

Supporting Information

Electrochemical behavior of anode-respiring bacteria on doped carbon electrodes

Nael G. Yasri,^[a] and George Nakhla^{*[a]}

^a Department of Chemical and Biochemical Engineering, University of Western Ontario,
London, Ontario N6A 5B9, Canada

Corresponding author

* E-mail: gnakhla@uwo.ca

Phone: 519-661-2111 ext. 85470; Fax: 519-661-3498

Number of pages: 5

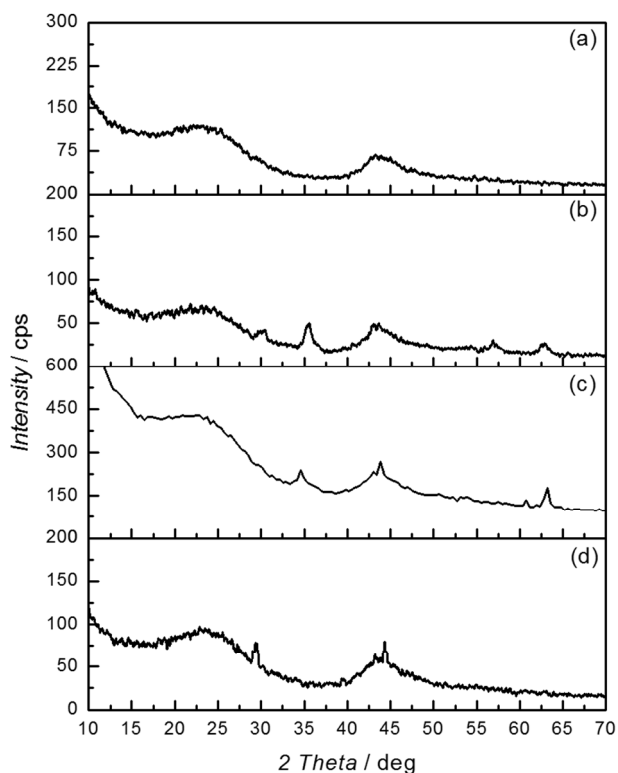
Number of tables: 2

Number of figures: 2

XRD of the GAC doping

The XRD pattern (Fig. SI-1) of control GAC particles revealed two standard broad peaks at 2-theta of 25° and 45° ⁷⁰. The doped materials on GAC showed poorly resolved XRD peaks due to the low reflection of the low amount of material present in the doped-GAC and the interference with the broad peaks resulting from the pristine GAC. However, the XRD patterns still present distinguished data as compared with data available in the literature. For example, the Fe_3O_4 -doped material showed poorly resolved XRD peaks which are consistent with previously reported data ³⁹, particularly the major reflections at 30.0° , 36.0° , 56.8° and 62.6° ⁴⁰. The FeS-doped revealed several peaks at 34.5° , 43.8° , 60.7° , and 63.1° that are indexed to FeS ⁴¹ and fairly distinguished from those indexed to FeS_2 ⁷¹. The CaS-doped material showed poorly resolved XRD peaks at 29.5° and 44.3° which are consistent with previously reported data for CaS ³⁵.

Fig. SI-1: X Ray Powder Diffraction of: A) GAC, B) Fe_3O_4 -Doped GAC, C) FeS-Doped GAC, and D) CaS-Doped GAC.



Repetition of the growth process

Fig. SI-2 presents the replication of biofilm growth on the four functionalized electrodes. The bacterial growth during the attachment process on the electrode surface is expressed in terms of current density (J) as a function of time (t , day). The reproduction of both current profiles and the low CVs scan rate in the repeated experimental runs (as compared with profiles obtained in the results sections) on the various individual electrode emphasizes the reproducibility of the growth kinetics of the ARB on anodes.

Fig. SI-2: Replicate inoculation processes for: A) current density vs. time recorded during the ARB biofilm growth on: a) control-anode, b) Fe_3O_4 -anode, c) FeS -anode, and d) CaS -Anode. B) The corresponding (a'-d') cycle voltammograms (1mV S^{-1}) were done on the days represented by the blue dots “i, ii, iii, and iv” in the main current densities curves (A).

The biofilm was cultivated in a single compartment cell, using acetate (25 mM) as a substrate, and biofilm grown under potentiostatic electrode potential of 0.45 V (vs. SHE).

