LAUNDRY DETERGENT INGREDIENTS

INFORMATION SHEET

An initiative of

ACCORD

Advocate for the Consumer, Cosmetic,
Hygiene and Specialty Products Industry

SURFACTANTS

What do they do?

Surfactants are the active cleaning agents that perform three major roles:

- penetrating and wetting fabric
- loosening soils (assisted by the mechanical action of the washing machine)
- emulsifying soils and keeping them suspended in the wash solution

How do they work?

Surfactants have two domains within the one molecule: a polar, or hydrophilic ("water-loving") head group, and a non-polar, "fatty" or hydrophobic ("water-hating") tail. The basic principle at work is that polar substances interact well with other polar substances, and non-polar substances interact well with other non-polar substances.

Penetrating and wetting fabric (See **Figure 1***)*

Water has a high surface tension, that is, it resists distortion at its surfaces (water-air, water-oil, water-solid).

When a detergent is added, surfactant molecules accumulate near the surface of the water because the non-polar (hydrophobic) tail of the surfactant wants to get away from the water. Since the surfactant disrupts the bonding of water molecules, the water distorts and more surfactant molecules fit near the surface. Because the water now has reduced surface tension it can permeate previously non-wettable surfaces, such as fabrics.

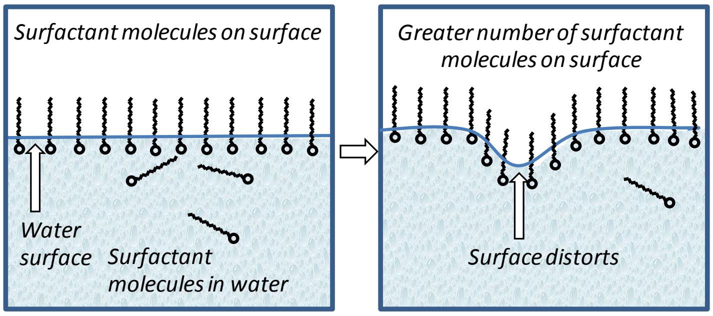

Figure 1: Surfactants lowering water surface tension

Loosening and emulsifying soils (See **Figure 2***)*

Oil and water do not usually mix. Oil is a non-polar substance and water is a polar substance. However, in the presence of a high enough concentration of surfactant molecules, oil can effectively be emulsified (suspended evenly) in water.

So, the polar (hydrophilic) part of the surfactant molecule is attracted to water, and the non-polar (hydrophobic) part is attracted to the oil. Surfactant molecules accumulate around the oil, and once there are enough molecules a spherical micelle forms. The portion of oil in the micelle is effectively suspended in water. The process can repeat as long as there are available surfactant molecules to interact with the oil deposit.

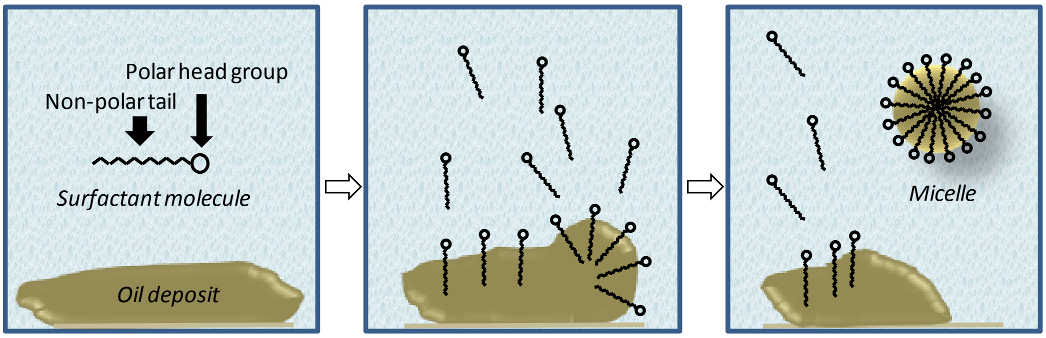

Figure 2: Cleaning action of surfactants

Examples

Surfactants are either derived from petrochemicals, vegetable oils or animal fats, or combinations of these sources. There are three main types of surfactants used in laundry detergents: *anionic*, *non-ionic* and *cationic*.

