SIIC064

Finite Element Simulation of Magnetic Nanoparticles Augmented Polymeric Microcapsules in Anaerobic Digestion

Saifuddin Bin Zulkeflee[1], Mohamed Syazwan Bin Osman[2] and Nur Shafieza Binti Azizan[3]
[1]Faculty of Chemical Engineering, Universiti Teknologi MARA Pulau Pinang, 13500 Permatang Pauh, Pulau Pinang Malaysia
[2] Faculty of Chemical Engineering, Universiti Teknologi MARA Pulau Pinang, 13500 Permatang Pauh, Pulau Pinang Malaysia
[2] Faculty of Civil Engineering, Universiti Teknologi MARA Pulau Pinang, 13500 Permatang Pauh, Pulau Pinang Malaysia

**Corresponding author: syazwan.osman@uitm.edu.my*

Abstract:
The application of magnetic nanoparticles (MNPs) in anaerobic digestion (AD) had become adverse as it can increase the performance of AD. Nevertheless, the MNPs have a very significant effect to AD as it can inhibit the microbial activities by increasing the iron content thus reduce the performance of AD. This study was conducted to determine the role of MNPs-Polymer microcapsules in anaerobic digestion of sludge. Moreover, it was also conducted to perform the finite element simulation of MNPs-Polymer microcapsules in anaerobic digestion. For the experimental setup, the MNPs-Polymer microcapsules was synthesis by using phase inversion method and the effect MNPs-nanoparticle polymer microcapsules was investigated. The iron oxide (Fe3O4) was used for the nanoparticles while the Polyvinylidene fluoride (PVDF) as the immobilization agent. There will be 3 batches anaerobic digestion setup in which all of the digesters were filled with the same amount of sludge but the Reactor 2 (R2) was added with 2g of MNPs, while Reactor 3 (R3) was added with 58.8g of MNPs-Polymer microcapsules. The result from the experimental indicates that cumulative methane production increased to 7.5% and cumulative carbon dioxide production decreased to 74.38% when MNPs-Polymer microcapsules were introduced to the process. However, from the simulation conducted, the methane production had decrease to 1.09% and the production of carbon dioxide had reduced to only 0.59%. Moreover, for the iron concentration analysis, it had shown that the MNPs-Polymer microcapsules had reduce the iron content by 90.6% from the experimental analysis and 77% from the simulation analysis. Lastly, as for the efficiency of the MNPs-Polymer microcapsules, it can still perform well in anaerobic digestion after 14 days. Lastly, the physico-chemical analysis were performed on both influent and effluent sample of digestates for total suspended solids (TSS), turbidity, pH value, Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD).

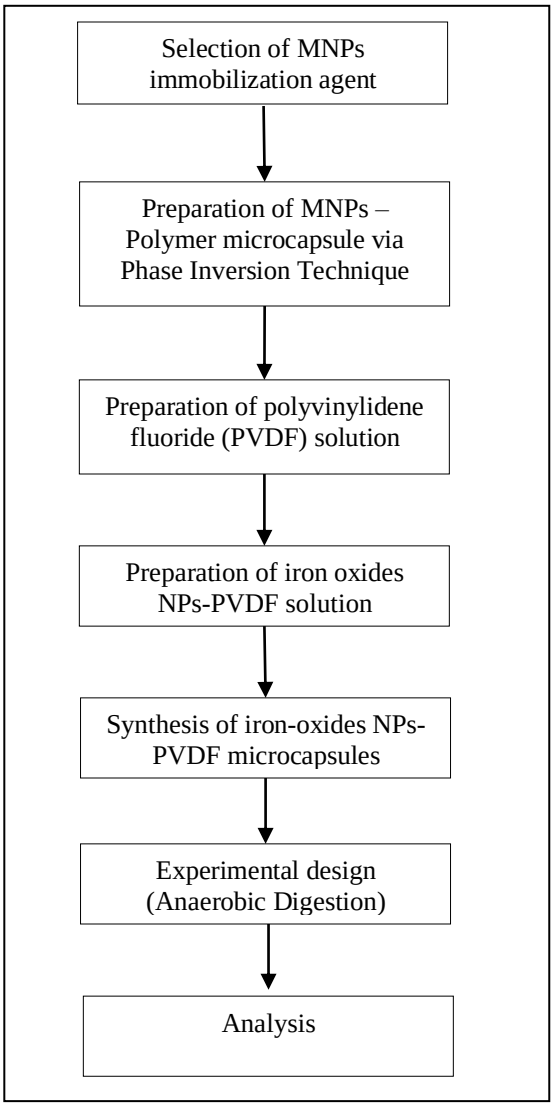
***Keywords*:**
Iron Oxide Nanoparticles, Polyvinylidene Fluoride, Microcapsules, Anaerobic Digestion, Phase Inversion, Finite Element Analysis, Simulation

