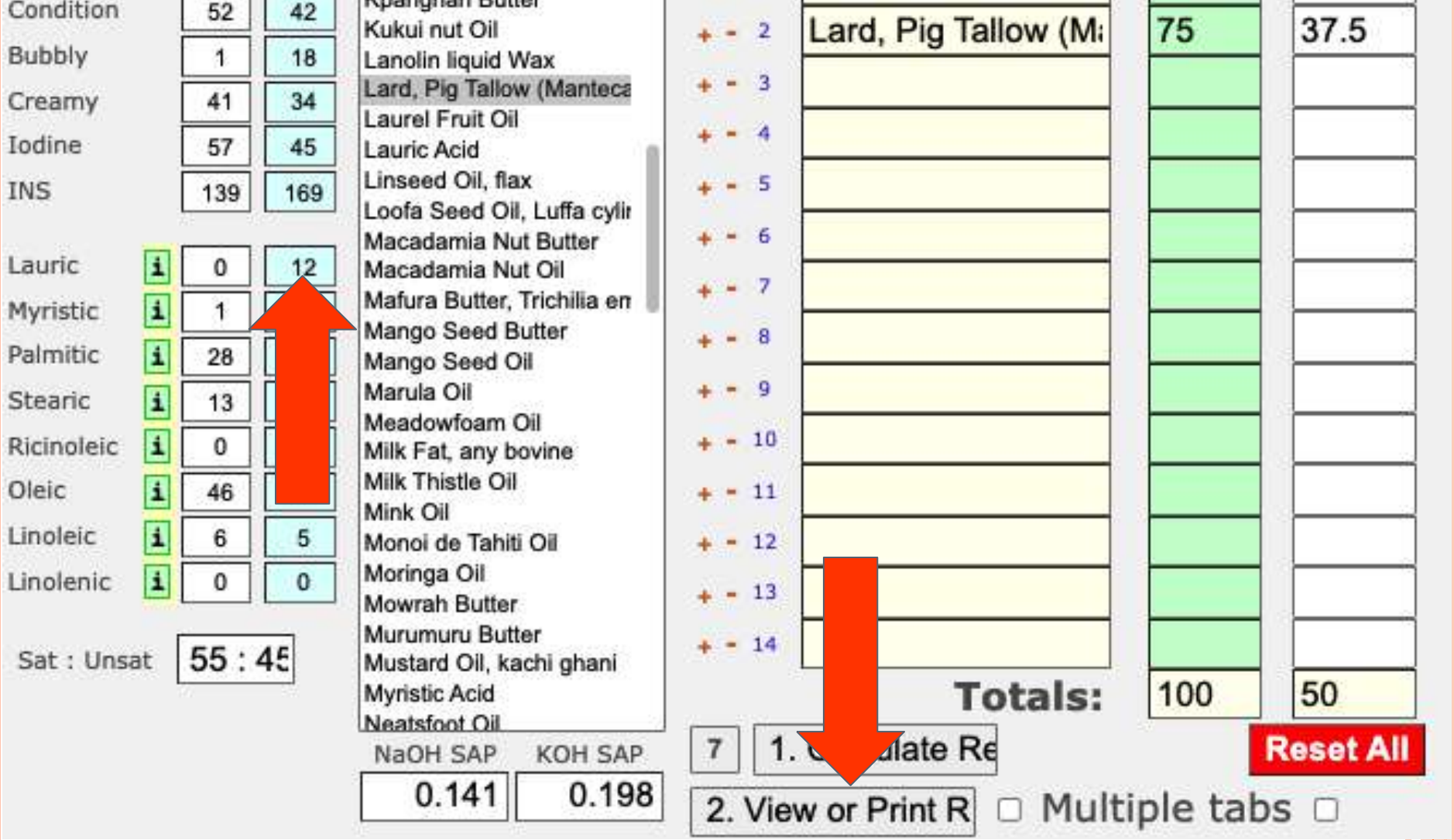
Leave these things as they are



Select your Fats from the List, Click the plus sign and enter the % you want. The "One" column tells you the properties of that fat/oil



Click on “Calculate Recipe” to see the properties of your soap



Click on "View/Print Recipe." Keep your recipe and don't lose it!

