The open circuit potential for my coating is +4.9 V. Should I believe it??

We have seen several examples where a customer has recorded an open circuit voltage of 3, 4, or even 5 volts when running EIS on a coated sample. Voltages this size probably do not represent a real "Open Circuit Potential" or "Corrosion Potential." In fact, they represent an instrumental artifact. This artifact becomes more important when an ECM8™ Electrochemical Multiplexer is used in the measurement.

No electrical circuit (including our potentiostats!) is ideal. The electrometer circuitry of the potentiostat should ideally draw no current from the electrochemical cell. In practice, however, a small current is drawn from the cell. For a PC4/300 or PC4/750, this current is 10 pA or less. For the FAS1™ Femtostat it is less than 100 fA in the slow mode and less than 10 pA is the 'fast' mode.

Although these currents sound small, their effects can be great when very good (high impedance) coatings are studied. A very good coating can be modeled as a capacitor with a capacitance of about 1 nF. A capacitor will charge up at a constant rate if a constant current is imposed on it.

$$i = C\, dE/dt$$

i is the constant current C is the capacitance
dE/dt is the rate of change of the voltage on the capacitor.

For a 1 nF capacitance (a coating) being charged with a 10 pA constant current (the specified input current of a PC4/300 electrometer) this equation predicts that the capacitor will charge up at a rate of 10 mV/sec (=10 pA/1 nF)! Figure 1 shows the open circuit curve recorded for 1 nF capacitor using a PC4/300. The slope at the start of the delay is just about 10 mV/s. This curve is consistent with the input current specification of <10 pA. The drift would be 100 times smaller for an FAS1 in the 'slow' mode. The voltage continues to rise until a maximum of about 12 V. The voltage stops rising only because of the overvoltage protection circuitry of the electrometer

Figure 2 shows the open circuit delay recorded for the same potentiostat and capacitor, but this time using an ECM8 Electrochemical Multiplexer as well. The drift characteristics have obviously changed. In this case, the initial slope is 115mV/s,

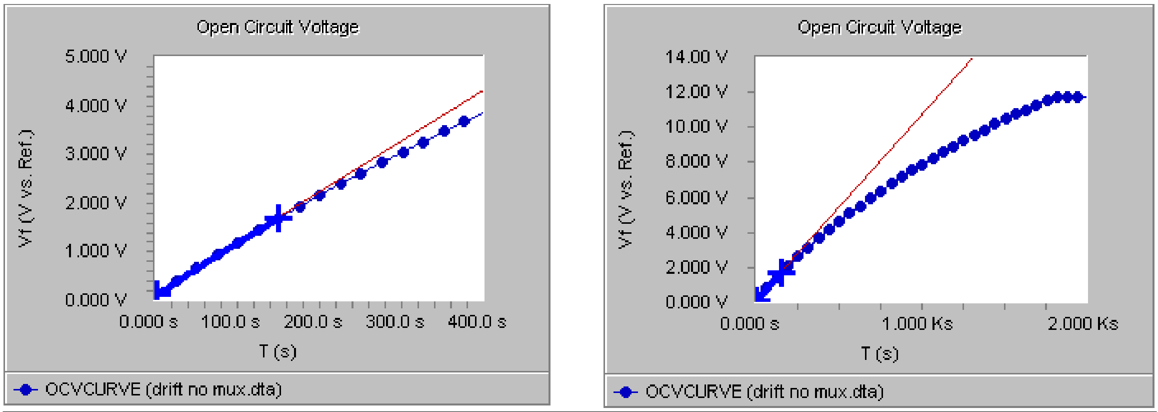

Figure 1. Voltage vs. time for a 1nF capacitor recorded using a PC4/300. Left: Initial slope = 10mV/s. Right: Maximum value is 12V.

over 10 times the slope in Figure 1. The current drawn through the capacitor calculated from this slope is 115pA. The larger current arises from leakage currents associated with the ECM8. Although the current is much larger than in Figure 1, it is also much smaller than the maximum allowed leakage current (2 nA) for the ECM8.

The increased leakage current is only one of the effects of using the ECM8, however. The voltage rises only to about 5V before becoming essentially constant. This is far below the maximum allowed voltage for the electrometer. This may be due to the discharge of the capacitor by the internal impedance of the multiplexer. If this is the case, we may estimate the internal leakage resistance from the voltage (5V) and the current (115pA). The resistance calculated from these values is 430GΩ. Again, this is better than the specifications of the ECM8 which claim >500MΩ impedance

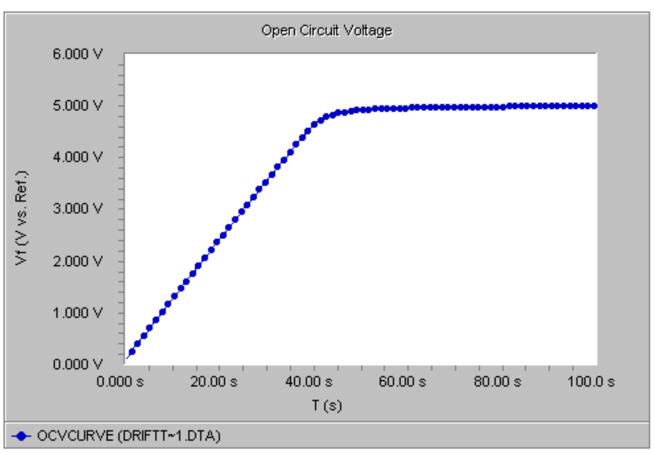

Figure 2. Open circuit delay recoded for the same 1 nF capacitor, but this time including an ECM8 Multiplexer.

This data illustrates some of the problems that may arise when studying very high impedance coatings. It also illustrates why one should be careful when running impedance experiments at a potential "*vs.* E_{oc}." Vastly different potentials would be selected if the open circuit voltage were measured after 10s, 20s, or 100s! See our FAQ entitled "Should I run EIS on my coatings ***vs.*** **Eref** or ***vs.*** **Eoc**?"