Objectives:

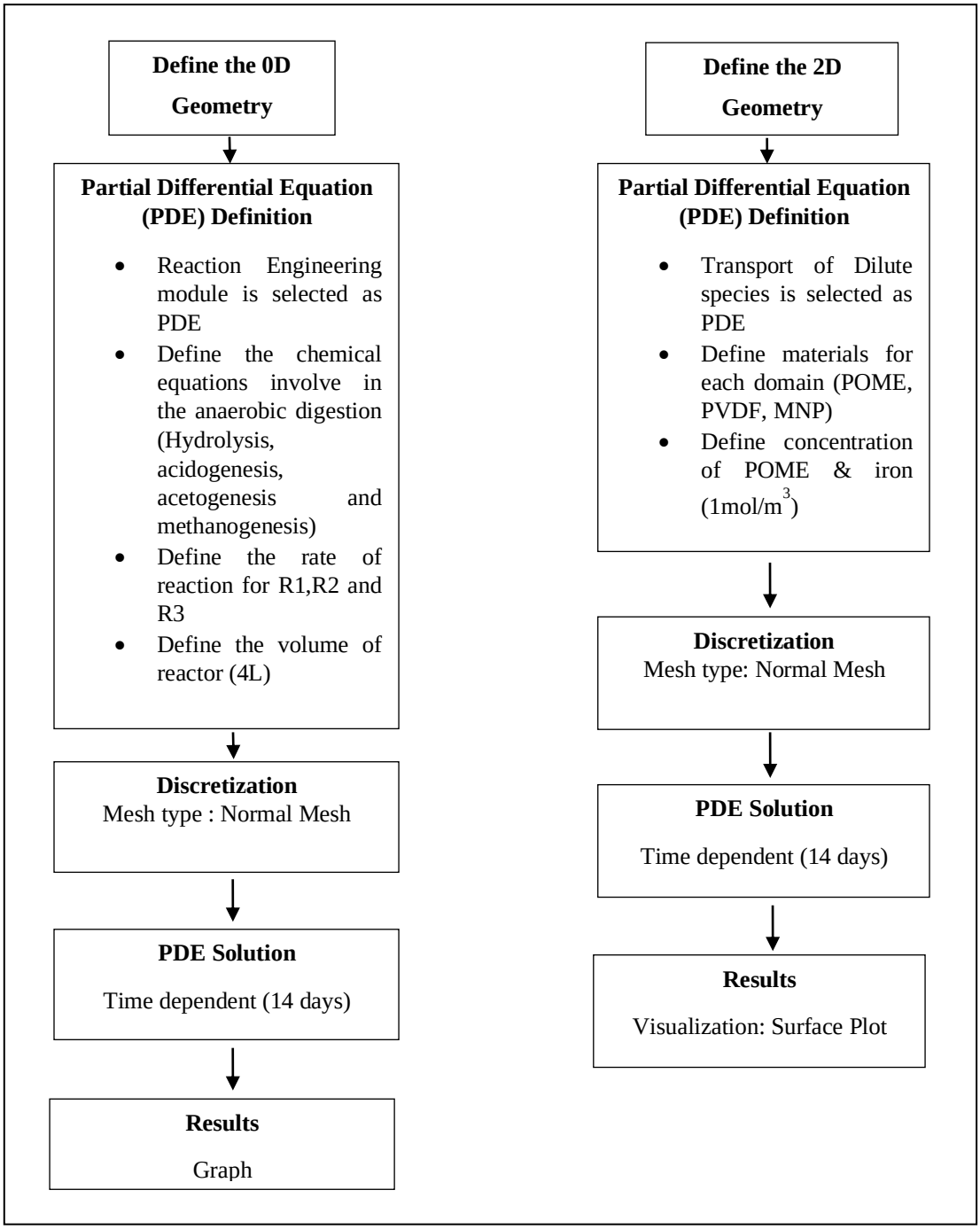
- To determine the effect of magnetic nanoparticles-polymer microcapsules in anaerobic digestion of sludge performance.
- To investigate the influence of nanoparticles-polymer microcapsules to the concentration of iron in anaerobic digestion of sludge.

