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Lye Calculation Using a Saponification Chart – Tutorial

2
SEP 2018

posted in: Blog Post, Tutorial | 51

A couple of weeks ago, just as I was pulling into a parking bay at the local mall here in Cape Town, my niece #4, who is in her final year of high school in Finland, called me on the phone.

"Clara, I'm doing a project on soapmaking for school", said she.

"Excellent!", said I.

Clara Lindberg is passionate about making soap. Originally from Helsingfors in Finland and now a happy resident of Somerset West, South Africa, she is soapmaker-in-chief and creative dynamo at Auntie Clara's Handcrafted Cosmetics.

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"I think I should make some soap for the project", said she.

"That's a very good idea", said I.

"Could you share a recipe, please?", asked she.

"Nope", said I.

At this point you might be rolling your eyes thinking "What a mean auntie!"

But wait, there's more. Before you judge do read on because the story continues.

Soapmaking Tools

Instead I told her what I've told many others: good soapmaking is not about having a good recipe, good soapmaking is about understanding what makes the recipe good.

I told her that what she needed more than a recipe was to actually understand how lye is calculated for soap. To do that she needed to google 'saponification chart' and start by finding the sodium hydroxide saponification coefficient for olive oil.

It took her all of 7 minutes to message me back with the correct number for olive oil. Now I suggested that she calculate how much lye she would need for a small batch of e.g. 650g of olive oil – and show me her calculation. Three minutes later I get the correct calculation on Whatsapp.

Then I told her to google 'superfat' and a few minutes later she was able to tell me what superfat is. I asked her to do a 5% superfat aka lye discount on her 650g olive oil batch and a couple of minutes later she messaged me her calculation. Correct again.

Instead of quickly brushing off my niece with a ready recipe to copy, I had taken a few minutes (while shopping) to point her in the direction of some tools to put together her own recipes – complete with lye and superfat calculations.

A couple of days later she made her first soap from a recipe she had formulated herself (I checked that the formulation and the calculations were sound and correct) and by all accounts the soap turned out beautiful and is now curing nicely.

So let's look at how it's done. Let's see what it is that your lye calculator does when it calculates lye for your recipes.

First Lye Calculation

Let's pick a mock recipe and work through the steps of calculating lye for it. When I say 'mock recipe' I really mean that: the recipes in this article are NOT meant to be examples of good soap formulation so don't try soaping them at home. Instead, they were chosen to illustrate how lye calculations and lye discount calculations work.

So, let's say our first recipe looks like this:

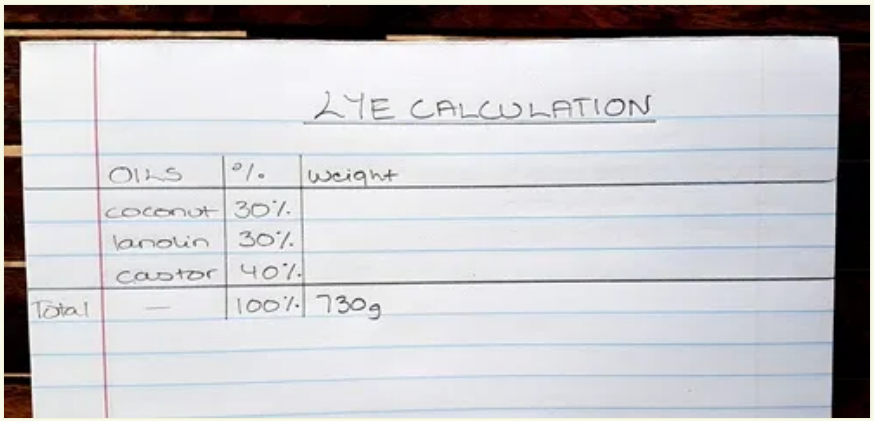
30% coconut oil

30% lanolin

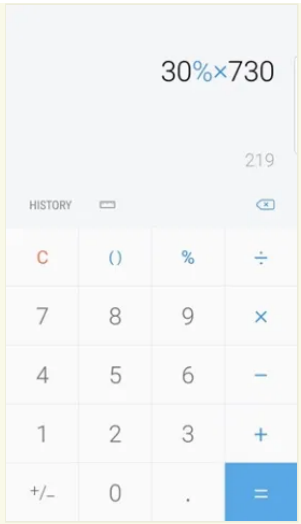
40% castor oil

We have a nice new mould and we know that it fits a batch of **730 grams** of oils. I'm using grams, but you could just as well do the calculations in ounces – or any other weight unit. In soapmaking we always go by weight, never by volume.

