SOAPS and DETERGENTS

Cleaning products play an essential role in our daily lives. By safely and effectively removing soils, germs and other contaminants, they help us to stay healthy, care for our homes and possessions, and make our surroundings more pleasant.

The Soap and Detergent Association (SDA) recognizes that public understanding of the safety and benefits of cleaning products is critical to their proper use. So we've revised *Soaps and Detergents* to feature the most current information in an easy-to-read format. This second edition summarizes key developments in the history of cleaning products; the science of how they work; the procedures used to evaluate their safety for people and the environment; the functions of various products and their ingredients; and the most common manufacturing processes.

SDA hopes that consumers, educators, students, media, government officials, businesses and others find *Soaps and Detergents* a valuable resource of information about cleaning products.

2nd Edition

CONTENTS

SDA

The Soap and Detergent Association

HISTORY

1 The origins of personal cleanliness date back to prehistoric times. Since water is essential for life, the earliest people lived near water and knew something about its cleansing properties — at least that it rinsed mud off their hands.

2 A soap-like material found in clay cylinders during the excavation of ancient Babylon is evidence that soapmaking was known as early as 2800 B.C. Inscriptions on the cylinders say that fats were boiled with ashes, which is a method of making soap, but do not refer to the purpose of the "soap." Such materials were later used as hair styling aids.

3 Records show that ancient Egyptians bathed regularly. The Ebers Papyrus, a medical document from about 1500 B.C., describes combining animal and vegetable oils with alkaline salts to form a soap-like material used for treating skin diseases, as well as for washing.

4 At about the same time, Moses gave the Israelites detailed laws governing personal cleanliness. He also related cleanliness to health and religious purification. Biblical accounts suggest that the Israelites knew that mixing ashes and oil produced a kind of hair gel.

5 The early Greeks bathed for aesthetic reasons and apparently did not use soap. Instead, they cleaned their bodies with blocks of clay, sand, pumice and ashes, then anointed themselves with oil, and scraped off the oil and dirt with a metal instrument known as a strigil. They also used oil with ashes. Clothes were washed without soap in streams.

6 Soap got its name, according to an ancient Roman legend, from Mount Sapo, where animals were sacrificed. Rain washed a mixture of melted animal fat, or tallow, and wood ashes down into the clay soil along the Tiber River. Women found that this clay mixture made their wash cleaner with much less effort.

The ancient Germans and Gauls are also credited with discovering a substance called soap, made of goat's tallow and ashes, that they used to tint their hair red.

7 As Roman civilization advanced, so did bathing. The first of the famous Roman baths, supplied with water from their aqueducts, was built about 312 B.C. The baths were luxurious, and bathing became very popular. By the second century A.D., the Greek physician, Galen, recommended soap for both medicinal and cleansing purposes.

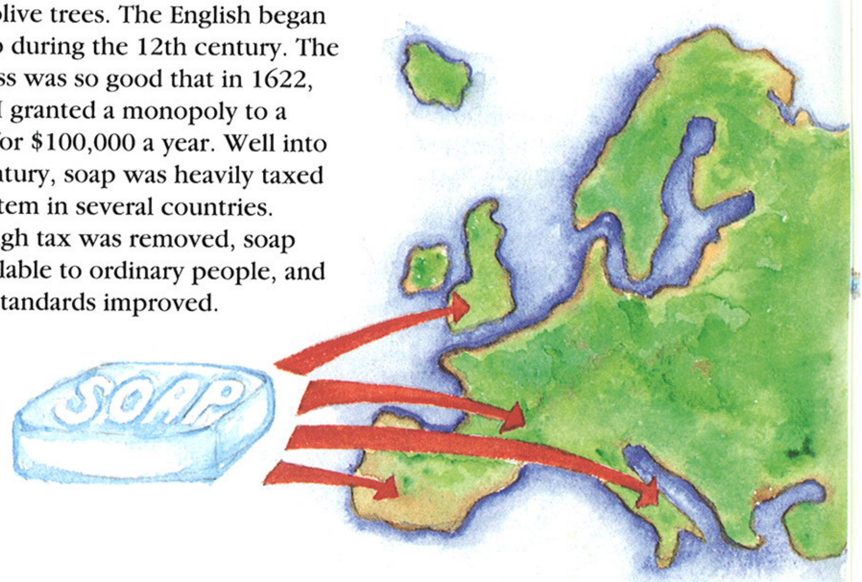
8 After the fall of Rome in 467 A.D. and the resulting decline in bathing habits, much of Europe felt the impact of filth upon public health. This lack of personal cleanliness and related unsanitary living conditions contributed heavily to the great plagues of the Middle Ages, and especially to the Black Death of the 14th century. It wasn't until the 17th century that cleanliness and bathing started to come back into fashion in much of Europe.

Still there were areas of the medieval world where personal cleanliness remained important. Daily bathing was a common custom in Japan during the Middle Ages. And in Iceland, pools warmed with water from hot springs were popular gathering places on Saturday evenings.

9 Soapmaking was an established craft in Europe by the seventh century. Soapmaker guilds guarded their trade secrets closely. Vegetable and animal oils were used with ashes of plants, along with fragrance. Gradually more varieties of soap became available for shaving and shampooing, as well as bathing and laundering.

11 Commercial soapmaking in the American colonies began in 1608 with the arrival of several soapmakers on the second ship from England to reach Jamestown, VA. However, for many years, soapmaking stayed essentially a household chore. Eventually, professional soapmakers began regularly collecting waste fats from households, in exchange for some soap.

10 Italy, Spain and France were early centers of soap manufacturing, due to their ready supply of raw materials such as oil from olive trees. The English began making soap during the 12th century. The soap business was so good that in 1622, King James I granted a monopoly to a soapmaker for $100,000 a year. Well into the 19th century, soap was heavily taxed as a luxury item in several countries. When the high tax was removed, soap became available to ordinary people, and cleanliness standards improved.



NICHOLAS LEBLANC

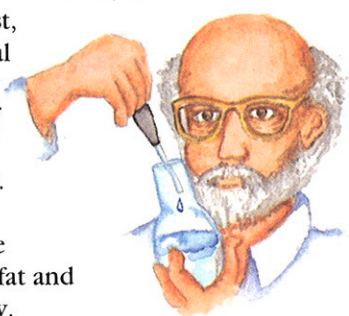
12 A major step toward large-scale commercial soapmaking occurred in 1791 when a French chemist, Nicholas Leblanc, patented a process for making soda ash, or sodium carbonate, from common salt. Soda ash is the alkali obtained from ashes that combines with fat to form soap. The Leblanc process yielded quantities of good quality, inexpensive soda ash.

ERNEST SOLVAY

14 Also important to the advancement of soap technology was the mid-1800s invention by the Belgian chemist, Ernest Solvay, of the ammonia process, which also used common table salt, or sodium chloride, to make soda ash. Solvay's process further reduced the cost of obtaining this alkali, and increased both the quality and quantity of the soda ash available for manufacturing soap.

MICHEL EUGENE CHEVREUL

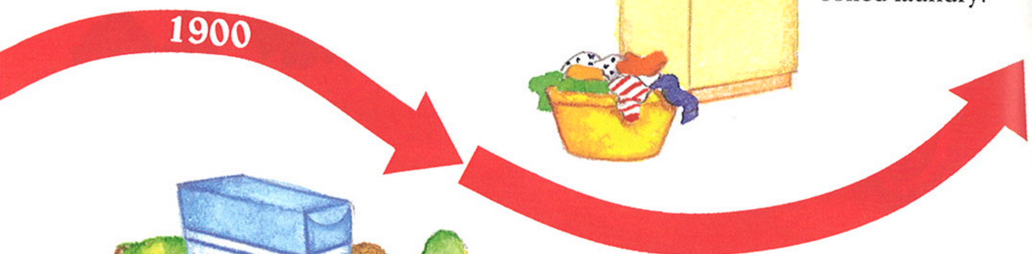
13 The science of modern soapmaking was born some 20 years later with the discovery by Michel Eugene Chevreul, another French chemist, of the chemical nature and relationship of fats, glycerine and fatty acids. His studies established the basis for both fat and soap chemistry.



15 These scientific discoveries, together with the development of power to operate factories, made soapmaking one of America's fastest-growing industries by 1850. At the same time, its broad availability changed soap from a luxury item to an everyday necessity. With this widespread use came the development of milder soaps for bathing and soaps for use in the washing machines that were available to consumers by the turn of the century.

16 The chemistry of soap manufacturing stayed essentially the same until 1916, when the first synthetic detergent was developed in Germany in response to a World War I-related shortage of fats for making soap. Known today simply as detergents, synthetic detergents are non-soap washing and cleaning products that are "synthesized" or put together chemically from a variety of raw materials. The discovery of detergents was also driven by the need for a cleaning agent that, unlike soap, would not combine with the mineral salts in water to form an insoluble substance known as soap curd.

