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Enzymes in Laundry Detergents

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ABSTRACT: The five classes of enzymes found in laundry detergent include proteases, amylases, lipases, cellulases, and mannanases. They break down proteins (e.g. in blood and egg stains), starch, fats, cellulose (e.g. in vegetable puree), and mannans (e.g. in bean gum stains) respectively. In today's laundry detergents, enzymes such as proteases and amylases are some of the active ingredients. In the U.S., about 50% of liquid detergents, 25% of powder detergents, and almost all powdered bleach additives now contain enzymes to help break down stains that are otherwise hard to remove with conventional surfactants alone. For example, amylase catalyzes the breakdown of starch-based stains to smaller segments that make up the larger starch molecule. Oligosaccharides and dextrins released from the enzyme's hydrolytic action are soluble; thus, the stain is physically cut off from the surface of the fabric piece by piece, with the enzyme acting as scissors. The action of proteases, as implied by the name itself, is similar to that of amylase, except that a large protein molecule is hydrolyzed. During the process of hydrolysis, the peptide bonds that hold various amino acids together to form a protein molecule are broken down, releasing smaller polypeptides and individual amino acid units. Generally, polymers made of less than approximately one hundred amino acid monomer units are called polypeptides and larger ones are called proteins.

KEYWORDS-laundry, detergents, enzymes, hydrolysis, bleach, cleansing

I. INTRODUCTION

Enzymes are catalysts that increase the rate of chemical reactions occurring in a variety of biological processes including digestion and growth. In the detergent industry, commercial enzymes are used to provide a higher degree of stain removal, whiteness, fabric and colour care and overall cleaning performance. These ingredients are selected based on performance and the use that is required. Enzymes act like small selective scissors to break down stains into pieces. Typically, enzymes are carefully optimised molecules for their respective processes – such as the removal of a specific protein, starch or fat stain. Thus, each enzyme has specificity for one type of reaction, which results in specific enzymes being targeted to specific types of stains. By being broken down into smaller pieces, stains on laundry are more easily removed. Enzymes are used in various cleaning applications - these highly targeted bio-catalysts help effectively eliminate stains by making them more easily removed by surfactants.

Specific enzymes target specific stains · Protease: Proteases degrade stains comprised mainly of protein, such as grass, blood, egg, and others, giving clothes a clean appearance. · Amylase: Amylases break down starch-based stains commonly caused by pasta, potatoes and baby food, which are commonly found on dishes. · Lipase: Lipases target fat-based stains such as butter, oil, and human sebum. These types of stains can cause unsightly marks after washing. Fat based stains can also contribute to increased appearance of staining after repeated washes. · Cellulase: For cotton fabrics, cellulases improve overall cleanness by reducing redeposition of particulate soils such as soot, clay, and rust during the wash. In addition, cellulases also provide fabric and colour care. · Mannanase: Mannanases degrade stains containing mannans. These stains are commonly caused by things like barbecue sauce, chocolate, ice cream and toothpaste. · Pectate lyase: Pectate lyases act on pectin-based stains from fruits and vegetables, jams and other food containing thickeners. Enzymes have a high safety profile Enzymes have a low order of toxicity (see Basketter et al). The main toxicological endpoint associated with enzymes is the potential to cause respiratory sensitisation. Inhaled enzyme dust or aerosols may potentially lead to the development of allergen-specific immunoglobulin E (IgE) antibodies. To minimise this, since the early 1970s, enzymes used in detergents are provided as low dust, granulated, and coated enzyme preparations or liquid formulations. Several studies have demonstrated that the risk of consumers being sensitised is extremely low and that enzymes can be safely used in consumer products[1,2,3]

II. DISCUSSION

Enzymes enable significant environmental savings Washing at low temperatures Did you know that 60% of CO_2 emissions from laundry and dish detergents come from the use phase? For example, the energy consumed by the washing machine and the dishwasher to heat the wash water is the largest environmental impact of washing across all life cycle stages. Thus, washing at lower temperatures is a pivotal driver to improve the overall sustainability profile of the washing process. Lower wash temperatures reduce CO2 emissions and save energy and money. Low temperature washing also ensures that clothes will last longer. Enzymes are important ingredients in low temperature wash applications for laundry detergents, due to their ability to provide washing performance at lower temperatures. In Europe, the average temperature for washing in 2020 was 42.4°C (108.32 F) based on consumer research done by the European detergent industry (see A.I.S.E. consumer research). Data collected through the "I Prefer 30°" campaign (which promotes washing at 30°C/86F) estimated a saving of 1307.9 GWh/year of current total laundry energy in the five campaign countries, based on a 3°C reduction of the average wash temperature

