

## Special Article

## Bleaching Agents: Chemicals that Ensure Stain-Free Clothes

SITARAM DIXIT

Application Manager (Fragrances)

International Flavours and Fragrances (India) Ltd.

The human race since early times has considered whiteness to be an embodiment of purity and cleanliness and the quest for cleaner and purer fabrics led to the invention of several different types of cleaning and bleaching processes. Fabrics are cleaned satisfactorily only if the interactions of the wash components in the entire washing process are optimised. The major components in this context would be the nature of the soil to be washed, the fibre to be cleaned the chemicals present in the detergent used and so in the wash liquor and the type of equipment used for cleaning. Re-removal of soil from the fabric during the washing process also depends on the mechanical action, the wash time duration and the temperature of washing.

The cleaning achieved during a washing procedure is a combination of washing and bleaching. Washing or cleansing in an aqueous medium is a complex process involving several different types of physical and chemical forces. Washing, broadly, can be defined as the removal of soil and the dissolution of any water-soluble impurities present on the fabric, by use of water or an aqueous surfactant solution. The physical removal of the soil from the fabric substrate occurs due to non-specific adsorption of surfactants on different interfaces present and through specific adsorption of chelating agents on certain polar soil components present on the fabric. Added to above, the indirect effect caused by calcium ion exchange, results in the freeing of calcium ions from the soil deposits and fibres dislodging any remaining residue. Electrolytes present in detergents, and in turn in the wash liquor, significantly compresses the double layer at boundary surfaces. All these effects contribute to dislodge and remove the oily and coloured pigmented soils from the textile fibres or solid substrate.

Bleaching means the destruction of the chromophore system of a coloured soil that cannot be removed from the fibres by simple washing. The resulting colourless reaction product of a bleached

soil is either left off, as is, in the cleaned fibre or is subsequently washed off the fabric during rinsing. Bleaching as a part of the cleaning process is usually carried out by oxidising chemicals and sometimes by reducing agents. Bleaching induces a change from a darker shade to a lighter shade in the colour of the soil and thereby increasing the reflectance of visible light and reducing absorption. The overall effect obtained on the washed fabric as a result of the cleaning process in totality is the most important aspect that is to be considered.

Generally bleaching occurs by mechanical, physical and/or chemical methods, specifically by the removal or change of pigmented soils adhering to the fibre. During washing all the above processes occurs simultaneously at varying levels. The importance of the process depends on the nature and the class of the soil present on the fibre. Soils like carbon black, inorganic oxides, carbonates and silicates, fats and waxes, higher hydrocarbons, denatured proteins, certain dyes that are present in the fibres as mixed soils are difficult to remove from fabrics. Removal of bloodstains from fabrics can also present problems during washing.

Staining in fibres is normally due to the result of either a chemical interaction between the soil and the garment, or the soil sticking superficially to the surface to the fabric. It depends on the chemistry of the stain and the type of the substrate it is present. In most cases, the staining reaction is not instantaneous, which is the reason that fresh stains are easier to remove. Physical and mechanical forces are effective in removing pigmented and greasy soils. Chemical bleaching is used to remove non-washable soil stains adhering to the fibres. Chemical bleaching agents are used for this purpose. In an actual situation both physical and chemical methods of removal are combined. There are situations when the soil consists of substances that cannot be removed by chemical treatment, but can be dislodged only by interfacial processes, using modern detergents containing

## Special Article

quality surfactants, water soluble complexing agents, water insoluble ion exchangers, enzymes, etc.

Commonly encountered stains in daily life usually consist of substances belonging to the plant kingdom, namely, tea, coffee, wine, fruit juice, beer, spices, grass, vegetable sauce, egg yolk, etc. All these soil contain compounds that can be bleached to reduce them to colourless end products. Sometimes these colourless end products regain their colour due to air oxidation. Stains of Urobilin and Urobilinogen that are derived from blood haemoglobin degradation is excreted through human urine. Perspiration stains are another major stains associated with humans that have to be eliminated. Stains of certain commercial products used by individuals in their daily life like cosmetics, hair dyes, nail polish and enamels, shoe polish and creams, ink, tobacco, etc. are also sometimes required to be eliminated from fibres.