Anionic surfactants have a negatively charged polar head group. The negative charge of this head group is usually balanced by the sodium cation (Na^+), arising from the manufacturing procedure. However, the negatively charged head group can also interact with other cations (positively charged particles) in the water such as calcium (Ca^{2+}) and magnesium (Mg^{2+}), which effectively deactivates the surfactant molecule. Hard water contains high levels of these cations.

Anionic surfactants are the most common surfactants in laundry detergents. They are effective at emulsifying oil and clay soils, fabric softener residue, and are high sudsing. Some examples are *linear alkyl sulfonates (LAS), alkyl aryl sulfonates* such as *dodecylbenzene sulfonate* (DDBS), and *alcohol ether sulfates* such as *sodium lauryl ether sulfate* (SLES).

Non-ionic surfactants have a neutral (non-polar) head group, and so are not deactivated by ions (charged particles) in hard water. They are often used in low-sudsing detergents, and can be used in conjunction with anionic surfactants. Some examples are *alcohol ethoxylates*.

Cationic surfactants have a positively charged polar head group. These surfactants are generally not the primary cleaning agent, but are used in fabric softeners and as mild antibacterial agents. Some examples are *long-chain quaternary ammonium compounds*.

It is common for more than one surfactant to be used in a laundry detergent. This is because the actions of the surfactants can reinforce each other, giving rise to a greater cleaning ability from the combination than would be expected from a mixture of the two working independently. However, anionic and cationic surfactants are incompatible due to their opposite head-group charges.

BUILDERS

What do they do?

Builders enhance the action of surfactants. For example, various types of builders are used to soften water, to help disperse soils and prevent their redeposition out of solution, and to provide alkalinity, which assists the dissolving of oil-based soils.

How do they work?

Water naturally contains positively charged metal ions (cations). The concentrations of two of these cations, calcium (Ca^{2+}) and magnesium (Mg^{2+}), determine how hard the water is. Ca^{2+} and Mg^{2+} can react with anionic surfactants, causing them to work less efficiently or to precipitate onto fabrics or the inside of the washing machine. Ca^{2+} can also hinder stain removal by binding soils to the fabric. Thus hard water hinders the action of surfactant.

Builders soften water by complexing with Ca^{2+} and Mg^{2+} (See **Figure 3**). When these cations are complexed with the builder, they do not interfere with the action of surfactants.

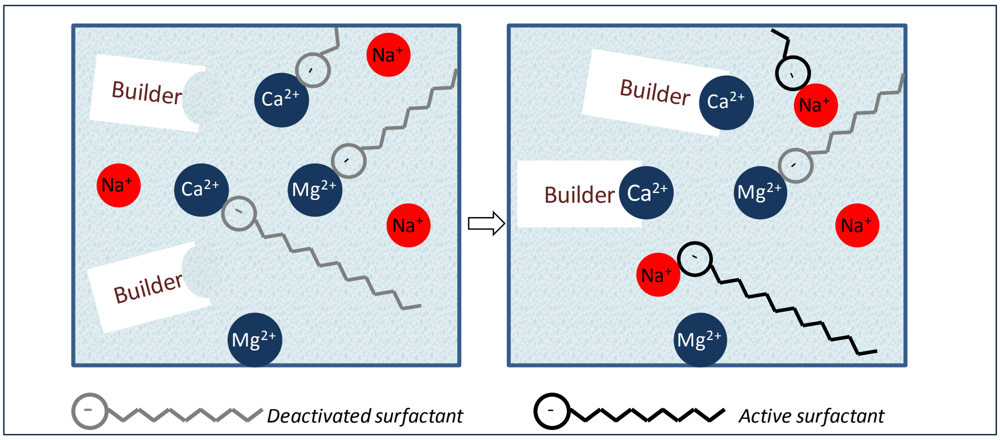

Figure 3: Builders binding to calcium and magnesium ions in water

Examples

There are three types of water-softening builders:

Sequestrating: These are water-soluble builders that form soluble complexes with Ca^{2+} or Mg^{2+}. The most common example is *sodium tripolyphosphate* (STPP); other phosphates include *tetrasodium pyrophosphate*, *hexametaphosphate*, and *tetrapotassium pyrophosphate*. Some non-phosphate examples are *citrates*, *tartrates*, *succinates*, *gluconates*, *polycarboxylates*, *ethylenediamine tetraacetic acid* (EDTA), *diethylene triamine pentaacetic acid* (DTPA), *hydroxyethylene diamine triacetic acid* (HEDTA), *dihydroxyethyl glycine* (DEG), and *triethanolamine*.

Precipitating: These builders are water-soluble until they form a complex with Ca^{2+} or Mg^{2+} and precipitate (fall out) of solution. The main example is *sodium carbonate*.

Ion exchange: These builders are insoluble in water and form insoluble complexes with Ca^{2+} or Mg^{2+}. Examples are zeolites and sodium disilicate (SKS-6).

ALKALIS

What do they do?

Alkalis raise the pH of the laundry wash water, which assists in breaking up oily and acidic soil components. However since high pH can also damage fabrics the pH of laundry detergents is carefully controlled.

How do they work?

Liquid water in its neutral state (pH 7) is primarily composed of water as molecules (see **Figure 4**). These contain one atom of oxygen bound to two atoms of hydrogen. But there is also a very small number (1 x 10^{-14}) of water molecules which have broken up into H^+ and OH^- ions (charged particles).

$$H_2O \rightleftharpoons H^+ + OH^-$$

water molecule *ions*

Figure 4: Equilibrium equation describing the natural dissociation of water molecules into ions

If a substance is added to the water to make the concentration of H^+ ions increase, the water solution becomes more acidic, and the pH falls below 7 (see **Figure 5**). If a substance is added to the water to make the concentration of OH^- ions increase, the water solution becomes more alkaline and the pH rises above 7. Alkalis increase the concentration of OH^- ions and so raise the pH of the laundry wash.

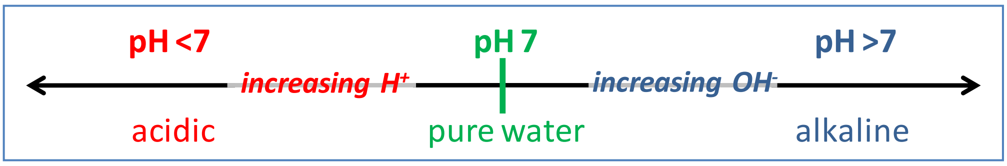

Figure 5: The pH scale

Soils and fabric surfaces generally have an overall negative charge. With an increase of negative ions in solution, the negative charge of the surface is increased, and because like charges repel each other, dirt removal from the surface is facilitated.

Examples

Sodium carbonate, sodium bicarbonate, *sodium silicate, sodium citrate* and *ammonium hydroxide*, may be used to increase detergent pH.

Anti-Redeposition Agents

What do they do?

Anti-redeposition agents prevent soils that have been dislodged from fabric from being redeposited.

How do they work?

Anti-redeposition agents increase the negative charge on the fabric surface, so that the surface repels soil particles because these are also negatively charged (see **Figure 6**).

