Effect of encapsulated nanoparticles on thermophillic anaerobic digestion

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Introduction

The growing need of energy globally and the unavoidable increasing dependency on energy being produced from non-renewable source is unsustainable. The world is turning to a search for another energy source, among the possible fuel sources; methane produced by the anaerobic digestion offers tremendous potential as a renewable energy currency. Due to their characteristics, nanoparticles have a great potential in application to many science field. In anaerobic digestion microorganisms may tack advantages of nanoparticles by transferring more efficiently electrons to acceotors (1) and enhancing the activity of microorganisms

Objectives

The purposes of this study are to investigate encapsulated nanoparticles that may be used as catalysts to enhance the anaerobic digestion. Specific objectives of this study are:

- Study the effect of 10^{-5} mol/L of nanoparticles on methane production kinetic and aceticlastic methanogenes using acetate as substrate.
- Test different concentrations of nanoparticles which showed the best catalytic effect.

Results

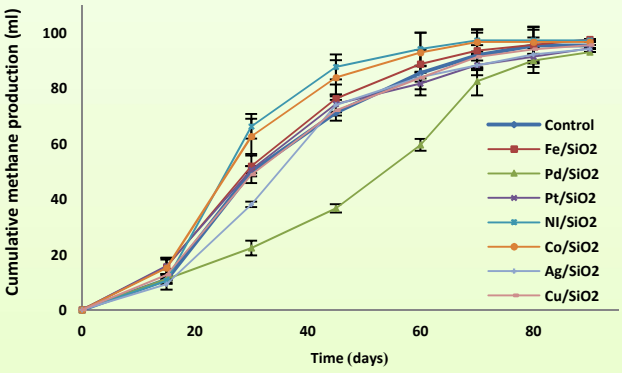

Fig .1 : Effect of nanoparticles addition at concentration of 10^{-5} mol/L on cumulative methane production after 90 days of the anaerobic fermentation of acetate (5 g/L).

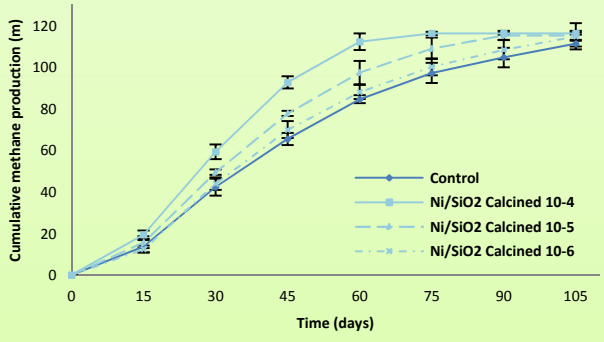

Fig. 2(a-d) :Catalytic effect of nickel nanoparticles at concentrations of 10^{-6}, 10^{-5} and 10^{-4} mol/L on methane production using 5 g/L of glucose monohydrate as substrate.

Materials and Methodes

- Nanoparticles were added in 120 mL batch serum bottles with 65 mL of MDT medium + substrate (acetate/glucose) + 5 mL of inoculums → rubber septum → nitrogen → incubated at 55°C.
- The biogas production was measured by using appropriately sized syringes.
- Methane production was monitored by using a KoH displacement system
- and its percentage was measured using (GC).
- Volatile fatty acids (VFA), and ethanol were quantified in (HPLC).
- The Modified Gompertz (Eq.1) has been used to predict rates of fermentative methane production processe.

$$y = A\exp\left\{-\exp\left[\frac{\mu_m e}{A}(\lambda - t) + 1\right]\right\} \qquad (1)$$

Table 1 Kinetic parameters of methane production from acetate at 10^{-5} mol/L concentration of nanoparticles

	Concentration of metal (mol/L)	A (ml)	µm (ml/day)	λ (days)	R^2
Control	-	96.47	2.37	10.30	0.999
Fe/SiO2	10^{-5}	96.73	2.53	9.77	1.000
Pd/SiO2	10^{-5}	96.54	1.45	16.65	0.994
Pt/SiO2	10^{-5}	93.22	2.50	8.03	0.999
Co/SiO2	10^{-5}	96.66	3.50	11.67	1.000
Ag/SiO2	10^{-5}	94.28	2.27	13.85	0.999
Cu/SiO2	10^{-5}	96.06	2.29	9.58	0.999
Ni/SiO2	10^{-5}	96.78	4.02	12.94	1.000

Table 2. Kinetic parameters of methane production from glucose at 10^{-4}, 10^{-5} and 10^{-6} mol/L concentrations of Ni/SiO_2 nanoparticles

	Concentration of metal (mol/L)	(ml)	(ml/day)	λ (days)	R^2
Control	-	114.17	1.82	8.21	0.999
Ni/SiO2	10^{-4}	118.41	3.14	9.91	0.999
	10^{-5}	118.32	2.30	9.09	0.999
	10^{-6}	116.30	1.98	9.08	0.999

Conclusion and Perspectives

In this work, methane production was catalyzed by nickel, cobalt and iron nanoparticles. Nickel nanoparticles improve the efficiency of methane production especially at high concentration.
For the experimental work will be carried out using biomolecules tools and enzymes investigation for better understanding of catalytic mechanism.

References

1. L. Beckers, S. Hiligsmann, S.D. Lambert, B. Heinrichs, and P. Thonart, 'Improving Effect of Metal and Oxide Nanoparticles Encapsulated in Porous Silica on Fermentative Biohydrogen Production by Clostridium Butyricum', *Bioresour Technol*, 133 (2013), 109-17.