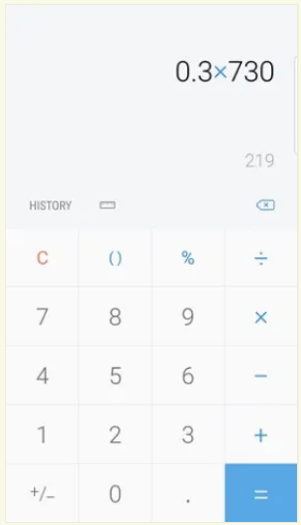
Our **first task** is to find out **how much of each oil** we need for our **730g** batch. To keep our numbers in order let's keep them in a table. We could create a neat excel sheet, but since we don't need a computer for this I'm doing it in good old paper-and-pencil style:



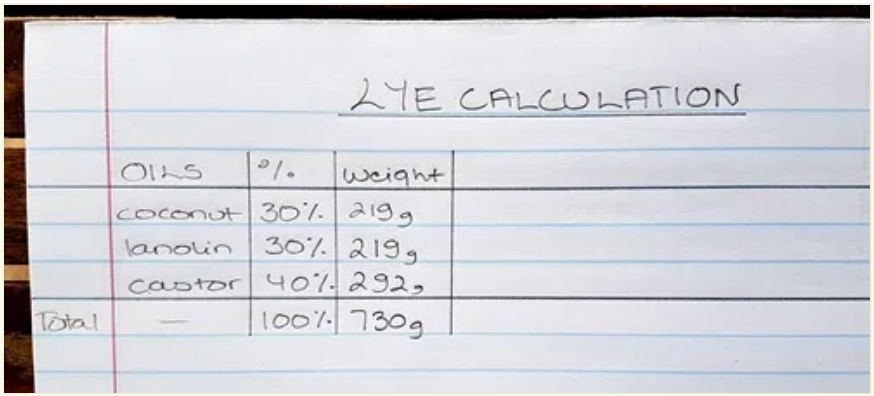
To get the weight of each individual oil we'll multiply each percentage by 730. You can do the calculations in your head, on an abacus, on a slide rule; anything that gives you correct answers. I'm doing it on the calculator on my phone:



30% = 30/100 = 0.3 so if you don't have a handy %-button on your calculator you can do it like this and it will give you the same answer:



There we go. Here we have figured out the weight of each individual oil in our recipe:



Saponification Chart

Now we need a saponification chart. A saponification chart is a list of oils and fats and their respective SAP (saponification) values.

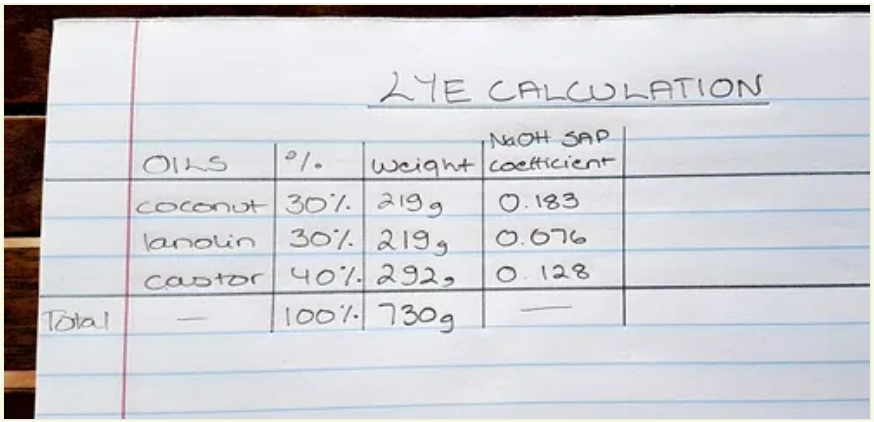
On technical data sheets saponification values are expressed as **milligrams of KOH per gram of oil.** They tell you how many milligrams of potassium hydroxide you will need to fully saponify one gram of a particular oil. These values are often given as a range of numbers, typically somewhere between 100 and 300.

