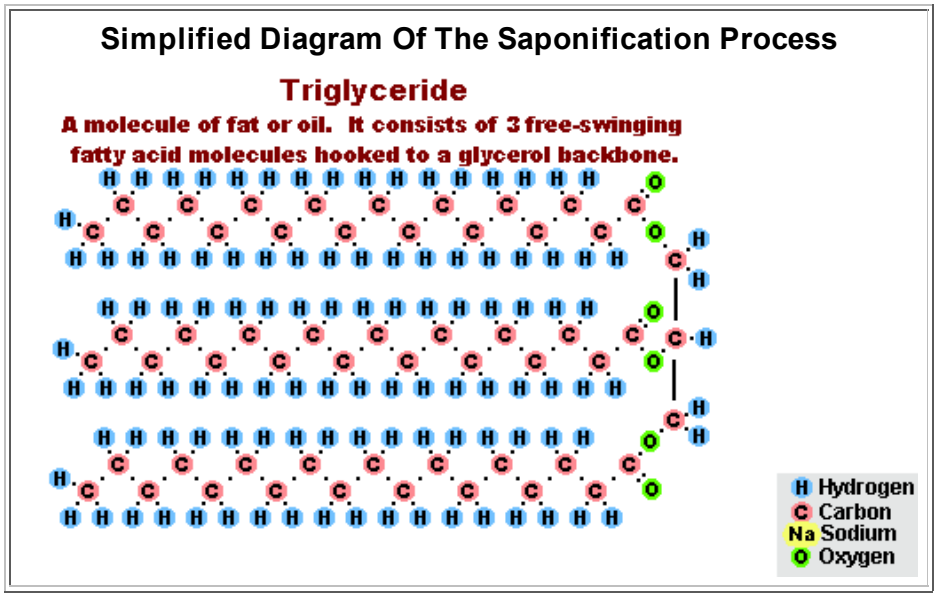
Making Soap With James Hershberger, A Chemical Engineer

What is soap and how does it work? Soap is saponified fat; a chemical reaction that takes place between oil and lye. I'm often ask the question, "Can I make soap without lye or some other caustic agent?" The answer is, "No." Some places sell spaghetti for "making soap" but this is already soap. This is only a remelt or a "rebatch operation."

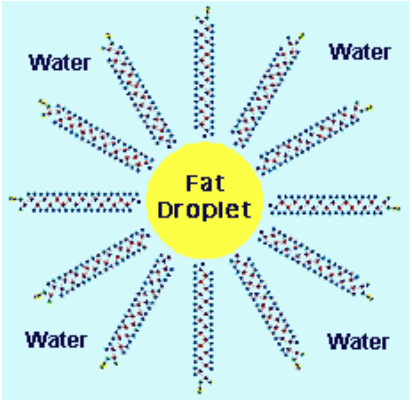
Fats are made up of fatty acid molecules. Three fatty acid molecules are tied together into what are called "triglyceride" molecules. View the movable image below to see what happens when a stearic acid triglyceride molecule and three lye (sodium hydroxide) molecules come together to form 3 soap molecules and 1 glycerin molecule.

James Hershberger or "Hersh"



Interestingly enough, there actually isn't that much glycerin compared to the soap. Figuring the atomic weights, there's only 1% glycerin compared to 99% soap.

A soap molecule has an amazing characteristic. One end of the molecule is attracted to fats and repels water and the other end of the soap molecule with the two oxygen atoms and the sodium atom (Na) loves to be around water but repels fat. If you placed soap molecules directly between a layer of fat and a layer of water, all the soap molecules would flip so the oil loving part of each molecule pointed towards the oil and the water loving part of each molecule pointed towards the water layer. This doesn't really happen in real life but something just like it does. When oil is placed in soapy water, the soap molecules break the oil into billions of microscopic droplets. These tiny oil droplets are only about one ten-thousandth (0.0001) inch in diameter. Surrounding each droplet are 20 million soap molecules creating a soap film 1 molecule thick. Many people incorrectly think soap dissolves oil. Rather, it puts the oil in a fine suspension in the water, more correctly called an emulsion. This permits the water to 'wash it away' from whatever is being cleaned. For soap to work, it must be agitated to emulsify the fats.



A fat droplet in suspension, surrounded by soap molecules.

The hydrogenation of fat was first developed for the soap making industry in the late 1800's because of a shortage in animal fats. The unhealthy idea of eating them came later. Totally hydrogenated soybean oil is the main fat I use in all of my soap making. It's used for deep fat frying in the fast food restaurants so is readily accessible from any restaurant supply store. This type of fat makes great soap that's gentle on the skin. As

this makes very hard soap, I use olive oil to soften it. Non-virgin oil is cheaper and just as good - maybe even better in soap. For people just learning to make soap, I suggest vegetable shortening as it's so much easier to get.

