Sustainability in commercial laundering processes

Module 4
Usage of energy and detergents

Chapter 1

Background of ingredients

Contents

Learning targets

Education and Culture

Leonardo da Vinci

After finishing this chapter, you will

- Know the essential building blocks of detergents
- Know the functions and classifications of surface active agents
- Know the functions and types of alkalis used in modern detergents
- Know the functions of builders and mechanism of action
- Know the types of builders and their advantages/disadvantages

Learning targets

Education and Culture

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- Know the function and types of anti re-deposition agents
- Know the function of optical brightening agents used in detergents
- Know the function and types of enzymes used in detergents
- Know the function and types of bleaches and activators used in detergents
- Know the function and types of chelating agents used in detergents
- Know the function and effects of soil release polymers in detergents

Detergent Options

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The Detergent Options for a Commercial Launderer are Numerous

- Autodosed Powders
- Stock Solution Powders
- Dry Feed Powders
- Single Shot Liquid Autodosed from Bulk
- Multi Liquid Systems Autodosed from Bulk
- Detergent Pastes with Autodose System

Laundry Classifications

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The ever increasing number of laundry classifications gives rise to a wide range of detergents for commercial laundry use

- Workwear Classifications (Engineering, Food Industry, General)
- Hospital Classifications (Foul & Infected, Stained, Light Soiling)
- Hotel and Restaurant Linen Classifications (Light, Medium & Heavy Soiling, Duvets)
- Hospital Theatre Linen (“Special” Fabrics)
- Clean Room Linen (“Special” Requirements)
- Dust Mats (HTN and Cotton)
- Roller Towels
- High Visibility Garments

Powder – Liquid – Paste Detergents all use fundamentally the same ingredients to achieve wash performance.

Whatever the classification to be laundered – the ‘Building Blocks’ of the detergent are essentially the same.

The essential components of a laundry detergent are:

1. Surfactants
2. Alkalis
3. Builders
4. Other Performance Ingredients

The essential components of a laundry detergent are:

1. **Surfactants**
2. Alkalis
3. Builders
4. Other Performance Ingredients

Surfactants

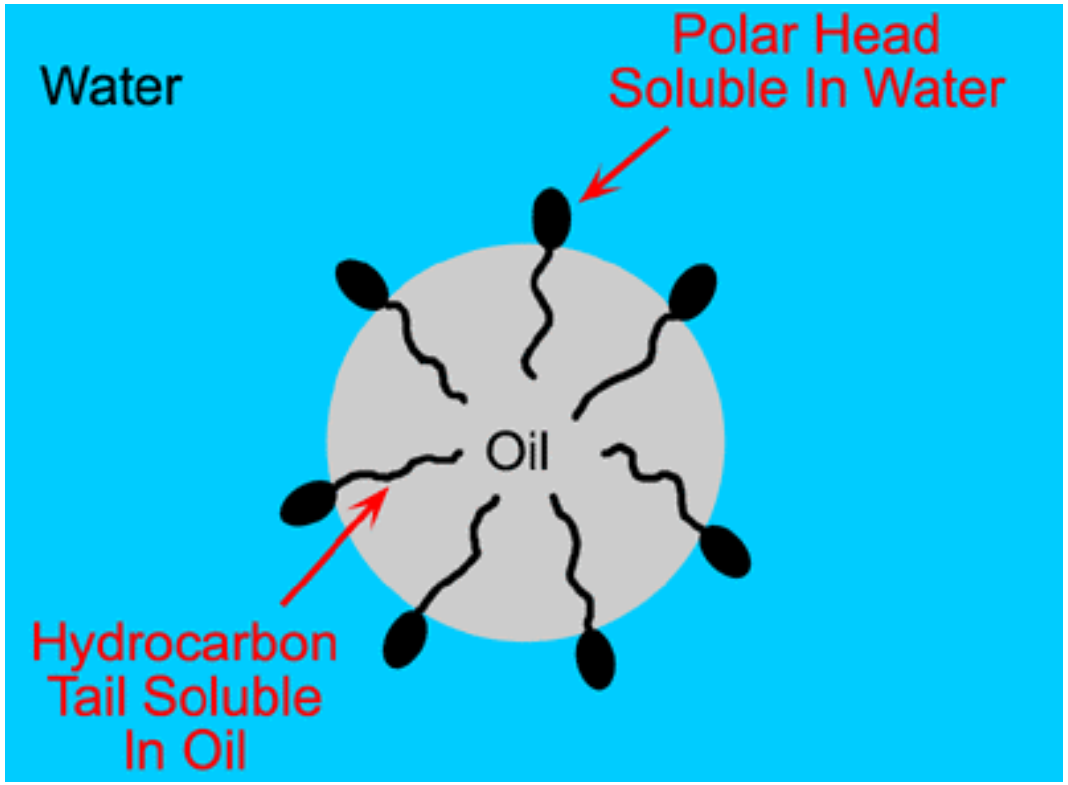
(Surface Active Agents)

