

INVESTIGATION OF MicroC™ AS AN ALTERNATIVE CARBON SOURCE FOR DENITRIFICATION

Annalisa Onnis-Hayden¹, Carla Cherchi¹, Samuel Ledwell², Phil Pedros³ and April Z. Gu¹

¹Northeastern University ²Environmental Operating Solutions, Inc. ³F.R. Mahony & Associates



INTRODUCTION

The addition of external carbon sources for enhancing denitrification and biological phosphorus removal is becoming more common as POTW's face increasingly stringent effluent nutrient limits.

In the US, methanol has been the most commonly used carbon source, however, the safety issues associated with its transportation and storage and rise in price has motivated the investigation of alternative carbon sources. MicroC™ is a proprietary chemical developed by Environmental Operating Solutions, Inc. and designed specifically for use as an electron donor/carbon source for biological denitrification of wastewater. MicroC™ was developed as a viable non-flammable alternative carbon source to methanol.

OBJECTIVES OF STUDY:

- Basic characterization of the MicroC™ compound (e.g. BOD,COD values)
- Determine the denitrification potential and kinetic parameters of MicroC™ and compare with other commonly used carbon sources for supporting denitrification such as methanol and acetate
- Determine the key parameters that are required for designing denitrification processes such as maximum growth rate, observed yield and carbon to nitrogen ratio
- Investigate the effect of temperature on denitrification rates and kinetics
- Investigate the cross-carbon-feed response of a specific carbon-acclimated denitrifying population to different carbon sources
- Assess the practical implications of the difference in denitrification kinetics on nitrogen removal performance at full-scale plants using BIOWIN simulations.

MATERIALS AND METHODS

SBR set-up

Three sequencing batch reactors (Figure 1) were established to acclimatize a biomass to three different carbon sources, MicroC™, methanol and acetate. The SBRs were operated for 1 year and the acclimated sludge was used for batch testing, over 50 tests were completed on MicroC™ over the course of this study.

Denitrification Rates and kinetics

Two different batch tests (Figure 2) were carried out with a low F/M ratio (short test) and a high F/M ratio (long test) to determine the maximum specific denitrification rate k_{dmax} and the maximum growth rate of denitrifiers (μ_{max}). Different types of sludge and two different temperatures were tested

Data Analysis

SPSS software and Microsoft Excel Solver were used for the parameters estimation: 1) Monod-kinetics equation was applied to fit the data in the short tests to calculate k_{dmax} and K_s , using the k_d obtained with specific sCOD concentrations in different tests, as variables; 2) the non-linear least square method was used for the high F/M tests in order to determine the μ_{max} , based on the nitrate response over time.

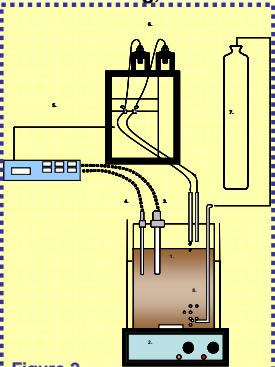


Figure 2



Figure 1

RESULTS

MicroC™ Characterization: COD = 663 g / L BOD5 = 429 g / L

Table 1: Summary of denitrification rates and kinetics of different substrates at 20°C and at 10°C.

SLUDGE	CARBON SOURCE	MicroC™			Methanol		Acetate
		MicroC™ WWTP	Pre-Den WWTP	SBR	SBR	SBR	
K_d max (20°C)	mgN/gVSS-h	4.72 ± 0.48	4.34 ± 0.52	6.37 ± 3.6			
		Average: 4.6 ± 0.43			6.07 ± 0.7	13.6 ± 1.86	
K_d max (10°C)	mgN/gVSS-h	-	-	2.5	2.3	3.62	
K_s	mg sCOD/l	28 ± 11.48	49.74 ± 18.8	58 ± 59	15.64 ± 11.18	38.1 ± 16.2	
		Average: 34.75 ± 12 TM					
COD/N	mg sCOD/mgN	6.98 ± 1.4	3.98	6.45 ± 3.7	4.82 ± 1.51	5.74 ± 1.29	
		Average: 5.8					
Yield _{obs} (1)	mgVSS/mgCOD	0.42	0.2	0.39	0.29	0.35	
		Average: 0.36					
μ_{max} (20°C) ⁽²⁾	d ⁻¹	3.90	-	3.66	1.25	-	
μ_{max} (10°C) ⁽²⁾	d ⁻¹	-	-	1.22	0.34	-	

Figure 3: Plant layout with kinetic and stoichiometric parameters used for Biowin simulations.

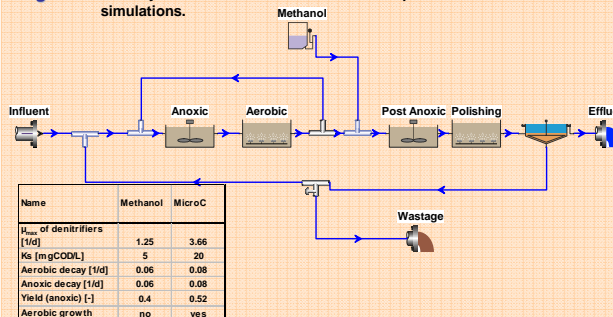
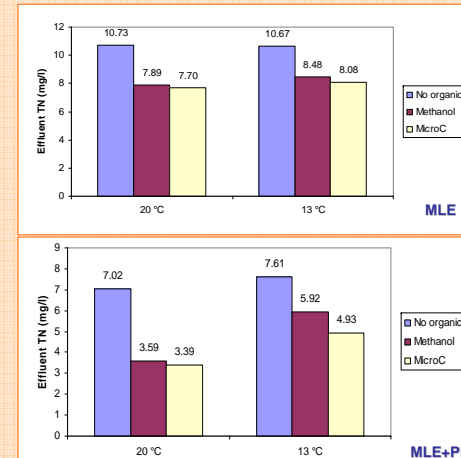


Table 2: Denitrification rates during the cross response tests

CARBON SOURCE	MicroC	Kd (mgN/gVSS·h)		
		MicroC Sludge	Methanol Sludge	Acetate Sludge
MicroC	17.11	12.65	0.92	
Methanol	5.36	11.32	1.14	
Acetate	15.75	8.64	12.9	
Ethanol	7.77	13.44	-	
Glucose	8.92	0.4	0.23	

Figure 4: Biowin steady state results for MLE and MLE plus post denitrification without and with external addition at 20 °C and 13 °C.



CONCLUSIONS

1. MicroC™ can effectively support denitrification with maximum denitrification rates comparable to those of methanol, but with higher maximum growth rate. Similar denitrification rates observed with both non-acclimated WWTP and MicroC™ acclimated WWTP indicates that MicroC™-using denitrifiers are indigenous in the WWTP and therefore no acclimatization is needed.
2. Using BIOWIN simulations, with equivalent amount of COD as either MicroC™ or methanol being added to a MLE or a MLE post-denitrification process, a slightly better performance was shown with MicroC™ than methanol, especially for the post-denitrification process and under low temperature conditions.
3. Cross-response tests for evaluating the response of a specific carbon-acclimated sludge to utilize other alternative carbon sources showed that MicroC™-acclimated sludge can readily utilize other carbon sources.