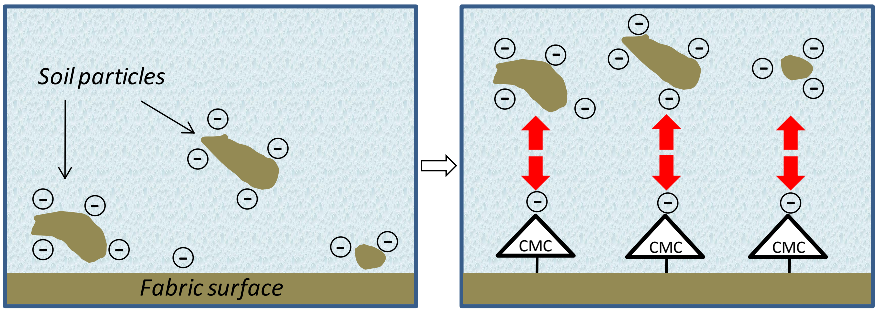

Figure 6: Anti-redeposition agent CMC acting on the fabric surface

Examples

Carboxy methyl cellulose (CMC) is effective with cotton fabrics. *Polyvinyl pyrrolidone* is more effective with wool and synthetic fabrics. *Polyethylene glycol* (PEG) and *polyvinyl alcohol* may also used as anti-redeposition agents.

ENZYMES

What do they do?

Enzymes can perform two main roles in a laundry detergent:

- effect stain removal
- provide colour and fabric care

How do they work?

Enzymes break down large molecules such as proteins, carbohydrates and fats into smaller segments. These smaller segments are either water-soluble, or are of size and polarity compatible with surfactants meaning that they can be suspended in solution.

Enzymes are catalysts. Catalysts speed up chemical reactions without themselves becoming consumed in the process. So, only a small amount of an enzyme is required in the laundry detergent formulation because the enzyme can work over and over again. However this does not mean that the same detergent solution can be used again and again for many washes - although enzymes may remain active, the finite amounts of other key ingredients limit the amount of soil that can be suspended in solution by each detergent dose.

Most enzymes are destroyed by high temperatures, i.e. above 60 °C. They are usually most effective at warm water temperatures (e.g. 40 °C), however some enzymes are best for use in cold water.

Stain removal

Different enzymes are able to break down different types of stains. Some enzymes degrade protein stains, (such as blood, dairy products, eggs, meat, mud, and grass), into small units called “peptides”. Other enzymes degrade carbohydrates (such as potato, pasta and rice) into smaller molecules called “oligosaccharides” or “monosaccharides”. Others degrade fats (or “lipids”) such as butter and oil. Whatever the type of stain, after its enzymatic breakdown, surfactants suspend the resulting fragments in solution.

Colour and fabric care

Some enzymes act to smooth cotton fabrics by cleaving fibres that protrude from the surface. A smoother cotton surface means that soils are less readily taken up by fibres, and are more easily liberated.

Enzymes can also help remove fuzz and pills, and can assist colour protection of fabrics.

Examples

The most commonly used enzymes are *proteases* (break down protein), *amylases* (break down starch – a type of carbohydrate) and *lipases* (break down fats).

ACTIVE OXYGEN BLEACHES

What do they do?

Active oxygen bleaches remove stains from fabric to improve fabric whiteness and brightness. These bleaches are usually suitable for use on coloured fabrics without damaging their colour.

How do they work?

Active oxygen bleaches work by oxidation of the stain. This means that the active component of the bleach accepts electrons from the stain, resulting in either:

- cleavage of chemical bonds in the stain and its breakdown, following which fragments can be suspended in solution by surfactant action
- a change in the oxidation state of the stain, rendering it colourless

The active ingredient in oxygen bleach is hydrogen peroxide.

Examples

Sodium percarbonate is the most common oxygen bleach, but is only active above 60 °C. For this reason, bleach activators are added to detergents designed for use in cold water.

ANTIMICROBIAL AGENTS

What do they do?

Antimicrobial agents, also called disinfectants or sanitisers, are either microbiocidal (kill microorganisms) or microbiostatic (inhibit the growth of microorganisms). Microorganisms include bacteria, fungi and viruses.

These agents hygienically clean fabrics to help prevent spread of disease and to reduce odour-causing microorganisms.

How do they work?

Antimicrobial agents can work in a number of ways. Some interfere with the formation of the microbial cell walls or cell membranes, usually having microbiocidal effect. Some interfere with the synthesis of microbial proteins, nucleic acids, or essential metabolites. The effect of this interference could be either microbiocidal or microbiostatic.

Examples

Quaternary ammonium chlorides and *alcohols* may be used as antimicrobial agents.

Fabric Softeners

What do they do?

