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Sequential process for bacterial production of poly-3-hydroxybutyrate from methane generated from anaerobic digestion of rice straw

This study aims to produce bioplastic raw material from anaerobic digestion of agricultural waste rice straw followed by bacterial polyhydroxyalkanoate (PHA)-accumulating activity. PHA can be biocompatible and thus be a raw material for medical plastics depending on its composition. The sequential process for producing PHA from methane generated from anaerobic digestion of rice straw was studied. Pretreatment of rice straw, mixing intensity of reactor in anaerobic digestion step, and gas compositions in PHA accumulation step were selected for major components to optimize overall process in this study. Three pretreatment strategies including hot water extraction, acid and alkali treatment were tested to effectively liberate lignin, hemicellulose, and cellulose from rice straw. Through anaerobic digestion of pretreated samples, the highest methane amounts of 827.8, 831.9, 703.2 mL CH_4 gas/g TC (total carbon) were obtained with hot water (i.e., DI water for 30 min), 1% NH_3 solution, and 0.01% H_2SO_4 solution, respectively. Various mixing intensities (i.e., no mixing, once a week, twice a week, once a day, 50 rpm, 150 rpm, and 300 rpm) were also tested with batch and semi-continuous reactors operated for up to 50 and 300 days, respectively. In both batch and semi-continuous reactors, highest content of methane (i.e., 47.3% and 53.2%, respectively) and maximum amount of methane (i.e., 373.0±4.1 mL/g TC and 437±2.3 mL/d·g TC, respectively) in biogas (i.e., mixture of 50% methane, 45% carbon dioxide, and 5% nitrogen) produced from the anaerobic digestion of rice straw were observed with once-a-day mixing condition. A bacterial species capable of accumulating PHA from methane was isolated from activated sludge, and identified and named *Methylocystis parvus* MK1. Under nitrogen-deficient condition, *M. parvus* MK1 was able to accumulate 15.7 mg of poly-3-hydroxybutyrate (P3HB) using the biogas. Different gas compositions (i.e., 100% methane, 100% biogas, 80% biogas with 20% air, 70% biogas with 30% air, 50% biogas with 50% air, and 25% biogas with 75% air) were applied for P3HB accumulation test. P3HB accumulation under 100% methane and 100% biogas conditions was remarkably slow. Highest concentration of P3HB (i.e., 17.1 mg with a molecular weight of 55,330 Da) was accumulated under 80% biogas and 20% air condition. The sequential process has been set with most favorable conditions (i.e., hot water extraction for 30 min, once a day mixing, and 80% biogas and 20% air) in order to enable the continuous and stable production of P3HB from rice straw via anaerobic digestion.

Biography

Kyoungphile Nam has completed his PhD from Cornell University in 1998. Currently, he is Professor at the Department of Civil and Environmental Engineering, Seoul National University, Korea. He also serves as the Director of Remediation Technology and Risk Assessment Center. Recently, he initiated a research project about production of bio-based plastics from agricultural wastes. He has published more than 80 papers in peer-reviewed journals.

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