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Lipase enzyme based green chemistry detergents for cleaning industry

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Abstract

A detergent composition is divided into different classes on the basis of raw materials such as surfactants, builders, bleaching agents, enzymes, and minors which remove dirt, stain and soil from surfaces or textiles gave them pleasant feel and odour. This review paper describes the history, composition, types, mechanism, how detergent work, environmental effects and consumption of laundry detergents. This article also reviews the use of enzymes, especially lipases as detergents and different types of lipase containing detergents available in the market. This review describes the applications of microbial lipases in detergents which can reduce the environmental load of detergent products as the chemicals used in conventional detergents, biodegradable, non-toxic and leave no harmful residues. Besides lipases, other enzymes are widely used in household cleaning products, in laundering, medical & agriculture.

1. Introduction

Detergent has traditionally been a powdered or granular solid, but the use of liquid laundry detergents has gradually increased over the years and nowadays uses of liquid detergent equals or even exceeds the use of solid detergent. Some brands also manufacture laundry soap in tablets and dissolvable packets, so as to eliminate the need to measure soap for each load of laundry. The term 'detergency' is used to describe the process of cleaning by surface active agent. Detergency can be defined as removal of unwanted substance (soil) from a solid surface brought into contact with a liquid. The word 'soil' in connection with textile surfaces most frequently denotes the unwanted accumulation of oily or particulate materials on the surfaces or interior of fibrous structure [5].

There are two kinds of detergents with different characteristics:

1. **Phosphate detergents**: These types of detergent contain phosphates and are highly caustic. Phosphate detergents are used in laundry detergent to soften hard water and help to suspend dirt.

2. **Surfactant detergents**: These types of detergents contain surfactants are very toxic in nature. The differences are that surfactant detergents used to enhance the wetting, foaming, dispersing and emulsifying properties of detergents.

Lipases are added to detergents such as household and industrial laundry and in household dishwashers, where their function is in the removal of fatty residues and cleaning clogged drains. The cleaning power of lipase (or other enzyme containing) detergents increases markedly. The enzymes such as proteases, amylases, cellulases and lipases are added to the detergents to improve their efficiency.

Sixty years ago it was discovered that chemical technology could change the molecular structure of water with the introduction of the very first laundry detergent. It was understood that lowering of surface tension is needed for better cleaning and this was achieved by using chemical surfactants

Prior to world war first, laundry products consisted principally of sodium and potassium neutralized fatty acid soaps. The first synthetic detergents were produced in Germany during World War II as replacement of scarce animal fats traditionally used in the production of soaps, during the shortages. These were called branched chain alkyl benzene sulfonates and short chain alkyl naphthalene sulfonates. Like soap, they could take hard minerals out of water, leaving it soft[5,6].

At the time of conversion to compacts the most widely used surfactants in synthetic powder detergents were the anionic, linear alkyl aryl sulfonates (LASs) and long chain fatty alcohol sulfates (ASs), to a lesser extent, long chain fatty acids, and the nonionic alkyl ethoxylates. With the recent change in formulations and manufacturing processes precipitated by a transition to compact detergents, the major U. S. manufacturers took the opportunity to formulate out of phosphate together.

Composition: Composition of soaps and detergents are as follows,

3.1 Surfactants

The term surface-active agent represents a heterogeneous and long-chain molecule containing both hydrophilic and hydrophobic moieties. By varying the hydrophobic and hydrophilic part of a surfactant, a number of properties may be adjusted, e.g. wetting ability, emulsifying ability, dispersive ability, foaming ability and foaming control ability.

detergents may contain more than one kind of surfactants. These surfactants differ in their ability to remove certain types of soil, in their effectiveness on different fabrics and in their response to water hardness.