On saponification charts for soapmaking the values are given as **coefficients (numbers) that can be used with any weight unit you choose**. For each oil you will have one coefficient for **KOH (potassium hydroxide aka caustic potash)** and another one for **NaOH (sodium hydroxide aka caustic soda)**. These numbers will all be fractions of one, i.e. zero point something. E.g. the NaOH saponification coefficient for olive oil is 0.135

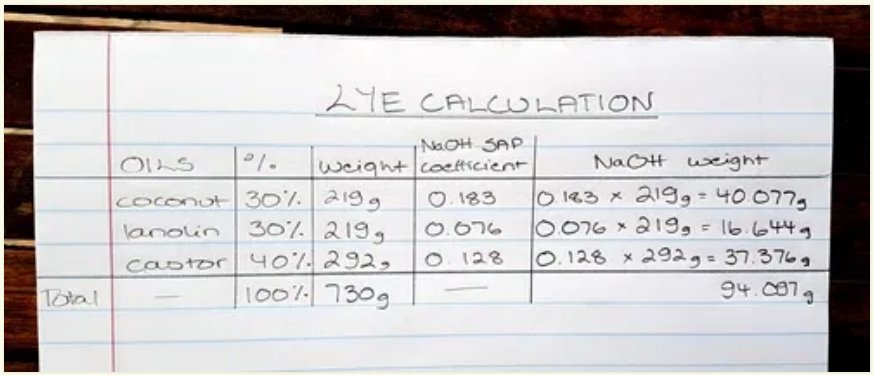
In reality saponification values for oils vary depending on factors such as growing conditions, varietals, extraction method etc. The values you will find in any saponification chart are approximations and may vary slightly from one chart to another depending on the source. For convenience I'm using values from SoapCalc.net on this saponification chart of the most common soaping oils and fats:

OIL	KOH	NaOH
Almond Oil, Sweet	0.195	0.139
Apricot Kernel Oil	0.195	0.139
Avocado Oil	0.186	0.133
Beef Tallow	0.200	0.143
Beeswax	0.094	0.067
Canola Oil	0.186	0.133
Castor Oil	0.180	0.128
Cocoa Butter	0.194	0.138
Coconut Oil	0.257	0.183
Grape Seed Oil	0.181	0.129
Jojoba Oil	0.092	0.066
Lanolin Oil	0.106	0.076
Lard	0.198	0.141
Laurel Berry Oil	0.198	0.141
Macadamia Nut Oil	0.195	0.139
Mango Butter	0.191	0.136
Neem Oil	0.193	0.138
Olive Oil	0.19	0.135
Palm Oil	0.199	0.142
Peanut Oil	0.192	0.137
Rice Bran Oil	0.187	0.133
Sesame Oil	0.188	0.134
Shea Butter	0.179	0.128
Soybean Oil	0.191	0.136
Stearic Acid	0.198	0.141
Sunflower Oil	0.189	0.135

We are making bar soap so from the chart above let's pick out the NaOH values for our chosen oils and add them to our table:



Then it's time to multiply our SAP values by our oil weights to get the amount of NaOH needed to saponify each of our oils:



If we take a look at the NaOH weights we can see how it takes a lot more lye to saponify 219g of coconut oil than to saponify 219g of lanolin. If we were to swap the coconut oil for an oil that requires less lye without adjusting our calculation, our soap would end up with with an excess of lye – which can be dangerous. **This makes it obvious why it's so important never to swap or omit oils without doing the corresponding adjustment to the lye calculation.**

So, we need 94.097 grams of sodium hydroxide to fully saponify our 730 grams of oil. This leaves us with a 0% superfat. But if we're making skincare soap we should make sure to have a little bit of **superfat** too.

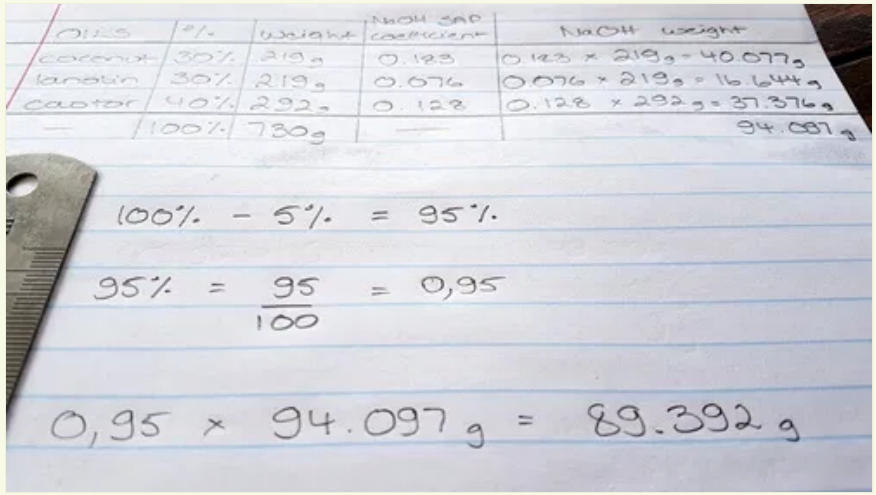
What is Superfat?