Methodology:

Experimental Procedure

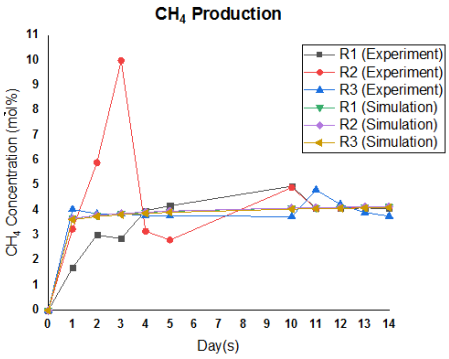


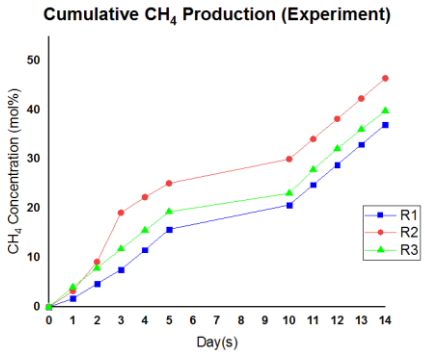
Simulations Procedure

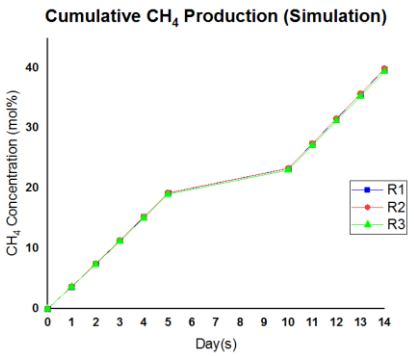


Results

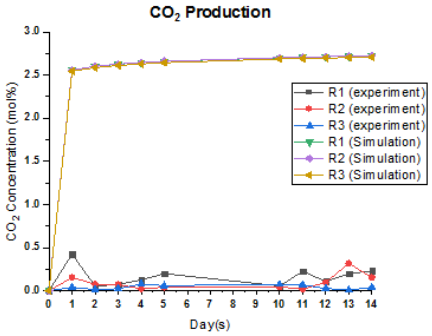
CH_4 Productions

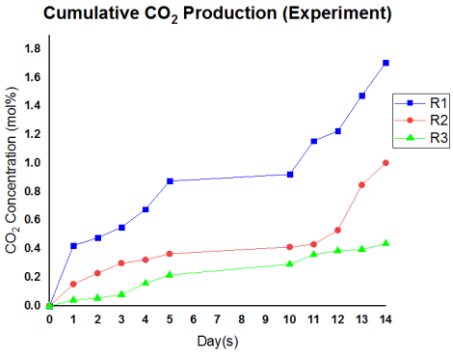


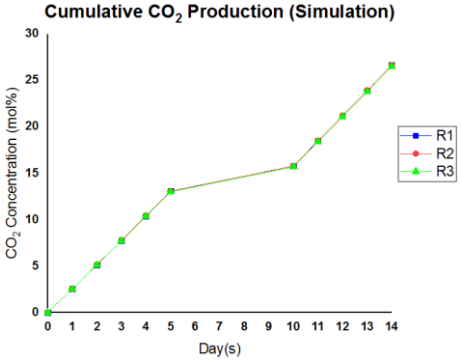




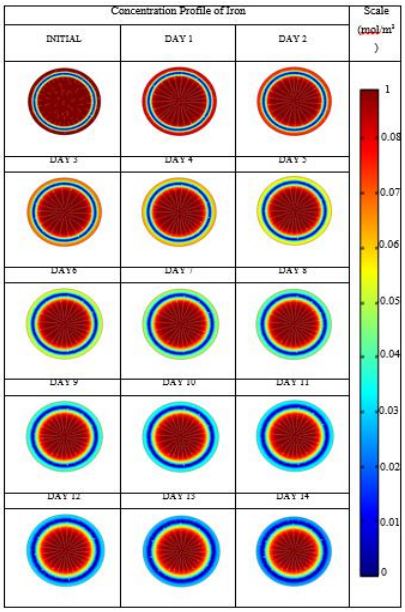
CO_2 Production



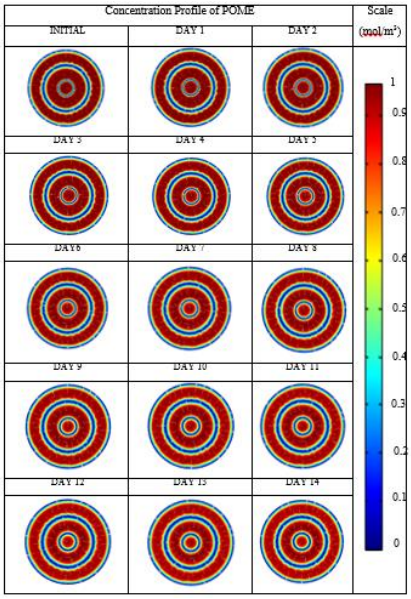




Concentration of Iron



Concentration of POME



Conclusion:

As a conclusion, the presence of iron oxide nanoparticles polymer microcapsules in anaerobic digestion of POME have a remarkable effect. From the analysis of experimental data, the addition of iron oxide nanoparticles polymer microcapsules in anaerobic digestion resulting to an increase of methane production to 7.5% and it can reduce the production of carbon dioxide to 74.38%. Meanwhile from the simulation data, the methane production had decrease to 1.09% and the production of carbon dioxide had reduced to only 0.59%. %. Therefore, it was observed that the data of methane production between experimental and simulation was not significant as the data was not showing the same trend because the rate of reaction of R3 which is at 0.0214 m3/s.mol was lower than R1 which was at 0.02560 m3/s.mol. This is because the amount of substrate consumed in R3 was lower than R1 which was at 1097.19 mg/L and 1016.46 mg/L respectively. Moreover, it was also discovered that the addition of iron oxide nanoparticles polymer microcapsules have an excellent effect in the reduction of iron from the sludge. From the experimental data, the microcapsule had reduce the iron concentration to 90.6%. This data had been supported by the analysis in simulation as the iron concentration had been reduced to 77%. Next, from the simulation done, the iron oxide nanoparticles polymer microcapsules was discovered to have an excellent performance although it has been reacted in anaerobic process for more than 14 days. This is because the POME still able to diffuse into the microcapsule efficiently after 14 days and it shows that the microcapsule can perform well in anaerobic digestion for a longer period of time. Furthermore, the iron oxide nanoparticles polymer microcapsule have a significant effect to reduce the total suspended solids, turbidity, pH value, COD and BOD concentrations. However, the iron oxide nanoparticles polymer microcapsule does not show a significant improvement to the COD and BOD concentrations. Thus, the retention time of microcapsules in the anaerobic digestion need to be studied.