# Sodium Carbonate (Washing Soda)

Alex Furlong, Kate Jakubas, Mike Mayer

*Meliora Cleaning Products*

Figure 1: Sodium Carbonate Powder[4]

**Summary**: Sodium carbonate is a white and odorless crystalline solid. It is non- flammable, non-carcinogenic, and it has a high pH. Its main applications are in the production of glass, soaps and detergents, as well as other consumer products. It is used as a builder (water softener) in detergents, and it can also be used to capture odors and remove stains. Alkaline substances are likely to cause irritation if inhaled or ingested, but long-term exposure poses no risks as long as proper PPE is used. It is not a known pollutant or environmental toxin, but its potential to increase the pH of water means its concentration in ecosystems should be kept to a minimum when possible. It is a versatile, tough cleaner that is rougher than its cousin, sodium bicarbonate. It is extremely plentiful, with the ores (trona) main source of mining and production for the U.S. being an ancient dried lakebed located in Green River, Wyoming.

**Chemical formula**

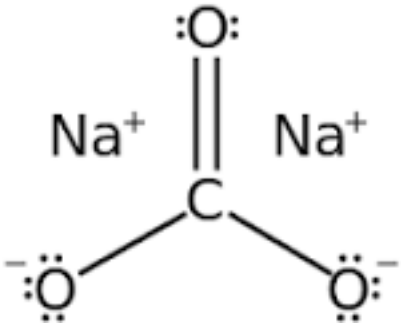



Figure 2: $Na_2CO_3$ (aqueous)[7]

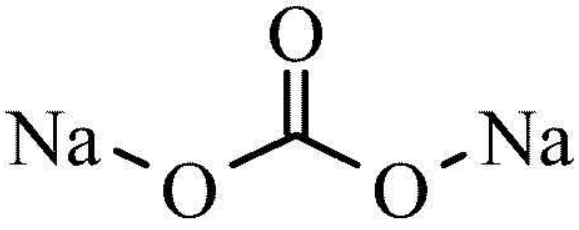



Figure 3: $Na_2CO_3$ (solid)[5]

## Common cleaning uses and interactions

Sodium carbonate is used in a variety of applications. The following are uses outside of the domestic sphere. Silica is one of the main ingredients in glass, and sodium carbonate lowers its melting temperature, which allows it to be melted in conventional furnaces. It is also added to glass to help make it more insoluble. Adding it to pools neutralizes the corrosive properties of chlorine, and raises the pH. It can also be used as a base, such as when it replaces sodium hydroxide in lying, a cooking process that changes the pH of the surface of a food to improve browning during cooking.

In domestic applications, it is used as a water softener in laundry powders and detergents. Its purpose is to compete with the calcium and magnesium ions found in hard water, stopping them from binding with the substances in the detergent. If these metal ions bind to the detergent molecules they precipitate out of solution, which contributes to lime scale buildup and takes them

out of action as detergent molecules, reducing the detergent's efficiency. As a cleaning agent, it is known to be useful when removing wine, grease or oil stains. It is also used to remove lime scale accumulations (or soap scum), which are the solid deposits of ions found in hard water left over after the water evaporates or a surface is in contact with hard water for prolonged periods of time. Sodium carbonate is slightly coarse which makes it useful for removing tougher stains. [1][4]

### Contraindications

Due to the coarser nature of sodium carbonate, it has the potential to scratch glass, plastic, some stone, and other softer materials. It should not be used in applications with materials that are easily scratched or that would react with the carbonate ions, such as highly concentrated strong acids.[2][8]

### Hazards

Sodium carbonate is an irritant in case of contact with the eyes, skin (for few people), ingestion and inhalation. In case of contact followed by irritation, wash area for fifteen minutes and get medical attention if symptoms persist. It has no carcinogenic properties according to the National Institutes of Health's Carcinogenic Project. Sodium carbonate does not affect fetuses or reproductive health. It is not flammable. It is not corrosive unless highly concentration quantities are left in prolonged contact with steel. [3][7]

### How it's made

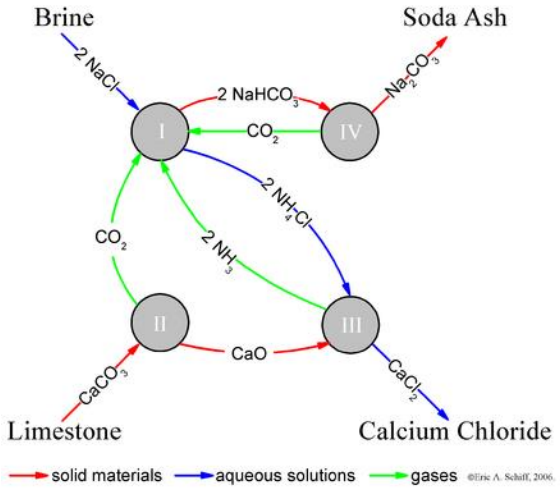



Figure 4: Schematic Diagram of the Solvay Process [6]