18 The first detergents were used chiefly for hand dishwashing and fine fabric laundering. The breakthrough in the development of detergents for all-purpose laundry uses came in 1946, when the first "built" detergent (containing a surfactant/builder combination) was introduced in the U.S. The surfactant is a detergent product's basic cleaning ingredient, while the builder helps the surfactant to work more efficiently. Phosphate compounds used as builders in these detergents vastly improved performance, making them suitable for cleaning heavily soiled laundry.



17 Household detergent production in the United States began in the early 1930s, but did not really take off until after World War II. The war-time interruption of fat and oil supplies as well as the military's need for a cleaning agent that would work in mineral-rich sea water and in cold water had further stimulated research on detergents.

19 By 1953, sales of detergents in this country had surpassed those of soap. Now detergents have all but replaced soap-based products for laundering, dishwashing and household cleaning. Detergents (alone or in combination with soap) are also found in many of the bars and liquids used for personal cleansing.

Since those early achievements in detergent and builder chemistry, new product activity has continued to focus on developing cleaning products that are efficient and easy to use, as well as safe for consumers and for the environment. Here's a summary of some of those innovations.

1950s

Automatic dishwasher powders
Liquid laundry, hand dishwashing and all-purpose cleaning products
Fabric softeners (rinse-cycle added)
Detergent with oxygen bleach

1960s

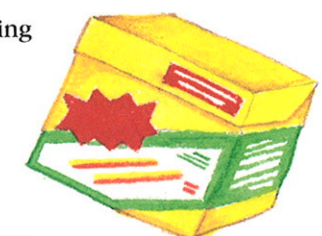
Prewash soil and stain removers
Laundry powders with enzymes
Enzyme presoaks

1970s

Liquid hand soaps
Fabric softeners (sheets and wash-cycle added)
Multifunctional products (e.g., detergent with fabric softener)

1980s

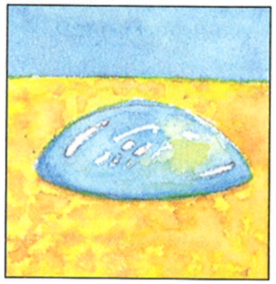
Detergents for cooler water washing
Automatic dishwasher liquids
Concentrated laundry powders



1990s

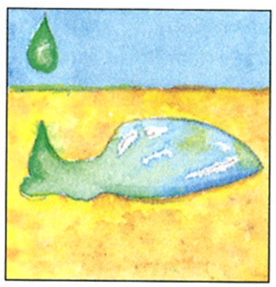
Ultra (superconcentrated) powder and liquid detergents
Ultra fabric softeners
Automatic dishwasher gels
Laundry and cleaning product refills

To understand what is needed to achieve effective cleaning, it is helpful to have a basic knowledge of soap and detergent chemistry.



SURFACE TENSION

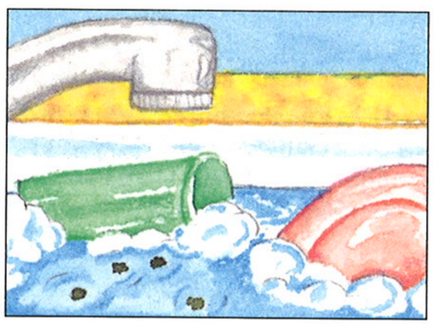
Water, the liquid commonly used for cleaning, has a property called surface tension. In the body of the water, each molecule is surrounded and attracted by other water molecules. However, at the surface, these molecules are surrounded by other water molecules only on the water side. A tension is created as the water molecules at the surface are pulled into the body of the water. This tension causes water to bead up on surfaces (glass, fabric), which slows wetting of the surface and inhibits the cleaning process. You can see surface tension at work by placing a drop of water onto a countertop. The drop will hold its shape and will not spread.



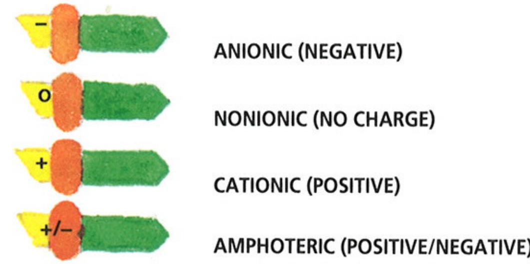
SURFACTANT

In the cleaning process, surface tension must be reduced so water can spread and wet surfaces. Chemicals that do this effectively are called surface active agents, or surfactants. They are said to make water "wetter."

Surfactants perform other important functions in cleaning, such as loosening, emulsifying (dispersing in water) and holding soil in suspension until it can be rinsed away. Surfactants can also provide alkalinity, which is useful in removing acidic soils.



Surfactants are classified by their ionic (electrical charge) properties in water: anionic (negative charge), nonionic (no charge), cationic (positive charge) and amphoteric (either positive or negative charge).



Soap is an anionic surfactant. Other anionic as well as nonionic surfactants are the main ingredients in today's detergents. Now let's look closer at the chemistry of surfactants.

SOAPS

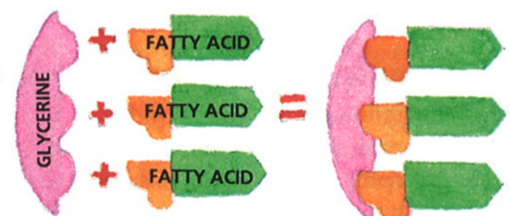
Soaps are water-soluble sodium or potassium salts of fatty acids. Soaps are made from fats and oils, or their fatty acids, by treating them chemically with a strong alkali.

First, let's examine the composition of fats, oils and alkalis; then we'll review the soapmaking process.

Fats and Oils

The fats and oils used in soapmaking come from animal or plant sources. Each fat or oil is made up of a distinctive mixture of several different triglycerides.

In a triglyceride molecule, three fatty acid molecules are attached to one molecule of glycerine. There are many types of triglycerides; each type consists of its own particular combination of fatty acids.

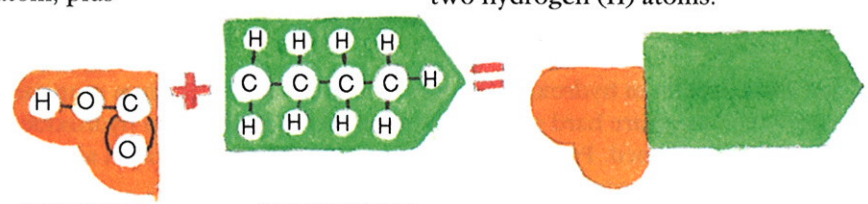


TRIGLYCERIDE (FAT MOLECULE)

Fatty acids are the components of fats and oils that are used in making soap. They are weak acids composed of two parts:

a carboxylic acid group consisting of one hydrogen (H) atom, two oxygen (O) atoms, and one carbon (C) atom; plus

a hydrocarbon chain attached to the carboxylic acid group. Generally, it is made up of a long, straight chain of carbon (C) atoms each carrying two hydrogen (H) atoms.



CARBOXYLIC ACID GROUP

HYDROCARBON CHAIN

FATTY ACID

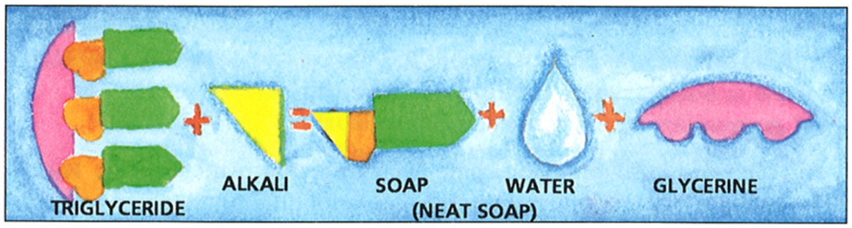
Alkali

An alkali is a soluble salt of an alkali metal like sodium or potassium. Originally, the alkalis used in soapmaking were obtained from the ashes of plants, but they are now made commercially. Today, the term alkali describes a substance that chemically is a base (the opposite of an acid) and that reacts with and neutralizes an acid.

The common alkalis used in soapmaking are sodium hydroxide (NaOH), also called caustic soda; and potassium hydroxide (KOH), also called caustic potash.

How Soaps Are Made

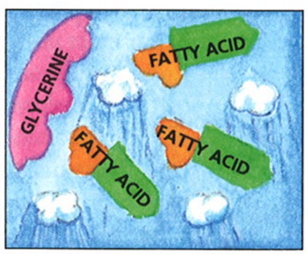
Saponification of fats and oils is the most widely used soapmaking process. This method involves heating fats and oils and reacting them with a liquid alkali to produce soap and water (neat soap) plus glycerine.

