

Topic;- preparation properties and uses of sodium carbonate;

Class;- Bsc.Ist year chemistry

Introduction

Sodium carbonate (also known as **washing soda**, **soda ash** and **soda crystals**), Na_2CO_3 , is the water-soluble sodium salt of carbonic acid. It most commonly occurs as a crystalline heptahydrate, which readily effloresces to form a white powder, the monohydrate. Pure sodium carbonate is a white, odourless powder that is hygroscopic (absorbs moisture from the air). It has a strongly alkaline taste, and forms a moderately basic solution in water. Sodium carbonate is well known domestically for its everyday use as a water softener. It can be extracted from the ashes of many plants growing in sodium-rich soils, such as vegetation from the Middle East, kelp from Scotland and seaweed from Spain. Because the ashes of these sodium-rich plants were noticeably different from ashes of timber (used to create potash), they became known as "soda ash" It is synthetically produced in large quantities from salt (sodium chloride) and limestone by a method known as the Solvay process.

Production

Mining

Trona, trisodium hydrogendicarbonate dehydrate ($\text{Na}_3\text{HCO}_3\text{CO}_3 \cdot 2\text{H}_2\text{O}$), is mined in several areas of the US and provides nearly all the domestic consumption of sodium carbonate. Large natural deposits found in 1938, such as the one near Green River, Wyoming, have made mining more economical than industrial production in North America. There are important reserves of trona in Turkey; two million tons of soda ash have been extracted from the reserves near Ankara. It is also mined from some alkaline lakes such as Lake Magadi in Kenya by dredging. Hot saline springs continuously replenish salt in the lake so that, provided the rate of dredging is no greater than the replenishment rate, the source is fully sustainable.

Barilla and kelp

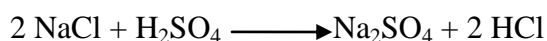
Several "halophyte" (salt-tolerant) plant species and seaweed species can be processed to yield an impure form of sodium carbonate, and these sources predominated in Europe and elsewhere until the early 19th century. The land plants (typically glassworts or saltworts) or

the seaweed (typically *Fucus* species) were harvested, dried, and burned. The ashes were then "lixiviated" (washed with water) to form an alkali solution. This solution was boiled dry to create the final product, which was termed "soda ash"; this very old name refers to the archetypal plant source for soda ash, which was the small annual shrub *Salsola soda* ("barilla plant").

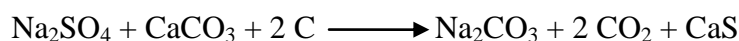
The sodium carbonate concentration in soda ash varied very widely, from 2–3 percent for the seaweed-derived form ("kelp"), to 30 percent for the best barilla produced from saltwort plants in Spain. Plant and seaweed sources for soda ash, and also for the related alkali "potash", became increasingly inadequate by the end of the 18th century, and the search for commercially viable routes to synthesizing soda ash from salt and other chemicals intensified.

Leblanc process

In 1791, the French chemist Nicolas Leblanc patented a process for producing sodium carbonate from salt, sulphuric acid, limestone, and coal. First, sea salt (sodium chloride) was boiled in sulphuric acid to yield sodium sulphate and hydrogen chloride gas,



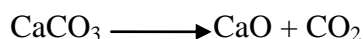
The sodium sulphate was blended with crushed limestone (calcium carbonate) and coal, and the mixture was burnt, producing calcium sulphide.



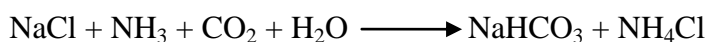
The sodium carbonate was extracted from the ashes with water, and then collected by allowing the water to evaporate.

Solvay process

In 1861, the Belgian industrial chemist Ernest Solvay developed a method to convert sodium chloride to sodium carbonate using ammonia. The Solvay process centered around a large hollow tower. At the bottom, calcium carbonate (limestone) was heated to release carbon dioxide:



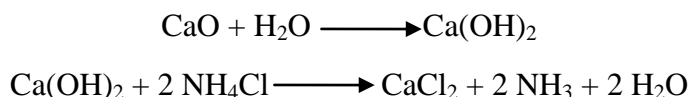
At the top, a concentrated solution of sodium chloride and ammonia entered the tower. As the carbon dioxide bubbled up through it, sodium bicarbonate precipitated:



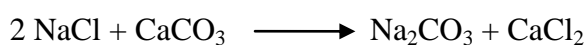
The sodium bicarbonate was then converted to sodium carbonate by heating it, releasing water and carbon dioxide:



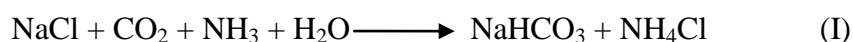
The ammonia was regenerated from the ammonium chloride by-product by treating it with the lime (calcium hydroxide) left over from carbon dioxide generation:



overall process is:



A simplified description can be given using the four different, interacting chemical reactions. In the first step in the process, carbon dioxide (CO₂) passes through a concentrated aqueous solution of sodium chloride (table salt, NaCl) and ammonia (NH₃).



