TRIMETALLIC NANOPARTICLES IN ANAEROBIC DIGESTION PROCESS FOR BIOGAS PRODUCTION

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DOCTOR OF PHYLOSOPHY

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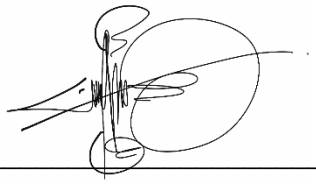

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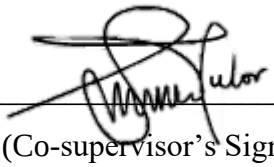

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ABSTRAK

Nanopartikel (NPs) telah muncul sebagai bahan yang luar biasa dengan spektrum contoh yang luas iaitu sekurang-kurangnya satu dimensi dalam julat 1 hingga 100 nm. Logam NPs boleh dihasilkan dengan sifat magnetik, elektrik, optik, mekanikal dan pemangkin yang menakjubkan yang jauh lebih baik. Pada masa kini, NPs digunakan dalam proses pencernaan anaerobik (AD) untuk meningkatkan hasil pengeluaran biogas. Walau bagaimanapun, aktiviti NPs dan kapasiti pertukaran elektron bergantung kepada interaksi dan kesan perencatan mereka pada mikrob dalam proses AD. Mutakhir ini, pelbagai kaedah sintesis organik dan bukan organik telah digunakan selama dua dekad yang lalu untuk meningkatkan aktiviti dan fungsi NPs. Dengan cara yang sama, kaedah kerpasan bersama digunakan untuk menyediakan NPs yang kurang berbahaya dan sangat aktif untuk interaksi mikrob-ke-mikrob berbanding kaedah lain. Kajian ini memberi tumpuan kepada nanozarah trimetal (TMNPs) yang diperbuat daripada besi (Fe), nikel (Ni), zink (Zn), kuprum (Cu) dan kobalt (Co) serta dianggap sebagai bahan yang paling berkesan untuk penukaran biojisim melalui proses AD. Kajian ini juga menggunakan efluen kilang kelapa sawit (POME) sebagai biojisim, dan kepekatan TMNP aktif yang berbeza digunakan untuk pengeluaran biogas. Fe-Ni-Zn, Fe-Co-Cu dan Fe-Co-Zn TMNPs berinteraksi dengan mikrob dan membantu merendahkan biojisim di bawah keadaan anaerobik. 10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L dan 50 mg/L TMNPs dan mesofilik berasaskan POME (37±1°C) AD telah disiasat untuk pengeluaran biogas. Seterusnya, 20 mg/L Fe-Co-Zn TMNPs pada pH 7.0 telah meningkatkan pengeluaran biogas sebanyak 60.11% berbanding AD kawalan. Kerja ini bertujuan untuk menentukan keadaan ideal bagi biogas yang lebih tinggi dengan TMNP yang lebih rendah dengan menggunakan kaedah permukaan tindak balas (RSM). Natijahnya, keadaan mesofilik proses AD berasaskan POME telah meningkat sebanyak 85% pengeluaran biogas berbanding proses AD kosong ($p < 0.05$). Walau bagaimanapun, proses AD mempunyai beberapa had dan perlu diberi tumpuan daripada pembuangan sisa kepada pengeluaran tenaga. Namun begitu, hasil biogas telah meningkat kepada 85% dalam keadaan AD sederhana dengan penambahan TMNP Fe-Co-Zn yang minimum. Akhir sekali, perspektif masa depan lain yang patut disiasat dilaporkan mempunyai interaksi mikrob dan ketoksikan TMNP secara mendalam untuk pengeluaran biogas yang lebih tinggi dengan kepekatan TMNP yang lebih rendah.

ABSTRACT

Nanoparticles (NPs) have emerged as an amazing class of materials with a broad spectrum of examples with at least one dimension in the range of 1 to 100 nm. Metallic NPs can be produced with outstanding magnetic, electrical, optical, mechanical, and catalytic properties that are substantially different from their bulk counterparts. Nowadays, NPs are used in the anaerobic digestion (AD) process for enhancing biogas yield. However, NPs activity and electron exchange capacity depend on their interaction and inhibition effects on microbes in the AD process. Currently, to increase NPs activity and functionality, various organic and inorganic synthesis methods have been applied for the last two decades. In the same way, the co-precipitation method was used to prepare less hazardous, highly active NPs for microbes-to-microbes interaction compared to other methods. The present study focused on the trimetallic nanoparticles (TMNPs) made of iron (Fe), nickel (Ni), zinc (Zn), copper (Cu) and cobalt (Co) are considered the most effective materials for biomass conversion through the AD process. This study used palm oil mill effluent (POME) as biomass, and different concentrations of active TMNPs were used for biogas production. Fe-Ni-Zn, Fe-Co-Cu and Fe-Co-Zn TMNPs interact with microbes and help to degrade biomass under anaerobic conditions. At 10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L and 50 mg/L TMNPs and POME-based mesophilic (37±1°C) AD was investigated for biogas production. Secondly, 20 mg/L Fe-Co-Zn TMNPs at pH 7.0 increased biogas production by 60.11% compared to the control AD. This work aims to determine ideal conditions for higher biogas with lesser TMNPs using response surface methodology (RSM). As a result, the mesophilic condition (25^0C -35^0C) of the POME-based AD process increased by 85% biogas production compared to the blank AD process ($p < 0.05$). However, The AD process has some limitations (TMNPs toxicity, antibacterial effects, less microbes interaction) and needs to focus on organic waste-to-energy production. Nevertheless, the biogas yield increased to 85% from moderate AD conditions with minimal Fe-Co-Zn TMNPs addition. Finally, other future perspectives worth investigating are reported to understand the microbial interaction and toxicity of TMNPs in deep for higher biogas production with lesser TMNPs concentration.

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