Enzyme-based oxygen scavengers based on glucose oxidase/catalase

Identification

Key words  immobilized enzymes, packaging, glucose oxidase, sachets
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How does it work?

Primary objective  Certain enzymes have been shown to improve the shelf life of packed food, acting as oxygen scavengers.
Working principle  Residual oxygen can react biochemically with contained food and cause long-term adverse oxidative effects. Some barrier and vacuum packaging has been supplemented recently by an oxygen-scavenger component of active packaging. By attaching oxygen scavengers to the packaging material the oxygen content in food packaging is reduced. In addition to ferrous compounds, catechol, ascorbic acid and its analogues, unsaturated hydrocarbons and polyamides, enzymes can be used as oxygen scavengers.
Glucose oxidase is a potential enzyme for oxygen-adsorbing processes. The oxidation of glucose to gluconic acid and hydrogen peroxide is catalyzed by glucose oxidase, which is rendered harmless by a further enzyme, catalase, in that it is degraded to water and oxygen. Glucose must also be present, either as a part of the food or as a component in the enzyme formulation. The presence of catalase is important for the elimination of the produced hydrogen peroxide. Mixed enzymes (glucose oxidase and catalase) are commonly used. For food safety reasons, the enzyme used in oxygen-scavenging packaging has to be attached to the packaging material (i.e. incorporated in the packaging films) or to be present in sachets. The enzyme-based oxygen absorbers can (in principle) be produced as: sachets, laminates or enzymes immobilized on PP and PE films. In the case of laminates and films, the enzymes have to be immobilized in order to prevent contamination of the packed food. The substrate for the enzymes (oxidoreductases and other enzymes consuming oxygen) should be carefully selected and distributed in the coatings.

Images

Additional effects  Immobilized enzymes are retained at the reaction site and do not contaminate the products. A broad range of enzymatic reactions arising from their incorporation into package materials are available, only a relatively small number have actually been attempted on a practical basis, the major examples being oxygen removed by means of glucose oxidase plus catalase.
Important process parameters

The major variables are the speed of the enzyme reaction, the quantity of glucose available, and the rate at which oxygen enters into the package. One mole of glucose reacts with one-half mole of oxygen, thus decreasing the overall effectiveness of the system. Catalase is introduced to break down the hydrogen peroxide. The sum of these two reactions yields half the oxygen originally present, and therefore ultimately the free oxygen approaches zero. Scavengers are capable of eliminating relatively large volumes of oxygen and continuing their action indefinitely as long as the scavenger is present.

Important product parameters

What can it be used for?

Products
Oxygen absorbers (sachets, labels, fils, cork) are commonly found in meat and poultry products, coffee, tea, ready-to-eat meals, pizzas, baked goods and dried foods (milk powder).
Development of coated sheets or films with active enzymes to prolonged shelf-life using enzymatic oxygen scavengers in barrier dispersion coatings. Boxes and flexible packaging based on enzymatic oxygen scavengers. Oxidation of cheese surfaces: by the presence of the enzyme containing package material (a dry glucose oxidase/catalase/glucose/buffers blend to be placed in small packets).

Operations
Packaging

Solutions for short comings
Certain enzymes have been shown to improve the shelf life of packed food, acting as oxygen scavengers.
Reduce the need for additives or preservatives.

What can it NOT be used for?

Products
Enzyme-containing sheets are only active upon activation in liquid. Water is needed for enzymatic reactions to take place and it has also been shown that the enzyme-containing sheets are only active in the presence of liquid (5). The enzymes oxidize a lot of the glucose when the film is wet (the case for the film dried only at 23°C and 50% RH)(4).

Operations
The drying step of the coating process is performed at high temperatures. The temperature needs to be above the minimum film forming temperature, but not so high so that the activity of the enzyme is lost (4).

Other limitations
The rate at which oxygen enters into the package.
Given the proper substrate, enzymes can directly affect the formation and/or degradation of sensory active compounds. In general, enzymes are very expensive and are obviously only reacting with oxygen under special well-defined conditions (pH, humidity, temperature). The process drying conditions for the production of enzyme-containing oxygen-scavenging papers with a sufficient enzyme activity are very important. The preferred short-time drying conditions also indicated that it is possible to use traditional drying units (drying hoods and IR dryers) in the full-scale production of enzyme-containing coated papers (4).

Risks or hazards
Sachets have the risk of accidental ingestion by consumers and this may account for their limited commercial success in North America and Europe (2).
Implementation

Maturity
Commercially available O2-absorbing sachets based on reactions catalysed by food-grade enzymes exist on the market. Patent in Finland

Modularity/Implementation
Can be incorporated into small gas-permeable flexible pouches or bags placed into the food package, not only to remove residual oxygen, but also to later intercept any oxygen entering the package.

Consumer aspects
Consumers demand for fresh-like, minimally processed foods without artificial additives and without unnaturally long shelf lives. Consumers are actually willing to pay more for products with an oxygen absorber to get food of high quality without the use of food additives. Use of absorbers was well accepted for foods like pizza and rye bread.

Legal aspects
European regulations do not allow many of innovative active packaging concepts to be used, especially nano applications. The advantages of this system reside in the harmlessness of the natural components regarding food laws.

Environmental aspects
New environmental directives on re-use and re-cycling. All packaging on the EU market should be manufactured according to the European Parliament and Council Directive 94/62/EC on packaging and packaging waste. Less environment impact

Facilities that might be interesting for you

Further Information

Institutes
SP, Karlstad University, Mugla University

Companies
Bioka

References