SoapCalc © Recipe Name: New INCI Names Print Recipe

Total oil weight	50 g
Water as percent of oil weight	**38.00 %**
Super Fat/Discount	5 %
Lye Concentration	27.496 %
Water : Lye Ratio	2.6369:1

Sat : Unsat Ratio	55 : 45
Iodine	45
INS	169
Fragrance Ratio	31
Fragrance Weight	1.55 g

	Pounds	Ounces	Grams
Water	0.042	0.67	19.00
Lye - **NaOH**	0.016	0.25	7.21
Oils	0.110	1.76	50.00
Fragrance	0.003	0.05	1.55
Soap weight before CP cure or HP cook	0.171	2.74	77.76

#	√	Oil/Fat	%	Pounds	Ounces	Grams
1	☐	Coconut Oil, 76 deg	25.00	0.028	0.44	12.50
2	☐	Lard, Pig Tallow Manteca	75.00	0.083	1.32	37.50
		Totals	100.00	0.110	1.76	50.00

Soap Bar Quality	Range	Your Recipe
Hardness	29 - 54	51
Cleansing	12 - 22	18
Conditioning	44 - 69	42
Bubbly	14 - 46	18
Creamy	16 - 48	34
Iodine	41 - 70	45
INS	136 - 165	169

Lauric	12
Myristic	6
Palmitic	23
Stearic	11
Ricinoleic	0
Oleic	37
Linoleic	5
Linolenic	0

The Fats/Oils I Have Available

Coconut Oil, 76

Canola Oil

Olive Oil

Castor Oil (max 10%)

Pig Lard

Deer Tallow (recommend at least 50%) OR

Beef Tallow (recommend at least 50%)

Myristic Acid (max 5%)

Our Procedure

1. Measure out the amount of **distilled** water into a 250 mL glass beaker
2. Measure the amount of NaOH and dissolve into the water. It will get hot. Label this "beaker A"
3. Use dixie cups to Measure the correct amounts of oils for your recipes. Put them all into a 250 mL beaker. Melt them if they are a solid. Label this "beaker B"

   Recommendation: add Myristic Acid last if it is in your recipe.

1. **Slowly** add Beaker A into Beaker B as you stir with a stirring rod.
2. Mix quickly until saponification has completed as shown by turning white and thick. You can use a stirring rod or your may be able to use a blender or other mixing device.
3. Pour into a dixie cup/mold.
4. Let harden and cure for at least one week.
5. Test the soap. Record observations for texture, bubbles, softness, pH, etc.
6. Decide if you want to make more bars with this recipe.

Things to be aware of before making soap: LYE

Lye (NaOH) is a key ingredient in the production of soap. Through a chemical reaction it converts oils and fats to what we know as soap. Lye is in drain openers (Drano, etc.) because it can clear clogs by converting greasy buildups into something that can be rinsed away.

Lye is a strong base and is corrosive. It can burn you, blind you, and kill you if ingested. Lye should be handled with care, like you would handle drain cleaner, bleach or pool chemicals.

Working with lye:

1. Wear long gloves and goggles.
2. Be aware that your clothes can get wrecked if splashed with lye.
3. In making soap, you will have to mix lye and water. **Never pour water into lye. Always pour lye into water (s l o w l y).** If you pour water onto lye it can cause a violent reaction.
4. Always pour, stir, and handle lye gently, to avoid splashing and spilling.
5. Always know where your lye is, to keep it from being mistaken for something else (e.g., water, which is also used in soapmaking).
6. Have a "lye sink", where stuff that contacted lye will be washed. Then people will know not to use that sink except with gloves.
7. Wash utensils/bowls that came in contact with lye soon after using, so it will not be touched/used mistakenly by someone else.
8. Do not touch utensils/bowls from others' areas or use clear liquids that may not be yours. You may be unknowingly coming into contact with lye!
9. Do not inhale lye fumes. Work outside or use a fume hood.

