NaOH or KOH Purity Check for Soap Makers

Soap makers often assume the purity of the alkali in their soaping stash is whatever the distributor says it is. Even if the purity is high when the alkali (NaOH or KOH) is newly purchased, the purity can drop, sometimes by quite a bit, as time passes. Alkali becomes less pure by absorbing water vapor and by reacting with carbon dioxide gas in the air. Based on a method from Kevin Dunn, here is a method to quickly and easily check the purity of your NaOH or KOH --

Ingredients

- Citric acid powder (canning supplies at a grocery or hardware store, online suppliers)
- Distilled water -- do not use tap water! (grocery store)
- NaOH or KOH for soap making (hardware store, online)
- Phenolphthalein indicator solution (beer brewing suppliers, online)

Equipment

- Clear glass container that holds about 2 cups (1 pint, 0.5 liter) of liquid. A pint canning jar works well if you have one.
- Scale (also called a balance) that can weigh to 0.1 gram or better
- Safety glasses, rubber gloves, and other safety gear for working with NaOH or KOH
- Plastic or stainless steel spoons for measuring citric acid and alkali
- Oven-safe glass or ceramic dish
- Paper, pencil or pen, and calculator

Make anhydrous citric acid

This is optional if you know your citric acid is already in anhydrous form. If you do not know your citric acid is anhydrous (water free), please do this step. It is not hard to do and it will ensure you get the most accurate results.

Heat your oven to about 200 degrees F (95 C).

Put at least 100 grams of citric acid powder in a thin layer in the bottom of an oven-safe ceramic or glass dish. Weigh the entire dish and citric acid. Record this starting weight.

Put the dish into the oven. Heat it for 1/2 to 1 hour. Reweigh the entire dish and citric acid and record this weight.

If the last weight is less than the previous weight, put the dish back in the oven and heat for another 15 minutes. Reweigh and record the total weight. Compare this weight to the previous weight. If the weight continues to drop, repeat the heating and reweighing steps until the last weight is the same as the previous weight.

When the weight stays the same from one reading to the next, the citric acid is anhydrous and is ready for use.

Store anhydrous citric acid in an air-tight container. About 100 grams of anhydrous citric acid will do 9 or 10 tests of alkali purity.

NaOH purity check

Put the glass container on the scale. Tare (zero) the scale. Pour 100 to 105 grams of distilled water into the container. Do not use tap water.

Add 3 or 4 drops of phenolphthalein solution to the water. Swirl to mix. This solution should stay water clear. If it turns pink, discard the solution, carefully clean the container with soap and water, rinse thoroughly with distilled water, and try again.

Tare the scale. Weigh 10.0 to 10.5 grams of anhydrous citric acid into the water. Swirl to mix until the citric acid powder dissolves -- about 30 seconds. The solution will be a cloudy white color.

Record the actual weight of citric acid added to the water: ________________ g citric acid

With the container still on the scale, tare the scale. Weigh 6.0 to 6.2 grams of NaOH into the solution. Swirl to dissolve the NaOH and mix the solution well. The solution will heat up, but it should remain cloudy white. If the solution turns pink, you have added too much NaOH. Discard this solution and start over.

Carefully add about 0.1 gram of solid NaOH to the solution. Swirl to dissolve the NaOH and mix the solution well.

Check the color of the solution by holding the container in front of a white surface (sheet of paper or paper towel works well). Compare the color of the solution against the white paper.

If the solution remains cloudy white, add another 0.1 gram of NaOH, mix, and compare. Repeat the color check until the solution turns the barest shade of faint pink. Stop adding NaOH.

Put the container back on the scale.

Record the total weight of NaOH added to the solution: ________________ g NaOH

Calculate the NaOH purity:

NaOH purity % = 62.46 X (grams citric acid) / (grams NaOH)

NaOH purity % = 62.46 X ________________ g citric acid / ________________ g NaOH

= ________________ %

Repeat this test at least two more times for the best accuracy. Find the average of the three answers, and that is your result.

	Grams citric acid	Grams NaOH	Purity %
Test 1			
Test 2			
Test 3			
Average			

KOH purity check

Repeat the NaOH purity test except use KOH instead of NaOH.

Weigh 8.5 to 8.7 grams of solid KOH into the citric acid solution at first. Swirl to dissolve the KOH and mix well.

Add 0.1 gram of KOH, swirl to dissolve the KOH and mix well, and check the color. Repeat until the solution turns from cloudy white to the barest faintest pink.

Stop adding KOH at that point and record the total weight of KOH added to the mixture.