The superfat in a soap is unsaponified oil (fatty acid) remaining after saponification is complete. In cleaning and laundry soap we don't want any unsaponified oil, but in skincare soap we want superfat – for two resons:

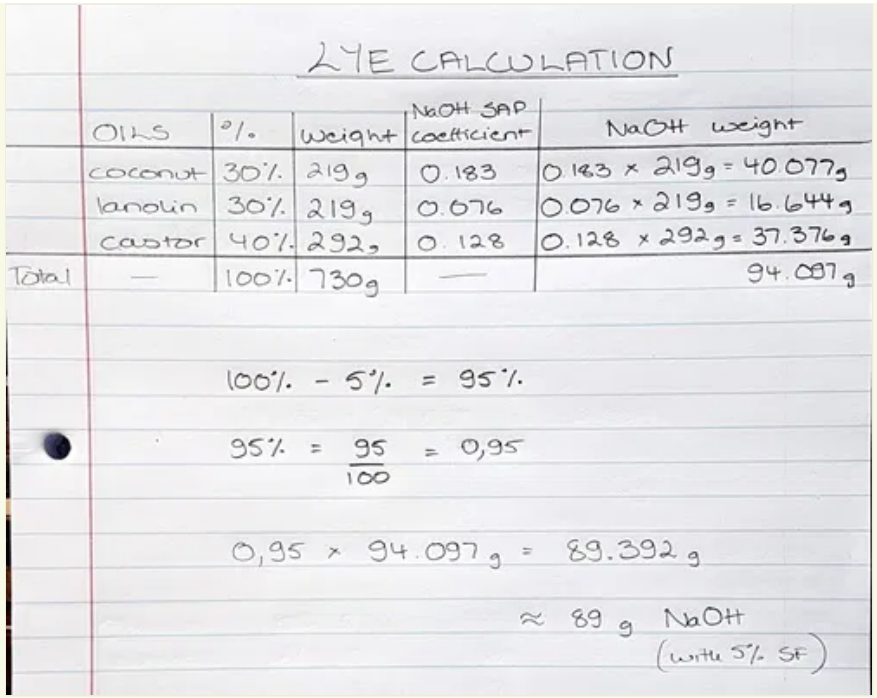
1. Unsaponified oil in soap helps condition skin by adding oils instead of the natural skin oils that get washed off by the soap. It makes the soap more conditioning while making it less cleansing. It also inhibits lather to some extent.
2. A slight surplus of oil gives us a safety margin in our lye calculation. To make sure that we never end up with an excess of lye, e.g. due to slight measurement errors, we allow for a slight surplus of oil instead.

So, in order to be left with some unsaponified oil in our soap we discount the lye. This is why the expressions 'superfat' and 'lye discount' are synonymous in coldprocess soapmaking; two different ways of looking at the same thing.

In our recipe we want to allow for a 5% superfat. A 5% superfat means a 5% lye discount, i.e. we will use 100% – 5% = 95% of our lye.



Here I get a number with fractions of a gram, but since my scale will not weigh units smaller than one gram I will simply round down that number:



LYE CALCULATION

	OILS	%	weight	NaOH SAP coefficient	NaOH weight
	coconut	30%	219 g	0.183	0.183 × 219 g = 40.077 g
	lanolin	30%	219 g	0.076	0.076 × 219 g = 16.644 g
	castor	40%	292 g	0.128	0.128 × 292 g = 37.376 g
Total	—	100%	730 g	—	94.097 g

100% − 5% = 95%

95% = 95/100 = 0,95

0,95 × 94.097 g = 89.392 g

≈ 89 g NaOH (with 5% SF)

To make this recipe with a 5% superfat I need 89 grams of sodium hydroxide.

