WHEELHOUSE
INDUSTRIES LLC

White Paper

Understanding Organic, Inorganic and Biodegradable Descaling Cleaners

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Introduction

The purpose of this white paper is to provide an explanation of organic, inorganic and biodegradable descaling cleaners. With the concern over the impact chemicals are making on the environment and waterways, understanding the differences in descaling options will help you make an informed decision for you project.

The Difference Between Organic and Inorganic Compounds

Organic compounds are living organisms in their natural form without chemicals. Inorganic compounds are non living things like rocks or cement. Organic compounds are a source of life, such as plants, trees and animals. Inorganic compounds have no energy or life in them.

Organic Bases

An organic base is an Organic Compound which acts as a base. Organic bases are usually, but not always, proton acceptors. They usually contain nitrogen atoms, which can easily be protonated. Amines and nitrogen-containing heterocyclic compounds are organic bases. Examples include:

- Pyridine
- Imidazole
- Phosphazene bases
- Methyl amine
- Benzimidazole
- Hydroxides of some organic cations

Factors Affecting Alkalinity

While all organic bases are considered to be weak, many factors can affect the alkalinity of the compounds. One such factor is the inductive effect. A simple explanation of the term would state that electropositive atoms (such as carbon groups) attached in close proximity to the potential proton acceptor have an “electron-releasing” effect, such that the positive charge acquired by the proton acceptor is distributed over other adjacent atoms in the chain. The converse is also possible as alleviation of alkalinity: electronegative atoms or species (such as fluorine or the nitro group) will have an “electron-withdrawal” effect and thereby reduce the basicity. To this end, triethylamine is a more potent base than merely ammonia,, due to the inductive effect of the methyl groups allowing the nitrogen atom to more readily accept a proton and become a cation being much greater than that of the hydrogen atoms. In guanidines, the protonated form (guanidinium) has three resonance structures, giving it increased stability and making guanadines stronger bases.

Phosphazene bases also contain phosphorus and are, in general, more alkaline than standard amines and nitrogen-based heterocyclics. Protonation takes place at the nitrogen atom, not the phosphorus atom to which the nitrogen is double-bonded.

Inorganic Bases

Base, a chemical compound that is capable of accepting hydrogen ions from another substance. (An ion is an electrically charged atom or radical—a group of atoms that acts as a single atom). Bases will neutralize acids by combining with the hydrogen of the acid. A salt is always formed by the reaction of an acid with a base.

Most bases are solids at ordinary temperatures. Many, however, are liquids and a few are gases. When dissolved in water, bases typically have a bitter taste, feel soapy, will turn red litmus blue and can conduct an electric current. Many bases are highly flammable. Some, such as sodium hydroxide, can cause severe chemical burns on the skin.

Bases are classified as either inorganic or organic. Some inorganic bases (such as magnesium hydroxide) occur in nature as minerals. Most, however, are manufactured from mineral substances. Organic bases occur in, or can be produced from, animal or plant matter.

Most common inorganic bases are hydroxides—compounds that contain the hydroxyl radical (OH^-). Other inorganic bases include ammonia and many metal oxides; some salts (such as potassium carbonate) function as bases in solution and therefore are also considered bases. In chemistry, the term alkali is often used for inorganic bases that can either release or form hydroxyl radicals in water solution. The term is applied to the hydroxides and carbonates of ammonia and of the alkali metals and to the oxides and hydroxides of the alkaline-earth metals.

Common inorganic bases are sodium hydroxide (caustic soda), potassium hydroxide (caustic potash), calcium oxide (quicklime), and sodium carbonate (soda ash). Inorganic bases are used in making soap, glass, paper, chemicals, plastics, dyes, and many other substances.

Organic Acids

An organic acid is an organic compound with acidic properties. The most common organic acids are the carboxylic acids, whose acidity is associated with their carboxyl group –COOH. Sulfonic acids, containing the group –SO2OH, are relatively stronger acids. Alcohols, with -OH, can act as acids but they are usually very weak. The relative stability of the conjugate base of the acid determines its acidity. Other groups can also confer acidity, usually weakly: the thiol group –SH, the enol group, and the phenol group. In biological systems, organic compounds containing these groups are generally referred to as organic acids. A few common examples include:

- Lactic Acid
- Formic Acid
- Oxalic Acid
- Acetic Acid
- Citric Acid
- Uric Acid

In general, organic acids are weak acids and do not dissociate completely in water, whereas the strong mineral acids do. Lower molecular mass organic acids such as formic and lactic acids are miscible in water, but higher molecular mass organic acids, such as benzoic acid, are insoluble in molecular (neutral) form.