Things to be aware of before making soap: TRACE

- When mixing your fats with the lye-water mixture to make soap, it is important not to overmix or undermix. The trick is to STOP mixing at the moment of "trace."

- Watch this video:

http://candleandsoap.about.com/od/coldprocesssoapmaking/g/glosstrace.htm

Other Materials

MOLDS:

- A wooden or cardboard box lined with saran wrap
- Candy molds
- A PVC pipe capped on one end (spray the inside with PAM, pour the solution into the pipe, let it set, and then uncap and push out the soap).
- Silicone bakeware
- Lego!
- Yogurt containers, plastic containers, ice cream containers, tupperware, pringles boxes, etc.

BLENDER:

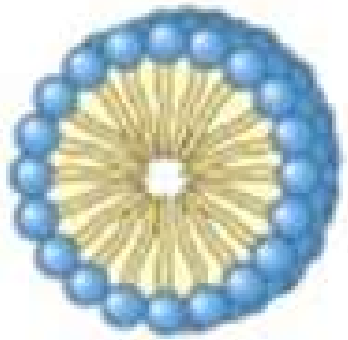
- Soap can be stirred by hand, but can take a really long time for the chemical reaction to happen
- It is much easier to use a stick blender or actual blender. It only takes seconds or minutes to reach trace.

History of Soap Making - A Brief Overview

- Soap may be the first chemical compound ever synthesized by man!
- 2,800 B.C. – excavations reveal Babylonians were making soap by boiling animal fat with ashes.
  - Used to clean wool and cotton used in textile making
  - Used for medicinal purposes
- 1550 B.C. – Egyptian writing reveals soap Egyptians made soap by mixing animal and vegetable oils with alkaline (base) salts
  - Egyptians medical scrolls recommend a soap for skin conditions

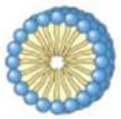
Chemistry of Soap

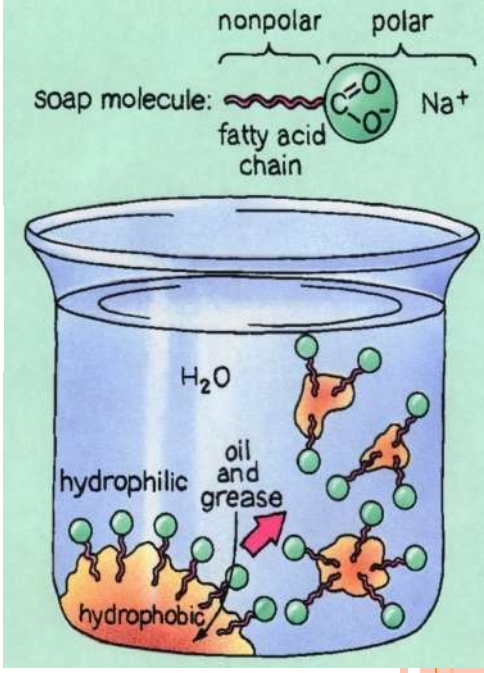
- Soap molecules act like a diplomat, improving the relationship between water and oil.
- How?
  - When soap is added to the water, the hydrophilic (polar) heads of its molecules stay in the water (they are attracted to water),
  - The long hydrophobic (nonpolar) chains join the oil particles and remain inwards (escaping from the water).
- This behavior forms a micelle.