That's the whole calculation and that's how simple it is.

Let's recap:

1. **You multiply the weight of each oil in your formula with its respective NaOH saponification coefficient. This gives you the amount of NaOH needed to saponify that particular oil.**
2. **You then add up all the NaOH amounts to get the total amount of NaOH needed to fully saponify all the oils in the formula.**
3. **Finally you discount the total NaOH amount by your superfat percentage of choice – and round down the resulting number to a unit you can weigh on your scale.**

Another Example

Now that we know how this works, let's try another recipe. Again, I recommend that you don't try to make this recipe at home; it's only formulated to illustrate lye calculation – not to make great soap.

For this bar soap recipe we are planning a **total oil weight of 3270g** with the following oils and proportions:

13% beef tallow

22% beeswax

7% shea butter

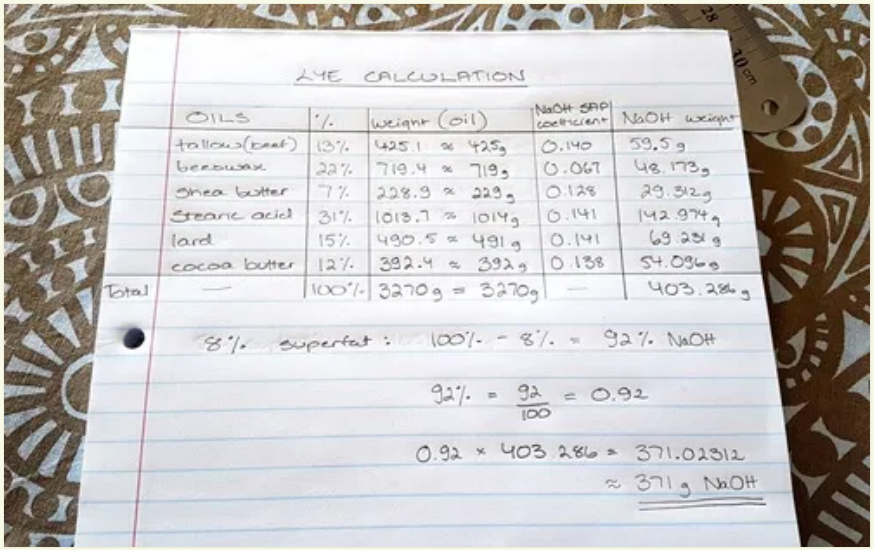
31% stearic acid

15% lard

12% cocoa butter

and a **superfat of 8%**

Instead of going through all the steps separately, let's just look at the full calculation here:



LYE CALCULATION

OILS	%	weight (oil)	NaOH SAP coefficient	NaOH weight
tallow (beef)	13%	425.1 ≈ 425g	0.140	59.5 g
beeswax	22%	719.4 ≈ 719g	0.067	48.173g
shea butter	7%	228.9 ≈ 229g	0.128	29.312g
stearic acid	31%	1013.7 ≈ 1014g	0.141	142.974g
lard	15%	490.5 ≈ 491g	0.141	69.231g
cocoa butter	12%	392.4 ≈ 392g	0.138	54.096g
Total	—	100%	3270g = 3270g	—	403.286g

8% superfat : 100% - 8% = 92% NaOH

$92\% = \frac{92}{100} = 0.92$

$0.92 \times 403.286 = 371.02312$

≈ 371 g NaOH

Here my **oil weights** came up as numbers with fractions of a gram. Since my scale doesn't weigh fractions of a gram and I need to be able to weigh each oil exactly, I want to round the numbers to the closest full gram **before** I calculate the lye. In contrast, the **NaOH weights** are added up including all the decimals and the total is only rounded down **after** the lye discount

(superfat) has been calculated. **(Please note my error here: the saponification coefficient for tallow is 0.143 as per my saponification chart – not 0.140 as written down in this example. A good reminder how important it is to always check and double check recipes and calculations. Thank you Katherine for paying close attention and spotting the error!)**

A final example. Here we know our individual oil weights and we want to do a **3% superfat:**