3.1.1 Cationic surfactants

Cationic surfactants are compounds with a positively charged nitrogen atom and at least one hydrophobic, long chain substituent in the molecule. The most common cationic surfactants are the quaternary ammonium compounds with the general formula R'R''R'''R''''N+X–, where X– is usually chloride ion and R represents alkyl groups such as alkyl trimethylammonium chloride, dodecyl trimethyl ammonium chloride etc.

3.1.2 Anionic surfactants

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Anionic surfactants, such as soap, often have a sodium, potassium, or ammonium group, as in sodium stearate. Linear chains are preferred since they are more effective and more degradable than branched ones. The most commonly used hydrophilic groups are carboxylates, sulphates, sulphonate and phosphates.

3.1.3 Nonionic surfactants:

Nonionic surfactants do not ionize in solution. Lack of charge enables them to avoid water hardness deactivation. The most common nonionic surfactants are those based on ethylene oxide, referred to as ethoxylated surfactants, alcohol ethoxylates, alkyl phenol ethoxylates, fatty acid ethoxylates, mono alkanol amide ethoxylates, sorbitol ester ethoxylates, fatty amine ethoxylates and ethylene oxide-propylene oxide copolymers. Another important class of nonionic is the polyhydroxy products such as glycol esters, glycerol (and polyglycerol) esters, glucosides (and polyglycolides) and sucrose esters. Amine oxides and sulfonyl surfactants represent nonionic with a small head group.

3.1.4 Amphoteric surfactants

These are surfactants containing both cationic and anionic groups. The most common amphoteric surfactants are the N-alkyl betaines, which are derivatives of trimethyl glycine (CH3)3NCH2COOH (described as betaine). An example of betaine surfactant is lauryl amido propyl dimethyl betaine. These alkyl betaines are sometimes described as alkyl dimethyl glycinates. The main characteristic of amphoteric surfactants is their dependence on the pH of the solution in which they are dissolved. In acid pH solutions, the molecule acquires a positive charge and behaves like a cationic surfactant, whereas in alkaline pH solutions they become negatively charged and behave like an anionic one. A specific pH can be defined at which both ionic groups show equal ionization (the isoelectric point of the molecule). In addition to above there is addition of builders, zeolites, alkaline agents, corrosion inhibitors, colorants, fragrances, oxygen bleach, Opacifiers, bleaching agents etc.

Main focus of this review is on enzymes which are now popularly blended into detergent formulations. Enzymes aid in breaking down complex soils, especially proteins such as blood and grass, so they can be more easily removed from fabrics. Protease and lipase are used to digest the soils of proteins and lipids, respectively. Cellulose is recently developed as an enzyme component of a detergent that attacks a substrate (cotton) to remove the soils [1,2].

Mechanism of action of detergent: Soaps and detergents are made from long molecules that contain a head and tail. These molecules are called **surfactants**; the diagram below represents a surfactant molecule.

The head of the molecule is attracted to water (hydrophilic) and the tail is attracted to grease and dirt (hydrophobic). When the detergent molecules meet grease on clothes, the tails are drawn into the grease but the heads still sit in the water.

The attractive forces between the head groups and the water are so strong that the grease is lifted away from the surface. The

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blob of grease is now completely surrounded by detergent molecules and is broken into smaller pieces which are washed away by the water. The detergent molecules also help to make the washing process more effective by reducing the **surface tension** of the water. Surface tension is the force which helps a blob of water on a surface hold its shape and not spread out. The surfactant molecules of the detergent break apart these forces and make water behave, well, wetter!

Emulsification is of key importance for a large number of processes such as oil recovery, detergency and the preparation of foodstuffs Emulsion is the main application of surfactant adsorption at liquid/liquid interfaces. An emulsified mixture of water in oil is commonly called mousse. During laundry, detergent is act as an emulsifier which stabilizes an emulsion and lowers the oil-solution interfacial tension and makes easy emulsification of the oily soils possible. Solubilization is usually describes as the process of incorporation of an "insoluble" substance (usually referred to as substrate or solubilization) into surfactants micelles (the solubilizer). The process of solubilization involves the transfer of co-solute from the pure state, either crystalline solid or liquid to micelles.