Surfactants are an essential component of all laundry detergents.

In simple terms, surfactants are organic molecules which comprise a hydrophobic portion and a hydrophilic portion on the same molecule.

Due to this structure, surfactants in solution will migrate to phase boundaries, for example, oil-water, oil-solid, water-air, where they have very significant effects.

Oil-Water


Water
Polar Head
Soluble In Water
Oil
Hydrocarbon
Tail Soluble
In Oil

Surfactants

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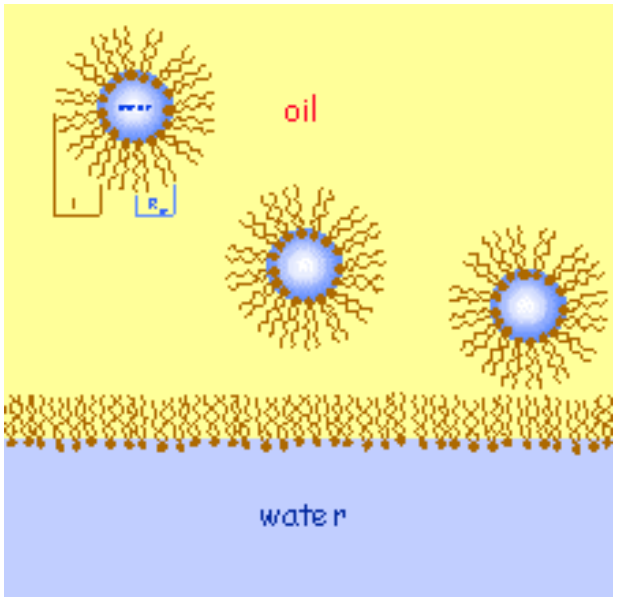
Surfactants Perform the Following Functions:



- **R**apid wetting of the fabric
- **R**emoval of particulate soil from the fabric, achieved by electrostatic repulsion
- **S**olubilisation of oil, achieved by micellar action
- **S**uspension of soiling matter in the wash liquor

Surfactants

There are thousands of **surface active agents** commercially available for many applications. Surfactants are normally classified according to ionicity when dissolved in water.

