The Industrial Production of Enzymes

Introduction

- Enzymes are protein molecules (except ribozymes which are RNA molecules) that catalyze biochemical reactions.
- In enzymatic reactions, the molecules at the beginning of the process, called substrates, are converted into different molecules, the products.
- The enzymes speed up the reaction by forming transition state complexes with the substrate which reduces the activation energy of the reaction.

Introduction

- Enzymes are attractive for industrial purposes because they are effi cient and selective in the chemistries they accelerate and they act in a similar way to the inorganic catalysts used in the chemical industry.
- Enzymes have been used throughout human history in cheese manufacturing and in food manufacturing indirectly via yeasts and bacteria

Introduction

- Isolated enzymes were fi rst used in detergents in 1914, although their protein nature was not proven until 1926, and their large - scale microbial production started in the 1960s.
- The industrial enzyme business is steadily growing due to improved production technologies, engineered enzyme properties, and new applications.

Introduction

- Enzyme technology is an interdisciplinary fi eld, and enzymes are routinely used in many environmental friendly industrial sectors.
- Recent advancements in biotechnology, especially in the areas of genetics and protein engineering, have opened a new arena for the application of enzymes in many industrial processes.
- The industrial enzymes represent the heart of biotechnology processes.

Enzyme Production

- Most of the enzymes are commercially produced by microorganisms through submerged fermentation though some are produced by solid - state fermentation.
- The major industrial enzymes are produced by GRAS (generally recognized as safe) - status microorganisms in large biological reactors called fermenters.