Sodium carbonate begins as Trona, also known as trisodium hydrogendicarbonate dihydrate ($Na_3HCO_3CO_3 \cdot 2H_2O$). It is mined almost entirely from reserves found in Wyoming, USA. There are similar, smaller reserves in Turkey and Kenya. It is mined using a bore miner, which burrows underground, as opposed to strip mining, which involves visible, aboveground mining that is notorious for the damage it does to landscapes and the environment. The ore is removed from underground, crushed to a fine powder, and then heated in a calciner, which is a steel cylinder rotation in a furnace. This releases impurities in the form of gasses and leaves behind crude sodium carbonate. This material is dissolved in water and then further filtered. The resulting solution is evaporated, spun through a centrifuge and dried in rotary driers before they are shipped off in the form of soda ash, also known as washing soda.

In other parts of the world that mine less pure ore, sodium carbonate is produced through the Solvay process. The Solvay process begins with carbon dioxide gas that passes through a solution of dissolved sodium chloride and ammonia. In industry, this is done by passing saltwater brine through two towers. In the first, ammonia bubbles up through the brine and is absorbed. In the second, carbon dioxide bubbles up through ammoniated brine, and baking soda precipitates. In order to produce sodium carbonate, the Solvay process is continued, but for the purposes of making sodium bicarbonate, the process is cut short here. The reaction for this part of the process is shown below:

$$NaCl + CO_2 + NH_3 + H_2O \rightarrow NaHCO_3 + NH_4Cl$$

The ammonia ($NH_3$) buffers the solution at a more basic pH; otherwise, the hydrochloric acid byproduct would make the solution too acidic which would arrest the precipitation.

The needed ammonia "catalyst" for reaction is reclaimed later, and little ammonia is lost. The carbon dioxide needed for the reaction is made by heating limestone at 950 - 1100 °C. The calcium carbonate ($CaCO_3$) in the limestone is changed to quicklime (calcium oxide (CaO)) and carbon dioxide:

$$CaCO_3 \rightarrow CO_2 + CaO$$

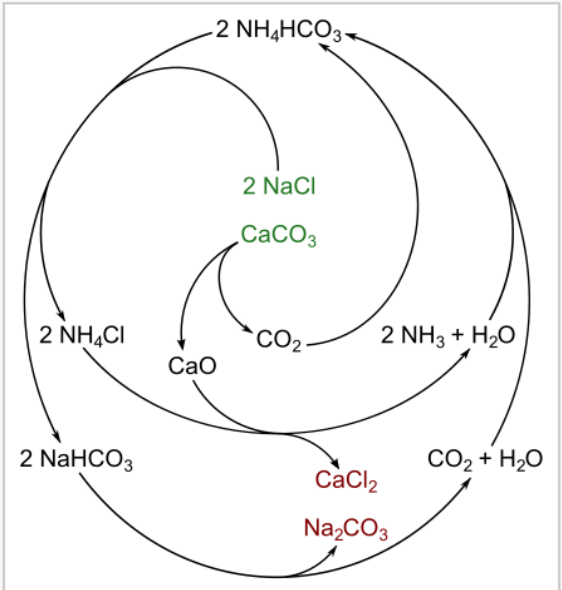
The sodium bicarbonate ($NaHCO_3$) that then forms from the reaction is filtered out from the hot ammonium chloride ($NH_4Cl$) bath, and the solution is then reacted with the quicklime (calcium oxide (CaO)) that was left over from heating the limestone).

$$2\ NH_4Cl + CaO \rightarrow 2\ NH_3 + CaCl_2 + H_2O \text{ (III)}$$

CaO creates a strong basic solution. The ammonia is recycled back to the initial brine solution of the first reaction.

The sodium bicarbonate ($NaHCO_3$) that initially precipitated is then converted to the final product, sodium carbonate, by calcination (160 - 230 C), producing water and carbon dioxide as byproducts:

$$2\ NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$$




The Solvay Process as an example of a cyclic process in chemical industry (green = reactants, black = intermediates, red = products)

The carbon dioxide from step is cycled back in to be re-used in the first step. If correctly designed and operated, a Solvay plant can reclaim almost all its ammonia, needing only a little additional ammonia to replace losses. The only major inputs to the Solvay process are salt, limestone and thermal energy, and its only major waste is calcium chloride, which is sold as road salt. [1][6]

Extra details of the industrial details of this process can be found in the report prepared for the European Soda Ash Producer's Association.