During the prehistoric early times, the bleaching agent used was wood ash, consisting mainly of potash, as a fat cleaving or lipolytic agent to remove oily stains. At about 70 AD, bleachers in Rome effectively made use of urine that contains ammonium carbonate as a mild alkaline detergent. The use of urine as a cleaning agent was so popularised by the bleachers of Rome that Emperor Vespasian taxed the commercial collection of urine by the bleachers. Croft or Grass bleaching in which bleaching used to take place due to the formation of hydrogen peroxide by the action of sunlight on moist fabric spread out in the open on Bleach Croft-Grass was also practised.

The Dutch used potash lye, buttermilk, as a bleaching agent that was eventually replaced by dilute sulphuric acid in 1756. Subsequent developments gradually culminated in the introduction of modern chemical bleaches toward the end of the 18th century when Javelle water was accidentally discovered. In 1792, a French national based in Javelle near Paris found that addition of caustic potash to chlorinated water in the ratio of 1:8, produced a solution that was effective as a bleach. This solution was called as "Eau de Javelle" and was commercially sold to textile bleachers even though the potassium hypochlorite solution formed was not very stable.

In 1799 Charles Tennant of England produced a more stable "Chloride of Lime or Bleaching powder" by absorbing chlorine to wet lime. By the end of the 19th century sodium hydroxide and chlorine were electrolytically produced from brine, leading to the commercial manufacture of an inexpensive, but relatively stable, sodium hypochlorite solution in 1820 to be used as an inexpensive bleaching agent for household purposes.

The perennial quest to achieve cleaner and brighter laundry, led mankind to continuously improve, and the concept of whiteness was revolutionised by the development of Fluorescent Whitening Agents, alongwith greatly improved chemical bleaches systems

### CHEMICAL BLEACHES FOR LAUNDRY

Chemical bleaches used for bleaching laundry can be differentiated as follows:

#### Chlorinated bleaches

Sodium Hypochlorite, bleaching powder, chlorinated isocyanurates, isocyanuric acid, dichlorodimethyl hydantoin, chlorinated phosphates, chloramines, lithium hypochlorites, etc., are some bleaching chemicals which in an aqueous medium produce hypochlorite ions or hypochlorous acid depending on the pH (alkalinity) of the resultant solution.

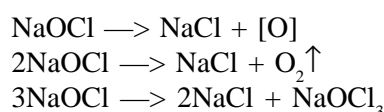
The stability of hypochlorite solution is achieved by use of 1 to 2% sodium hydroxide in the final resultant bleach mixture. Stability of hypochlorite solution is affected by light and trace amounts of heavy metals, copper, nickel, cobalt, chromium, iron, manganese and so care should be taken to avoid contact of the bleach solution with materials made of the above metals. It is advisable to fill and store the bleach solution in opaque glass bottles, plastic containers, glazed porcelain or rubber or glass-lined vessels to maintain stability of the bleach solution.

Hypochlorite decomposes into sodium chloride (NaCl) and nascent oxygen [O] which reacts with the oxidizable material or soil present to bleach to soil. In a hypochlorite bleach the active bleaching agent is nascent oxygen [O]. In case no bleaching

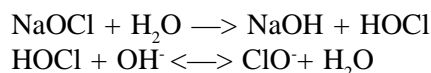
## Special Article

takes place then nascent oxygen produced combines slowly to form inactive oxygen ( $O_2$ ). During the decomposition of hypochlorite some amount of chlorate is also produced.

The rate of the reaction depending on various factors like temperature, presence of trace metals, light, concentration of hypochlorite in the bleach and the pH of the wash liquor. The reaction taking sodium hypochlorite as a bleaching agent is shown below:



Another school of thought claims that hypochlorite solution decomposes to hypochlorite anion ( $\text{ClO}^-$ ) in the alkaline medium as under:



H. Kauffmann concludes that hypochlorous acid is the active species in the hypochlorite bleach. I.E. Flis claims that free hypochlorous acid along with its anion hypochlorite is responsible for the bleaching process. A. Agster believes that bleaching occurs because of the decomposition of hypochlorous acid to hydrochloric acid and oxygen.