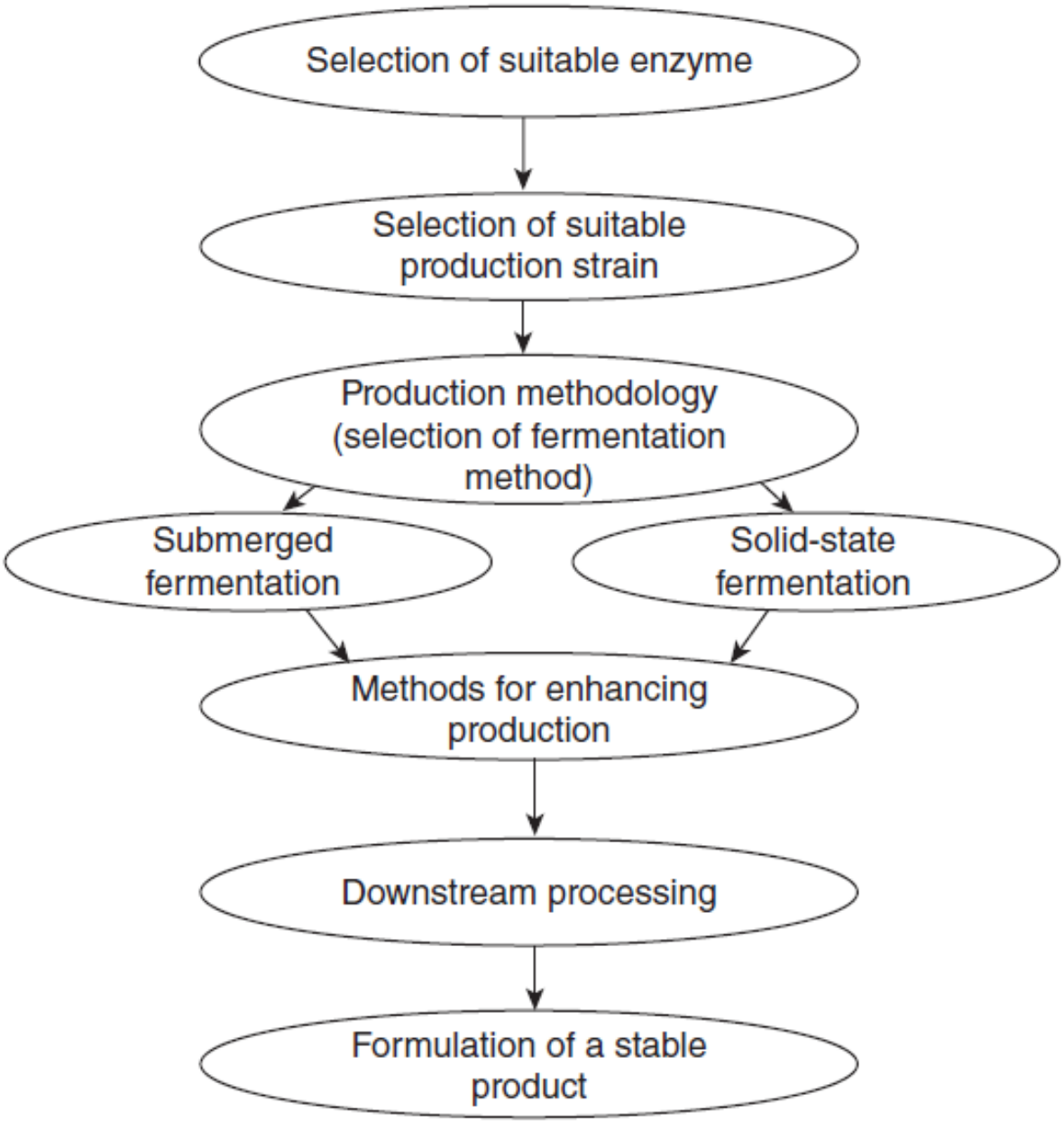

Figure 5.1 Steps involved in enzyme production.

Table 5.1 Application of various enzymes in important industrial sectors.

Industry	Enzyme	Application/function/role
Detergent	Protease	Removing protein stains by degrading them
	Cellulase	Loosening of cellulose fibers to easily remove dirt and color brightening
	Lipase	Removing fat stains by degrading them
Paper and pulp	Xylanase	Biobleaching
	Cellulase	De-inking of paper for recycling
	Laccases and peroxidase	Polymerizing materials with wood-based fibers
Textile	Cellulase	Bio stonewashing denim, biopolishing
	Amylase	Desizing of textiles
	Catalase	Bleach clean-up
Leather	Protease, lipase	Soaking, bating, and de-hairing of animal skin
Animal feed	Phytase	Release of phosphate
	Xylanase	Fiber solubility

Table 5.1 Application of various enzymes in important industrial sectors.

Industry	Enzyme	Application/function/role
Food industry		
Starch	α- and β-Amylase, pullulanase, invertase, glucose isomerase	Production of various types of syrups from starch and sucrose
	Glucose oxidase	Enhancing the storability of food by removing oxygen and glucose from the food stuff
Fruit juice	Cellulase, xylanase, pectinase	Juice clarification and juice extraction
Bakery	Xylanase	Dough conditioning
	α-Amylase	Loaf volume, shelf-life
	Glucose oxidase	Dough quality
Dairy	Renin	Protein coagulation
	Lactase	Lactose hydrolysis
	Protease and lipase	Ripening of cheese
Brewing	Glucanase	Filter aid
	Papain	Haze control
Biofuel	Cellulase and β-glucosidase	Hydrolyzing cellulosic biomass to generate glucose
	Xylanase	Hydrolyzing hemicelluloses to generate pentoses

Selection of a Suitable Enzyme

- Criteria used in the selection of an industrial enzyme include specificity, reaction rate, pH and temperature optima and stability, effect of inhibitors, and affinity to substrates.
- Specific enzymes are required with specific properties based on particular applications.
- For example, enzymes used in the paper industry should not contain cellulose - degrading activity as a side - activity because this would damage
- the cellulose fibers.

Selection of a Suitable Production Strain

- Microorganisms are the preferred source for industrial enzymes, rather than plants or animals, because of their fast multiplication rate and ease of culture
- The use of filamentous fungi for the production of primary and secondary metabolites has increased rapidly
- The extracellular enzyme producers are preferred to intracellular producers because the recovery and purification processes are much simpler

Production Methodology

- Once the organisms has been selected, the production process has to be developed.
- Submerged fermentation has been extensively used for the industrial production of enzymes to date, but solid - state fermentation is rapidly gaining interest worldwide for the production of primary and secondary metabolites
- The optimization of a fermentation process includes choice of media composition, cultivation type, and process conditions irrespective of the type of bioprocess and considerable effort and time needs to be expended to accomplish these tasks.

Production Methodology

- Is the organism in question safe?
- Are extra precautions needed?
- What kind of nutrients does the organism need and what are their optimal/economic concentrations?
- How should the nutrients be sterilized?
- What kind of reactor is needed (mass transfer, aeration, cooling, foam control, sampling)?
- What variables need to be measured and how should the process be controlled?

Production Methodology

- What method of cultivation is best for this organism (batch, fed - batch, or continuous cultivation)?
- What are the optimal growth conditions, the specific growth and product formation rate, the yield and volumetric productivity?
- How can cell concentration be maximized in the reactor?
- How should the cell be degraded if the product is intracellular and how should the product be recovered, purified, and preserved?