Calculate the KOH purity:

KOH purity % = 87.62 X (grams citric acid) / (grams KOH)

Repeat this test at least two more times for the best accuracy. Find the average of the three answers, and that is your result.

	Grams citric acid	Grams KOH	Purity %
Test 1			
Test 2			
Test 3			
Average			

Adjusting the weight of alkali (NaOH or KOH) for making soap

All of the soap recipe calculators I have checked as of the time of this writing assume NaOH is 100% pure.

Many calcs also assume KOH is 100% pure. There are a few exceptions --

Soapcalc allows you to choose either 100% or 90% KOH purity
Summerbeemeadow and Brambleberry calcs assume KOH is 95% pure
Soapee.com calc allows you to enter the KOH purity

What if your alkali (NaOH or KOH) purity is something other than what your soap recipe calculator assumes? You can hand-correct the alkali weight produced by the soap calculator if you know the actual purity.

Here's how --

Corrected alkali weight = (Alkali weight from the soap recipe calculator) X
(Soap recipe calculator purity %) / (Actual alkali purity %)

This works for NaOH or for KOH. Use this "corrected alkali weight" when measuring your NaOH or KOH for soap.

The Math -- in fine print, of course!

Background chemistry info

Molecular Weight (MW) of H3Cit (anhydrous citric acid) = 192.12 grams/mole
MW NaOH = 39.997 grams/mole
MW KOH = 56.1056 grams/mole

Stoichiometric ratio NaOH:Citric acid = (3 mol NaOH / 1 mol H3Cit)
Stoichiometric ratio KOH:Citric acid = (3 mol KOH / 1 mol H3Cit)
The stoichiometric ratio means "How many molecules of NaOH (or KOH) will neutralize 1 molecule of citric acid?

Part 1. How did Dunn create his formula for calculating NaOH purity? (See Reference 1)

He gave this formula in his presentation: NaOH purity % = 62.46 X (grams H3Cit) / (grams NaOH). (See Reference 1 below for the source.) How did he get this?

Equation 1a -- How many grams of 100% pure NaOH are required to neutralize 100% pure H3Cit ?

The stoichiometric ratio and the molecular weights of citric acid and NaOH come into play here

grams pure NaOH = (grams H3Cit) / (192.12 g/mol H3Cit) X
(3 mol NaOH / 1 mol H3Cit) X (39.997 g/mol NaOH)

Simplify this to --

grams pure NaOH = 0.6246 X (grams H3Cit) Eq 1a

Equation 2a -- What is a general equation to calculate the purity of real life NaOH?

NaOH purity % = (grams pure NaOH) / (grams real NaOH) X 100 Eq 2a

Equation 3a -- Replace "grams pure NaOH" in Equation 2a with the stuff on the right side in Equation 1a.

NaOH purity % = 0.6246 X (grams H3Cit) / (grams real NaOH) X 100

Simplify this to --

NaOH purity % = 62.46 X (grams H3Cit) / (grams real NaOH) Eq 3a

Part 2. Can a similar formula be created to calculate KOH purity?

Kevin Dunn did not provide a formula for calculating KOH purity, but it can be done by following the method given in Part 1 and substituting the chemistry info for KOH.

Equation 1b -- How many grams of 100% pure KOH are required to neutralize 100% pure H3Cit ?

grams pure KOH = (grams H3Cit) / (192.12 g/mol H3Cit) X
(3 mol KOH / 1 mol H3Cit) X (56.1056 g/mol KOH)

Simplify this to --

grams pure KOH = 0.8762 X (grams H3Cit) Eq 1b

Equation 2b -- What is a general equation to calculate the purity of real life KOH?

KOH purity % = (grams pure KOH) / (grams real KOH) X 100 Eq 2b

Equation 3b -- Replace "grams pure KOH" in Equation 2b with the stuff on the right side in Equation 1b.

KOH purity % = 0.8762 X (grams H3Cit) / (grams real KOH) X 100

Simplify this to --

KOH purity % = 87.62 X (grams H3Cit) / (grams real KOH) Eq 3b

Accuracy of this method

Dunn's method requires simple equipment, modest chemistry skill, and easy-to-find ingredients. With a decent scale and careful technique, it is plenty accurate enough for soap making; I estimate the accuracy is plus or minus 1% to 2%. This is not how alkali purity is measured in the real world, however. A chemist would use a more detailed and rigorous method to accurately measure the purity of an alkali.

References

(1) Dunn, Kevin. Video lecture at http://fyi101.com/the-balancing-act-part-ii-presented-by-dr-kevin-dunn/