ENZYMES USED IN DETERGENTS

Enzymes is a biological catalyst and a substance produced by a living organism, which act as catalysts for example protease & lipase [1,3,4].

Table 2. Four classes of enzymes are generally used in detergents.

Proteases	Most widely used enzymes in the detergent industry remove protein stains such as grass, blood, egg and human sweat which tend to adhere strongly to textile fibers.
Amylases	Used to remove residues of starch-based foods like potatoes, spaghetti, custards, gravies and chocolate.
Lipases	Decompose fatty material. Lipase is capable of removing fatty stains such as fats, butter, salad oil, sauces and the tough stains on collars and cuffs.
Cellulases	Modify the structure of cellulose fiber on cotton and cotton blends. When it is added to a detergent, it results in; color brightening, softening and soil removal.

SOURCE

The enzyme protease was produced from alkaliphilic Bacillus clausii KSM-K16 and strain KP-43 and Bacillus sp. strain KSMKP43 and have been incorporated into laundry detergents. Subtilisin-like serine proteases belonging to family A of subtilize super family has been used in laundry and dishwashing detergents. A number of alkaliphilic Bacillus produce alkaline cellulase (carboxy methyl cellulase) that is used as an additive for improving the

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cleaning effect of detergents. Enzymatic properties of some cellulases fulfilled the essential requirements for enzymes to be used practically in laundry detergents.

LIPASES IN DETERGENTS

There has been a tremendous increase in the significance of the biotechnological applications of lipases since the last two decades. Lipases and cellulases in certain detergents remove dirt/ cattle manure from domestic animals. Lipases are also used in degreasing and water reconditioning in combination with oxido-reductases that require less surfactants and work at low temperatures [3].

Table 1: Composition of ingredients to production detergents

Ingredients	Powder (%wt)	Liquid (% wt)
Anionic Surfactants.	2-10	8-10
nonionic surfactants	0.5-6	18-20
soap	1-5	7-12
Bleach & activators	20-30	-
Triethanolamine	-	7-13
Ethanol	-	4-6
Enzymes	1-5	1-5
Perfume	0.2	0.4
Optical brighteners	0.4-0.8	0.2
Sodium sulfate	To make 100%	-
Water	-	To Make 100%

APPLICATION

The enzyme-based detergents have better cleaning properties as compared to synthetic detergents. They are active at low washing temperatures and environment friendly also and these enzymes in the detergents do not lose their activity after removing stain. The enzyme containing detergents also improve the fabric quality and keeping color bright. The enzyme-based detergents are used in small quantity as compared synthetic chemicals. They can work at very low temperature, environment friendly and completely biodegradable [7-9

Enzymes in detergent formulations are stable at high pH and temperature and remove protein and lipid stains. Enzymatic detergent requires low workable temperature, low mechanical energy and is less toxic and non-corrosive [4]. Thermostable enzymes are usually stable in solvents and detergents therefore, they also have considerable potential for many biotechnological and industrial applications. The cold active lipases will have a larger share of enzymes of industrial importance in the coming years with the increasing interest in psychrophiles. These enzymes offer a great industrial and biotechnological potential due to their capability to catalyze reactions at low temperature.

Conclusion

Enzymes are used in detergents to increase the cleaning ability of detergents. Enzymes can be used instead of chlorine bleach for removing stains on cloth. The enzyme-based detergents have better cleaning properties as compared to synthetic detergents. Enzymes in detergent formulations are stable at high pH and temperature and remove protein and lipid stains. The diversity of products to perform basic cleaning tasks in the house is growing, and soap and detergent producers renew their product lines by introducing new additives, improved surfactants, or new formulations to enhance performance. Several trends influence the development of consumer detergent products.

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Ethical issue

No

Conflict of interest

no

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