Micelle

Micelles Formation


Micelle

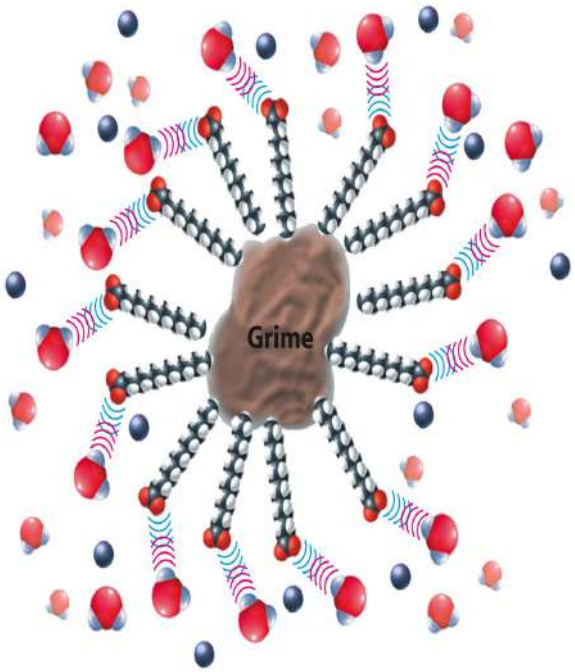


How Soap Works – Video

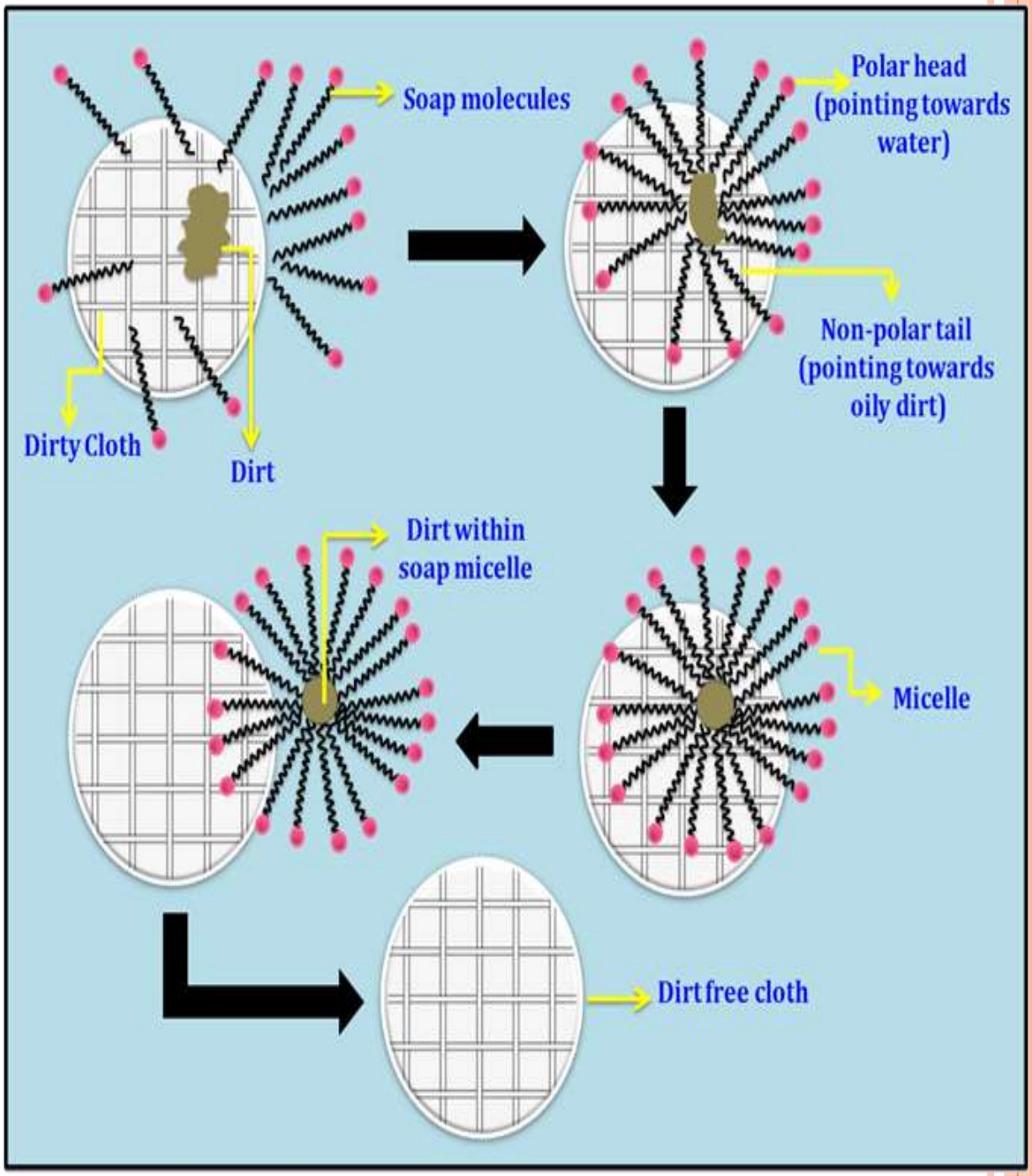
- When enough soap is added to water the soap molecules (sodium stearate) aggregate into micelles.
- Micelles are colloid particles
- Colloid particles stay suspended in solution due to collisions with other molecules in the solution
- The specific colloid formed is called an Emulsion
  - Emulsion: when the dispersing solute (micelles) is in liquid form within a liquid solvent (water)
- When viewed under a microscope, colloids are very jittery due to Brownian Motion