On the other hand, most organic acids are very soluble in organic solvents. p- Toluenesulfonic acid is a comparatively strong acid used in organic chemistry often because it is able to dissolve in the organic reaction solvent.

Exceptions to these solubility characteristics exist in the presence of other substituents that affect the polarity of the compound.

Simple organic acids like formic or acetic acids are used for oil and gas well stimulation treatments. These organic acids are much less reactive with metals than are strong mineral acids like hydrochloric acid (HCl) or mixtures of HCl and hydrofluoric acid (HF). For this reason, organic acids are used at high temperatures or when long contact times between acid and pipe are needed.

Citric and oxalic acids are used as rust removal. As acids, they can dissolve the iron oxides, but without damaging the base metal as do stronger mineral acids. In the dissociated form, they may be able to chelate the metal ions, helping to speed removal.

Biological systems create many and more complex organic acids such as L-Lactic, citric, and D-glucuronic acids that contain hydroxyl or carboxyl groups. Human blood and urine contain these plus organic acid degradation products of amino acids, neurotransmitters, and intestinal bacterial action on food components.

Mineral (Inorganic) Acids

A mineral acid (or inorganic acid) is an acid derived from one or more inorganic compounds. All mineral acids form hydrogen ions and the conjugate base ions when dissolved in water.

Commonly used mineral acids are sulfuric acid, hydrochloric acid and nitric acid (They are also known as bench acids). Mineral acids range from acids of great strength (example: sulfuric acid) to very weak (boric acid). Mineral acids tend to be very soluble in water and insoluble in organic solvents.

Mineral acids are used in many sectors of the chemical industry as feedstocks for the synthesis of other chemicals, both organic and inorganic. Large quantities of these acids, especially sulfuric acid, nitric acid and hydrochloric acid are manufactured for commercial use in large plants.

Mineral acids are also used directly for their corrosive properties. For example, a dilute solution of hydrochloric acid is used for removing the deposits from the inside of boilers, with precautions taken to prevent the corrosion of the boiler by the acid. This process is known as descaling. Examples include:

- Hydrochloric Acid - HCl
- Phosphoric Acid - H3PO4
- Boric Acid - H3BO3
- Hydrobromic - HBr
- Nitric Acid - HNO3
- Sulfuric Acid - H2SO4
- Hydrofluoric Acid - HF
- Perchloric Acid - HClO4

What is Scale?

Wikipedia defines scale this way: Hard water is water that has high mineral content (in contrast with soft water). Hard water minerals primarily consist of calcium (Ca^{2+}), and magnesium (Mg^{2+}) metal cations, and sometimes other dissolved compounds such as bicarbonates and sulfates. Hard water causes scaling, which is the left-over mineral deposits that are formed after the hard water had evaporated. This is also known as limescale. The scale can clog pipes, ruin water heaters, coat the insides of tea and coffee pots, and decrease the life of toilet flushing units.

Dishwashers

The buildup of hard water scale in your dishwasher will show up as flakes on your dishes and glassware. The scale buildup on the heating element also substantially reduces the of the drying cycle. The drain system will clog from the hard water buildup, causing leaking and even flooding into the kitchen.

Problems in Water Boiler Systems and Pipework

Hard water also contributes to inefficient and costly operation of water- using appliances. Heated hard water forms a scale of calcium and magnesium minerals (limescale deposits) that can contribute to the inefficient operation or failure of water-using appliances. Pipes can become clogged with scale that reduces water flow and ultimately requires pipe replacement. Limescale has been known to increase energy bills by up to 25%.

Scale in Solar Heating Systems

Solar heating, often used for heating swimming pools is prone to limescale buildup, which can reduce the efficiency of the electronic pump and therefore the overall systems performance will deteriorate.

Scale Buildup in Showers/Tubs

Shower doors easily show the buildup of hard water scale. Bathtubs/tiles become quite dull due to the hard water film. This film allows for organic growth. Shower heads become clogged, and often have colorful scale growth. Scale inside a shower head may facilitate the growth of microbes and bacteria.

Sprinkler Buildup

The sides of buildings show the hard water scale buildup as rust stains quite often. The building is not rusting. The rust is trapped in the scale buildup.

Removal

Traditional methods for scale removal include:

Harsh chemicals:

- Hydrochloric Acid
- Sulfuric Acid
- Muriatic Acid
- Phosphoric Acid

Mechanical Means:

- Pressure Washing
- Sandpaper
- Harsh Brushes
- Sand Blasting

Acids and Bases

Acids and Bases Are Everywhere

Every liquid you see will probably have either acidic or basic traits. Water (H_2O) can be both an acid and a base, depending on how you look at it. It can be considered an acid in some reactions and a base in others. Water can even react with itself to form acids and bases. It happens in really small amounts, so it won't change your experiments at all. It goes like this:
$2H_2O \rightarrow H_3O^+ + OH^-$

See how the hydrogen ion was transferred?