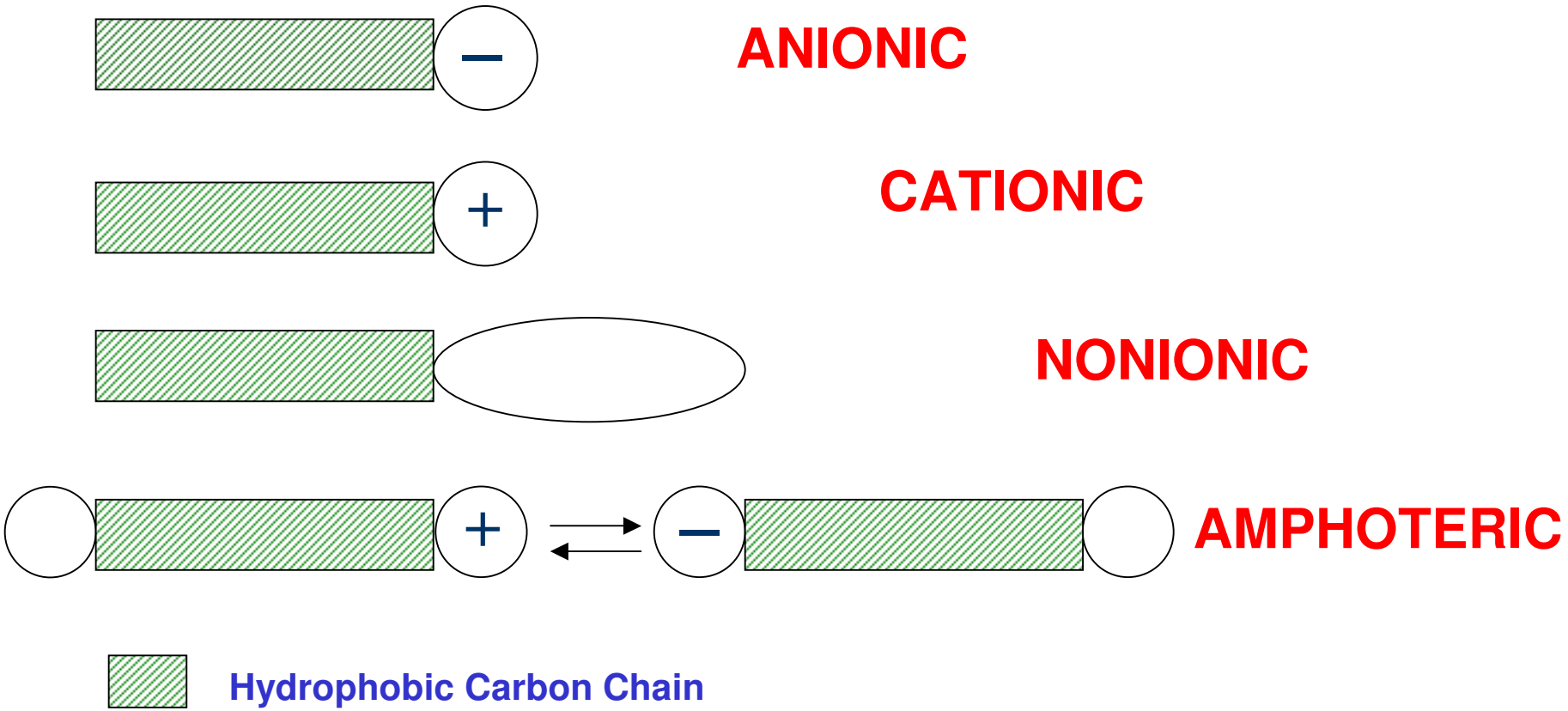
Anionic: Hydrophilic part of molecule is negatively charged