Thus, it can be seen that the reaction mechanism is much more complex and is still not fully understood. One major disadvantage of hypochlorite bleaches is that it has to be added separately in the wash liquor and cannot be incorporated directly into a detergent formulation. Moreover chlorine bleach solution is dependent of user experience and strict adherence to the manufacturers' recommendations is required to derive the maximum benefit; wrong usage can lead to serious laundry damage.

Concentration of hypochlorite solution is usually specified for its available chlorine content. This is usually expressed as the amount of chlorine produced when hypochlorite solution is acidified. Household hypochlorite bleaches are sold in strengths up to 10% (maximum) of available chlorine. Hypochlorite has a good reactivity and high

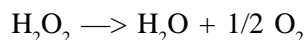
oxidation potential and so is effective at low temperature. Nevertheless, it has problems with textile dyes and Fluorescent Whitening Agents that are unstable to chlorine. This restricts the widespread usage of hypochlorite bleaches for coloured and superior quality fabrics. Sodium hypochlorite is still used as an inexpensive bleaching agent and a sanitizer for household purposes although in many developed countries it is being replaced by oxygenated bleaches and photobleaching agents.

### Reduction bleaches

Sodium dithionate, sodium or zinc formaldehyde sulfoxylates, formadine sulfinic acid, sodium hydrosulphite are some of the commercial materials that are available for use as special reductive bleaches to treat specific types of discoloration. They are usually used in textile, dyeing industry or institutional settings and very rarely used for household detergent formulations.

### Oxygenated bleaches

They are complex per salts of organic or inorganic compounds with hydrogen peroxide. Alkali percarbonate, perborates, persulphates, perpolyphosphates, organic peroxides, etc., produce hydrogen peroxides in aqueous medium that decomposes to produce active oxygen that provides the bleaching activity. The discovery of hydrogen peroxide ( $\text{H}_2\text{O}_2$ ) in 1818 by Thenard as a bleaching agent triggered of commercial production of stable peroxide compounds in 1925. The bleaching action of hydrogen peroxide like hypochlorite bleach also depends on factors like temperature and pH. Bleaching takes place due to an active form referred to as "active oxygen." Different opinions exist about the reaction mechanisms of  $\text{H}_2\text{O}_2$  bleaching.  $\text{H}_2\text{O}_2$  liquor on close inspection reveals ascending gas bubbles. It was therefore erroneously concluded that it decomposes into molecular oxygen and water and bleaches accordingly to the following equation:

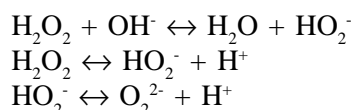


We know that ordinary atmospheric oxygen has practically no bleaching effect and so a more reactive form of oxygen *in situ* or nascent oxygen was considered to cause bleaching and this form of oxygen

## Special Article

is separated in the atomic form from the bleaching agent (Kind 1932, Agster 1978). The above theory does not find favour with some as molecular oxygen in its elemental electronic ground state has practically no bleaching power under actual wash conditions. A second school of thought proposes that when  $\text{H}_2\text{O}_2$  decomposes some of the oxygen is released in electronically excited state termed as the "singlet oxygen" that has been postulated as the active substance in peroxide bleaching.

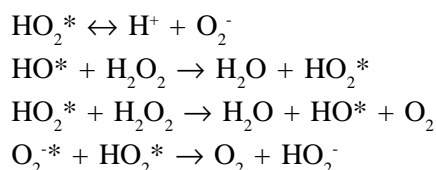
The most widely accepted hypothesis was put forward in 1979 by P. Kuzel to explain the mechanism of hydrogen peroxide bleaching and is attributed to perhydroxyl anion ( $\text{HO}_2^-$ ).  $\text{H}_2\text{O}_2$  decomposes in an alkaline medium to the active intermediate hydrogen peroxide anion and peroxodi-anion ( $\text{O}_2^{2-}$ ) which are responsible for bleaching according to the following equations:



