Int. J. Unconventional Computing, **2**(3), 2006, 2491-265.

Microbial Computing using *Geobacter* biofilm electrodes: output stability and consistency

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Received: May 25, 2004. In Final Form: March 1, 2006.

Abstract

The direction of our work is towards a proof of concept of a novel biological processing unit and a new paradigm of computation based on neurone-like and transistor-like behaviour in the same units. This paper describes a non accumulating, steady state microbial biofilm that can be constantly monitored using electrodes. Experimental biofilm units have been constructed and produced steady-state current output readings over the whole experimental period of 4 weeks. Changing the external electrical load (resistor) resulted in a new steady state at a different level of electrical output than the original. Transition times between steady-states were relatively short (<4 minutes). Switching streams of substrate also resulted in new steady-states but the transition times between steady states were of longer duration (~ 4-5 minutes) and flow-rate dependent. Both steady-states and the transitional behaviour between steady-states were consistent and reproducible. Although envisaged to utilize non-silicon, non-binary multi-valued logic processing, a first step to understanding their behaviour may be made by the theoretical comparison with conventional binary gates such as AND, OR, NOT, NAND, NOR, XOR, and XNOR. Multiple valued systems could potentially lead to large size memories (many combinations) at low rates of speed which could be exploited in terms of parallel computing.

Keywords: biofilm continuous culture, microbial logic gates, biological processors, *Geobacter sulfurreducens*, perfusion systems.