Fabric softeners can impart a number of properties to fabrics:

- Softness (or fluffiness for towels) and smoothness
- Reduced static electricity (preventing fabric from clinging)
- Reduced crinkling (and greater ease of ironing)

How do they work?

Softness, smoothness and reduced crinkling (see **Figure 7***)*

Fabric softeners are cationic surfactants, meaning that their polar head-groups bear a positive charge. These are attracted to the negatively charged fabric surface and associate with the fibres. With the positively charged headgroup associated with the fabric, the fatty tail protrudes from the surface and imparts a feeling of softness or smoothness to the fabric. The layer of molecules on the surface may also endow the fabric with some water-proofing properties.

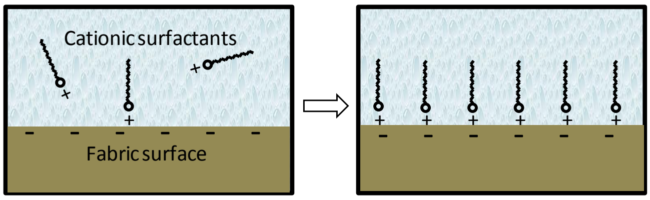

Figure 7: Molecules of fabric softener align at the fabric surface

Reduced static

Electrical charge, or static, builds up on fabrics as the fibres rub together, especially in the clothes drier. When fabric softeners coat the fibres (as described above), they provide a lubricating coat that enables fibres to rub together without the same static build up. The coat of fabric softener molecules also conducts electricity, and so allows discharge of any static that has built up.

Examples

Cationic surfactants may be used, such as *long-chain amines* and *long-chain quaternary ammonium compounds.*

Fragrances

What do they do?

Fragrances do more than give laundry a pleasant smell. They neutralise the inherent odour of the detergent chemicals, and also of the soils in the laundry wash. They can also enhance mood and help create pleasant associations with 'doing the laundry'.

How do they work?

Fragrances are chemicals with an odour that is detectable by humans. The human nose contains hundreds of olfactory receptors to which odour molecules can bind. Just like a key in a lock, certain odour molecules will fit into certain receptors if they have the right shape. This is called "molecular recognition". Therefore, odour is related to the shape and structure of the chemical molecules.

Examples

There are many different fragrances used in the detergent industry.

OPTICAL BRIGHTENERS

What do they do?

Optical brighteners enhance the light reflected from the fabric surface and can make fabrics appear whiter and brighter, helping to keep them looking newer for longer.

How do they work?

Optical brighteners mask the appearance of an undesirable colour, such as the yellowing of fabric that occurs naturally over time. They do this by introducing a complementary colour.

Different colours exist because light can have many different wavelengths, depending on the nature of the substance that the light is being emitted or reflected from. The colour that is observed comes from a combination of all the wavelengths of light that reach the eye. Humans can only see a small fraction of all the wavelengths of light that exist, known as the visible spectrum; white is a combination of all the wavelengths in the visible spectrum. Just beyond the visible spectrum lies the ultraviolet region.

Optical brighteners attach to fabrics, absorb invisible ultraviolet light and convert it to visible blue-violet light (see **Figure 8**). The blue light that is emitted interacts with the yellow light emitted by the fabric, giving an overall appearance of whiteness.

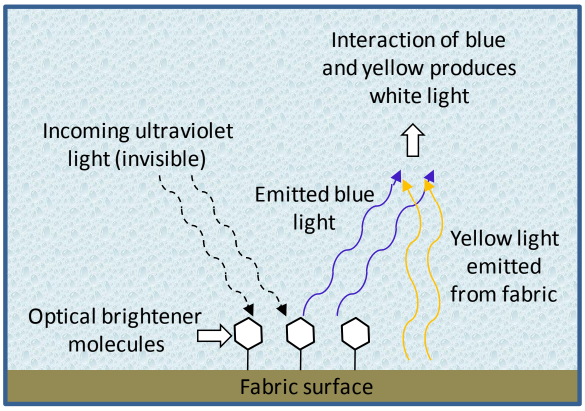

Figure 8: Molecules of optical brightener convert UV light, leading to white appearance of fabrics

Examples

Some classes of optical brighteners include *aminotriazines*, *coumarins*, and *stilbenes*.