An intermediate product exerting bleaching action and forming decomposition products, depending on the co-reactant is assumed as a working hypothesis to explain the decomposition of hydrogen peroxide and its bleaching effects by the free radical mechanism. The decomposition of hydrogen peroxide is explained by a radical mechanism in which free radical functions as chain propagators. These radicals  $\text{HO}^*$  and  $\text{HO}_2^*$  have been proposed as possibly responsible for bleaching action by the formation of super oxide of oxygen  $\text{O}_2^-$ . Taher and Cates suggested that disproportionation of hydrogen peroxide in the wash liquor leads to the super oxidation stage according to the following equation:



The radicals so formed enter into a chain reaction with  $\text{H}_2\text{O}_2$  to give superoxide, as below:



As can be seen the decomposition of hydrogen peroxide liquor and its relationship with bleaching activity is still unclear and much similar to the situation prevailing in case of hypochlorite bleach mechanism, with several different theories proposed by research scientists' around the world.

Crystalline sodium perborate (sodium peroxyborate tetrahydrate, 25% max. is the most widely used oxidative bleach in laundry detergents worldwide. The perborate ion hydrolyses in the aqueous wash liquor to form hydrogen peroxide. It exhibits a comparatively superior shelf-life to other oxidative bleaches like sodium percarbonate ( $\text{Na}_2\text{CO}_3 \cdot 1.5 \text{H}_2\text{O}_2$ ), sodium perphosphate ( $\text{Na}_4\text{P}_2\text{O}_7 \cdot 3\text{H}_2\text{O}_2$ ), percarbamide ( $\text{CO}(\text{NH}_2)_2 \cdot \text{H}_2\text{O}$ ). Peroxomono- and peroxodi-, sulphuric and phosphoric acid salts are not popular because of their poor bleaching power and low oxidation potential. The salts, sometimes fail to hydrolyse to hydrogen peroxide in the alkaline wash liquor of a detergent formulation. The activity of sodium perborate increases with increasing, pH and temperature. The bleaching activity significantly increases with higher ratio of perborate concentration in the wash liquor and so in the detergent formulation. Unfortunately sodium perborate exhibits low bleaching effect at temperature below  $60^\circ\text{C}$  as the hydrogen peroxide anions present in the wash liquor shows poor bleaching power.

To improve the bleaching efficacy at lower temperature than  $60^\circ\text{C}$  acylating agents or bleach activators like, tetraacetylglucouril (TAGOU), tetraacetylenediamine (TAED) or sodium pisononanoxybenzene sulfonate (iso-NOBS) is incorporated. Among them TAED at 5% max. level is the most widely used. Bleach activators at an alkaline pH of 9-12 preferentially react with  $\text{H}_2\text{O}_2$  to form organic peroxyacid (PAA) that has a higher oxidation potential when compared to  $\text{H}_2\text{O}_2$  showing better bleaching activity at lower temperature. Organic peroxyacid bleaching agents *in situ* are also less aggressive to fabric dyes and optical brighteners than sodium hypochlorite bleaches. Unwanted impurities like metal ions of copper, manganese, and iron, if present in the bleach liquor catalyses the release of oxygen that reduces the effect of bleach and damages the fabrics. To suppress this

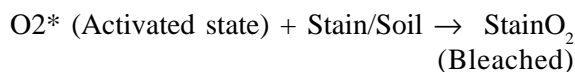
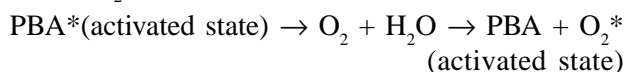
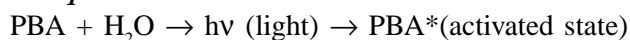
## Special Article

catalysis 0.1 to five per cent of finely divided magnesium silicate is added along with small amounts of complexing agents like ethylenediaminetetraacetic acid (EDTA) or Nitrilotrimethylene phosphonic acid (NTPO) that exhibit a significant stabilising effect.