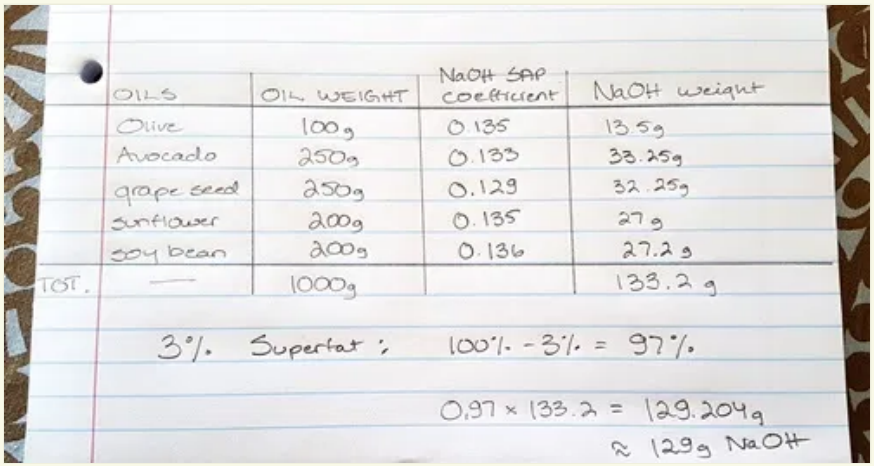
100g olive oil

250g avocado oil

250g grape seed oil

200g sunflower oil

200g soy bean oil



OILS	OIL WEIGHT	NaOH SAP coefficient	NaOH weight
Olive	100g	0.135	13.5g
Avocado	250g	0.133	33.25g
grape seed	250g	0.129	32.25g
sunflower	200g	0.135	27g
soy bean	200g	0.136	27.2g
TOT.	1000g		133.2g

3% Superfat: 100% - 3% = 97%

0.97 × 133.2 = 129.204g

≈ 129g NaOH

With a 3% superfat this recipe requires 129g of NaOH.

If you run these 'recipes' through SoapCalc.net you'll get slightly different numbers because Soap Calc uses more decimals and doesn't round oil weights, but the differences are very small. Yet, the differences confirm the value of a slight superfat as a safety margin in soapmaking.

What about the water?

Soap is made by saponifying oils with lye. In order for lye and oil to combine lye crystals need to be dissolved in water. The water activates the lye and makes the saponification reaction possible.

The amount of water **necessary** to facilitate the saponification reaction is **equal weight to lye**. I.e. our example recipe above which requires 129g NaOH would require a minimum of 129g water. Less water than that and we risk that the lye crystals don't fully dissolve. This may leave our soap with pockets of unsaponified lye and we want to avoid that.

The upper limit is a little more fluid but in general when making coldprocess soap you don't want to go higher than three times the weight of the lye. Beyond that the risk of separation increases as does the risk of soap volcanoes and overheating – not to mention that the freshly saponified soap might be very soft and take a long time to dry out.

So the water range is from 1:1 water:lye to 3:1 water:lye. For beginners it's usually prudent to stay in the middle of the range and use water at 1.5 or 2 times the weight of lye. More water does not make the process safer either for soapmaker or soap so it's not worth adding extra water for that reason.

'Water discount' is a misnomer since we can't reduce water from the necessary 1:1 water:lye ratio. Any water amount in excess of a 1:1 water:lye ratio is in fact a surplus. The expression refers to a discount from the water default in SoapCalc.net which at 38% of oil weight is rather excessive for coldprocess soap.

Abacus vs Lye Calculator

If it's this simple to caculate lye with a saponification chart and a calculator (or an abacus, or just your head), can't we just abandon lye calculators altogether? The answer is no.

While the lye calculation itself along with lye discount and determining water content are simple operations, a good lye calculator offers additional functions that are both handy and important in formulating good soap. A lye calculator should at least give a fatty acid breakdown, along with INS and iodine numbers for each formulation. In addition soap properties like hardness, lather and cleansing numbers are broad but valuable guidelines for formulation. And unless you have remarkable computing skills, making adjustments, tweaks, and changes to formulations will be a lot quicker on a lye calculator than by means of pen and paper.

Yet, being familiar with the steps involved in lye calculation gives a more detailed understanding of the soapmaking process. It can a be a very valuable tool for troubleshooting not to mention how useful it is for those who don't have access to smartphones or the internet.

And next time your favourite lye calculator does the calculation for you you'll be able to say "I see what you did there!" ☺

My very first soap for which I did the lye calculation just the way I've done in this post

Coldprocess soap, Lye Calculation, Lye Discount, Saponification, Saponification Chart, Soapmaking Tutorial, Superfat

51 Responses

cheryl Pereira

September 2, 2018 | Reply

Excellent explanation Clara!