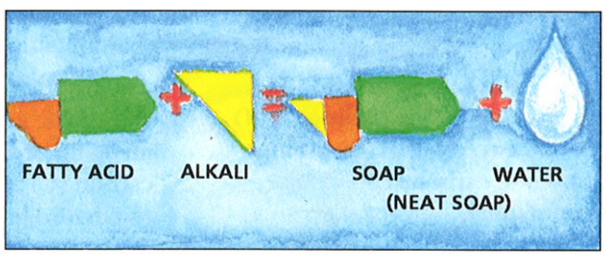


The other major soapmaking process is the neutralization of fatty acids with an alkali.

Fats and oils are hydrolyzed (split) with high-pressure steam to yield crude fatty acids and glycerine.

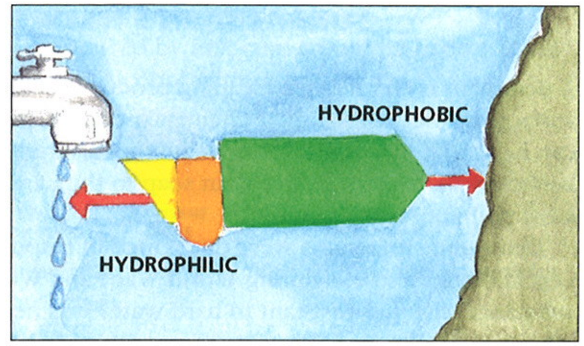
The fatty acids are then purified by distillation and neutralized with an alkali to produce soap and water (neat soap).



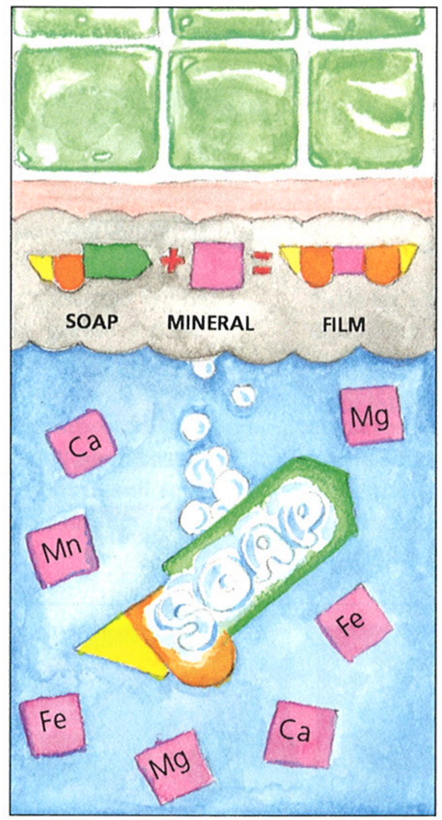


When the alkali is sodium hydroxide, a sodium soap is formed. Sodium soaps are "hard" soaps. Bar soaps are hard soaps. When the alkali is potassium hydroxide, a potassium soap is formed. Potassium soaps are softer and are found in some liquid hand soaps and shaving creams.

The carboxylate end of the soap molecule is attracted to water. It is called the hydrophilic (water-loving) end. The hydrocarbon chain is attracted to oil and grease and repelled by water. It is known as the hydrophobic (water-hating) end.



How Water Hardness Affects Cleaning Action



Although soap is a good cleaning agent, its effectiveness is reduced when used in hard water. Hardness in water is caused by the presence of mineral salts — mostly those of calcium (Ca) and magnesium (Mg), but sometimes also iron (Fe) and manganese (Mn). The mineral salts react with soap to form an insoluble precipitate known as soap film or scum.

Soap film does not rinse away easily. It tends to remain behind and produces visible deposits on clothing and makes fabrics feel stiff. It also attaches to the insides of bathtubs, sinks and washing machines.

Some soap is used up by reacting with hard water minerals to form the film. This reduces the amount of soap available for cleaning. Even when clothes are washed in soft water, some hardness minerals are introduced by the soil on clothes. Soap molecules are not very versatile and cannot be adapted to today's variety of fibers, washing temperatures and water conditions.

SURFACTANTS IN DETERGENTS

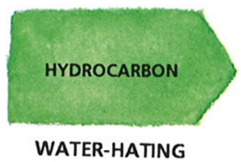
A detergent is an effective cleaning product because it contains one or more surfactants. Because of their chemical makeup, the surfactants used in detergents can be engineered to perform well under a variety of conditions. Such surfactants are less sensitive than soap to the hardness minerals in water and most will not form a film.

Detergent surfactants were developed in response to a shortage of animal and vegetable fats and oils during World War I and World War II. In addition, a substance that was resistant to hard water was needed to make cleaning more effective. At that time, petroleum was found to be a plentiful source for the manufacture of these surfactants. Today, detergent surfactants are made from a variety of petrochemicals (derived from petroleum) and/or oleochemicals (derived from fats and oils).

Let's discuss the main components of detergent surfactants.

Petrochemicals and Oleochemicals

Like the fatty acids used in soapmaking, both petroleum and fats and oils contain hydrocarbon chains that are repelled by water but attracted to oil and grease in soils. These hydrocarbon chain sources are used to make the water-hating end of the surfactant molecule.



Other Chemicals

Chemicals, such as sulfur trioxide, sulfuric acid and ethylene oxide, are used to produce the water-loving end of the surfactant molecule.

Alkalis

As in soapmaking, an alkali is used to make detergent surfactants. Sodium and potassium hydroxide are the most common alkalis.

How Detergent Surfactants Are Made

Anionic Surfactants

The chemical reacts with hydrocarbons derived from petroleum or fats and oils to produce new acids similar to fatty acids.

A second reaction adds an alkali to the new acids to produce one type of anionic surfactant molecule.

Nonionic Surfactants

Nonionic surfactant molecules are produced by first converting the hydrocarbon to an alcohol and then reacting the fatty alcohol with ethylene oxide.

These nonionic surfactants can be reacted further with sulfur-containing acids to form another type of anionic surfactant.

HOW SOAPS AND DETERGENTS WORK

Three types of energy are needed for good cleaning results:

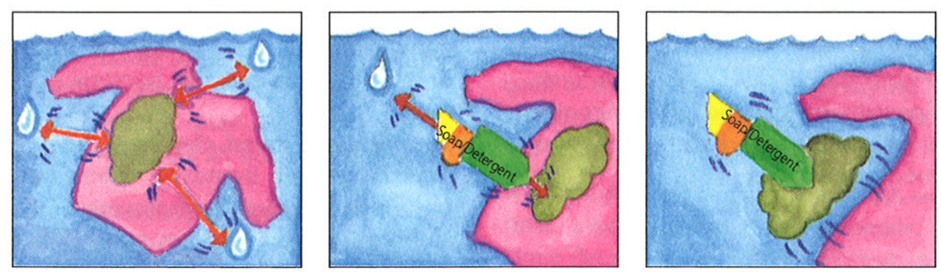
- chemical energy, provided by the soap or detergent;
- thermal energy, provided by warm or hot water; and
- mechanical energy, provided by a machine or hands.

These types of energy interact and should be in proper balance. Let's look at how they work together.

Let's assume we have oily, greasy soil on clothing. Water alone will not remove this soil. One important reason is that oil and grease present in soil repel the water molecules.

Now let's add soap or detergent. The surfactant's water-hating end is repelled by water but attracted to the oil in the soil. At the same time, the water-loving end is attracted to the water molecules.

These opposing forces loosen the soil and suspend it in the water. Warm or hot water helps dissolve grease and oil in soil. Washing machine agitation or hand rubbing helps pull the soil free.



Soaps and detergents are essential to personal and public health. Through their ability to loosen and remove soil from a surface, they contribute to good personal hygiene; reduce the presence of germs that cause infectious diseases; extend the useful life of clothes, tableware, linens, surfaces and furnishings; and make our homes and workplaces more pleasant.

Soaps and detergents found in the home can be grouped into four general categories: personal cleansing, laundry, dishwashing and household cleaning. Within each category are different product types formulated with ingredients selected to perform a broad cleaning function as well as to deliver properties specific to that product. Knowing the different products and their ingredients helps you select the right product for the cleaning job.

PRODUCTS

Personal Cleansing Products

include bar soaps, gels, liquid soaps and heavy duty hand cleaners. These products get their cleaning action from soap, other surfactants or a combination of the two. The choice of cleaning agent helps determine the product's lathering characteristics, feel on the skin and rinsability.

Bar soaps or Gels are formulated for cleaning the hands, face and body. Depending on the other ingredients, they may also moisturize the skin and/or inhibit odor-causing bacteria. Specialty bars include transparent/translucent soaps, luxury soaps and medicated soaps.

Liquid soaps are generally formulated for cleaning hands, and feature skin conditioners. Some contain antimicrobial agents that kill or inhibit disease-causing bacteria.