### Photobleaching agents (PBA)

Aluminium or zinc tetrabenzotetraazaphorphine derivatives represent another form of laundry bleach. *Tinolux BS*, a tetrabenzotetraazaphorphine derivative, which can readily exhaust on to a cellulosic fibre from the detergent wash liquor, are used in present day detergents for superior bleaching effect. Unlike in the other bleach systems described above, in photobleaching, oxygen from the atmosphere is catalytically made active by the photobleach and the active oxygen in turn bleaches oxidizable stains on the fibre. Further, the bleaching performance from PBA is obtained when the damp washed laundry is exposed to light in presence of water, that is, during soaking, washing or drying. The PBA absorbs light energy from the reddish part of the light spectrum and transmits it to the oxygen molecules available in water. The activated oxygen [ $O_2^*$ ] is then able to oxidise stains and micro-organisms to provide a clean, hygienic laundering even at low temperature. The PBA exhausts on to the cellulosic fibres from the alkaline detergent liquors used for washing. Bleaching by photoactivation mechanism using is shown below:

#### *In aqueous medium*



#### *With or without water*

$PBA \rightarrow hv \text{ (light)} \rightarrow \text{Colourless decomposition products.}$

*Tinolux BBS* is an anionic dark blue aqueous liquid, having a pH of around 5.8 that is incorporated into detergent powders, bar, liquid detergent and rinsing agents at 0.01 to 0.09% (w/w) of the formulation. When added to the slurry in the crutcher it gives a

light blue or pastel shade detergent. *Quantum* is a dark green aqueous liquid and is used in a similar fashion. Dry mixing of a PBA in form of granules can produce a detergent powder with blue or green speckles. PBA's is converted into solid granular form by physical mixing with solid substrates like, anhydrous sodium carbonate, anhydrous sodium sulphate, sodium tripolyphosphate, sodium triphosphate, starch, citric acid, other dicarboxylic acids, bentonite clay, etc.

*Laundrosil RT* is a blue bentonite agglomerate containing *Tinolux BBS* as an active PBA.

When PBA is to be incorporated into a detergent powder as granules, one should take care that the granular agglomerate disintegrates and disperses itself in the wash liquor to prevent the risk of localised action of the PBA in the fabric. PBA's, bleach soils that can be oxidised by activated oxygen like tea, coffee, red wine, fruit juices, spices, egg-yolk, grass, sauces, vegetable stains, etc. The bleaching efficacy of a PBA strongly depends on the detergent formulation and the concentration of the wash liquor.

Maximum substantivity of the bleach active component is achieved at a pH value of 9-11 in the wash liquor, with high electrolyte concentration in the formulation. As bleaching depends on the natural environmental conditions, the light intensity, air humidity, drying conditions and temperature all have an influence, in effective bleaching. It is especially suitable for use in the Indian subcontinent with high sunlight energy, where wash habits involve soaking, for at least 5 to 10 minutes and the washed fabric is line-dried in the open, exposed in sunlight.

PBA's are stable to storage under normal storage conditions, however care must be taken to prevent exposure of the product as such or its solution to light. Prolonged exposure to temperatures above 70°C leads to partial decomposition. It also has limited stability to chlorine at higher temperatures and at pH levels above 12. In a detergent formulation PBA's can be used either as a single active PBA or in combination with sodium perborate, or sodium

	<b>Special Article</b>	
--	------------------------	--

### COMMONLY USED STAIN REMOVERS

Stains	Stain remover	Method to follow	Precautions
Beer, gelatine, glue	Warm soap water. #Acetic acid/vinegar	Sponge, then wash with water.	# For stubborn stains.
Blood	Soap water/carbon tetrachloride	Try removing it with soap water. Sponge out the stain with carbon tetrachloride.	Handle carbon tetrachloride with care.
	Javelle water or hydrogen peroxide or acetic acid/vinegar	Wash or pour hot water from a height of about 175 cms.	It is dangerous to inhale Javelle water fumes. Concentrated solution of hydrogen peroxide and acetic acid are corrosive.
Chewing gum	Chloroform	First, scrap with knife after hardening with ice. Sponge off residue with chloroform.	Do not inhale chloroform directly. You can become unconscious.
Chocolate, wine	Soap water or petrol	Sponge	Avoid flame when using petrol. It will catch fire.
Coffee, milk, tea, ice-cream	Egg yolk and glycerine mixture	Sponge and later wash. Iron on opposite side.	Avoid ammonia on silks if colour runs.
	On wool: Treat with a 1:9:0.5 mixture of glycerine:water: ammonia Borax solution and glycerine	Repeat the process at 12 hour intervals Wash the stain with borax solution. Dip the stained portion in glycerine for 24 hours. Wash with soap.	
Fruits and fruit juices	Salt solution, glycerine	Wash the stain with salt solution. Dip the stained portion in glycerine for 24 hours. Wash with soap.	If fabric is coloured then dilute by mixing acetic acid and alcohol before use. Avoid flame when using alcohol. It can catch fire.
	On cotton/polyester: Soap water with borax On silk, wool, nylon: Acetic acid/vinegar		
Grass	Spirit or ether		Avoid flame when using spirit or ether. It will catch fire.