Cationic: Hydrophilic part of molecule is positively charged

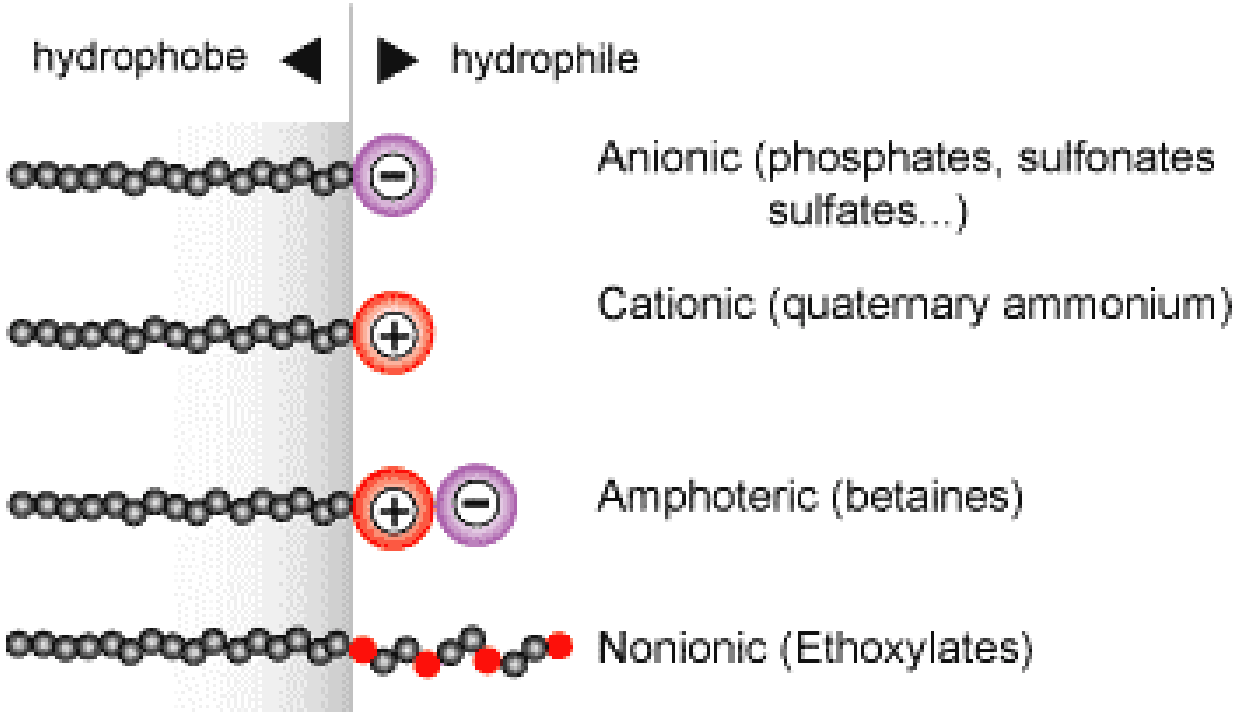
Nonionic: No ionisation in water

Amphoteric: May be negatively or positively charged depending upon pH

Surfactants – Representation



Surfactants – Representation



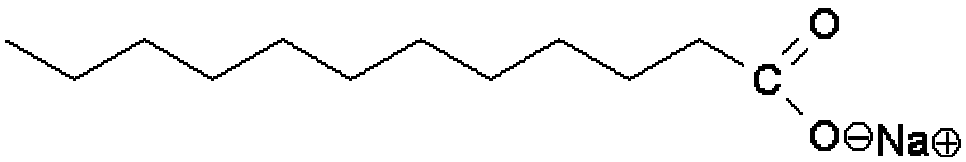
Anionic Surfactants

- Soap is an **Anionic Surfactant** but has been largely superseded by **synthetic anionic surfactants** which are less sensitive to the adverse effects of hard water ions (*Ca^{2+}, Mg^{2+}).*

- **Anionic Surfactants** are used in most general purpose laundry detergents for wetting, particulate soil removal and soil suspension.

- Most modern laundry detergents contain a blend of **anionic** and **nonionic surfactants** to optimise performance and cost effectiveness.

Soap

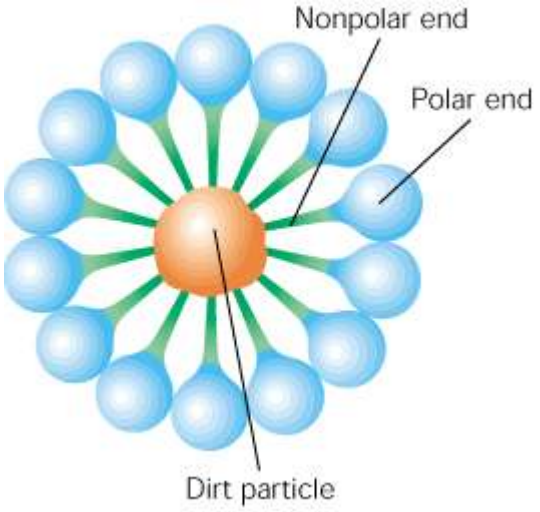


Hydrophilic Head

Hydrocarbon Chain

(Hydrophobic)

During soil removal

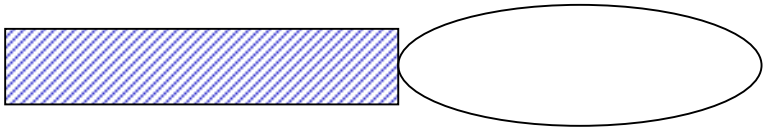


Surfactants

- **Nonionic Surfactants** are by far the numerical largest group of surfactants. Those nonionics predominantly used for laundry detergents are **ALCOHOL ETHOXYLATES**.