Most of the time, the positive and negative ions in distilled water are in equal amounts and cancel each other out. Most water you drink from the tap has other ions in it. Those special ions in solution make something acidic or basic. In your body there are small compounds called amino acids. The name tells you those are acids. In fruits there is something called citric acid. That's an acid too. But what about baking soda? When you put that in water, it creates a basic solution. Vinegar? Acid.

So, what makes an acid or a base?

A chemist named Svante Arrhenius came up with a way to define acids and bases in 1887. He saw that when you put molecules into water, sometimes they break down and release an H^+ (Hydrogen) ion. At other times, you find the release of an OH^- (hydroxide) ion. When a hydrogen ion is released, the solution becomes acidic. When a hydroxide ion is released, the solution becomes basic. Those two special ions determine whether you are looking at an acid or a base. For example, vinegar is also called acetic acid. (Okay, that gives away the answer.) If you look at its atoms when it's in water, you will see the molecule CH_3COOH split into CH_3COO^- and H^+. That hydrogen ion is the reason it is called an acid. Chemists use the word "dissociated" to describe the breakup of a compound.

Scientists use something called the pH scale to measure how acidic or basic a liquid is. Although there may be many types of ions in a solution, pH focuses on concentrations of hydrogen ions (H^+) and hydroxide ions (OH^-). The scale measures values from 0 all the way up to 14. Distilled water is 7 (right in the middle). Acids are found between 0 and 7. Bases are from 7 to 14. Most of the liquids you find every day have a pH near 7. They are either a little below or a little above that mark. When you start looking at the pH of inorganic chemicals, the numbers can go to the extremes. If you ever go into a chemistry lab, you could find solutions with a pH of 1 and others with a pH of 14. There are also very strong acids with pH values below 1, such as battery acid. Bases with pH values near 14 include drain cleaner and sodium hydroxide (NaOH). Those chemicals are very dangerous.

Does Biodegradable really mean environmentally safe?

What do actual biodegradable substances leave behind?
Ideal biodegradability means that a substance will degrade without leaving any toxins behind. As an example, plant-based products break down into their core elements as well, just as plastics do. In this case, these byproducts are carbon dioxide, water, and other naturally occurring minerals. These items mix seamlessly back into the earth, leaving nothing negative behind. They can also do this within a season under ideal conditions.

How do I know what is biodegradable and what isn't?

When you are looking for items that are supposedly biodegradable or labeled as such, look for products whose base components are purely non-chemical. Wood, paper, food-based products, and even compostable products are all viable and environmentally-safe. It's important to note that some brands use the phrase "biodegradable" in a pretty cavalier way. As we stated earlier, biodegradable is often used as a marketing term, and just because a label says biodegradable, doesn't mean that it actually is.

This misleading type of marketing is called "greenwashing" and it is a way that big corporations mislead people who are trying to be environmentally-conscious into buying something that isn't actually good for the environment at all. Always do your research before making any assumptions based on a label.

How long does it take for things to biodegrade?

Nearly every biodegradable material, whether it be an apple core or a hunk of cement, will eventually break down into its component parts, if given enough time. Even metals and plastics will eventually biodegrade, though they might end up being far worse for the environment in their new form.

Plastics can take decades or even centuries to break down on their own. Depending on the type of plastic, this process can result in chemicals, toxic gasses, or minuscule globules of water-faring pollutants called microplastics; one of the biggest problems our world is currently facing.

So, you see, that is why time is a factor when it comes to biodegradability. Sure, plastic and polystyrene will eventually break down; you just won't like when they do, and they won't be going away anytime soon.

Are mineral/inorganic acids biodegradable?

From Section 12 of multiple SDS sheets: Persistence and degradability - No data is available on the degradability of this product.

Biodegradation is not applicable to inorganic substances.
Main Difference – Hydrogen Chloride vs Hydrochloric Acid

Hydrogen chloride and hydrochloric acid are two terms used to name chemical compounds having the same chemical formula: HCl. Hydrogen chloride is the name of HCl compound that can be in any phase of matter: solid, liquid or gas. But at room temperature, it is a colorless gas. Hydrochloric acid is the aqueous hydrogen chloride solution that has acidic properties. Therefore, the main difference between hydrogen chloride and hydrochloric acid is that hydrogen chloride is a colorless gas at room temperature whereas hydrochloric acid is a solution.

The Difference Between Organic and (Biodegradable?) Inorganic Cleaners

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