PRESERVATIVES

What do they do?

Preservatives can prevent detergent spoilage during storage. Generally, preservatives are only required in laundry liquids.

How do they work?

All organic detergent ingredients, such as the surfactants and enzymes, are biodegradable. This means that they can be broken down by bacteria in the environment. However, bacteria can also infiltrate detergent containers and cause the detergent to spoil during storage. Preservatives prevent this spoilage by killing bacteria.

Examples

Some examples of preservatives are *glutaraldehyde* and *EDTA*.

HYDROTROPES

What do they do?

Hydrotropes, or solubilisers, assist in maintaining the pouring characteristics of liquid detergents by preventing gel formation or separation into layers in the bottle.

How do they work?

Hydrotropes are similar to surfactants in that they have two domains: a polar (hydrophilic) domain and a non-polar (hydrophobic) domain. Despite these similarities they are typically smaller and less linear than surfactant molecules. They interrupt the formation of surfactant micelles in the bottle that can lead to high viscosity gel structures and insoluble phases.

In this way, inclusion of hydrotropes in liquid detergent formulations help maintain a uniform composition throughout the liquid detergent and also maintain the pouring properties required for ease of use.

Examples

Short-chain aromatic sulfonates such as *xylenesulfonate*, *cumenesulfonate*, some *glycol ether sulphates*, and *urea*.

PROCESSING AIDS

What do they do?

Processing aids maintain the physical characteristics of laundry detergents during processing, storage and consumer use.

How do they work?

There are several different types of processing aids:

- Desiccants are able to bind multiple molecules of water, forming “hydrates”. This effectively locks up any moisture that enters the detergent, maintaining a dry, free-flowing powdered detergent. *Sodium sulphate* is a common example.
- Solvents help dissolve the detergent ingredients in liquid laundry detergents. Some solvents that are miscible (can mix) with water are able to dissolve ingredients that water alone does not dissolve. This maintains a uniform composition throughout the liquid detergent.
- Alcohols are one example of solvents that have an additional effect of lowering the freezing point of liquid laundry detergents. This prevents disruption to the physical properties of the detergent that would be caused by crystal formation during cold storage. Examples are *ethanol* and *propanol*.

FOAM REGULATORS

What do they do?

Foam regulators inhibit the formation of suds during the washing cycle. Particularly in front-loading washing machines, mechanical energy comes from the wash items colliding with the sides of the rotating tub. High amounts of foam cushion the collision impact and decrease the effectiveness of the wash.

Foam regulators either prevent the formation of foam by disrupting the surfactants at the air-water interface of the forming bubble, or cause foam bubbles to collapse by forming hydrophobic bridges across multiple bubbles.

Examples

Foam regulators are typically oily or hydrophobic long-chain molecules. Some *soaps*, *siloxanes* and *paraffins* are used as foam regulators.

CORROSION INHIBITORS

What do they do?

Corrosion inhibitors inhibit corrosion of metallic washing machine interior parts. These are becoming less important as washing machine interiors are increasingly made from stainless steel or plastics.

How do they work?

For corrosion to occur, the following elements of the “galvanic cell” all have to be present:

- The anode (the positively charged electrode, from which electrons flow; the electrode where oxidation takes place)
- The cathode (the negatively charged electrode, to which electrons flow; the electrode where reduction takes place)
- An electricity conduit between the anode and cathode (e.g. a metal)
- A liquid that can carry charge (“electrolyte”) connecting the anode and cathode

In the washing machine, the anode and cathode are areas of the metallic surface between which a difference in charge exists, even if this is only momentary. The electricity conduit is provided by the metal surface between these two areas, and the electrolyte is the water/detergent mixture. The flow of electricity in this cell causes corrosion of the metal surface over time.

Corrosion inhibitors act by preventing or reducing the areas of charge difference by forming a thin film over them.

Examples

Sodium silicate is a common corrosion inhibitor.