Micelles to the rescue

- The micelles carry the oily dirt particles away from the skin (or surface).
- The water molecules hold the micelles in solution and carry them down the drain!



Describe what is happening:



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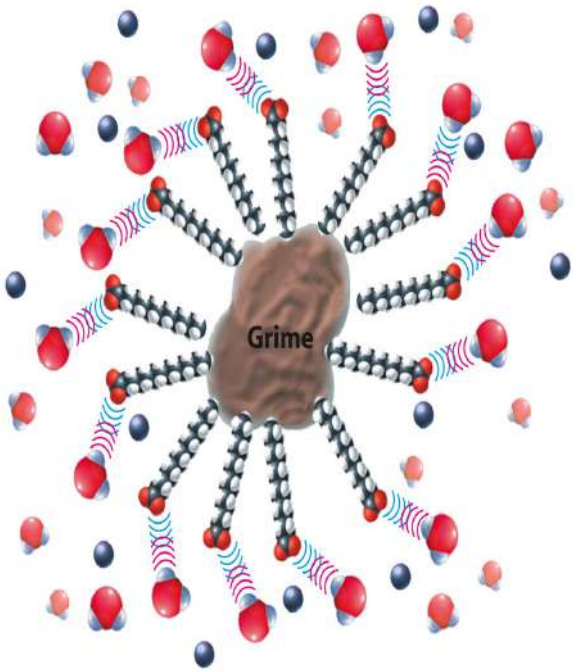


Micelle Formation

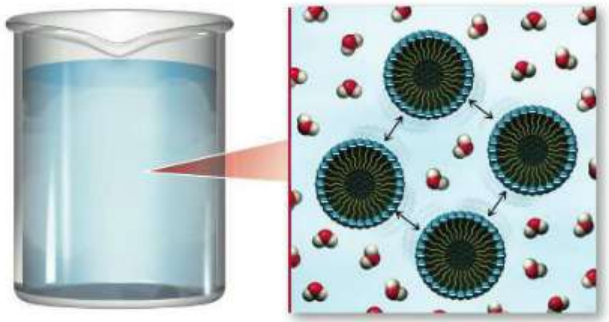
- The "colloidal particles" are micelles which form immediately when the soap dissolves in water.
- This forms a 'haze'
- Individual micelles are too small to be seen by the naked eye.
- 50-100 nm in size

▲ **FIGURE 12.19 A Colloid** Soapy water is an example of a colloidal dispersion. The haze is due to the scattering of light by the colloidal particles.

Micelle Formation

- You can tell if a substance is a colloid if the substance refracts light when shined into a colloidal solution. This refraction is called the Tyndall Effect.

▲ **FIGURE 12.23 The Tyndall Effect** When a light beam passes through a colloidal suspension (left), it is visible because the colloid particles scatter some of the light. The beam is not visible in pure water (right), nor would it be visible in a noncolloidal solution.



▲ **FIGURE 12.24 Micelle Repulsions** Micelles do not coalesce, because the charged surface of one micelle repels the charged surface of another.