Heavy duty hand cleaners are available as bars, liquids, powders and pastes. Formulated for removing stubborn, greasy dirt, they may include an abrasive.

Laundry Detergents and Laundry Aids

are available as liquids, powders, gels, sticks, sprays, pumps, sheets and bars. They are formulated to meet a variety of soil and stain removal, bleaching, fabric softening and conditioning, and disinfectant needs under varying water, temperature and use conditions.

Laundry detergents are either general purpose or light duty. *General purpose detergents* are suitable for all washable fabrics. Liquids work best on oily soils and for pretreating soils and stains. Powders are especially effective in lifting out clay and ground-in dirt.

Light duty detergents are used for hand or machine washing lightly soiled items and delicate fabrics.

Laundry aids contribute to the effectiveness of laundry detergents and provide special functions.

Bleaches (chlorine and oxygen) whiten and brighten fabrics and help remove stubborn stains. They convert soils into colorless, soluble particles that can be removed by detergents and carried away in the wash water. Liquid chlorine bleach (usually a sodium hypochlorite solution) can also disinfect and deodorize fabrics. Oxygen (color-safe) bleach is more gentle and works safely on almost all washable fabrics.

Bluings contain a blue dye or pigment taken up by fabrics in the wash or rinse. Bluing absorbs the yellow part of the light spectrum, counteracting the natural yellowing of many fabrics.

Boosters enhance the soil and stain removal, brightening, buffering and water softening performance of detergents. They are used in the wash in addition to the detergent.

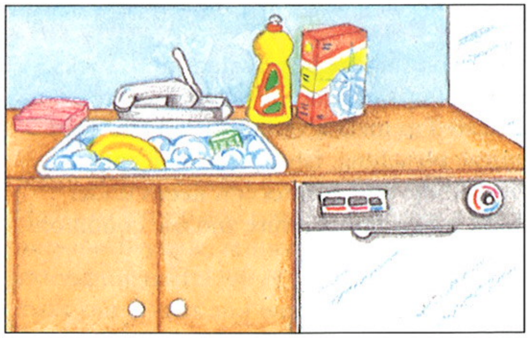
Enzyme presoaks are used for soaking items before washing to remove difficult stains and soils. When added to the wash water, they increase cleaning power.

Fabric softeners, added to the final rinse or dryer, make fabrics softer and fluffier; decrease static cling, wrinkling and drying time; impart a pleasing fragrance and make ironing easier.

Prewash soil and stain removers are used to pretreat heavily soiled and stained garments, especially those made from synthetic fibers.

Starches, fabric finishes and sizings, used in the final rinse or after drying, give body to fabrics, make them more soil-resistant and make ironing easier.

Water softeners, added to the wash or rinse, inactivate hard water minerals. Since detergents are more effective in soft water, these products increase cleaning power.



Dishwashing Products

include detergents for hand and machine dishwashing as well as some specialty products. They are available as liquids, gels, powders and solids.

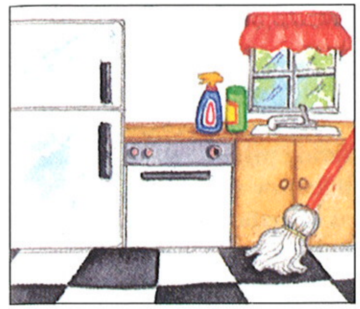
Hand dishwashing detergents remove food soils, hold soil in suspension and provide long-lasting suds that indicate how much cleaning power is left in the wash water.

Automatic dishwasher detergents, in addition to removing food soils and holding them in suspension, tie up hardness minerals, emulsify grease and oil, suppress foam caused by protein soil and help water sheet off dish surfaces. They produce little or no suds that would interfere with the washing action of the machine.

Rinse agents are used in addition to the automatic dishwasher detergent to lower surface tension, thus improving draining of the water from dishes and utensils. Better draining minimizes spotting and filming and enhances drying.

Film removers remove build-up of hard water film and cloudiness from dishes and the interior of the dishwasher. They are used instead of an automatic dishwasher detergent in a separate cycle or together with the detergent.

Lime and rust removers remove deposits of lime and/or rust from the interior of the dishwasher. They are used when no dishes or other dishwasher products are present.



Household Cleaners are available as liquids, gels, powders, solids, sheets and pads for use on painted, plastic, metal, porcelain, glass and other surfaces, and on washable floor coverings. Because no single product can provide optimum performance on all surfaces and soils, a broad range of products has been formulated to clean efficiently and easily. While all-purpose cleaners are intended for more general use, others work best under highly specialized conditions.

All-purpose cleaners penetrate and loosen soil, soften water and prevent soil from redepositing on the cleaned surface. Some also disinfect.

Abrasive cleansers remove heavy accumulations of soil often found in small areas. The abrasive action is provided by small mineral or metal particles, fine steel wool, copper or nylon particles. Some also disinfect.

Specialty cleaners are designed for the soil conditions found on specific surfaces, such as glass, tile, metal, ovens, carpets and upholstery, toilet bowls and in drains.

Glass cleaners loosen and dissolve oily soils found on glass, and dry quickly without streaking.

Glass and multi-surface cleaners remove soils from a variety of smooth surfaces. They shine surfaces without streaking.

Tub, tile and sink cleaners remove normal soils found on bathroom surfaces as well as hard water deposits, soap scum, rust stains, and/or mildew and mold. Some also treat surfaces to retard soiling; some also disinfect.

Metal cleaners remove soils and polish metalware. Tarnish, the oxidation of metal, is the principal soil found on metalware. Some products also protect cleaned metalware against rapid retarnishing.

Oven cleaners remove burned-on grease and other food soils from oven walls. These cleaners are thick so the product will cling to vertical oven surfaces.

Rug shampoos and upholstery cleaners dissolve oily and greasy soils and hold them in suspension for removal. Some also treat surfaces to repel soil.

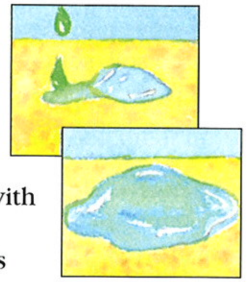
Toilet bowl cleaners prevent or remove stains caused by hard water and rust deposits, and maintain a clean and pleasant-smelling bowl. Some products also disinfect.

Drain openers unclog kitchen and bathroom drains. They work by producing heat to melt fats, breaking them down into simpler substances that can be rinsed away, or by oxidizing hair and other materials. Some use bacteria to prevent grease build-up which leads to drain clogging.

INGREDIENTS

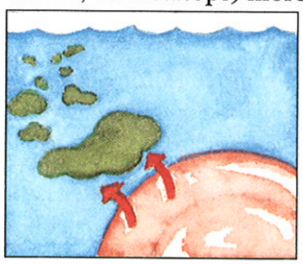
Surfactants and builders are the major components of cleaning products. Other ingredients are added to provide a variety of functions, such as increasing cleaning performance for specific soils/surfaces, ensuring product stability and supplying a unique identity to a product. Let's examine how surfactants and builders work and then review other commonly used ingredients.

Surfactants



Lower surface tension

Surfactants, also called surface active agents, are organic chemicals that change the properties of water (see page 10). By lowering the surface tension of water, surfactants enable the cleaning solution to wet a surface (e.g., clothes, dishes, countertops) more quickly, so soil can be readily loosened and removed (usually with the aid of mechanical action). Surfactants also emulsify oily soils and keep them dispersed and suspended so they do not settle back on the surface. To accomplish their intended jobs effectively, many cleaning products include two or more surfactants.



Emulsify, disperse, suspend soils

Surfactants are generally classified by their ionic (electrical charge) properties in water.

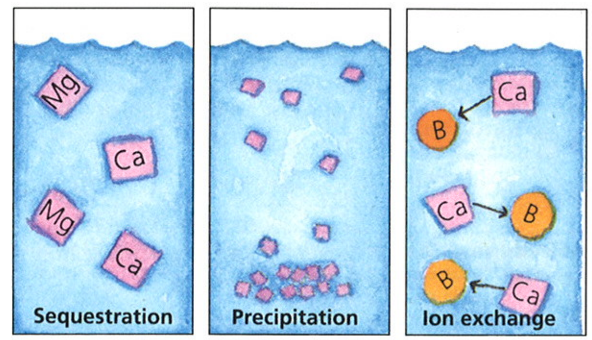
Anionic surfactants are used in laundry and hand dishwashing detergents; household cleaners; and personal cleansing products. They ionize (are converted to electrically charged particles) in solution, carry a negative charge, have excellent cleaning properties and generally are high sudsing. Linear alkylbenzene sulfonate, alcohol ethoxysulfates, alkyl sulfates and soap are the most common anionic surfactants.

