Electrochemical exploration of mechanisms for radioprotection and enhanced microbial growth in radiation fields

C.E. TURICK[1]*, A.A. EKECHUKWU[1], C.E. MILLIKEN[1], D.C. BEAM[1], A.CASADEVALL[2] AND E. DADACHOVA[2]

[1]Savannah River National Laboratory, Aiken, SC 29808 USA (*correspondence: Chalres.Turick@srnl.doe.gov)

[2]Albert Einstein College of Medicine, Bronx, NY, USA

The presence of melanin pigments in microorganisms is linked to radioprotection and enhanced growth from ionizing radiation [1, 2]. Melanin pigments are polymers composed of quinone moieties that contribute to their redox behavior. The polymeric structure of melanins permits oxidation and reduction to occur simultaneously. Hence, melanin represents a novel, radioprotective material that could play a significant role in enhanced growth under the oxidizing conditions of ionizing radiation. This finding poses the intriguing possibility of gamma radiation as an energy source coupled to cellular growth. For sustained protection from the oxidizing conditions of gamma radiation to occur, electron flow to melanin is necessary in order to maintain a redox balance. We hypothesized that in the presence of gamma radiation, electron flow from microbes or their immediate environment, to continuously gamma-oxidized melanin provides reducing power to sustain the protective properties of melanin.

Here we demonstrate through the electrochemical techniques of chronoamperometry, chronopotentiometry and cyclic voltammetry that microbial melanin is continuously oxidized in the presence of gamma radiation. Cyclic voltammetry data suggest a 2-step reduction from semiquinone to hydroquinone followed by a 1-step oxidation to the quinone state. The oxidation is explained by the reducing capacity of melanin and its release of recoil electrons during Compton scattering. This work establishes that gamma radiation alters the oxidation-reduction properties of melanin, an important mechanistic insight into how this pigment could function as an energy-transducing molecule for radioprotection and microbial growth in radiation fields.

[1] Dadachova, Bryan, Huang, Moadel, Schweitzer, Aisen, Nosanchuk & Casadevall. (2007) *PLoS ONE*. **5**, e457.
[2] Dadachova & Casadevall. (2008) *Cur. Opin. Microbiol.* **11,** 525–531.

Low noise Faraday cup measurements using multicollector mass spectrometers

D. TUTTAS*, J.B. SCHWIETERS AND N.S. LLOYD

Thermo Fisher Scientific, Hanna-Kunath-Str. 11, 28199 Bremen, Germany (*correspondence: Dietmar.Tuttas@ThermoFisher.com)

Instrumental sensitivity is regarded to be one of the key parameters for multicollector mass spectrometers. Instrumental parameters such as ion source efficiency and instrument transmission contribute to instrumental sensitivity as much as the noise level of the detection system itself. With the Jet Interface developed for the Thermo Scientific NEPTUNE Plus (MC-ICPMS) sample utilization of up to 4% has been demonstrated for U; for the Thermo Scientific TRITON (TIMS) sample utilization has been demonstrated for Os in negative ion mode. Because instrument transmission and ion source efficiency can be very high, detector noise can be the limiting factor for ultra-small sample analysis. Faraday cup detectors are the detectors of choice for high accuracy and high precision isotope ratio measurements because of their unmatched stability and linearity and because of the electronic cross calibration network available to precisely and accurately cross calibrate the multiple Faraday detector channels against each other.

Today, most multicollector TIMS and MC-ICPMS are equipped with current amplifiers using a 10^{11} Ohm resistor coupled to the feedback loop of a high stability and temperature-stabilized operational amplifier. For ion beam currents >10 pA, precisions of less than 5 ppm are achieved routinely. However for smaller signal intensities, the achievable precisions are limited by the noise level of the detectors. For ion beam currents in the range of 1 pA and less, precision starts to become limited by the noise level of the current amplifier.

In this paper we will describe our latest investigations in Faraday cup measurements for signal intensities in the range of 1 pA to 1 fA. We will present data collected on a Thermo Scientific TRITON instrument using Faraday detectors tailored to the measurement of small signals into the fA range. In particular, we will compare the performance of Faraday cup measurements with multi-ion-counting measurements for ion beam intensities in the range 100 fA to 1 fA. The capabilities of the new compact discrete dynode multipliers integrated into the variable multicollector array of the Thermo Scientific TRITON will be discussed.