- The length of the alcohol chain typically varies between **C_9 and C_{18}** and provides the hydrophobic portion of the molecule.
- The length of the ethoxylate chain typically varies between **3 and 25 units** of ethylene oxide, and provides the hydrophilic portion of the molecule.
- The balance between the ***hydrophilic*** and ***lipophilic*** properties of the molecule **(HLB)** is used to optimise detergent and emulsifying properties.

Nonionic Surfactants - Properties

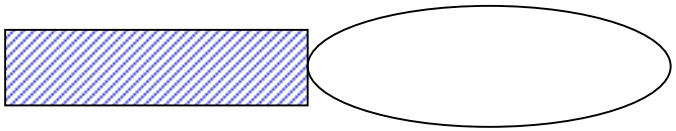


C13–15 EO7

General Detergency

C13–15 EO 3-5

More Hydrophobic ***- Oil Emulsifier***



C9–11 EO7

More Hydrophilic ***- Rapid Wetting Properties***

HLB Values of Nonionic Surfactants

Cationic Surfactants

- Not used for detergent properties.

- ***Cationic Surfactants*** are used in fabric conditioners and as the active ingredient for many disinfectant preparations.

Amphoteric Surfactants

- The Surfactant molecule ionicity depends upon the prevailing pH. Many **amphoteric** surfactants are **anionic in alkaline conditions** and **cationic under neutral / acidic conditions**.
- There are excellent synergistic effects between ***nonionic*** and ***amphoteric*** surfactants. The use of amphoteric surfactants in liquid laundry detergents is growing.
- The ***reduced irritancy*** properties of amphoterics compared with traditional anionics makes **amphoterics** ideal surfactants for **fine fabric detergents**.

The essential components of a laundry detergent are:

1. Surfactants
2. **Alkalis**
3. Builders
4. Other Performance Ingredients

Alkalis

- **Alkalis** are almost universally used in detergents for commercial laundries.
- The alkali blend is usually the major portion of laundry powder.
- **Alkalis** provide the wash liquor with:
  - An appropriate pH (*typically 10-11*)
  - An appropriate alkalinity (*Alkali Reserve*)

Alkalis

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Alkalis are highly effective in improving wash performance. Their functions include:

- **N**eutralisation of acidic soiling
- ***S****aponification of fatty soil*
- ***E****nhancement of soil removal, for example, with anionics*
- ***I****mproving soil suspension and preventing re-depostion*
- ***O****ptimising bleach conditions*
- ***O****ptimising enzyme conditions*

Alkalis

The alkalis generally used in laundry detergents are:

Sodium / Potassium* Silicates

Sodium / Potassium* Carbonates

Sodium / Potassium* Hydroxides

* The potassium salts are used for liquid detergent products due to their higher solubility.

Alkalis

Alkali	*pH 1%*	*Active Alkalinity as Na_2o*	*Soil Suspension Properties*	*Wetting Power*	*Soil Removing Properties*	*Rinsing Properties*
Sodium Metasilicate Pentahydrate	12.4	28%	*Good*	*Good*	*Very Good*	*Good*
Sodium Metasilicate Anhydrous	12.4	49%	*Good*	*Good*	*Very Good*	*Good*
Sodium Carbonate	11.5	29%	*Poor*	*Very Poor*	*Fair*	*Poor*
Sodium Hydroxide	13.3	76%	*Fair*	*Poor*	*Good*	*Very Poor*
STP	9.6	1.6	*Fair*	*Poor*	*Fair*	*Good*

Alkalis

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- The key alkali for commercial laundry detergent products is **Silicate**.
- **Sodium Metasilicate** (pentahydrate or anhydrous) is used extensively for **medium** / **heavy duty** detergent powders.
- The **potassium analogue** of sodium metasilicate is used for **liquid systems.**
- **Sodium Carbonate** is generally blended with silicates to provide an appropriate alkalinity and operating pH of 10-11.
- **Sodium Hydroxide** is utilised in detergent powders used for extreme levels of soiling.
- **Potassium and Sodium Hydroxide** are widely used as the main alkali for liquid detergent systems.