Nonionic surfactants are low sudsing and are typically used in laundry and automatic dishwasher detergents and rinse aids. Because they do not ionize in solution and thus have no electrical charge, they are resistant to water hardness and clean well on most soils. The most widely used are alcohol ethoxylates.

Cationic surfactants are used in fabric softeners and in fabric-softening laundry detergents. Other cationics are the disinfecting/sanitizing ingredient in some household cleaners. They ionize in solution and have a positive charge. Quaternary ammonium compounds are the principal cationics.

Amphoteric surfactants are used in personal cleansing and household cleaning products for their mildness, sudsing and stability. They have the ability to be anionic (negatively charged), cationic (positively charged) or nonionic (no charge) in solution, depending on the pH (acidity or alkalinity) of the water. Imidazolines and betaines are the major amphoterics.

Builders

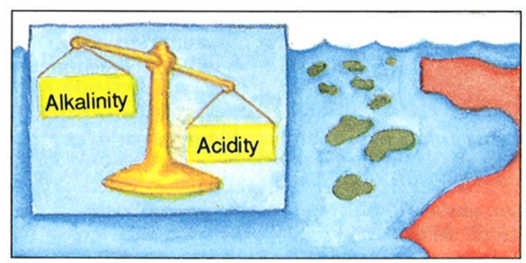


Sequestration

Precipitation

Ion exchange

Builders enhance or maintain the cleaning efficiency of the surfactant. The primary function of builders is to reduce water hardness. This is done either by *sequestration* or *chelation* (holding hardness minerals in solution), by *precipitation* (forming an insoluble substance), or by *ion exchange* (trading electrically charged particles). Complex phosphates and sodium citrate are common sequestering builders. Sodium carbonate and sodium silicate are precipitating builders. Sodium aluminosilicate (zeolite) is an ion exchange builder.



Builders can also supply and maintain alkalinity, which assists cleaning, especially of acid soils; help keep removed soil from redepositing during washing; and emulsify oily and greasy soils.

Ingredient Key

The following key indicates the product category in which an ingredient may be used. The key letters appear below each ingredient.

PC Personal Cleansing   L Laundry   DW Dishwashing   HC Household Cleaners

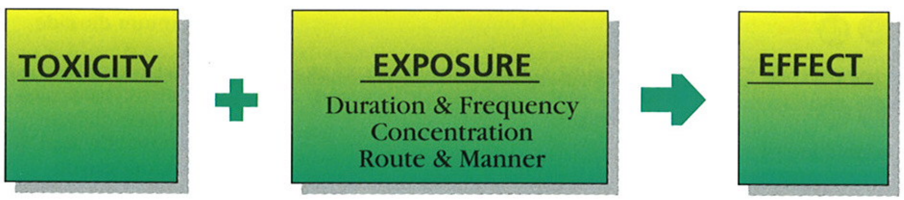
Ingredient	Primary Functions / *Comments*	Typical Examples
Abrasives PC DW HC	Supply smoothing, scrubbing and/or polishing action	Calcite Feldspar Quartz Sand
Acids HC	Neutralize or adjust alkalinity of other ingredients *Some specialty cleaners need extra acidity to remove mineral build-up.*	Acetic acid Citric acid Hydrochloric acid Phosphoric acid Sulfuric acid
Alkalis PC L DW HC	• Neutralize or adjust acidity of other ingredients • Make surfactants and builders more efficient • Increase alkalinity *Alkalinity is useful in removing acidic, fatty and oily soils. Therefore, detergents are more effective when they are alkaline.*	Ammonium hydroxide Ethanolamines Sodium carbonate Sodium hydroxide Sodium silicate
Antimicrobial agents PC L DW HC	Kill or inhibit growth of microorganisms that cause diseases and/or odor	Pine oil Quaternary ammonium compounds Sodium hypochlorite Triclocarban Triclosan
Antiredeposition agents L DW	Prevent soil from resettling after removal during washing	Carboxymethyl cellulose Polycarboxylates Polyethylene glycol Sodium silicate
Bleaches L DW HC	Help whiten, brighten and remove stains	
chlorine bleach	*Also disinfects.*	Sodium hypochlorite
oxygen bleach	*In some products, may be combined with bleach activator for better performance in lower water temperatures.*	Sodium perborate Sodium percarbonate
Colorants PC L DW HC	• Provide special identity to product • Provide bluing action	Pigments or dyes
Corrosion inhibitors L DW	Protect metal machine parts and finishes, china patterns and metal utensils	Sodium silicate

Ingredient	Primary Functions / *Comments*	Typical Examples
Enzymes L DW HC	• Proteins classified by the type of soil they break down to simpler forms for removal by detergent • Cellulase reduces pilling and greying of fabrics containing cotton and helps remove particulate soils	Amylase (starch soils) Lipase (fatty and oily soils) Protease (protein soils) Cellulase
Fabric softening agents L	Impart softness and control static electricity in fabrics	Quaternary ammonium compounds
Fluorescent whitening agents L	Attach to fabrics to create a whitening or brightening effect when exposed to daylight *Also called optical brighteners.*	Colorless fluorescing compounds
Fragrances PC L DW HC	• Mask base odor of ingredients and package • Cover odors of soil • Provide special identity to product • Provide pleasant odor to clothes and rooms	Fragrance blends
Hydrotropes L DW HC	• Prevent liquid products from separating into layers • Ensure product homogeneity	Cumene sulfonates Ethyl alcohol Toluene sulfonates Xylene sulfonates
Opacifiers PC L DW HC	• Reduce transparency or make product opaque • Provide a special effect	Polymers Titanium dioxide
Preservatives PC L DW HC	Protect against natural effects of product aging, e.g., decay, discoloration, oxidation and bacterial attack	Butylated hydroxytoluene Ethylene diamine tetraacetic acid Glutaraldehyde
Processing aids PC L DW HC	• Provide important physical characteristics, e.g., proper pour or flow, viscosity, solubility, stability and uniform density • Assist in manufacturing	Clays Polymers Sodium silicate Sodium sulfate Solvents
Solvents L DW HC	• Prevent separation or deterioration of ingredients in liquid products • Dissolve organic soils • Clean without leaving residue *Solvents used in cleaning products are water soluble.*	Ethanol Isopropanol Propylene glycol
Suds control agents	Ensure optimum sudsing (foaming) level needed for a cleaning job	
suds stabilizers DW HC	Maintain high sudsing where suds level is an important indicator of cleaning power	Alkanolamides Alkylamine oxides
suds suppressors L DW HC	Control sudsing where suds would interfere with cleaning action	Alkyl phosphates Silicones Soap

SAFETY

As consumer needs and lifestyles change, and as new manufacturing processes become available, the soap and detergent industry responds with new products. A commitment to safety is a top priority from the time a company begins working on a new product and continues as long as the product is in the marketplace. Companies evaluate the safety of existing cleaning products by talking with consumers, reviewing scientific developments and monitoring product use data that may affect the safety assessment process.

To determine the safety of a cleaning product ingredient, industry scientists evaluate the toxicity of the ingredient. *Toxicity* is generally defined as any harmful effect of a chemical on a living organism, i.e., a human, an animal, a plant or a microorganism. Since all chemicals, including water (H_2O), are toxic under certain conditions of *exposure*, scientists must consider a number of factors affecting exposure. These include the duration and frequency of exposure to the ingredient; the concentration of the ingredient at the time of exposure; and the route and manner in which the exposure occurs, e.g., eye, skin or ingestion. This information is essential whether assessing the *effect* on humans, animals, plants or microorganisms.



Because human safety and environmental evaluations consider different types of exposures, they are evaluated by different procedures. The principal steps in the assessment process are, however, the same. They involve:

1. assembling existing data on toxicity and exposure;
2. determining where new information is needed and, if necessary, carrying out appropriate studies; and
3. determining whether predicted exposure levels are below levels that cause significant toxic effects.

This safety evaluation process enables scientists to predict the potential risk, if any, associated with the use of the ingredient or product, and determine if it is safe for consumers and the environment.

HUMAN SAFETY

Medical science has long confirmed the important relationship between cleanliness and health. The regular use of cleaning products is fundamental to the health of our society and the well-being of its people.

Because cleaning products are part of our everyday lives, it is essential that they not present a significant risk to health. In considering the human safety of an individual ingredient or product, toxicologists (scientists who assess the safety of a chemical) are concerned with the effects from two types of exposures: intended and unintended. *Intended* exposures occur with use of a cleaning product according to the manufacturer's directions. *Unintended* exposures can result from misuse, through improper storage or by accidental contact, such as when a liquid detergent is splashed in the eye.