Innovating compact products The detergent industry has globally engaged in various projects to drive the compaction of detergent products as part of its strategy to drive sustainable cleaning. Compaction means that the product is in a form that reduces weight and packaging to be used, because it is more concentrated. This has had positive consequences leading to an optimal use of ingredients, reduced transport, savings in packaging and reduced CO2 emissions. Compaction has been enabled through process technology innovation. In early innovation efforts compaction was facilitated by removing water and fillers. Innovation became more sophisticated, by employing new catalytically active performance ingredients such as enzymes, which have a high performance at low concentrations in the formula. Such innovation with enzymes has enabled significant environmental savings, while securing equivalent cleaning performance .Alternative technology to replace phosphates Phosphates and phosphonates were previously used in detergent products to remove soap scum and mineral deposits caused by hard water. Within the United States, phosphates were phased out of laundry detergents in the 1990's and in automatic dishwasher detergents in 2010 due to concerns of negative impacts on water systems. The European Detergents Regulation restricted the use of phosphates and phosphonates due to concerns with excess of algae growth in water environment. The restriction in Europe resulted in the equivalent reduction of some 55 000 tonnes of phosphorus per year across the EU. Enzymes provided the alternative technology to transition away from phosphates and phosphonates, and still maintain cleaning performance.[4,5,6]

III. RESULTS

Specific applications for enzymes

In consumer detergents Dishwashing Automatic and hand dishwashing detergents contain enzymes that remove food soils effectively with only mild mechanical action required. This allows reduced usage of water, less time spent on cleaning dishes and tableware that lasts longer. Laundry Enzymes remove stains effectively under mild conditions. Clothes can last longer and keep a good appearance, thereby reducing the need to replace them. Whiteness Enzymes cleave off damaged cotton fibres, thus preventing particulate soil from depositing and participating in fabric greying, improving whiteness performance. Colour and fabric care Specific types of enzymes improve the appearance of fabrics (colour care and smoothening the surfaces) which helps to prolong their lifetime. Cellulases degrade cellulose and contribute to fabric care.

In detergents for professional use

Cleaning of medical devices The basic properties of enzymes being able to function at low concentration, low-temperatures and mild pH is useful in cleaning of medical devices that cannot be cleaned in normal sterilisation machines, e.g. endoscopes. Enzymes are effective at loosening soils on delicate pieces of equipment where mechanical action is difficult to achieve. This allows the devices to be properly cleaned prior to disinfection. Better cleaning is important to reduce risk of patient infection from contaminated equipment, it also leads to a longer lifespan of the device and less time wasted in the operating suite from turning away dirty equipment. Laundry Enzymes are necessary to remove blood stains, particularly in hospital linens.

Ware-washing applications

Industrial dishwashing products have begun to introduce enzymes for improved cleanliness by means of sump maintenance as well as less time cleaning and reduced water use. As commercial dishwashing machines recirculate wash water for the cleaning process the sump, or water reservoir, becomes soiled from food residue. Enzymes aid in the breakdown of food waste, helping to maintain the sump water for longer. Maintenance of sump water means not having to replace the water as frequently or heat new water.

Floor cleaning

Enzymes can be used to remove food soils from floors, especially in commercial kitchens. Lipases are effective at breaking down fat, or lipid, based soils. The soils can be destructive to grout in tiled floors. Fat based soils can also be a safety concern for staff in kitchens.[6,7,8]

Enzymes are increasingly used as active ingredients in consumer products, detergent enzymes being a very prominent example. Particularly proteases are well-established constituents of modern washing and cleaning products, allowing the removal of protein-containing soiling. Due to their stability at high pH and temperature and their tolerance towards elevated concentrations of denaturing agents such as detergents or oxidants, subtilases are mostly used in this field of application. Subtilases are non-specific serine endopeptidases (superfamily S8 according to the Merops system of classification, http://merops.sanger.ac.uk) and can be divided into six families by sequence alignment (Siezen and Leunissen, 1997). Commercially relevant enzymes group into true and high-alkaline subtilisins (family A), Thermitases (family B) and Proteinase K-type enzymes (family C). Family A comprises the widely used detergent proteases of Bacillus licheniformis[subtilisin Carlsberg (Smith al et., 1968; Jacobs al et., 1985)], amyloliquefaciens B.[subtilisin BPN' (Wells al et., 1983; Vasantha al et., 1984)] and lentus B.[subtilisin BL (Goddette al et., 1992)]. During the past decades, many efforts have been made to identify new proteases and optimize existing ones to meet the specific requirements for very diverse laundry and cleaning processes (Herbots, 2007).