**Anticipated human health impact of ingredient**

According to the NIH "It can be stated that the substance will neither reach the fetus nor reach male and female reproductive organs, which shows that there is no risk for developmental toxicity and no risk for toxicity to reproduction." Aside from being a mild irritant if it is inhaled, ingested or accidentally gotten in someone's eyes, it is not known to have any adverse health affects.

The HERA Project states "When humans are exposed to sodium carbonate, via the use of household cleaning products, the concentration of sodium in the blood and the pH of the blood will not be increased and therefore the exposure to sodium carbonate will not increase the normal physiological levels of sodium and carbonate/ bicarbonate. Therefore there is no concern about a possible systemic toxic effect after short term or repeated exposure to the substance. No genotoxic effects in bacteria or teratogenic effects in rabbits, rats and mice have been reported. The only critical endpoint for sodium carbonate seems to be local irritation. Consumers will be exposed to sodium carbonate due to direct skin contact with solutions, which contain sodium carbonate, which can be hand washing laundry or

use of a carbonate solution for personal care (e.g. skin treatment). However, the concentrations of sodium carbonate in these solutions are too low to cause local irritation."[9]

**Anticipated environmental impact of ingredier**

Large quantities of sodium carbonate can caus mild damage to ecosystems because of the ca bonate ion affecting the pH of water. Differe ecosystems have different buffer capacities ar are therefore affected differently by the sam concentrations of pollutants. As a general rul concentrations higher that 50 mg/L should b avoided, with concentrations higher than 65 mg/ becoming lethal to amphibians and concentra tions higher than 100 mg/L starting to becam lethal for other organisms. Because buffer capac ty varies so greatly by ecosystem finding th PNEC (predicted no effect concentration) is n particularly helpful. To test sodium carbonate effect, levels could be increased and compare p to natural values. [7]

The HERA Project also states "After use of th household cleaning product, the water (contain ing the sodium carbonate) will be disposed v the drain. However, the carbonate will not be di charged to aquatic ecosystems but will be neu tralized in the wastewater treatment plant. Sodi- um has a low toxicity and the emitted amount of sodium is relatively low compared to background concentrations and therefore the emitted amount of sodium will not have an effect on the aquatic organisms of the receiving water." A reasonable conclusion is that sodium carbonate has not been having a negative affect on the environment de- spite its widespread use. [9]

**References**


1. "Mining and Manufacturing." *ANSAC Mining and Manufacturing*. American Natural Soda Ash Corperation, n.d. Web. 30 June 2015. <http://www.ansac.com/about-ansac/mining-manufacturing/>.

2. INCHEM. "ICSC 1135 - SODIUM CARBONATE (ANHYDROUS)." *ICSC 1135 - SODIUM CARBONATE (ANHYDROUS)*. International Program on Chemical Saftery, 25 Oct. 2004. Web. 30 June 2015. <http://www.inchem.org/documents/icsc/icsc/eics1135.htm>.

3. Science Lab. "Material Saftey Data Sheet: Sodium Carbonate." *Sciencelab.com*. Science Lab, 21 May 2013. Web. 14 June 2015. < http://www.sciencelab.com/msds.php?msdsId=9927263>.

4. "Sodium Carbonate | Chemical Compound." *Encyclopedia Britannica Online*. Encyclopedia Britannica, n.d. Web. 22 July 2015. <http://www.britannica.com/science/sodium-carbonate>.

5. "Sodium Carbonate." , *Puriss., Meets Analytical Specification of Ph.Â Eur., BP, NF, FCC, E500, Anhydrous, 99.5-100.5% (calc. to the Dried Substance)*. Sigma Aldrich, n.d. Web. 22 July 2015. <http://www.sigmaaldrich.com/catalog/product/sial/13418?lang=en®ion=US>.

6. "Solvay Process." *Solvay Process-Industrial Chemistry*. University of Texas A&M, 1 May 2012. Web. 22 July 2015. <https://www.chem.tamu.edu/class/majors/chem470/Solvay.html>.

7. Toxnet. "Toxicology Data Network: Sodium Carbonate." *Toxicology Data Network*. National Institutes of Health, 20 Dec. 2012. Web. 30 June 2015. <http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+5

//www.nlm.nih.gov/medlineplus/ency/article/002486.htm

018>.

8. Zieve, David. "Sodium Carbonate Poisoning: MedlinePlus Medical Encyclopedia." *U.S National Library of Medicine*. U.S. National Library of Medicine, 9 Dec. 2012. Web. 30 June 2015. < http://www.nlm.nih.gov/medlineplus/ency/article/002486.htm >.

9. "Sodium Carbonate." *Human and Environmental Risk Assessment on Ingredients of Household Cleaning Products* (n.d.): n. pag. European Union Risk Assesment. Web. 13 July 2015. <http://www.heraproject.com/files/10-f-05_hera_sodium_carbonate_revised_version2%20.pdf>.