In industrial practice, the reaction is carried out by passing concentrated brine through two towers. In the first, ammonia bubbles up through the brine (salt water) and is absorbed by it. In the second, carbon dioxide bubbles up through the ammoniated brine and sodium bicarbonate (baking soda) precipitates out of the solution. The ammonia (NH₃) buffers the solution at a basic pH; without the ammonia, a hydrochloric acid by-product would render the solution acidic, and arrest the precipitation.

The necessary ammonia "catalyst" for reaction (I) is reclaimed in a later step, and relatively little ammonia is consumed. The carbon dioxide required for reaction (I) is produced by heating ("calcinations") of the limestone at 950 - 1100 °C. The calcium carbonate (CaCO₃) in the limestone is partially converted to quicklime (calcium oxide (CaO)) and carbon dioxide:

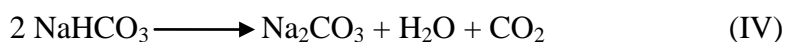


The sodium bicarbonate (NaHCO₃) that precipitates out in reaction (I) is filtered out from the hot ammonium chloride (NH₄Cl) solution, and the solution is then reacted with the quicklime (calcium oxide (CaO)) left over from heating the limestone in step (II).



CaO makes a strong basic solution. The ammonia from reaction (III) is recycled back to the initial brine solution of reaction (I).

The sodium bicarbonate (NaHCO_3) precipitate from reaction (I) is then converted to the final product, sodium carbonate (washing soda: Na_2CO_3), by calcinations (160 - 230 C), producing water and carbon dioxide as by-products:



The carbon dioxide from step (IV) is recovered for re-use in step (I). When properly designed and operated, a Solvay plant can reclaim almost all its ammonia, and consumes only small amounts of additional ammonia to make up for losses. The only major inputs to the Solvay process are salt, limestone and thermal energy, and its only major by-product is calcium chloride, which is sold as road salt.

Properties:-

The integral enthalpy of solution of sodium carbonate is -28.1 kJ/mol for a 10% w/w aqueous solution. The Mohs hardness of sodium carbonate monohydrate is 1.3.

Occurrence:-

Sodium carbonate crystallizes from water to form three different hydrates:

1. sodium carbonate decahydrate (natron)
2. sodium carbonate heptahydrate (not known in mineral form)
3. Sodium carbonate monohydrate (thermonatrite).
4. Sodium carbonate is soluble in water, and can occur naturally in arid regions, especially in mineral deposits (*evaporites*) formed when seasonal lakes evaporate. Deposits of the mineral natron have been mined from dry lake bottoms in Egypt since ancient times, when natron was used in the preparation of mummies and in the early manufacture of glass.
5. The anhydrous mineral form of sodium carbonate is quite rare and called natrite. Sodium carbonate also erupts from Ol Doi Nyio Lengai, Tanzania's unique volcano, and it is presumed to have erupted from other volcanoes in the past, but due to these minerals' instability at the earth's surface, are likely to be eroded. All three mineralogical forms of sodium carbonate, as well as trona, trisodium hydrogencarbonate dihydrate, are also known from ultra-alkaline pegmatitic rocks, that occur for example in the Kola Peninsula in Russia.

Uses

The manufacture of glass is one of the most important uses of sodium carbonate.

Sodium carbonate acts as a flux for silica, lowering the melting point of the mixture to something achievable without special materials. This "soda glass" is mildly water-soluble, so some calcium carbonate is added to the melt mixture to make the glass produced insoluble. This type of glass is known as soda lime glass: "soda" for the sodium carbonate and "lime" for the calcium carbonate. Soda lime glass has been the most common form of glass for centuries.

Sodium carbonate is also used as a relatively strong base in various settings. e.g, it is used as a pH regulator to maintain stable alkaline conditions necessary for the action of the majority of photographic film developing agents. It acts as an alkali because when dissolved in water, it dissociates into the weak acid: carbonic acid and the strong alkali; sodium hydroxide. This gives sodium carbonate in solution the ability to attack metals such as aluminium with the release of hydrogen gas.