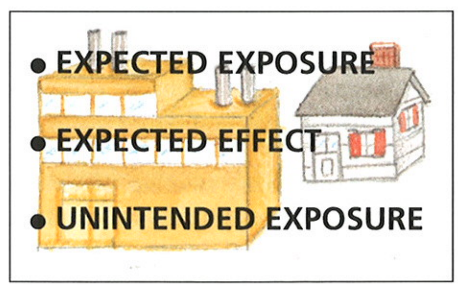

INTENDED


UNINTENDED

Hazards from these types of exposures are evaluated from information obtained through acute (short-term) and chronic (long-term) tests and through a review of existing data. Expected exposure routes are considered as part of this evaluation.

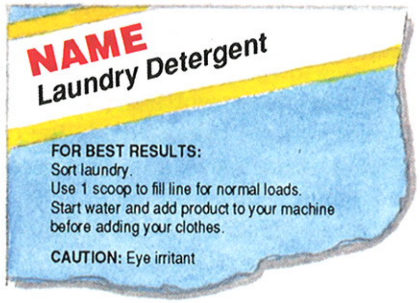
Human safety evaluations begin with the specific ingredients and then move on to the whole product. The effects for all ingredients are considered as the product is formulated.

Toxicologists compare the *expected exposure* to the *expected effect* during both product manufacture and use. How will workers be exposed in the plant? What is the intended use of the product? Is it to be diluted? Undiluted? Used daily in the home? Weekly in the workplace? Toxicologists also consider the expected effect of an *unintended exposure*. What is the potential hazard, for example, if a child drinks a product directly from the bottle?



If this human safety evaluation indicates an unacceptable risk, it may be possible to make the risk smaller by changing the manufacturing process; reformulating to reduce or eliminate an ingredient contributing to the toxic effect; or using labeling or a child-resistant closure. If the risk cannot be reduced, the product will not be marketed.

Even though manufacturers formulate cleaning products to ensure that they are safe or have very low risk, human health effects can still result from unintended exposure. To warn consumers about a specific hazard, household cleaning products carry cautionary labeling whenever necessary. For consumers, this is one of the most important features of the label.



Federal regulations govern how precautionary statements related to human safety are used on household cleaning product labels. The regulations require that statements follow a standard format. There is first a "signal word," followed by a short description of the potential hazard. The following chart shows the signal words - CAUTION or WARNING and DANGER - and what they mean:

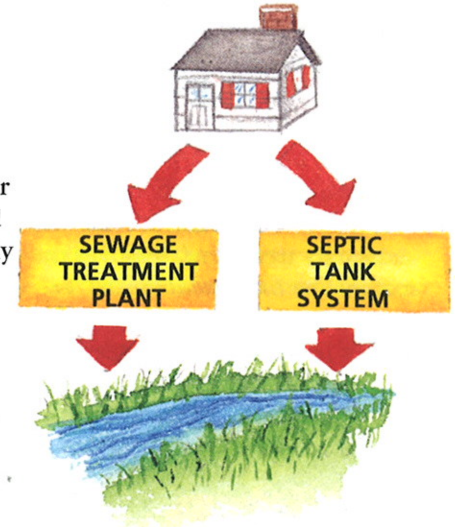
CAUTION or WARNING (indicates a mild hazard)	• Signal word usually found on cleaning products. • Product not likely to cause permanent damage as a result of accidental exposure if appropriate first aid is given. • Many laundry and automatic dishwasher detergents, disinfectants and all-purpose cleaners fall into this category.
DANGER (indicates that greater precaution should be taken)	• Signal word most often found on specialty products intended for tough jobs, such as oven cleaners or drain openers. • Accidental exposure of the eye or skin to the undiluted product or swallowing the undiluted product could cause long-term damage. • May be found on products which could ignite if exposed to open flame.

POISON, which rarely appears on household cleaning products, is the strongest indication of hazard and means that accidental exposure could cause severe medical effects. The term may be found on household lye and on some car care products, such as antifreeze.

Along with the safety evaluation process and cautionary labeling, an extensive consumer education program on the proper use, storage and disposal of cleaning products supports the human safety efforts of the soap and detergent industry. In addition, the industry works closely with poison control centers to assure that, should an accidental exposure occur, treatment information is available to health care providers. Together, these activities enable consumers to use cleaning products with confidence in both their safety and performance.

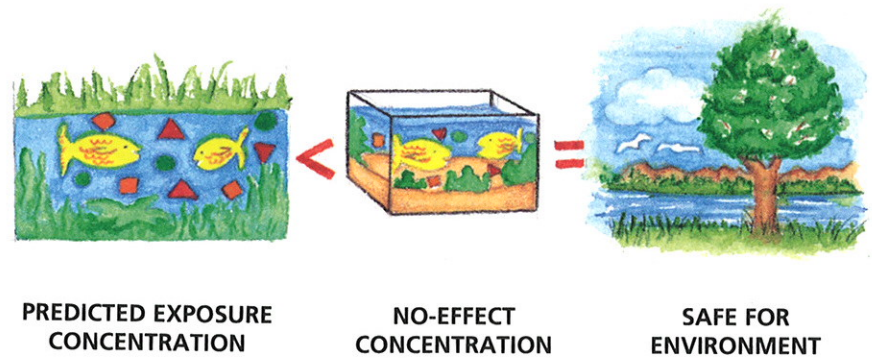
ENVIRONMENTAL SAFETY

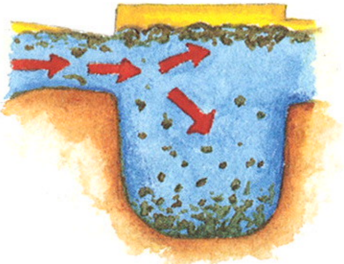
Most household cleaning products are formulated to be used with water and "go down the drain" into wastewater treatment systems (municipal sewage treatment plants or septic tank systems).



To assure that products are safe for the environment, manufacturers evaluate the impacts of product ingredients in wastewater treatment systems, streams, rivers, lakes and estuaries. Scientific principles that are widely recognized by the technical and regulatory communities are used to assess the risk to the environment of these impacts.

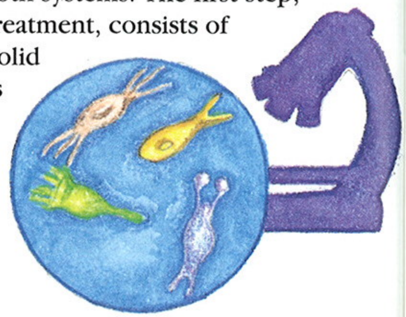
Environmental risk assessment considers the exposure concentrations and effects of individual ingredients. Two sets of information are used in these assessments. One set enables industry scientists to predict the concentration of the ingredient from all sources, including cleaning products, at various locations in the environment (the *predicted exposure concentration*). The other set is used to find the highest concentration of the ingredient at which no harm will occur to animals, plants or microorganisms living in the environment (the *no-effect concentration*). Comparing the predicted exposure concentration and the no-effect concentration enables scientists to determine whether the use of an ingredient is *safe for the environment*. The planned use of a cleaning product ingredient is acceptable if the predicted exposure concentration is lower than the concentration that would harm animals, plants or microorganisms.





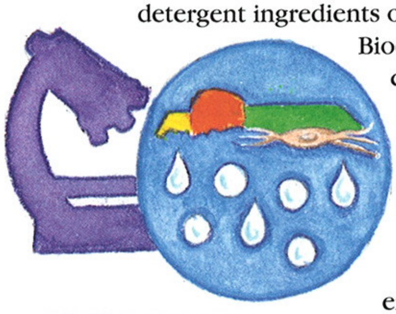
PHYSICAL

This information applies to ingredients processed through household septic tank systems as well as municipal treatment plants. Two basic steps occur in the treatment of wastewater in both systems. The first step, called primary treatment, consists of the removal of solid material, such as grit or grease, from the wastewater by *physical* means, i.e., settling and flotation in tanks. The second step, called secondary treatment, removes the dissolved material by *biological* means, i.e., consumption by microorganisms.



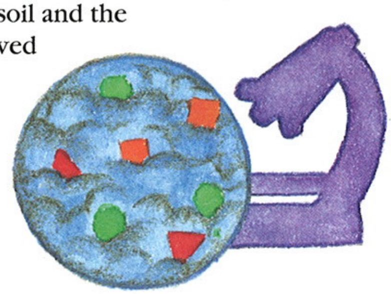
BIOLOGICAL

It is in the secondary treatment stage where the most important process in reducing the exposure concentration of detergent ingredients occurs. This is called *biodegradation*.



BIODEGRADATION

Biodegradation describes how organic (carbon-containing) detergent ingredients, like surfactants, enzymes and fragrances, are broken down into carbon dioxide, water and minerals by the action of microorganisms such as bacteria. At this stage, biodegradation reduces the amount of detergent ingredients discharged into the environment to levels that do not present a risk to fish or other aquatic life. Any small amounts of chemicals which are not biodegraded or removed during sewage treatment are diluted in surface waters, soil and the ocean. They continue to biodegrade or be removed from water by attaching to solids, a process known as *adsorption*.



