Supporting Information

Insights into short- and long-term effects of loading nickel nanoparticles on anaerobic digestion with flocculent sludge

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Methods and Materials:

Zero-, first- and second-order reaction kinetics were used to model glucose degradation for the AFS in anaerobic digestion at various Ni-NPs concentrations. The individual kinetic model is presented as below:

$$C_t = C_0 - k_0 t \qquad (1)$$

$$C_t = C_0 e^{-k_1 t} \qquad (2)$$

$$\frac{1}{C_t} = \frac{1}{C_0} + k_2 t \qquad (3)$$

where C_t (mg/L) is the glucose concentration at time t (d), C_0 (mg/L) is the initial glucose concentration, and k_0, k_1 and k_3 represent the apparent kinetic rate constants of zero-, first- and second-order reaction kinetics, respectively.

Regression coefficients (R^2) of glucose degradation for the AFS with exposure to different concentrations of Ni-NPs, as fitted by zero-, first-, and second-order kinetics, are summarized in Table S1.

Table S1 Regression coefficients of glucose degradation for the AFS with exposure to different concentrations of Ni-NPs, as fitted by zero-, first-, and second-order kinetics.

Experiments	Cycle	R^2		
		Zero-order	First-order	Second-order
Control	1	0.90	0.74	0.60
	2	0.93	0.78	0.60
	3	1.00	0.86	0.70
	4	0.98	0.91	0.69
1 mg/g-TSS Ni-NPs	1	0.94	0.74	0.61
	2	0.93	0.71	0.57
	3	0.98	0.77	0.57
	4	0.98	0.87	0.75
50 mg/g-TSS Ni-NPs	1	0.94	0.72	0.61
	2	0.94	0.58	0.79
	3	0.90	0.69	0.55
	4	0.94	0.91	0.78
200 mg/g-TSS Ni-NPs	1	0.93	0.74	0.65
	2	0.89	0.78	0.47
	3	0.94	0.86	0.49
	4	0.92	0.91	0.51
600 mg/g-TSS Ni-NPs	1	0.91	0.98	0.97
	2	0.93	0.82	0.65
	3	0.89	0.62	0.67
	4	0.96	0.76	0.72

Table S2 Comparison of the richness and diversity of the 16S rRNA gene libraries based on 0.03 distance