It is a common additive in swimming pools used to neutralize the corrosive effects of chlorine and raise the pH.

In cooking, it is sometimes used in place of sodium hydroxide for lyeing, especially with German pretzels and lye rolls. These dishes are treated with a solution of an alkaline substance to change the pH of the surface of the food and improve browning.

In taxidermy, sodium carbonate added to boiling water will remove flesh from the skull or bones of trophies to create the "European skull mount" or for educational display in biological and historical studies.

In chemistry, it is often used as an electrolyte. Electrolytes are usually salt-based, and sodium carbonate acts as a very good conductor in the process of electrolysis. In addition, unlike chloride ions, which form chlorine gas, carbonate ions are not corrosive to the anodes. It is also used as a primary standard for acid-base titrations because it is solid and air-stable, making it easy to weigh accurately.

Domestic use

It is used as a water softener in laundering: it competes with the magnesium and calcium ions in hard water and prevents them from bonding with the detergent being used. Sodium carbonate can be used to remove grease, oil, and wine stains.

In dyeing with fiber-reactive dyes, sodium carbonate (often under a name such as soda ash fixative or soda ash activator) is used to ensure proper chemical bonding of the dye with cellulose (plant) fibers, typically before dyeing (for tie dyes), mixed with the dye (for dye painting), or after dyeing (for immersion dyeing).

Sodium carbonate test

The sodium carbonate test is used to distinguish between some common metal ions, which are precipitated as their respective carbonates. The test can distinguish between Cu, Fe, and Ca/Zn/Pb. Sodium carbonate solution is added to the salt of the metal. A blue precipitate indicates Cu^{2+} ion. A dirty green precipitate indicates Fe^{2+} ion. A yellow-brown precipitate indicates Fe^{3+} ion. A white precipitate indicates Ca^{2+} , Zn^{2+} , or Pb^{2+} ion. The compounds formed are, respectively, copper(II) carbonate, iron(II) carbonate, iron(III) oxide, calcium carbonate, zinc carbonate, and lead(II) carbonate. This test is used to precipitate the ion present as almost all carbonates are insoluble. While this test is useful for telling these cations apart. It fails if other ions are present, because most metal carbonates are insoluble and will precipitate. In addition, calcium, zinc, and lead ions all produce white precipitates with carbonate, making it difficult to distinguish between them. Instead of sodium carbonate, sodium hydroxide may be added this gives nearly the same colours, except that lead and zinc hydroxides are soluble in excess alkali, and can hence be distinguished from calcium.

Other applications

Sodium carbonate is a food additive (E500) used as an acidity regulator, ant caking agent, raising agent, and stabilizer. It is one of the components of *kansui* a solution of alkaline salts used to give ramen noodles their characteristic flavour and texture. It is also used in the production of *snus* (Swedish-style snuff) to stabilize the pH of the final product. In Sweden, *snus* is regulated as a food product because it is put into the mouth, requires pasteurization, and contains only ingredients that are approved as food additives.

Sodium carbonate is also used in the production of sherbet powder. The cooling and fizzing sensation results from the endothermic reaction between sodium carbonate and a weak acid, commonly citric acid, releasing carbon dioxide gas, which occurs when the sherbet is moistened by saliva.

In China, it is used to replace lye-water in the crust of traditional Cantonese moon cakes, and in many other Chinese steamed buns and noodles.

Sodium carbonate is used by the brick industry as a wetting agent to reduce the amount of water needed to extrude the clay.

In casting, it is referred to as "bonding agent" and is used to allow wet alginate to adhere to gelled alginate.

Sodium carbonate is used in toothpastes, where it acts as a foaming agent and an abrasive, and to temporarily increase mouth pH.

Sodium carbonate is used by the cotton industry to neutralize the sulphuric acid needed for acid delinting of fuzzy cottonseed.

Sodium carbonate, in a solution with common salt, may be used for cleaning silver. In a nonreactive container (glass, plastic, or ceramic), aluminium foil and the silver object are immersed in the hot salt solution. The elevated pH dissolves the aluminium oxide layer on the foil and enables an electrolytic cell to be established. Hydrogen ions produced by this reaction reduce the sulphide ions on the silver restoring silver metal. The sulphide can be released as small amounts of hydrogen sulphide. Rinsing and gently polishing the silver restores a highly polished condition.

Sodium carbonate is used in some aquarium water pH buffers to maintain a desired pH and carbonate hardness.

Because of its ability to absorb CO₂, sodium carbonate is being investigated as a carbon-capturing material for power plants and in other industries that produce greenhouse gases.