ADSORPTION

Some inorganic (not carbon-containing) detergent ingredients, such as phosphates, zeolites and some dyes, also attach to solids, and are further treated during processing of the biosolids (sludge) produced in primary and secondary treatment. Biosolids are often used as fertilizers and soil conditioners.

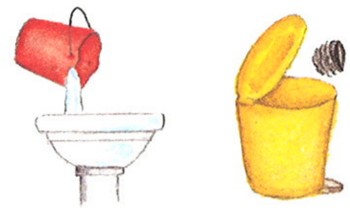
Because of modern treatment methods, only an insignificant amount of the ingredients used to clean clothes, dishes, home and workplace surfaces actually reaches the environment. And that amount is at such levels as to not cause any adverse effects.

Improving Environmental Quality

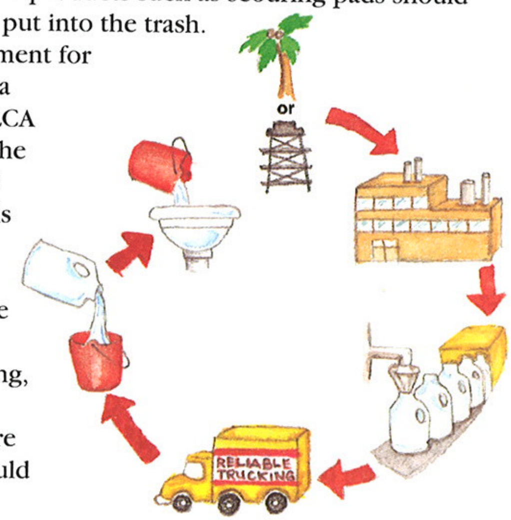
The soap and detergent industry is committed to understanding the impact of its products and packages on the environment. With this understanding comes the ability to reduce their impact and improve their environmental quality.

Manufacturers of cleaning products have been leaders in reducing packaging waste and encouraging sound waste disposal practices. Advances in technology have resulted in products that are more concentrated, products that combine two functions in one, products with refill packages and packages that use recycled materials. Concentrated products need less energy to manufacture and transport, and require less packaging. Multifunctional products eliminate the need for separate packages. Refill packages allow consumers to reuse primary packages many times, decreasing the amount of packaging used and the volume of trash generated. Plastic and paperboard that would otherwise be thrown away become usable materials through recycling.

Through education and community programs, the soap and detergent industry helps consumers learn how to reduce waste and how best to dispose of it. Consumers are reminded that the environmentally wise way of handling any household cleaning product is to buy only the amount that can be used; to use it all up or give it away; and, if it must be disposed, to dispose of it properly. As a rule of thumb, products designed for use with water should be disposed of by pouring down the drain; solid products such as scouring pads should be put into the trash.



A promising method under development for improving the environmental quality of a product is life cycle assessment (LCA). LCA describes a "cradle-to-grave" look at all the environmental impacts of a product and its package, from acquiring raw materials through manufacture and distribution to consumer use and disposal. One advantage of LCA is that it can determine whether reducing an environmental impact in one area, such as manufacturing, shifts the impact to another, such as disposal. LCA also helps to identify where environmental improvement efforts should be focused.



Sound scientific information provides the foundation for the soap and detergent industry's commitment to safety. The industry maintains this commitment without compromising product performance, convenience or cost-effectiveness.

MANUFACTURING

Soap and detergent manufacturing consists of a broad range of processing and packaging operations. The size and complexity of these operations vary from small plants employing a few people to those with several hundred workers. Products range from large-volume types like laundry detergents that are used on a regular basis to lower-volume specialties for less frequent cleaning needs.

Cleaning products come in three principal forms: bars, powders and liquids. Some liquid products are so viscous that they are gels. The first step in manufacturing all three forms is the selection of raw materials. Raw materials are chosen according to many criteria, including their human and environmental safety, cost, compatibility with other ingredients, and the form and performance characteristics of the finished product. While actual production processes may vary from manufacturer to manufacturer, there are steps which are common to all products of a similar form.

Let's start by looking at bar soap manufacturing and then we'll review the processes used to make powder and liquid detergents.

BAR SOAPS

FATS

OILS

Traditional bar soaps are made from fats and oils or their fatty acids which are reacted with inorganic water-soluble bases. The main sources of fats are beef and mutton tallow, while palm, coconut and palm kernel oils are the principal oils used in soapmaking.

The raw materials may be pretreated to remove impurities and to achieve the color, odor and performance features desired in the finished bar.

The chemical processes for making soap, i.e., saponification of fats and oils and neutralization of fatty acids, were described in the Chemistry chapter (see page 12).

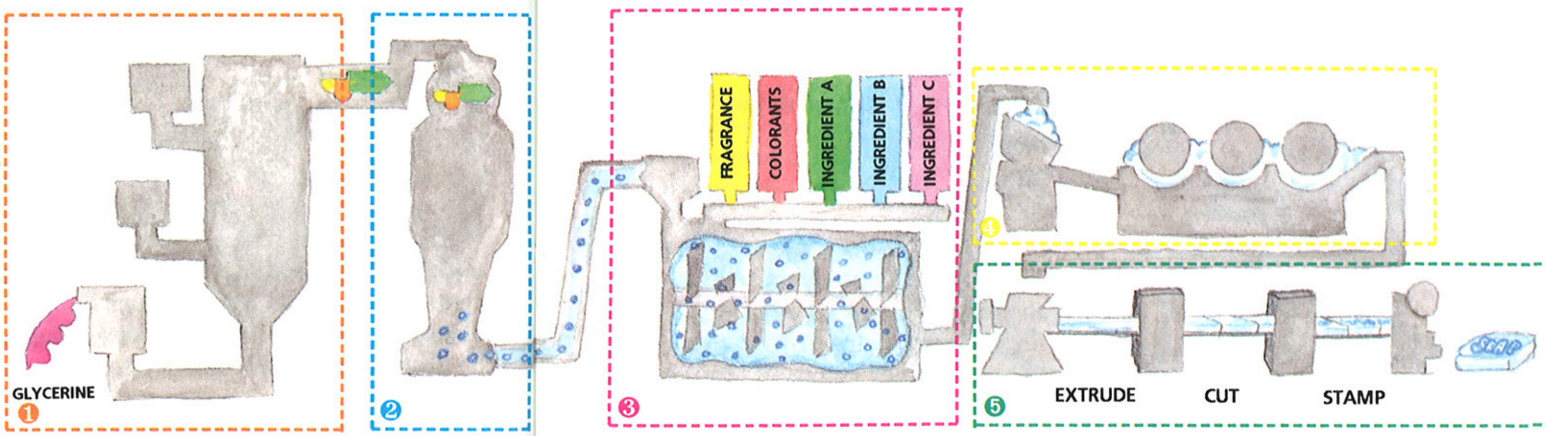
Soap was made by the batch kettle boiling method until shortly after World War II, when continuous processes were developed. Continuous processes are preferred today because of their flexibility, speed and economics.

Both continuous and batch processes produce soap in liquid form, called neat soap, and a valuable by-product, glycerine. ❶ The glycerine is recovered by chemical treatment, followed by evaporation and refining. Refined glycerine is an important industrial material used in foods, cosmetics, drugs and many other products.

The next processing step after saponification or neutralization is drying. Vacuum spray drying is used to convert the neat soap into dry soap pellets. ❷ The moisture content of the pellets will vary depending on the desired properties of the soap bar.

In the final processing step, the dry soap pellets pass through a bar soap finishing line. The first unit in the line is a mixer, called an amalgamator, in which the soap pellets are blended together with fragrance, colorants and all other ingredients. ❸ The mixture is then homogenized and refined through rolling mills and refining plodders to achieve thorough blending and a uniform texture. ❹ Finally, the mixture is continuously extruded from the plodder, cut into bar-size units and stamped into its final shape in a soap press. ❺

Some of today's bar soaps are called "combo bars," because they get their cleansing action from a combination of soap and synthetic surfactants. Others, called "syndet bars," feature surfactants as the main cleansing ingredients. The processing methods for manufacturing the synthetic base materials for these bars are very different from those used in traditional soapmaking. However, with some minor modifications, the finishing line equipment is the same.