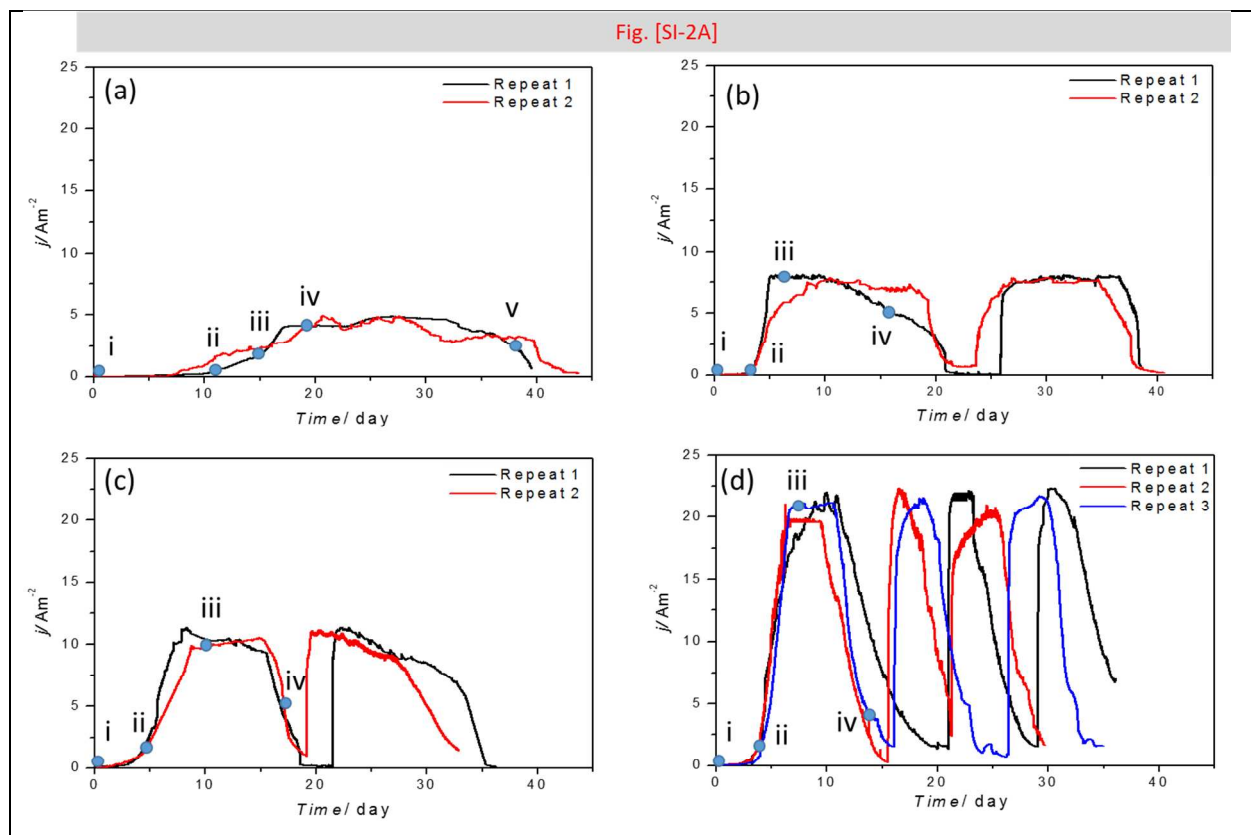


Fig. [SI-2B]