	OTUs	Shannon Diversity	Chao 1 richness estimation	Goods coverage (%)
AFS-Control	481	5.635	524	99.9
AFS-600 mg/g-TSS Ni NPs	416	4.776	444	99.8
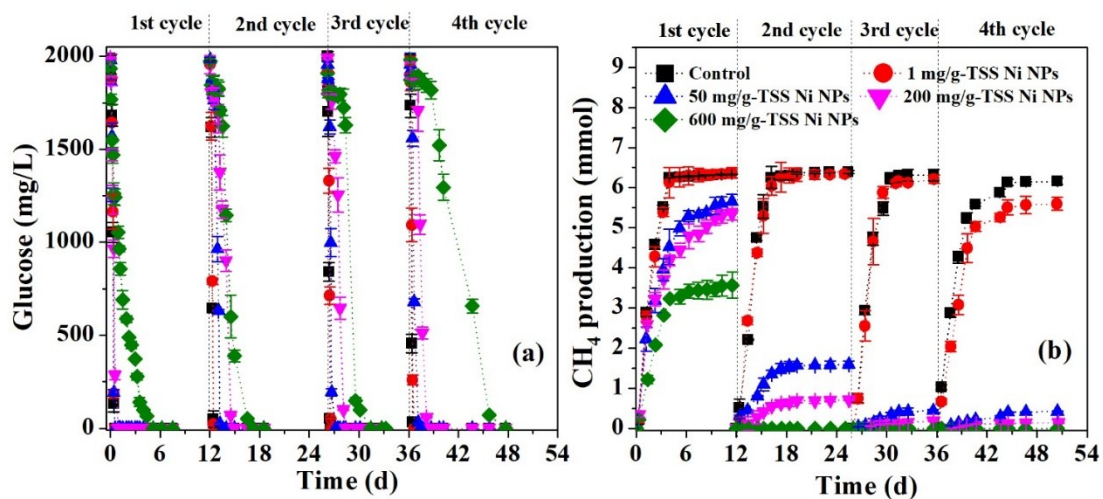
Figure S1 Effect of Ni-NPs on the activity of the AFS during four cycles: (a) glucose degradation and (b) CH$_4$ production in the absence and presence of Ni-NPs. Error bars represent standard deviations of triplicate tests. Conditions were 2 g/L glucose, pH 7.3, 115 rpm and 35 °C.
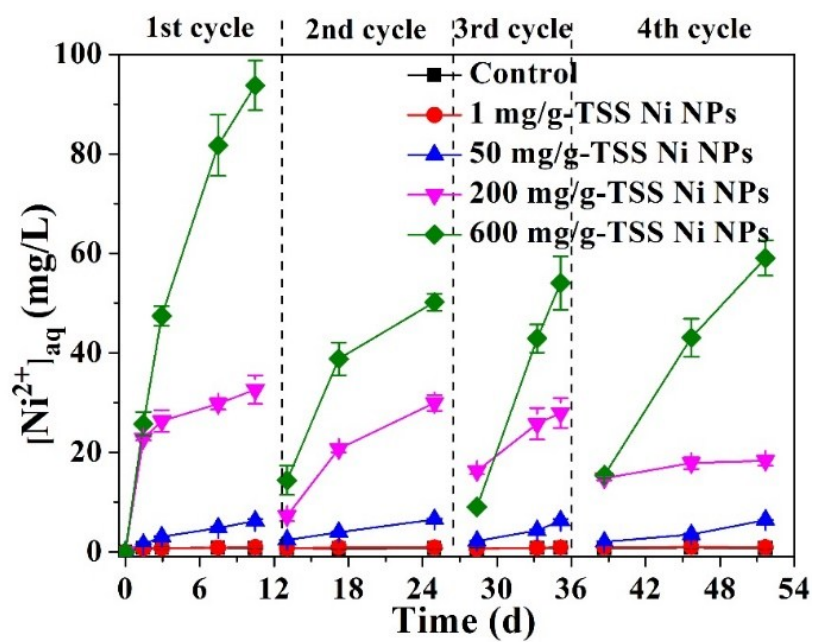
Figure S2 Ni^{2+} released from Ni NPs in the AFS systems during four cycles. The time was recorded from the addition of Ni NPs. 2 g/L glucose, initial pH 7.3, 115 rpm, 35 $^{\circ}$C.
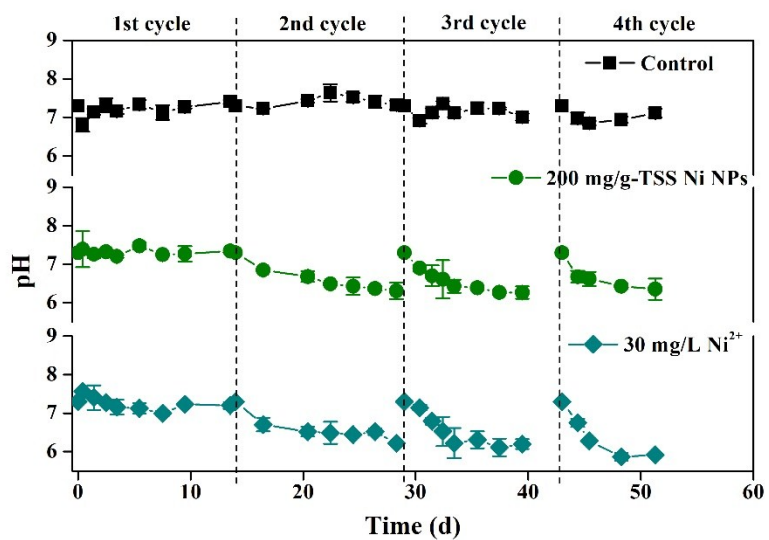
Figure S3 pH variations in the AFS systems with and without Ni-NPs and Ni^{2+} additions.