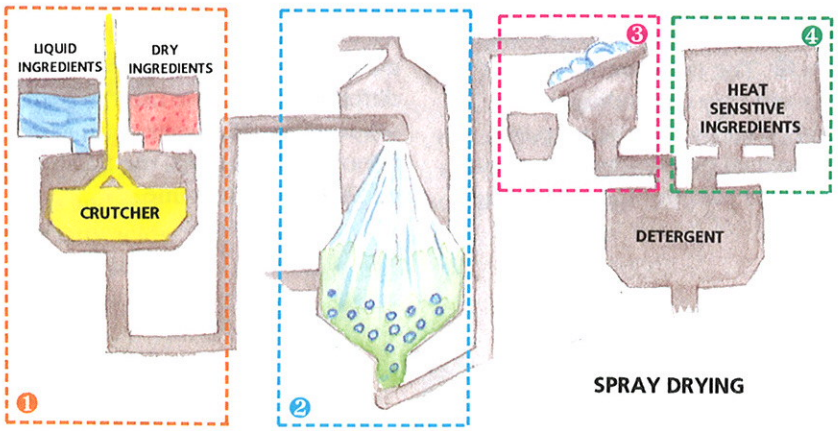
POWDER DETERGENTS

Powder detergents are produced by spray drying, agglomeration, dry mixing or combinations of these methods.

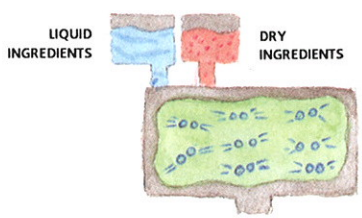
In the *spray drying* process, dry and liquid ingredients are first combined into a slurry, or thick suspension, in a tank called a crutcher. ❶ The slurry is heated and then pumped to the top of a tower where it is sprayed through nozzles under high pressure to produce small droplets. The droplets fall through a current of hot air, forming hollow granules as they dry. ❷ The dried granules are collected from the bottom of the spray tower where they are screened to achieve a relatively uniform size. ❸

After the granules have been cooled, heat sensitive ingredients that are not compatible with the spray drying temperatures (such as bleach, enzymes and fragrance) are added. ❹ Traditional spray drying produces relatively low density powders.

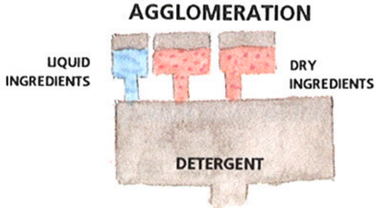
New technology has enabled the soap and detergent industry to reduce the air inside the granules during spray drying to achieve higher densities. The higher density powders can be packed in much smaller packages than were needed previously.



SPRAY DRYING



AGGLOMERATION



DRY MIXING

Agglomeration, which leads to higher density powders, consists of blending dry raw materials with liquid ingredients. Helped by the presence of a liquid binder, rolling or shear mixing causes the ingredients to collide and adhere to each other, forming larger particles.

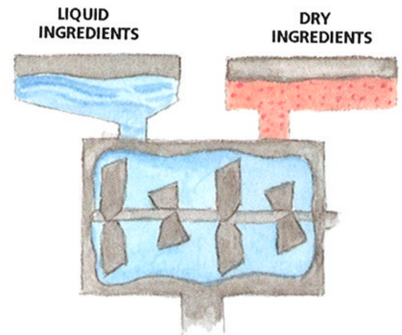
Dry mixing or dry blending is used to blend dry raw materials. Small quantities of liquids may also be added.

LIQUID DETERGENTS

Both batch and continuous *blending processes* are used to manufacture liquid and gel cleaning products. Stabilizers may be added during manufacturing to ensure the uniformity and stability of the finished product.

In a typical continuous process, dry and liquid ingredients are added and blended to a uniform mixture using in-line or static mixers.

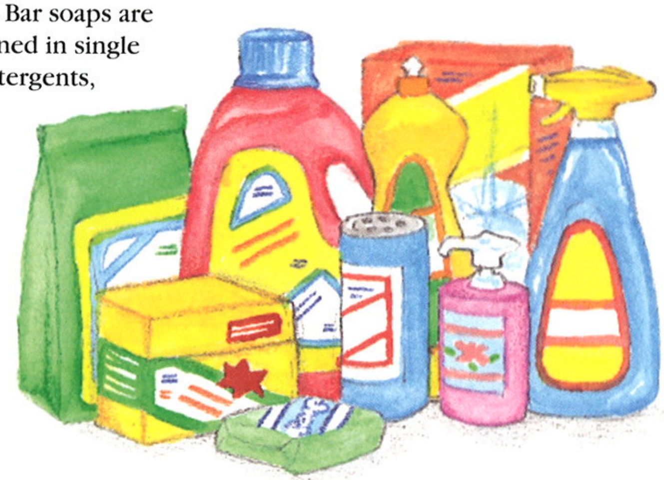
Recently, more concentrated liquid products have been introduced. One method of producing these products uses new high-energy mixing processes in combination with stabilizing agents.



BLENDING PROCESS

PACKAGING

The final step in the manufacture of soaps and detergents is packaging. Bar soaps are either wrapped or cartoned in single packs or multipacks. Detergents, including household cleaners, are packaged in cartons, bottles, pouches, bags or cans. The selection of packaging materials and containers involves considerations of product compatibility and stability, cost, package safety, solid waste impact, shelf appeal and ease of use.



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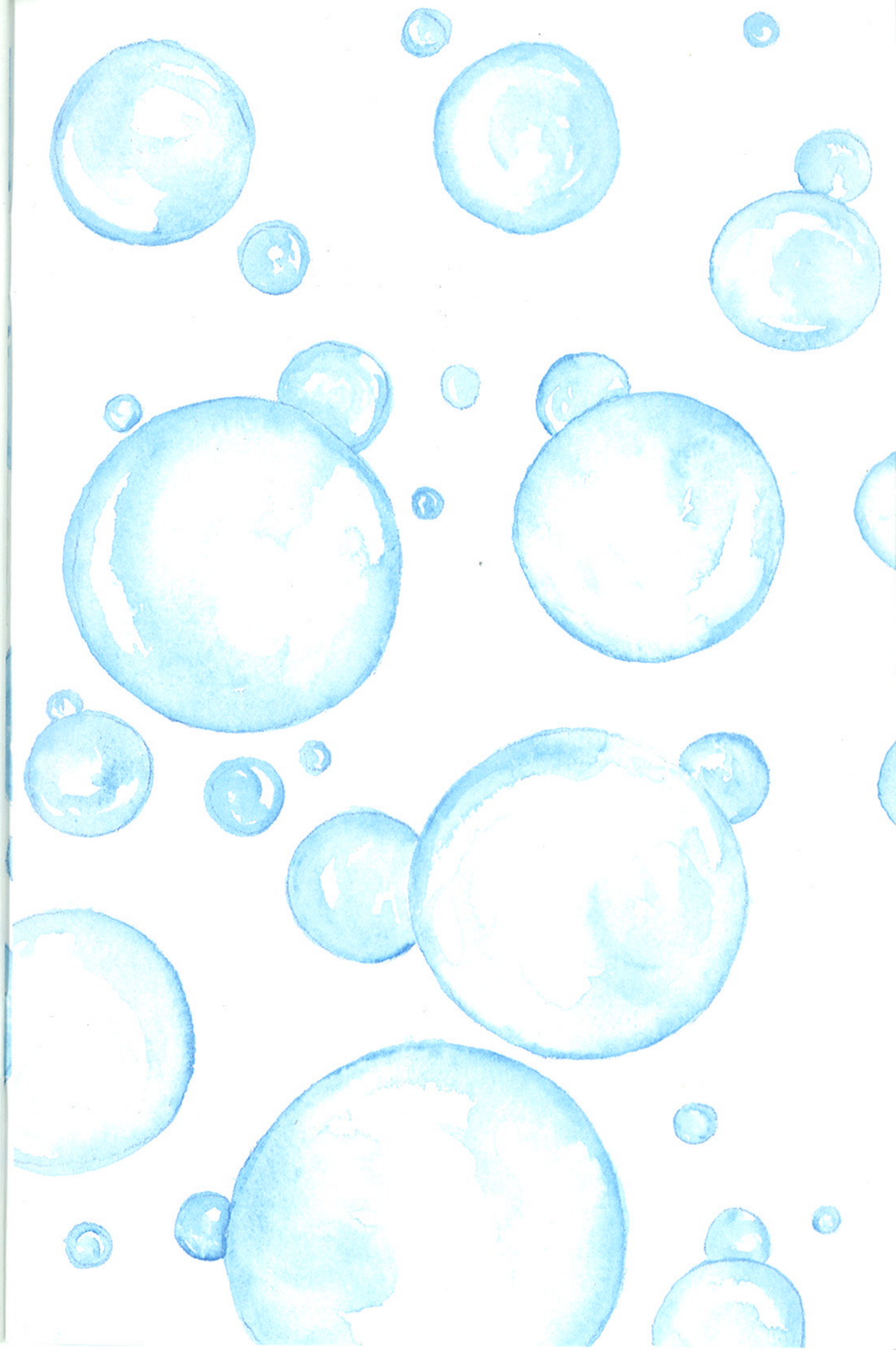

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