Micelles form when using Soap

- Why can't water just clean everything? Why use soap?
  - Surface tension keeps water from easily spreading across a surface
  - Surface tension must be weakened in order to get water to spread across an oily surface. Water is not attracted to oil because oil is a nonpolar substance
- Soap can weaken surface tension because soap is a surfactant
  - Surfactant: SURface ACTive agents (they reduce surface tension of water)
- Surfactants inhibit the intermolecular attractions between water molecules, and this IMF attraction is what causes strong surface tension in water.
- The soap allows the water to flow more smoothly which allow micelles spread across an oily surface to collect grime to be washed away.

Soap Breaks Surface Tension

- Soap Breaking Surface Tension

- Marangoni Effect – Soap Powered Boat

Water Hardness Affects Micelles Formation

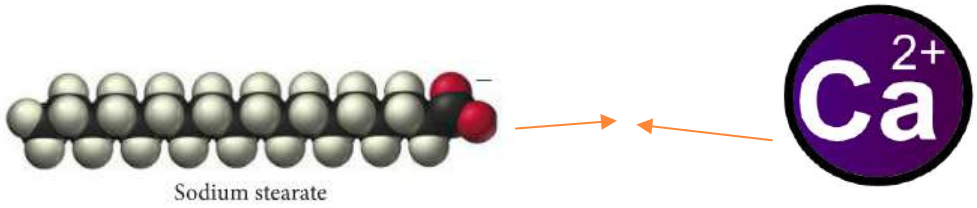
- What is water hardness?
  - Water that has a lot of dissolved ions in it is considered hard water.
  - A common dissolved ionic compound in water is Calcium Carbonate ($CaCO_3$)
    - 0-60 mg/L $CaCO_3$ (Soft Water)
    - 61-120 mg/L $CaCO_3$ (Moderately Hard)
    - 121-180 mg/L $CaCO_3$ (Hard Water)
- How does hard water affect soap?
  - The hydrophilic (polar) end of an individual soap molecule is negatively charged. So what do you think happens when using soap in hard water?

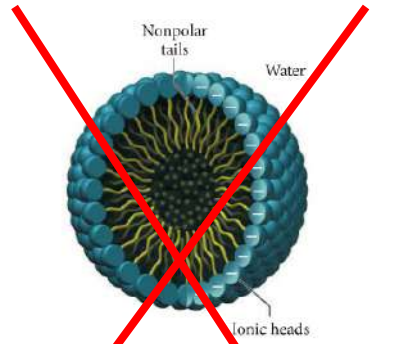
Sodium stearate

▲ **FIGURE 12.21 Structure of a Soap** A soap molecule has a charged ionic head and a long nonpolar hydrocarbon tail.

Water Hardness Affects Micelle Formation

- (IN WATER) $CaCO_3$ (s) Ca^{2+} (aq) + CO_3^{2-} (aq)



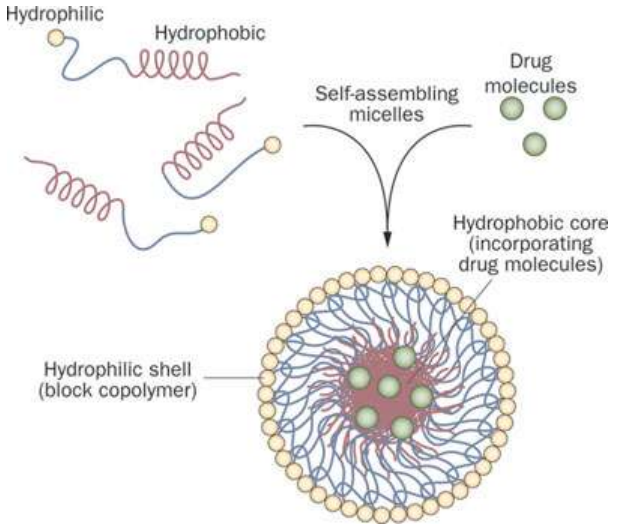


- Micelles will not form because the soap molecule will no long be amphoteric, it will become non-polar
- "Soap Scum" will form and the soap will not clean properly.