The essential components of a laundry detergent are:

1. Surfactants
2. Alkalis
3. **Builders**
4. Other Performance Ingredients

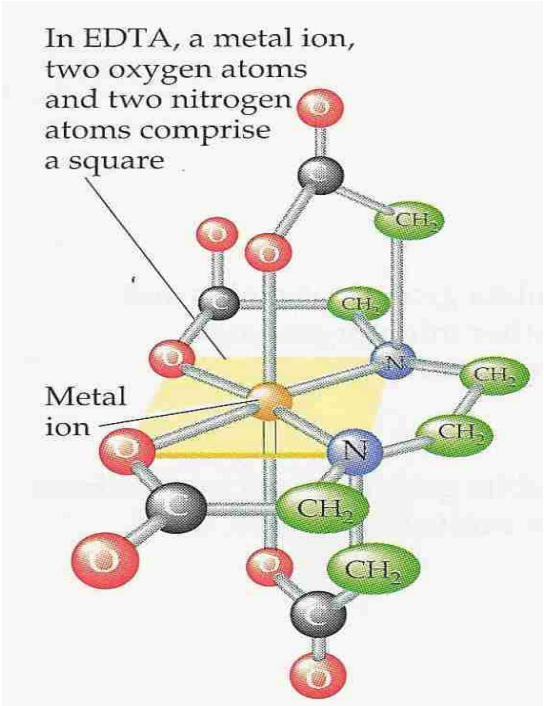
Builders

Laundry detergent builders are chemicals which remove hard water ions (Calcium and Magnesium) from the wash liquor.

If the Calcium and Magnesium ions are not removed, they have an adverse effect upon wash performance and the quality of washed fabrics.

Laundry Detergent Builders remove calcium and magnesium ions by one of two mechanisms:

- Ion Exchange
- Complexing



Builders

Builder	Mechanism	Advantages	Disadvantages
Zeolite	Ion Exchange	Economically viable 'phosphate' alternative	Performance with magnesium ions is poor. Unable to extract Ca/Mg from soil on textile. No soil suspending properties. Must be used with co-builders.
Condensed Phosphate	Complexing	Excellent water softening performance. Also provides alkalinity. Assists soil suspension. Synergistic with surfactants	Environmental / legislative issues
Sodium Citrate	Complexing	Biodegradable. Readily formulated in liquid products	No additional detergency benefits. Not suitable for powder detergents
NTA / EDTA Phosphonates	Complexing	Readily formulated in liquid and powder detergents	No additional detergency benefits. Environmental / legislative issues
Acrylate based Polymers	Complexing / Crystal growth inhibition	Readily formulated in liquid and powder detergents	No additional detergency benefits. Not suitable for some water reclamation systems

Builders

In the absence of builders, Calcium and Magnesium ions are removed by precipitation with detergent components.

Ca^{2+} + Silicate	Calcium Silicate Scale
Ca^{2+} + Carbonate	Calcium Silicate Scale (*Limescale*)
Ca^{2+} + Stearic Soap	Calcium Stearate

The essential components of a laundry detergent are:

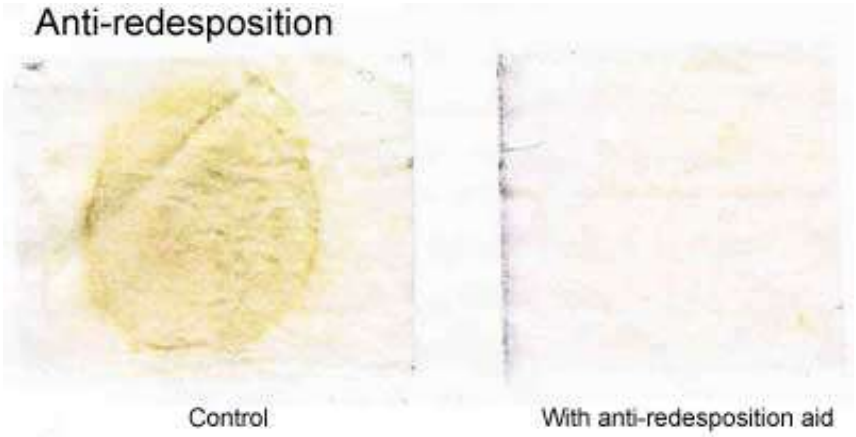
1. Surfactants
2. Alkalis
3. Builders
4. **Other Performance Ingredients**

It is usually the ‘other performance ingredients’ which, by their inclusion or exclusion will dictate the suitability of a detergent for washing a given classification.

Soil Anti Re-deposition Agents

It is essential for good laundering performance, for a detergent to prevent the re-deposition of soiling matter.

Re-deposition leads to greying of fabrics.



Prevention of Re-deposition

There are several mechanisms utilised to prevent soil re-deposition.

- **Alkaline** wash conditions increases repulsion between soiling matter and fibres.
- **Silicates** are particularly effective at soil suspension.
- **Anti re-deposition agents** which absorb onto fabrics (*CMC*)
- **Anti re-deposition agents** in the wash liquors (*Polyanions, Polycarboxylates, PVP*)

Soil Anti Re-deposition Agents

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Carboxy Methyl Cellulose: *Prevents soil re-deposition by absorption onto cotton fibres.*

Polyanions: for example, *Silicates and Phosphates prevent soil re-deposition by stabilising the suspended particulate matter*.

Polycarboxylates: *Specific group of polyanionic dispersing agents which stabilise pigments and particulates in suspension.*

Polyvinylpyrrolidones: *A dye scavenging polymer which absorbs fugitive dyes from the wash liquor and prevent re-deposition.*

Optical Brightening Agents

Optical Brightening Agents are ‘colourless dyes’ which are capable of absorbing invisible ultra violet light and remitting visible ‘blue’ light.

White fabrics treated with optical brightening agents are visually ‘whiter’ when viewed in light containing ultraviolet light (for example, in daylight)

Optical Brightening Agents

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- Virtually all white fabrics have **OBA** incorporated or applied during manufacture.
- Commercial laundry detergents contain **OBA(s)** to ‘top-up’, maintain or increase the level of OBA on the fabric.
- Specialist commercial laundry detergents for coloured articles are **OBA free**. OBAs can change the shade of pastel colours when applied during laundering.

Optical Brightening Agents

The type of **Optical Brightening Agents** incorporated into a detergent will depend upon:

- *Typical Wash Temperatures*
- *Type of Textile Fibre (cotton, polyester cotton, nylon)*
- *Shade of White Required*
- *Resistance to Oxidising Bleaches*
- *Light Fastness*

Enzymes

- **Enzymes** are natural catalysts which are effective in breaking down large organic molecules and thus improving the cleaning performance of a detergent.
- **Enzymes** are specific – one enzyme will break down one type of organic molecule.
- Laundry detergents containing enzymes are often referred to as **'biological'.**

Enzymes

The **four** types of enzyme considered for use in laundry detergents are:

Proteases: Act upon proteins, breaking down to amino acids.

Amylases: Act upon starches, breaking down to sugars.

Lipases: Act upon triglyceride fats, breaking down to fatty acids

Cellulases: Act upon cellulose, breaking down to saccharide groups.

Proteases are the most common enzyme type found in commercial laundry detergents.

Enzymes

Enzymatic (Biological) detergents are formulated to provide optimum conditions for enzyme activity and stability.

