Enhancement of Treatment System for Waste Activated Sludge and Methane Cogeneration Using Iron-based Nanoparticles

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Title:　　(ナノ鉄粒子を用いた廃棄物活性汚泥処理およびメタンコージェネレーションシステムの強化)

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論 文 内 容 の 要 旨

Thesis Summary

Employment of the nanoscale zero-valent iron (nZVI) in bioenergy enhancement is a prospective application for increasing the biogas generation for better economy of sludge treatment. nZVI and its modifications were applied for enhancement of the anaerobic digestion process as the core treatment process used universally to stabilize waste activated sludge. The utilized nZVI stock suspension was freshly synthesized based on the optimal reduction method and the nZVI particle has a mean diameter of 42 nm and the average surface area of 25 m^2/g. Moreover, bimetallic of copper-nZVI (nZVI/Cu^0) and nZVI coated zeolite materials (ICZ) also employed for more clarification and comparisons.

Synthesized additives were characterized and its kinetics and adsorption capacities were determined, subsequently, the toxicity effects on the wastewater microbial life, kinetics of phosphorus, ammonia stripping and the reduction of chemical oxygen demand were examined by the addition of different concentrations of nZVI and nZVI/Cu^0 under both aerobic and anaerobic operation conditions. Anaerobic laboratory scale bio-digester system was assembled and operated to study the effects of iron-based nanoparticles on biogas generation and methane content. The results showed that Fe^{2+} ions play a crucial role in the limitation of ammonium production and phosphorus concentrations during biological and chemical degradation processes of the domestic wastewater. Moreover, the addition of nZVI stimulates the biogas production, methane gas content and can accelerate the sludge fermentation. However, according to the experimental results, it is advisable to dose the optimum nZVI/Cu^0 bimetallic not more than 1500 mg/L, while the cell disruption will occur. The addition of ICZ, which reached a maximum value compared with the other bioreactors causes a lag period before starting to produce a significant biogas cogeneration. Finally, the nZVI presence in a bio-digester could effectively improve the performance of sulfate-containing sludge digestion because it can serve as an electron donor that could

mitigate the competition between sulfate-reducing bacteria and methanogenic bacteria for the same substrates. Also, it can precipitate the content of un-dissociated hydrogen sulfide that is the main factor inhibiting anaerobic digestion of sulfate-containing sludge.

The thesis has a framework composed of six chapters in addition to the conclusions and recommendations. These chapters explain the employment of a novel treatment enhancement system for waste activated sludge on the basis of biochemical methane potential setup. The thesis framework was organized as follow:

Chapter 1 includes an introduction to the wastewater treatment technologies and sludge stabilization and management. Overiew about the anaerobic digestion process and its key effect factors that control the biogas generation and methane yeild were detailed. The chapter also listed the research aim and objectives.

Chapter 2 presents the methodology that has been used to conduct the experimental works, i.e., chemicals preparation, nanoparticles synthesizing method, samples collections, characterization of produced nanomaterials and analytical investigations.

Chapter 3 displays the role of bimetallic nZVI/Cu^0 particles into wastewater contaminants degradation and the toxicity of nZVI/Cu^0 to the domestic wastewater microbial community was distinguished. The nZVI/Cu^0 effects were also compared with the reactivity of pure nZVI under different atmospheric conditions of nitrogen and air.

Chapter 4 lists the employments of nZVI/Cu^0 into laboratory scale anaerobic digestion system for improving the biogas production and methane yield through dosing wide-range bimetallic concentrations. For more than 14 days, the impact of nZVI and nZVI/Cu^0 bimetallic nanoparticles on anaerobic digestion of municipal wastewater was evaluated.

Chapter 5 include the application of a new freshly prepared ICZ particles for the anaerobic digestion enhancement of domestic activated sludge. The effect of two different nZVI particles loadings have been examined and the performance on biogas production of this novel composite ICZ was tested based on modified biochemical methane potential test, and compared with that of the bioreactors exposed to only nZVI particles or zeolite material.

Chapter 6 focuses on the observation of the anaerobic digestion performance of domestic activated sludge with various sulfate concentration and various nZVI dosing under a fixed condition. The chapter main objective is to assess the performance of anaerobic digestion process for the treatment of sulfate-containing sludge in presence of nZVI.

Eventually, chapter 7 describes the major findings of whole thesis and lists selected recommendations for future applications. The future work proposal is also suggested.