Lye: As lye heats water when being mixed, for the least chance of accidental boiling and to reduce fumes, I mix my lye into water that's 50% ice. Having ice in the water should prevent it from heating up to the point it causes strong vapors or emits lye droplets. I once mixed my lye in an old Clorox plastic jug. It got so hot the lye melted a hole in the bottom of the plastic and ran all over the place. Ice water will also help prevent this from happening. I now get my lye in a solution of 50% water. I like using lye like this because the chemical reaction between the lye and carbon dioxide in the air forming sodium carbonate won't go into suspension in the water. It settles out in the bottom of the container, keeping it out of my soap. Soap made from lye, or sodium hydroxide, makes solid soap. Potassium hydroxide makes liquid soap.

When adding the lye water to the melted fats, stir the mix in only one direction as you pour in the lye water. Pour it slowly so the water stream is no larger than the diameter of a pencil. Stirring in one direction only spins out the lye stream into a very thin thread. Adding the lye water in this way should should prevent it from settling out in the bottom of the pot. After you've added the water, quickly stir the mix in a figure 8 motion.

To saponify, I now use a stick blender on all of my soaps unless I'm doing one of my many demonstrations at old time re-enactments or Renaissance fairs. I used to exclusively use Di Propylene Glycol or DPG. DPG does the same thing a blender does - finely mix the fat and lye molecules together.

It seems to be very important for ease of pouring into a mold not to have it set in less than 15 to 20 minutes. The panic effects which result from trying to catch a run-away soap batch are not worth the time saved, however the quality of the soap does not seem to be too adversely affected from too much DPG. The plus is that the batch cures very quickly. Since several unknown compounds found even in essential oils accelerate or inhibit saponification, each batch type should be tested if you want predictable results. For instance, lavender oil inhibits a little and probably as much as 0.15% DPG would be added with lavender oil. A batch with no additives should start at 0.05% and if that isn't fast enough, increase in increments of around 0.05% until the soap "makes" in about 15 to 25 minutes. These percentages are out of the entire weight of substances used in a batch of soap including the fats, lye water, perfume color etc. One tsp holds 4 gms DPG which is enough to saponify a 8 kg (17 1/2 lb) batch of soap. I use a large veterinary syringe to meter the correct amount of DPG into the soap batch. I've also found that grape seed extract will speed saponification much the same as DPG.

Essential oils are just one form of natural concentrated scent. They, by definition, are steam distilled from the material (usually plant) as they are stable to steam heat and are soluble in steam but not water. Many natural scented oils cannot be steam distilled due to insolubility in steam or sensitivity to heat and must be extracted in some other way. The oils derived this way are called 'absolutes.'

Many natural fragrances are liable to saponification and can only be used in re-melt. Unfortunately, you can only find out about these by the sad experience of having no remaining scent in a cured batch of soap. Recombinant fragrances are usually labeled "fragrance oils," although many fragrance oils are mislabeled essential, or organic. It is best to make a recombinant oil from natural scented fractions vacuum distilled from natural sources, as many synthetic fragrant compounds have contaminants from synthesis that cannot be cheaply removed. That is why many perfumes smell off or cause bad reactions. Di Propylene Glycol (DPG) is also a favorite extender for fragrance oils and is a cosmetic emollient. As already mentioned, it causes soap to trace quickly and is good for the skin. If the fragrance oil you are adding has DPG in it and you don't know it, you could end up with a big surprise. It is best to purchase fragrance oils for soaps from a reputable soap-makers supply company. The prices are usually fair and the scents are designed to be used in cosmetics soaps.

Snippets Of Knowledge

Don't use softened water in soap making. There is no way to tell how the salts in various waters may affect the reaction. Use clean rainwater, distilled water, reverse osmosis or de-mineralized water. Condensate from air conditioners and de-humidifiers are all very good. If you are worried about bacteria, boil the water.

Beef tallow makes the hardest soap, but I feel lard has the ideal mix of stearates and oleates to give the best soap characteristics, hardness and adequate solubility.

If you find your soap is still a little harder than what you like even after using a softer fat, try decreasing your lye percentage 1 to 10% and adding 1.40 times as much potassium hydroxide (KOH) instead. You may remember that potassium hydroxide makes liquid soaps. A small amount of potassium hydroxide will soften an otherwise hard bar.

Cure-out times using a Braun hand blender (the best for the money in my opinion) are from 4 hours to three days. I only have a three day batch every year or so. This is without any accelerator such as grape

seed or DPG.

As for taste testing for alkalinity, I learned the hard way to touch one finger to the soap crutch (stirrer), and carefully taste the thin film of the soap on my finger. This does the job and and avoids lye burns to the tongue. The trick to taste testing cured bars is to just touch the tip of the tongue to the bar or, better still, get a smear off the bar with your finger and touch the tip of the tongue to that finger. Lye burns in the mouth are NO fun. I have made several painful mistakes that way.

For cooked soaps, use a LOT more water; the excess cooks out.

Polyethylene pails in a double boiler work well for making soap.

Even an amature soap maker should use some kind of scale to weigh the lye rather than try to make volume measurements. Trying to use volume measurements to determine lye needed is a very risky business!