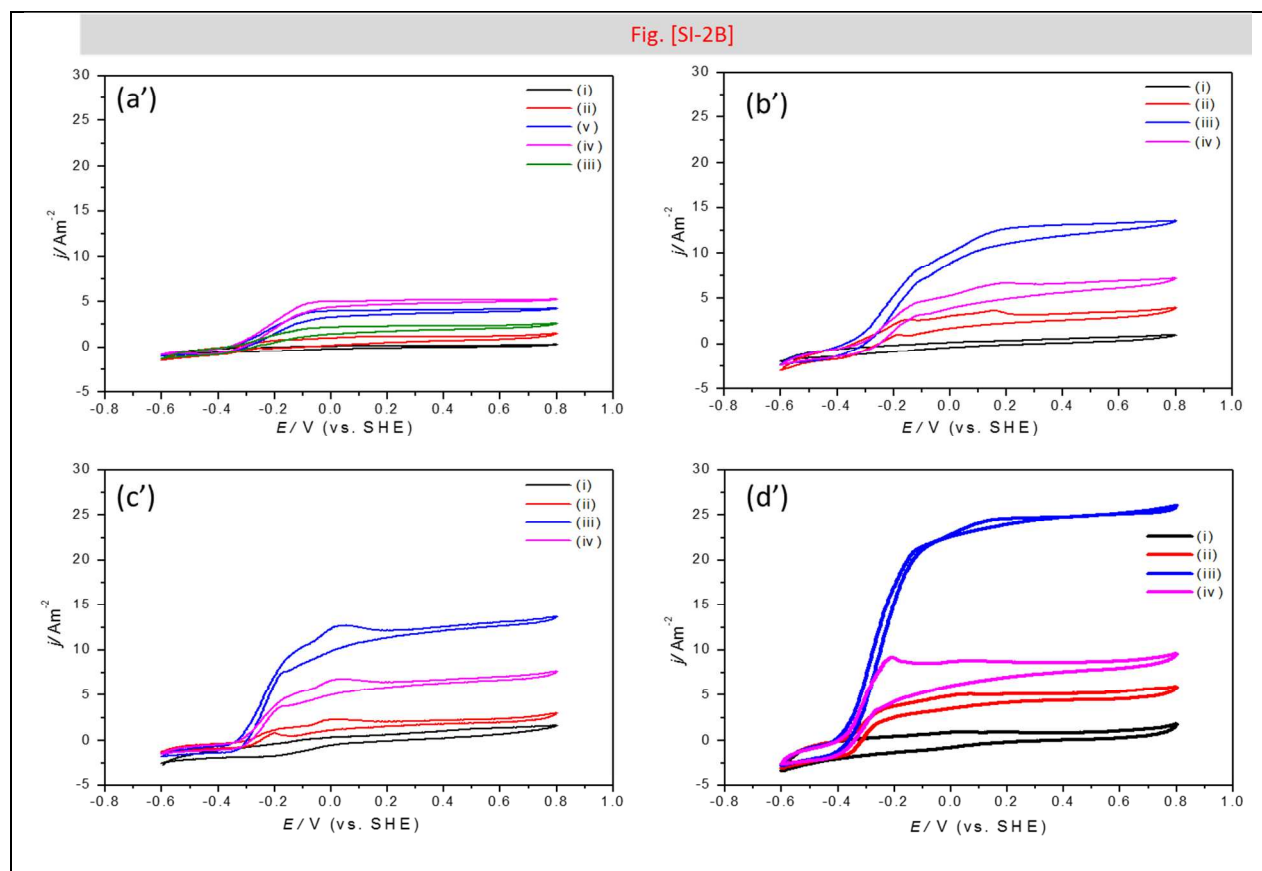


Table [SI 1]: Summary of linear regression correlation of peak current with scan rates during turnover conditions for the four electrodes. All R^2 values were greater than 99%.

Anode	Peak			
	i	ii	iii	iv
Control	$J = 8.5 v^{1/2} - 0.2$	$J = -1.28 v^{1/2} + 0.2$	$J = -1.9 v^{1/2} + 0.4$	
Fe_3O_4	$J = 5.7 v^{1/2} - 0.1$	$J = 12.9 v + 0.4$	$J = 27.2 v + 0.3$	$J = -24.9 v + 0.1$
FeS	$J = 4.4 v^{1/2} + 0.01$	$J = -13.9 v - 0.04$	$J = 12.9 v + 0.4$	$J = -14.6 v + 0.2$
CaS	$J = 3.1 v^{1/2} + 0.3$	$J = -3.5 v^{1/2} + 0.1$	$J = -4.2 v^{1/2} + 0.6$	

Unites; current density (J) in mA m^{-2} and scan rate (v) in mVs^{-1} .

Table [SI 2]: The pH, alkalinity [ALK] (mg CaCO₃/L), total iron (ppm), calcium (ppm), and sulphur (ppm) in the bioelectrochemical cells media prior to and after inoculation (mean $\pm$ SD; $n = 3$).

Sample Labels	Calcium	$\Delta\text{Ca}/\text{Ca-doped}^*$	Iron	$\Delta\text{Fe}/\text{Fe-doped}^*$	Sulphur	$\Delta\text{S}/\text{S-doped}^*$	pH	[ALK]
Initial	0.569 $\pm$ 0.026	--	0.448 $\pm$ 0.065	--	2.469 $\pm$ 0.035	--	7.29 $\pm$ 0.43	3167 $\pm$ 49.1
Control	0.293 $\pm$ 0.069	--	0.269 $\pm$ 0.056	--	0.890 $\pm$ 0.088	--	7.34 $\pm$ 0.14	3486 $\pm$ 67.3
Fe ₃ O ₄	0.307 $\pm$ 0.091	--	0.210 $\pm$ 0.072	0.0	0.615 $\pm$ 0.011	--	7.71 $\pm$ 0.63	3872 $\pm$ 72.6
FeS	0.296 $\pm$ 0.063	--	0.424 $\pm$ 0.047	0.007	0.702 $\pm$ 0.064	0.0	7.35 $\pm$ 0.22	3434 $\pm$ 69.4
CaS	0.778 $\pm$ 0.014	0.035	0.266 $\pm$ 0.036	--	1.288 $\pm$ 0.082	0.035	7.42 $\pm$ 0.35	3353 $\pm$ 46.7

Theoretical leachate concentrations

The theoretical values are the equivalent concentrations (ppm) of the doped material on the electrodes (17.5 μ M/50 mg GAC) if completely leached into the 50 mL inoculating medium at the end of the experiment. These value are:

- Fe-Doped = 58.6 ppm and 19.5 ppm of iron ions theoretically can be leached from Fe₃O₄ and FeS electrodes respectively.
- S-doped = 11.2 ppm of total Sulphur can be leached from FeS and CaS electrodes,
- Ca-doped = 14 ppm of total calcium ions can be leached from CaS electrode.

Values presented as an average measurement from 3 consecutive day samples.

* the percentage (%) of the concentration of element found – the concentration of the same element in control medium / the theoretical leachate of the same element.