	<b>Special Article</b>	
--	------------------------	--

Stains	Stain remover	Method to follow	Precautions
Ink (fountain pen)	Dilute oxalic acid or citric acid/lemon juice	Spread small quantities with a spoon	
Black colour ink (difficult)	Try Javelle water		It is dangerous to inhale Javelle water fumes.
Ball pen inks	Detergent solution	Treat the fabric for about 10-15 minutes	Sponge with ethylene glycol only if stain is not removed by detergent solution.
Marker inks	Mix sodium chlorite and potassium nitrate in water	Apply the mixture on the stain portion of the fabric with a sponge. Wash the fabric after some time with soap.	
Iodine tincture	For coloured and acetate rayon's. Methylated spirit mixed with water (1:3)  For white fabrics: Hypo solution 10% with some ammonia.  Potassium nitrate in hot water	Wash with soap and then with hot potassium nitrate solution.	Avoid flame when using spirit. It can catch fire.
Mud	Potato slice	Rub a cut potato on the stained portion. Then wash with soap.	
Nail polish	Neutral soap solution Acetone	Wash	Avoid acetone on acetate rayon fabrics.
Oil, ghee, butter	Carbon tetrachloride or alcohol or ether.	Use carbon tetrachloride or alcohol or ether and sponge out the stain. Then wash the fabric with soap or detergent.	Handle carbon tetra chloride, alcohol, and ether with care.
<i>Paan, katha</i>	Lime paste	Soak the stained fabric in water then apply lime paste. Keep it for half an hour. Wash with soap or detergent.	
Paint, tar	Turpentine, followed by petrol		Avoid flame when using petrol. It will catch fire.

	<b>Special Article</b>	
--	------------------------	--

Stains	Stain remover	Method to follow	Precautions
Perspiration	Hypo or sodium perborate solution	On silks: Soak in concentrated salt solution for 3-4 hours. Then wash with water.	
	Soap and hydrogen peroxide + ammonia mixture	Wash in soap and Hydrogen peroxide/ammonia mixture	
	Water and potassium permanganate mixture 8:1 ratio	Wash the fabrics in potassium permanganate mixture. Finally with soap/detergents.	
Plantain, jambul	Carbon tetrachloride		Handle carbon tetra-chloride, with care.
	Try Javelle water		It is dangerous to inhale Javelle water fumes.
Rust stains	Salt solution, lemon juice/citric acid, oxalic acid	Wash the stain with salt solution, then lemon juice or citric acid, oxalic acid and finally with water.	
Shoe polish	First loosen the stain with glycerine chloroform or carbon tetrachloride	After loosening bleach the stain with Javelle water	It is dangerous to inhale Javelle water fumes.
	On silks and wool: Dilute solution of potassium permanganate		
Tobacco, turmeric, curry, spices sambhar	Kerosene, soap solution	Apply kerosene with a sponge then wash the stain with warm soap solution.	If stains are stubborn then use potassium permanganate solution and hot oxalic acid.
	Javelle water		It is dangerous to inhale Javelle water fumes.
Ultramarine blue	1:4, Ammonia and water	Wash with a solution of 1:4 ammonia and water.	Do not inhale ammonia fumes.
Vegetable	Javelle water or hydrogen peroxide or acetic acid/vinegar		It is dangerous to inhale Javelle water fumes. Concentrated solution of hydrogen peroxide & acetic acid is corrosive.
Wax	Sandwich stain between blotting papers and iron out		

Javelle water: Mix solutions of bleaching powder and washing soda. Keep for few hours so that a white precipitate formed settles then decant. The upper clear solution is Javelle water.