Grapefruit seed oil is an antioxidant, germistat and stabilizer. I use 15 ml Citricidal concentrate (the trademark name for grapefruit seed concentrate) in about 15 lbs of soap. I use 10 times this much to make germicidal soap.

I use Dixon Crucibles Colorart Powder Tempra for color with good results for most colors. These are children's tempra paint colors mixed with 50 grams of shortening and whipped into a roux, then adding this at trace. The lye requirement includes this extra 50 grams of fat. I use 60 grams of tempra for a stronger color in a 15 lb batch of soap; 15 grams for a tint. This works nicely. Don't use any pigments with cadmium, mercury, lead or other poisons in them. You shouldn't find any of these things in children's paints but they are often found in professional artist's pigments.

Scent is 1.8% of the total mix.

Here is a novel idea that really works and saves on scenting oils. After the soap has cured, saturate a bit of muslin in the appropriate scent and layer the soap bars with it. Store in a tight keeper for about 3 weeks. The scent seems to penetrate clear to the center.

Shrink wrap is very good at holding scent in the soap.

Unlike plastic which breaths, cellophane is impervious to essential oils and won't let them pass. Use this to wrap your finished soaps and they won't lose their scent.

I pour the liquid, traced soap into 18" long 3" PVC schedule 40 tubes set in a wooden base and press fit with plastic sandwich bags for the seal. Using DPG, the soap often cures in 24 hours and I have used it that green quite often. I cure the soap in the tubes until it is waxy and hard. To remove the soap I warm the tubes in a Coleman cooler. The tube is set on a wooden shelf just above hot water. Cheap sandwich bags cover the ends to prevent the steam from softening the soap. When the soap is warmed to 130 deg F, it has the consistency of room temperature cheddar cheese and can be pushed out of the tubes with a wooden piston and cut with a monofilament line tied to two small handles like a garrote. Bars, when that warm, dent easily but can be pressed into rigid molds. When cool, they become quite hard again.

It doesn't hurt to have a bit of 1 part vinegar to 10 parts water on hand, especially at public soap making demonstrations. The weak acid in the vinegar will quickly neutralize the effects of a droplet of stray lye water on skin, clothing or the work area.

Often when doing a soap making demonstration, I'll use a cardboard box lined with a garbage bag for my setting tray.

Cured soap should have a pH of 9 or less.

Should you wish to make a neutral pH soap during a rebatch operation, use boric acid. Using a strong acid will turn your soap back into fat and salt!!! Even vinegar might be too strong for this.

My soap recipe is extremely gentle on the skin. I call it a 'High Toleration Soap.' People who have not been able to use anything else have been able to use my soap without adverse reaction. Coconut oil is very popular in soaps today. I don't use coconut oil because it makes a rather harsh soap for skin. Olive oil makes very fine bubbles and is very good for the skin. Concerning soap lather, I've had no complaints from people who use my soap. The fine bubbles from the olive oil are enough.

Four hundred forty grams of finely ground comfrey root in a 14 lb batch of soap stops poison ivy itch.

Old timers used to put pine tree rosin in their soap to help it suds.

People with psoriasis or exema need soap with 20% pine tar in it, often curing their condition. Beware of regular pine tar soaps as they generally only have 3% pine tar in them which is not enough. Soap with pine tar also makes an excellent pet soap. It's very soothing to their skin and tends to discourage bugs from getting on them. Beware! Pine tar added to soap makes it set up in 28 seconds. Be sure you have everything ready to pour before adding it, then immediately pour it into the setting tray. You can get pine tar at ranch supply stores. People with horses use it to cover lacerations.

Hard Water: Each doubly positively charged calcium or magnesium atom in your water will tie up two singly negatively charged soap molecules. When this happens, soap molecules can't do their jobs any longer. Instead of being evenly dispersed in the water, calcium or magnesium tied soap molecules clump together forming soap scum. As this reaction happens quickly, enough soap must be used to neutralize these metals first before additional soap can do any cleaning. Borax will neutralize these mineral salts leaving the soap to do it's job.

Soap is a good lubricant by itself and is added to petroleum oil making grease. Try rubbing soap on the contact surfaces of a sticking drawer or door.

Where I get my supplies:

Di Propylene Glycol is available under that name code RM135, from:

Intercontinental Fragrances Inc.
10422 West Gulf Bank Rd.
Houston TX 77040 Phone: (713)896-9991
25 lbs is the minimum quantity sold, enough DPG to accelerate over 20 tons of soap.

I get my fully hydrogenated soybean oil from US Foods Corp in 50 lb cubes. For general, small scale soap making use a shortening such as Crisco.

My caustic is 50% liquid from a 700 lb. drum from Van Waters Rogers. Hobbyists or casual soap makers use solid crystal or flake lye and mix it themselves in water.

My color comes from Dixon Crucible Colorart tempra powder, whipped into a roux with a little melted shortening.

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