Microbial pretreatment of biomass for renewable energy production

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Abstract

Anaerobic digestion of lignocellulosic biomass without pretreatment often transforms just one-third of the carbon into biogas, which is generally only 60% methane. Physical and chemical pretreatments to boost biomass biogas generation have shown to be ineffective. Caldicellulosiruptor bescii, an anaerobic thermophile, has been found to be capable of solubilizing up to 90% of lignocellulose, making the carbon available for anaerobic digestion. C. bescii has been shown to be capable of solubilizing a wide range of lignocellulosic materials in preliminary trials. Anaerobic digestion turns soluble materials into biogas with 70-80% methane quickly and efficiently. Isothermal biomicrocalorimetry experiments have shown the process's thermodynamics. We used the pretreatment-anaerobic digestion technique on gigantic king grass and saw a considerable increase in biogas generation. BEST is now gathering data on the pretreatment process using C. bescii and developing system prototypes to demonstrate the viability of scaling up to megawatt plants. Bioenergy is energy derived from biomass, and it plays a significant role in the promotion of renewable energy sources. LC biomass, which contains lignin, cellulose, and hemicelluloses, is one of nature's most abundant renewable bioresources. Lignocellulosic materials, such as agricultural and forest leftovers, energy crops, and municipal and food waste, are the finest sources for biofuel generation, such as biogas. According to the most recent biogas data data, energy crops, manure, and other agricultural leftovers account for over 72 percent of the feedstocks utilised in the anaerobic digestion (AD) process for biogas generation in Europe. The fundamental problem with utilising lignocellulosic (LC) biomass for biogas generation is biomass recalcitrance, which refers to the resistance of the biomass to chemical and biological degradation. Because of the complex structure that makes up LC biomass, which is utilised as a feedstock for biogas generation, the standard AD process has a lower hydrolysis rate. As a result, LC biomass pretreatment prior to AD is regarded as a critical step in improving biodegradability and biogas generation. Because of the short response time and increased requirement for nourishment for enzymatic reactions, as well as the fact that most enzymes do not react in the presence of inhibitors and other microbial metabolites, this pretreatment approach is gaining popularity. Because commercial and purified enzymes are too expensive for the AD process, using an enzyme-secreting, bacterial consortia for biomass is advantageous. Physical and chemical pretreatments for lignocellulosic resource breakdown are energy intensive and involve chemicals that may be harmful to the environment. Under this context, biological pretreatment (BP) is an appealing option that is carried out in considerably milder environmental conditions, requires less energy, and does not require any chemicals, and is thus an ecologically benign procedure. As a result, the primary purpose of BP is to remove as much lignin as possible while also breaking the crystalline structure of cellulose to make it more accessible to enzymes and microbes. For improving biogas production, BP has focused on enzymes, fungal strains, and microbial populations in both aerobic and anaerobic settings. Bioenergy is energy derived from biomass, and it plays a significant role in the promotion of renewable energy sources. LC biomass, which contains lignin, cellulose, and hemicelluloses, is one of nature's most abundant renewable bioresources. Lignocellulosic materials, such as agricultural and forest leftovers, energy crops, and municipal and food waste, are the finest sources for biofuel generation, such as biogas. According to the most recent biogas data data, energy crops, manure, and other agricultural leftovers account for over 72 percent of the feedstocks utilised in the anaerobic digestion (AD) process for biogas generation in Europe. The fundamental problem with utilising lignocellulosic (LC) biomass for biogas generation is biomass recalcitrance, which refers to the resistance of the biomass to chemical and biological degradation. Because of the complex structure that makes up LC biomass, which is utilised as a feedstock for biogas generation, the standard AD process has a lower hydrolysis rate. As a result, LC biomass pretreatment prior to AD is regarded as a critical step in improving biodegradability and biogas generation. Because of the short response time and increased requirement for nourishment for enzymatic reactions, as well as the fact that most enzymes do not react in the presence of inhibitors and other microbial metabolites, this pretreatment approach is gaining popularity. To breakdown the mixture of lignin and hemicellulose and extend the active contact surface between cellulose and enzymes, pretreatment is necessary. In order to increase AD efficiency, different pretreatment strategies for enhancing LC biomass digestibility have recently been advocated. Physical, chemical, and biological pretreatment procedures are available, and they can be applied separately or in combination. Physical and chemical pretreatments for lignocellulosic resource breakdown are energy intensive and involve chemicals that potentially harm the environment. Under this context, biological pretreatment (BP) is an appealing option that is carried out in considerably milder environmental conditions, requires less energy, and does not require any chemicals, and is thus an ecologically benign procedure. As a result, the primary purpose of BP is to remove as much lignin as possible while also breaking the crystalline structure of cellulose to make it more accessible to enzymes and microbes. For improving biogas production, BP has focused on enzymes, fungal strains, and microbial populations in both aerobic and anaerobic

settings. The report conducts a comprehensive review of recent research findings on the various techniques of BP of the substrate for biogas generation, excluding other physical and chemical approaches. The primary microorganism (bacteria and fungi) and enzyme-based strategies are described, as well as the results acquired in boosting biogas output. This comprehensive study aims to cover as many different types of biological treatments as possible, as well as a comparison of them, to aid future research into optimising the AD process.

Biography

Dr. Alhseinat is currently an Assistant Professor of Chemical Engineering at Khalifa University. Prior to join Khalifa University, Dr. Alhseinat completed his PhD from the University of Edinburgh. Then he worked in Abu Dhabi Petroleum Institute as Research and Teaching Associate; where he was heavily involved in research activity, writing and preparing scientific proposals and presentations, and publishing scientific articles. His current research activities address the development of novel separation processes compatible with renewable energy i.e. Magnetic nanoparticles, Electrical and Magnetic separation technologies, Foaming predication and monitoring, thermodynamics modelling and thermophysical properties characterization, Desalination and Water treatment, and Fouling science.

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