## Special Article

perborate plus activator. PBA's being compatible has no adverse effects. The slight bluing effect imparted on the washed fabric, by use of *Tinolux BBS* enhances the efficiency of a distyryl biphenyl type fluorescent whitening agent (FWA) that exhibit excellent wet and dry light stability, (e.g., *Tinopal CBS-X*). Conventional stilbene FWA's have a very limited light stability in the wash liquor and poor light fastness on the fabric, photodegrading to coloured end products when exposed to sunlight and is to be avoided in a PBA based detergent formulation.

### TOXICOLOGY & ENVIRONMENTAL ASPECTS

Present available evidence suggests that solutions containing up to 5% of sodium hypochlorite cause irritation on prolonged contact with skin or if they get into the eye. At concentrations of 10% and above burning of eyes and skin can occur.

Although hypochlorite does not appear to cause skin sensitisation, prolonged exposure can cause skin allergy. Fumes emanating from using bleach solutions generally do not appear to be irritating, but more harmful fumes can arise when hypochlorite bleaches are mixed with certain acidic products. Strict adherence to the manufacturers' recommendations on usage is necessary. Bleach solutions are very toxic to aquatic life at concentrations as low as 0.01mg/L. However, household bleach solution rapidly breaks down when it comes across mixed sewage containing inorganic and organic compounds, reducing to form inorganic chloride ions. Small quantities of organic chlorine products, certain chlorocarbons such as chloroform and carbon tetrachloride can be formed during storage and use of bleach solutions, but any health risk is generally considered to be negligible.

Tests conducted on sodium perborate, bleach active compounds show very slight acute toxicity. Prolonged contact with concentrated solutions can cause skin and mucous membrane irritation, which is more due to the alkalinity of the solution rather than the ingredient by itself. Sodium perborate undergoes rapid hydrolysis and the physiological effect is similar to borate or boric acid, which pass readily through the mucous membrane or through broken skin surface.

Intact skin does prevent excessive absorption. A dose of 18 to 20 g in adults is considered to be lethal. In the waste water systems, sodium perborate rapidly decomposes to free hydrogen peroxide, and at concentrations available in detergent formulations show no toxicity to bacteria. The ecological factor that must be considered is the increased boron concentration levels. Boron at levels of 1-2 mg/L, poses phytotoxicity concerning to plants like tomatoes, fruit trees and vineyards. It is therefore not recommended to recycle boron-containing waste water for agricultural purposes. Tetraacetythylenediamine (TAED) is a mild irritant to skin and eyes. It is non-sensitising, non-mutagenic and biodegradable with low toxicity to fish.

Extensive testing on animals and the present state of knowledge has confirmed that PBA's are safe and can be used without hazard in recommended concentrations and applications. The product however must not be swallowed. Median lethal dose tested in rats is more than 5000-mg/ Kg body weight. Tests with rabbits show no irritant effect on skin or eyes.

It is devoid of any skin sensitising, photo-allergic or mutagenic potential. It is eliminated by the microorganisms in activated sludge and does not impair their effectiveness. Today many products are available in the market that can eliminate stains. Some detergents claim to bleach out common household stains. However it is difficult to find one single or universal product that is able to remove all types of stains normally encountered by us. The self-explanatory table below gives a list, of stain removers that may be used by one to remove unwanted stains from our daily wear. The agents used are ones that one finds commonly at our homes and its use can greatly compliment household detergents to keep our laundry clean and pure.

### CONCLUSIONS

Growing awareness has vastly improved today's standard of personal health, domestic hygiene and cleanliness. Rapid industrialisation in a liberalised economy, the rising standards of living, will make modern consumer demand superior quality detergents will fulfil the consumer's perennial quest to don clothes washed clean without blotches and stains.