行政院原子能委員會

委託研究計畫研究報告

【纖維素轉變為酒精之微生物基因工程】

【Genetic engineering of a multifunctional yeast strain】

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中文摘要

對於全球性的能源耗竭，各國政府無不憂心忡忡，一方面想辦法節約能源，另一方面則是積極開發新的替代能源，諸如水力發電、風力發電、太陽能發電、生質能再利用等。本計劃之目的是希望利用微生物基因工程的方式將廣泛存在的纖維素及半纖維素等轉化為有用的能源－酒精。天然纖維素常與半纖維素、木質素及樹脂伴生在一起，是地球上存量最豐富的多醣化合物，也是植物細胞壁最主要的成分，廣泛存在於植物如樹幹、稻梗、草梗、玉米梗、及甘蔗渣中。值得注意的是：纖維素(cellulose)是由葡萄糖分子以 -醣苷鍵連接而成的多醣，因此不能被動物細胞直接消化利用，但能為若干微生物所消化分解。目前科學家們正在著手研究如何利用纖維素分解酵素（cellulase）將纖維素水解成葡萄糖，最後發酵成酒精。這對於缺乏天然資源的台灣而言尤其重要。酵母菌雖然具備絕佳的發酵代謝機制，但是因為本身缺乏纖維素或其它多醣體的分解酵素，因此無法直接分解及利用自然界廣泛存在的多醣體。本計劃之目的在於以微生物基因工程的方式將纖維素及半纖維素的分解酵素基因嵌入酵母菌的染色體中，使酵母菌能夠直接代謝這些多醣，並進一步將之發酵為酒精。首先我們將以 PCR 的方法將相關的分解酵素基因由不同的微生物中放大及分離出來，然後將這些基因分別選殖於不同的表現載體中，最後利用基因工程的方法將這些基因全部嵌入酵母菌的染色體中，創造出一個一貫作業式的微生物，能夠直接分解纖維素及半纖維素產生酒精。

Abstract

Global energy resources are consumed with increasing speed and will soon be running out. It is imperative for the officials to find alternative energy sources such as solar energy, wind energy, and biomass to reduce the exploitation of natural resources. Cellulose, the main component of plant cell walls, is a polysaccharide composed of -linked glucose molecules. Cellulose is the most abundant polysaccharide on earth, and along with hemicellulose, lignin, and plant pectins, make up a large part of wood, plant stalks, plant fibers, and leaves. Many bacteria are able to break down cellulose and absorb it in the form of simple sugars, but animals are unable to digest it. Currently, scientists are studying ways of using cellulase to digest cellulose and convert it into ethanol as an energy replacement for petroleum. Yeast is an ideal organism for fermentation and the production of ethanol, but it is unable to directly utilize cellulose or its derivatives found in the environment due to a lack of the necessary digestive enzymes. Therefore, we propose here to insert the genes that produce enzymes capable of digesting cellulose and hemicellulose and their derivatives into the yeast chromosome by genetic engineering, and produce a yeast strain capable of directly breaking down these polysaccharides and using them in the production of ethanol. First, we will use the polymerase chain reaction to obtain genes encoding digestive enzymes from different microorganisms and clone these genes into suitable vectors. These genes will then be inserted into the yeast chromosome through genetic engineering. Hopefully, we shall obtain a yeast strain capable of breaking down cellulose and hemicellulose (containing 5-carbon derivatives) into simple sugars and then fermenting these products to ethanol.