

Application of Immobilized enzymes

Immobilized enzymes are used across various industries, including food and beverage, pharmaceuticals, and biofuel production, as well as in biomedical and environmental applications. By binding enzymes to a solid support, they can be reused multiple times, exhibit higher stability, and allow for a continuous, cost-effective process.

Food and beverage industry

Immobilized enzymes are widely utilized for the efficient and reproducible processing of food and drink products.

- **Production of high-fructose corn syrup (HFCS):** Immobilized glucose isomerase is a key component in the large-scale, continuous conversion of glucose to fructose for HFCS production.
- **Lactose-free milk:** Immobilized lactase (β -galactosidase) breaks down lactose into glucose and galactose, making milk and other dairy products digestible for lactose-intolerant people.
- **Cheese making:** Enzymes like immobilized chymosin coagulate milk proteins for cheese production. Immobilized lipases can also enhance the flavor development of cheese.
- **Juice clarification:** Pectinases are immobilized to break down pectin in fruit and vegetable juices, which reduces turbidity and increases juice yield.
- **Brewing:** Immobilized enzymes are used to ferment sugars into ethanol and also to prevent "chill haze" from forming in beer.

Medical and pharmaceutical fields

Immobilized enzymes enable more efficient and precise applications in diagnostics and drug production.

- **Biosensors:** Enzymes are immobilized on electrodes to create biosensors that can detect specific compounds. A prime example is the glucose sensor, where glucose oxidase is used to measure blood glucose levels in diabetic patients.
- **Encapsulated enzymes** can be used to treat metabolic disorders by correcting metabolic imbalances or removing waste products from the body. Enzymes have been encapsulated within red blood cells or liposomes for this purpose.
- **Immobilized enzymes**, such as penicillin acylase, are used in the large-scale, cost-effective production of semi-synthetic antibiotics like amoxicillin and ampicillin.
- **Cancer therapy:** Immobilized enzymes can act as therapeutic agents to target and destroy cancer cells.

Biofuel production

The use of immobilized enzymes is a critical technology for producing cleaner, renewable energy sources.

- Bioethanol production:** Immobilized enzymes and yeast cells are used to ferment biomass, such as corn and lignocellulosic materials, into bioethanol.

- Biodiesel production:** Immobilized lipase catalyzes the transesterification of oils and fats to produce biodiesel. The ability to reuse the lipase makes the process more economically viable.

- Enzymatic biofuel cells (EBFCs):** EBFCs use immobilized enzymes as catalysts to convert chemical energy from biofuels, like glucose, into electrical energy under mild conditions.

Environmental remediation

Immobilized enzymes offer an eco-friendly and efficient method for treating various pollutants.

- Wastewater treatment:** Immobilized enzymes, particularly oxidoreductases like laccases and peroxidases, are used to degrade or detoxify a wide range of organic and chemical pollutants in wastewater.

- Phenolic compound degradation:** Laccases and tyrosinases are immobilized to degrade hazardous phenolic compounds, including bisphenol A (BPA) and chlorophenols.

- Dye decolorization:** Laccases and peroxidases are used in enzyme-immobilized reactors to break down synthetic dyes from textile industry wastewater.

- Plastics recycling:** Enzymes like PETase and cutinase have been immobilized to break down plastics, such as polyethylene terephthalate (PET), into recyclable monomers.