Clara

September 6, 2018 | Reply

Thank you Cheryl!

Patty Dalton

September 2, 2018 | Reply

Excellent! Many Thanks!

Clara

September 6, 2018 | Reply

It's a pleasure!

Amy

September 3, 2018 | Reply

As always, a lovelyinformative post. What a wonderful Aunt you are! Feed a man a fish and he eats for a day. Teach a man to fish, he eats for life. Thanks for sharing! Happy soaping!

Clara

September 6, 2018 | Reply

Thanks – and to you too!

Helen

September 3, 2018 | Reply

An excellent and very clear explanation! Thank you.

> ### Clara
>
> September 6, 2018 | Reply
>
> Thank you!

Theresa Mendez

September 3, 2018 | Reply

You are a very good Auntie, Clara. I Really enjoyed reading your blog and as an Occupational Therapist, I applaud you for be an excellent teacher and role model for your niece.
Warmest regards,
Theresa

> ### Clara
>
> September 6, 2018 | Reply
>
> Thank you!

Helen

September 3, 2018 | Reply

Excellent and very clear explications, so easy to follow.

Irene Saumur

September 3, 2018 | Reply

Thank you Clara. That is the most simple and elegant explanation of the process I have ever read.

> ### Clara
>
> September 6, 2018 | Reply
>
> Thank you Irene!

Anne

September 3, 2018 | Reply

This is fantastic. Thank you~!!

Clara

September 6, 2018 | Reply

It's a pleasure!

Susan Emem Monday

September 4, 2018 | Reply

Thanks ..Nice one

Clara

September 6, 2018 | Reply

Thanks!

Janet Matherly

September 5, 2018 | Reply

Such a great example for new soapers! This should be a must read for all just starting out. Because if they knew how to do this as well as understanding what each oil brings they would be way ahead of the game and wouldn't want to post asking other soapers for recipes!

Excellent post. I will be sending folks here for this. Thank you again for sharing with us all!

Clara

September 6, 2018 | Reply

It's a pleasure. I hope it's helpful both to older and newer soapers.

Irene

September 5, 2018 | Reply

Thank you for sharing how to calculate the amount of water. This is something that is usually not in the books I have seen. I have happily used soapcalc.net, for ease of use, however, I see now that they are using a very high percentage of water to lye. I sometimes have trouble with "soda ash" (as some people call it), and wonder if that could be related to using such a high percentage of water. I look forward to experimenting on varying water ratios. I enjoy your posts. Thank you for challenging soap makers to think more about the process and for challenging the soap making myths that are out there.

Clara

September 6, 2018 | Reply

Ash or sodium carbonate is often related to generous water use. Water facilitates the process where sodium picks up carbon from the air and slows down saponification making the window of opportunity wider for ash to form.

Katherine

February 13, 2019 | Reply

This was a great tutorial. I absolutely loved it and learned so much.
I did want to mention that in your second example, the incorrect saponification value was written down for beef tallow. It was written down as 0.140, rather than 0.143 that is in the chart. Though a small difference, it's just a reminder of how important it is to double check, not just your calculations, but the other given information as well.

Clara

February 21, 2019 | Reply

Hi Katherine. Thanks for spotting the error! As you say, it's a reminder how important it is to check information because typos happen easily. I've added a note to the text accordingly. Thank you again!

Roland Chiong

April 30, 2020 | Reply

Hi Clara. In the soap you made what is the water to lye ratio you used?

Clara

August 25, 2020 | Reply

The recipes in this tutorial are fictional and not really good for anything other than as examples for calculation. Recommended water to lye ratio is anything between 2.5:1 and 1:1. I usually make soap with a water to lye ratio of about 1.5:1

Ganesh

May 23, 2020 | Reply

I really enjoy to study and l learn more info from your tutorial thanks.

Clara

August 25, 2020 | Reply

Glad to hear that!

Ed

May 25, 2020 | Reply

This is fantastic. I think it's really useful to know how to do something for your useful before you start trusting everything to a calculator. The same with cooking and baking. I can use an electric mixer, but first I had to learn how to make a cake from scratch with just a bowl and a spoon.

