Lecture IV
Production of Bio-fuels and Chemicals from Biomass

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Abstract

Renewable lignocellulosic biomass, such as agricultural and forestry residues, waste paper and industrial waste, is an attractive feedstock for bioethanol production. Lignocellulose, which is composed of cellulose, hemicellulose and lignin, is often hydrolyzed by pretreatment and successive enzymatic breakdown. Then, hydrolyzed mixed sugar is converted to bioethanol or other compounds by genetically engineered bacteria or yeast. However, since such lignocellulose hydrolysate contains not only glucose, but also various monosaccharides, such as xylose, mannose, galactose and arabinose, and oligosaccharides, microorganisms should be required to efficiently ferment these sugars for the successful industrial production of bioethanol.

Recent research and development has reduced dramatically the production cost of enzymes for hydrolysis of lignocellulose. In addition, fermentation strains to convert mixed sugar to bioethanol have been improved. Using these enzymes and strains, simultaneous saccharification and fermentation (SSF) system, in which hydrolysis of lignocellulose and fermentation of resulting mixed sugar are combined in one step, has been developed. To further reduce the cost of bioethanol production, the development of super- microbial strains, which produce hydrolysis enzymes and ferment resulting mixed sugars, could enable combine enzyme production, enzyme hydrolysis and fermentation into one step. That is, super-microbial strains could directly convert cellulosic and himicellulosic sugars into bioethanol. This approach is called consolidated bioprocessing (CBP).

Among ethanol-producing microbial strains, yeast Saccharomyces cerevisiae, has several advantages owing to its high ethanol production from hexoses and high tolerance to ethanol and other inhibitory compounds in the hydrolysates of lignocellulosic biomass. We have developed the super yeast S. cerevisiae strain for CBP. The cell surface engineering is one of the key technologies for development of CBP yeast, because the diffusion problem of substrate and product is circumvented. In addition, the displayed enzymes are regarded as a kind of self-immobilized enzyme on the cell surfaces.

In this study, the bioethanol production from cellulosic materials was investigated by using yeast cells displaying cellulolytic enzymes. Due to the display of these enzymes, cellulosic materials were sequentially hydrolyzed to glucose on the yeast cell surface, immediately utilized and converted to ethanol by intracellular enzymes. The yield in terms of grams of ethanol produced per grams of carbohydrate utilized was over 0.45, which corresponds to over 89% of theoretical yield. Therefore, a combination of cell surface displayed enzymes and intracellular metabolic system is a very effective approach to develop CBP yeast cells.

Short Biography

Akihiko KONDO is currently Professor, Director of Biorefinery center. His research interests include development of novel cell surface display systems and their applications, combinatorial bioengineering, development of novel drag and gene delivery systems, application of nanomaterials to biomedical fields, development of intelligent bioreactors, and production of biofuels and chemicals from biomass for sustainable society. He is the member of The Society of Chemical Engineers, Japan, The Chemical Society of Japan, The Society for Biotechnology, Japan, Japanese Society for Bioscience, Biotechnology and Agrochemistry, JBA, Bioengineering Division. He received his PhD in Chemical Engineering, Kyoto University, Kyoto, Japan 1983. He was promoted as a full professor at Kobe University from 2003.

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