Industrially relevant proteases so far have been obtained by screening culture collections or by using classical microbial enrichment techniques. However, this approach is intrinsically limited to microorganisms that are able to grow under laboratory conditions, thereby only capturing a small fraction of the microbial diversity present in nature. It has been estimated that less than 1% of microorganisms in the environment can be cultivated by using standard laboratory techniques (Amann al et., 1995). Due to this general limitation of traditional culture-based enzyme recovery, the screening of metagenomic DNA libraries has become an attractive alternative. It does not require the cultivation of microorganisms, but solely relies on the genetic information stored in the collective genomes of all microorganisms present in an environmental sample, the so-called metagenome (Handelsman al et., 1998). During the past years, a variety of new enzymes has been recovered by this method (for a recent compilation see Eck al et., 2009), usually being only distantly related to sequence database entries.

Enzymes for textiles

Circular fashion starts with sustainable production; free from waste, water pollution, emissions and chemicals

Our biodegradable, environmentally-friendly enzymes can help your mill or laundry achieve the standards needed to be part of the circular fashion movement. They support more sustainable wet processing, improved working conditions and superior fabric quality. They also play a part in closing the fashion loop by helping textile recycling programs give garments a second life.[8,9,10]

IV. CONCLUSION

Merits

Household energy savings

For stain removal, conventional household washing machines use heated water, as this increases the solubility of stains. However, heating the water to the required temperature uses a considerable amount of energy; energy usage can be reduced by using detergent enzymes which perform well in cold water, allowing low-temperature washes and removing the need for heated water.[5]

Delicate materials

Clothes made of delicate materials such as wool and silk can be damaged in high-temperature washes, and jeans and denim can fade due to their dark dyes. Low-temperature washes with detergent enzymes can prevent this damage, meaning that consumers can buy clothes from a wider range of materials without worrying about damaging them during washing.[5]

Leather manufacturing

The leather industry was historically considered noxious due to the leather-making process. The traditional procedure involved soaking animal hides in a mixture of urine and lime to remove unwanted hairs, flesh and fat, then kneading them in dog or pigeon feces with bare feet. The subsequent discharge and refuse disposal was severely hazardous to both human health and the environment because of the high amounts of concentrated sulfide and chromium in the effluence.[6]

This method was eventually discarded by the industry in the early 20th century following Röhm's discovery, replaced by a more eco-friendly process involving detergent enzymes.[5] Consequently, hazardous sodium sulfide (used to remove animal hair from hides) usage is lessened by 60%, while water usage for soaking and hair cutting is lowered by 25%. Additionally, toxic pollution and emissions have been reduced by 30%. These enzymes have never completely substituted the industrial chemicals. Nevertheless, the working conditions, wastewater quality, and processing times have been greatly improved.[6]

Replacement for phosphate and synthetic surfactants

Increased legislation has led to a limit on the laundry detergent industry's use of environmentally-unfriendly synthetic surfactants and phosphate salts. In a bid to produce more environmentally-friendly products, several detergent manufacturers have increased their use of enzymes in the production process in combination with lower concentrations of the surfactants and phosphates. These biologically active enzymes include bacteria, yeast, and mushrooms,[7] which produce less chemical pollution and decompose certain toxicants.[8]

Public concerns

Damage to delicate materials

In contrast to the benefits of low-temperature washing, a study of the effects of detergent enzymes on untreated knit and woolen fabrics showed damage proportional to both soaking time and the enzyme concentration.[9]

Skin allergy and testing

Consumers' responses to detergent enzymes have varied. It is reported that some Philippine consumers who are used to laundering by hand slightly suffered from powder detergents, which mainly consisted of laundry enzyme formulations. As a result, it was thought that laundry enzymes have the potential to increase the likelihood of getting occupational type 1 allergic responses.[10] However, a large-scale skin prick test (SPT) containing 15,765 volunteers with 8 different types of detergent enzymes found that the allergy reaction is extremely rare among the public, with only 0.23% showing a reaction.[11] The issue in Filipino consumers is believed to be the rushed hand-laundering method.[10] After various tests with several volunteers worldwide, it is found that exposure to laundry enzymes leads to neither skin allergy (Type I sensitization) nor skin erosion[11]

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