Anyway, my question is, how do I calculate fragrance? I am thinking of using pre-made fragrance blends. Is there a rule of thumb, because I've looked online and seen everything from 0.75% to 8% of the total oils. This is a confusing part for me, so if you can help that would be appreciated.

Clara

August 25, 2020 | Reply

Fragrance oils are not part of the lye calculation. Reputable fragrance oil suppliers will give usage rate recommendations for their products. Generally 3% is a standard rate, but fragrance oils can vary a lot in strength so unless the supplier gives an indication you'll need to test your way ahead starting from 3%.

Chloe

May 30, 2020 | Reply

Thank you. It's super easy to understand!

Clara

August 25, 2020 | Reply

Thank!

Nsemeke Ugochinyere

June 3, 2020 | Reply

Auntie Clara, thank you for this very helpful post.
Please if I want to include additives, like vitamin E oil, fragrance oil and some skin treatment oils will they be included in my other soaping oil blend (like olive, coconut, p.k.o etc) that add up to 100%? OR after have gotten total oil weight then I just add the additives. Thanks

Clara

August 25, 2020 | Reply

The lye calculation is for fatty acids. Fragrance oil, vitamin E oil and such additives are typically not part of the lye calculation.

Barbara M

June 14, 2020 | Reply

Thank you. You have done well explaining this and how to do soap making. It is greatly appreciated.

Clara

August 25, 2020 | Reply

Glad if it helps!

Andrea Edmond

June 20, 2020 | Reply

Thank you I've been looking for a long time for simple instructions and found it.

Clara

August 25, 2020 | Reply

Glad if it's of help.

albert

July 6, 2020 | Reply

It is great madam

Clara

August 25, 2020 | Reply

Thank you!

Margaret Smith

July 12, 2020 | Reply

Fantastic tutorial! A step towards understanding the process.
Thank you Clara

Clara

August 25, 2020 | Reply

Glad you like it!

shams khan

July 19, 2020 | Reply

Owsome, god bless you beyond your imagination. It's will certainly boost my passion of doing soap/detergent business.

Clara

August 25, 2020 | Reply

Thanks!

gordon mac millan

July 23, 2020 | Reply

Many thanks..I had been making soap for 10 years as a business and had lost my lye calculations.
Many thanks for your blog that has gotten me back up and running.
All the best,
Gordon (P.E.I. .Canada.)

Clara

August 25, 2020 | Reply

Glad to hear!

Kris

July 23, 2020 | Reply

Hi clara. In this pandemic of covid 19, im planning to make soap for my online shop to have an extra income. Thank you for the great explanation on how to calculate lye solution I am worried about lye but now it is easy for me. Keep it up. I enjoyed your blog.

Kris from Philippines 2020

Clara

August 25, 2020 | Reply

You're welcome and good luck!

Brinson Brock

July 25, 2020 | Reply

Thank you so much for this explanation. I am a teacher in USA and am trying to understand the process myself. Your explanation has really helped me.

I would like to pose a question:

I saw a a recipie of another you tuber, and she shared all her ingredients, but not the proportions. She did say pine tar was a 30% ingredient, so are you saying if I identified the other ingredients, I could put them into the chart and figure out my own recipie?

This would be wonderful for my students.

Thank you.

Clara

August 25, 2020 | Reply

Pine tar is a bit tricky since very little of it is saponified. Many soapmakers regard it as a additive rather than an ingredient. 30% pine tar doesn't necessarily mean that Pine tar made up 30% of the ingredients and other oils the 70% balance. 30% pine tar could also mean that the recipe was 100% other oils and then an amount of pine tar equivalent to 30% of the oils was added

to the mix. In the first case the total will be 100% and in the second the total will be 130% as it were. You can google recipes for pine tar soap but if you want to make pine tar soap I would suggest using much less pine tar. 2% pure pine tar will give lots of smell and colour to your soap.

रमेश चंद्र सोनी

August 15, 2020 | Reply

अति सुंदर सरल और महत्वपूर्ण व्याख्या।
मैं भी साबुन बनाने की शुरुआत की।आप के द्वारा लिखित सरल भाषा के सूत्रों के कारण मुझे बहुत ज्यादा समाधान मिला है।
इतनी अच्छी जानकारी दी।बहुत बहुत धन्यवाद।
रमेश चंद्र सोनी रायपुर मारवाड़

Clara

August 25, 2020 | Reply

You're welcome! I'm glad if it was of help.

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