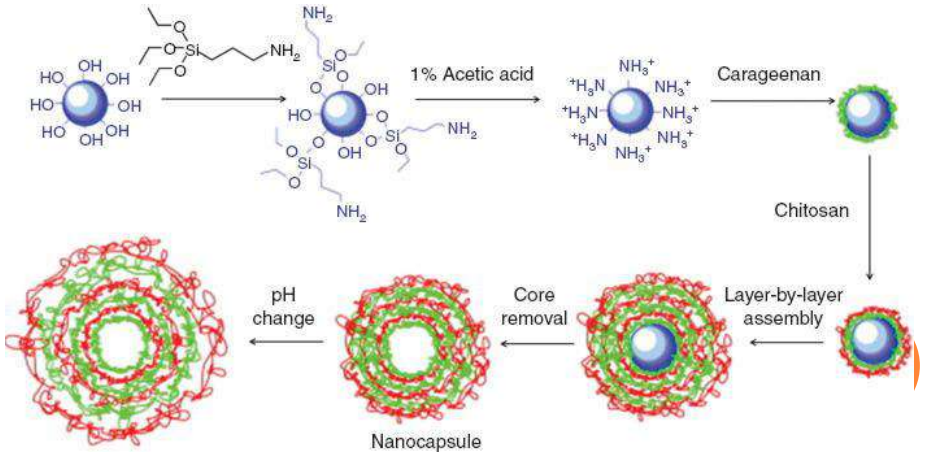
Soap Scum: Calcium Ions attached to Soap Molecules

Industrial Applications for Polymer Micelles

- A chemical delivery system for medication – polymers used to create a "nanocapsule" (University of Akron)



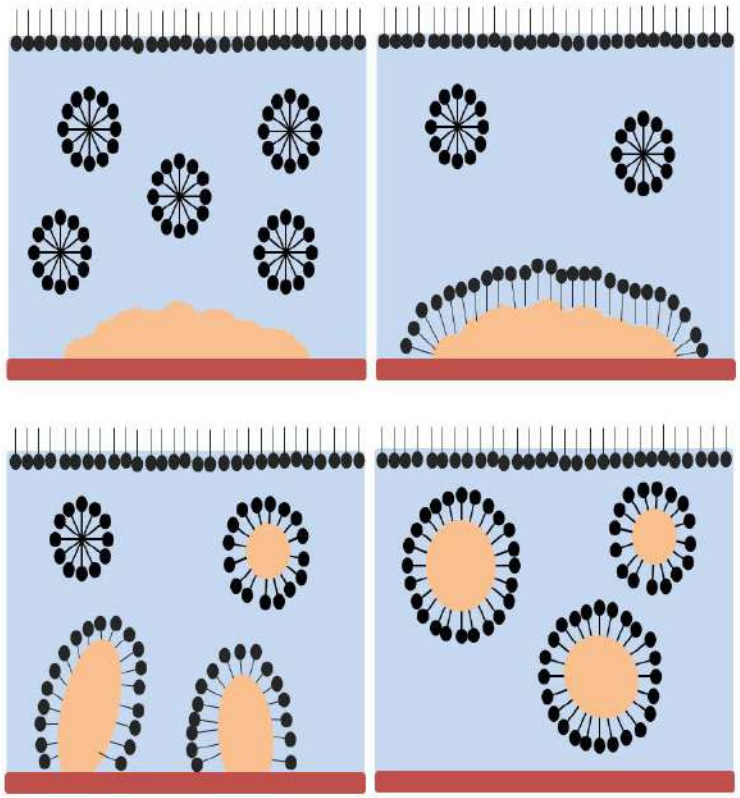
- Creating multi-layered micelles with polymers (University of Akron)



Industrial Applications for Polymer Micelles

- Many lotions and beauty products contain chemicals that enhance the effect of micelles.
- Lubrizol Corporation makes chemical additives that are placed into lotions which enhance the effectiveness of micelles.
- Detergent companies have been researching better methods of using micelles for over 100 years.

Can you describe what is happening in the images below using proper chemistry terms?



Reference

- http://www.soaphistory.net/
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- https://science360.gov/obj/tkn-video/81074969-11e0-4a2e-b674-8fc8886fd9c3
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