- ***Temperature***
- ***pH / Alkalinity***
- ***Protection against inhibition***

Enzymes are **NOT** compatible with Sodium Hypochlorite or Chlorine release agents.

Oxidising Bleach and Bleach Activators

A commercial laundry will generally add oxidant (in the form of ***Sodium Hypochlorite, Hydrogen Peroxide or Peracetic Acid***) as a separate addition to the laundry detergent.

There are options, however, to incorporate oxygen release bleach into commercial laundry detergent powders.

Bleaches and Bleach Activators

The three most commonly used oxygen release bleaching agents for laundry powders are:

- ***Sodium Perborate Tetrahydrate***
- ***Sodium Perborate Monohydrate***
- ***Sodium Percarbonate***

Detergent powders formulated with oxygen release bleaches require wash temperatures of 80-85^{0}C for optimum stain removal.

Bleaches and Bleach Activators

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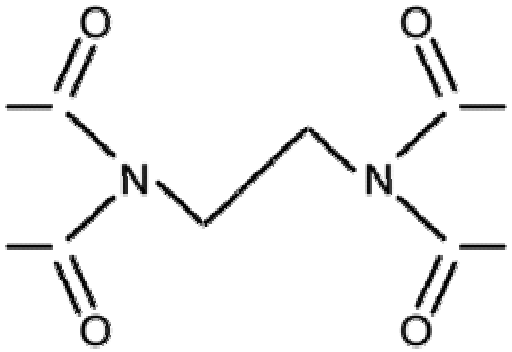
The inclusion of a **BLEACH ACTIVATOR** produces effective stain removal at 40-50^{0}C.

The most commonly encountered activator is:

T.A.E.D – *Tetra Acetyl Ethylene Diamine*

TAED effectively produces the 'peracetic' radical in the wash liquor.

The 'peracetic' radical is an effective oxidant and disinfectant at medium temperatures.



Chelating Agents

Chelating agents have been mentioned previously as 'builders' to control the adverse effects of hard water ions (Calcium and Magnesium).

Carefully selected chelating agents may also be incorporated into detergents to remove metal ions such as copper, manganese, iron, all of which can destabilise peroxygen bleaches, inactivate enzymes and discolour textiles.

Chelating Agents for this purpose include:

- ***Phosphonates***
- ***EDTA and NTA***
- ***Sodium Gluconate***

Soil Release Polymers (1)

SRPs are hydrophilic polymers that modify the surface properties of fibres and fabrics for improved soil release.

SRPs are particularly effective on polyester and polyester-cotton fabrics.

Soil Release Polymers (2)

- **SRPs** enhance detergency performance by promoting diffusion of wash liquor into the soil-fibre interface.
- **SRPs** provide polyester fibres with a degree of oily soil protection and facilitates better soil removal in subsequent washes.
- **SRPs** provide significant soil anti re-deposition properties.

Other Minor Ingredients

Powders:

- *Electrolyte Fillers*
- *Perfume*
- *Free Flow Agents*
- *Coloured Speckles*
- *Silicone Antifoam*

Liquids:

- *Water*
- *Viscosity Modifiers*
- *Perfume*
- *Glycol and Alcohol Solubilisers*
- *Silicone Antifoam*

Detergent Ingredients and Legislation

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Legislation and Regulations have an impact upon commercial laundry formulations. Some performance ingredients are restricted or not permitted in certain European countries.

Ingredients affected by Legislation and Regulations include:

- ***Phosphates***
- ***Surface Active Agents***
- ***Organic Chelating Agents (NTA, EDTA)***
- ***Optical Brightening Agents***

Ancillary Products

A commercial laundry will use a variety of ancillary products to support and complement the detergent. These ancillaries include:

Bleaches	Sodium hypochlorite, hydrogen peroxide, PAA for stain removal and disinfection
Emulsifiers	Hydrophobic nonionic adjuncts to improve oily soil removal from hydrophobic fibres
Antichlors	Final rinse additives to eliminate hypochlorite residues
Sours	Final rinse additives to eliminate alkalinity and lower pH
Starches	Final rinse additives to provide body and sheen to table linen etc.