

A Valid Argument against the use of Ac based Conductivity Measurements

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Abstract

Water is a dielectric and thus an insulator allowing electric current only to flow when ionic material is present. The more ionic matter in the water the higher the conductivity and the less ionic matter the lower the conductivity will be. Both electrolysis and electrochemistry are involved. Electrolysis is water containing ionic matter and in particular salts and electrochemistry is a useful tool in the purification of metals, production of nanometre sized atomic silver clusters, wet photo chemistry and metal plating. Both forms are considered wet chemistry, albeit, mostly in the realm of physics. Somewhere along the way, chemists introduced the concept of 'wet' conductivity measurement for conducting water and also introduced fraction of the Siemen to depict variations of the Siemen such as milli and micro-Siemen. Soon however, the DC measurement technique in vogue as MHO, (the reversal of OHM) was abandoned and a version having alternating current as its basis was introduced and adopted. Ever since that day, there have been numerous problems.

Introduction

A recent encounter with a questionable claim of very pure water has prompted me to analyse exactly what we are all facing when relying exclusively on conductance measurements expressed in milli and micro Siemens. The particular water quoted as being a "steamed distilled water" measured initially 1 uS/cm and shortly thereafter 2 uS/cm. However when the actual resistivity was measured it only came to 100,000 Ohm/cm when it should have been the reciprocal value of 1 million Ohm for the first reading. Having exclusively used deionised water for my electrochemical experiments, I was surprised that the normal 500uA/h had reduced to a mere trickle of just 9uA/h using the steamed distilled water. Many months earlier the same thing had happened. Thinking my equipment was somehow at fault and having insufficient current capacity, I undertook a complete rebuild. Unfortunately it was all a waste of time. It was the water somehow or what was in there that opposed the flow of current. At that point I decided to investigate what caused the reduced current flow.

My first point of call was the supplier of the water, but that also proved to be a waste of time. However somewhere along the time I acquired two test reports that are starting to explain what may

be the cause of the current impediment. Before I am able to go further, let us look at some facts.

Facts and fallacies.

1. The Term Siemens came first on the scene in the late 1800s, when a German engineer and inventor named Werner von Siemens created an Ohmic standard for a length of copper telegraph cable. This took the shape of a column of Mercury that measured 0.95 Ohm, a very low DC resistance for a solid.
2. The term Mho was introduced soon after in order to establish the reciprocal of Ohm in measuring a DC electric current flow over a specific distance, i.e. a metre, decimetre or centimetre.
3. Dissatisfied with the concept of MHO, that term was replaced by Conductance over 1 cm (10mm) for measuring the electrical current flow in water and its reciprocal of Resistivity/cm in line with Ohms law.
4. Due to the perceived polarisation of water DC, MHO measurements were replaced by Alternating Current irrespective of its frequency dependence. This reciprocal range is supposed to be

something like the chart hereunder, starting from a low resistivity (1 Ohm) and very high conductance to a very high Resistivity (100 M Ohm) and a very low Conductance.

1 Ohm/cm	=	1 Siemens/cm
10 Ohm/cm	=	100 milli S/cm
100 Ohm/cm	=	10 mS/cm
1 K Ohm/cm	=	1 milli S/cm
10 k Ohm	=	100 uS/cm
100K Ohm	=	10 uS/cm
1 M ohm	=	1 uS/cm
10 M Ohm	=	0.1 uS/cm
100 M Ohm	=	0.01 uS/cm

Sometimes a questionable anomaly is included that claims a resistivity of 18.24 M Ohm (conductivity of 0.0548 uS/cm) at a pH of 7, where water is claimed to be neutral, (neither acidic and below 7) or (alkaline and above 7). And here it is where everything goes belly-up.

There appears to be no verification that all of the values of Conductance are in fact the reciprocal of the corresponding resistivity values. Well, how could anyone. Conductance is a measured current at Alternating Current and resistivity can only be measured by DC, but let me explain.

5. So-called AC resistance is actually properly referred to as an Impedance. It is also frequency dependent. An impedance at 100 Hz is different to an Impedance at 1,000Hz and an impedance at radio frequencies is different again. DC resistance however has nothing whatsoever to do with frequencies and is just DC or Direct Current as from a battery. It does not have an impedance but instead refers to a high or low resistance input or output. AC impedances are what it says. There is an impediment or opposition to the flow of electrical current caused by the introduction of electro-magnetic field force lines.

6. Polarisation of the electrical properties of unpure water, other than the dipolar charge of the water molecules, i.e. positive for Hydrogen and negative for Oxygen. With the equilibrium voltage of water being 1.23 volt DC, introducing such and higher voltages in the water is going to interfere with its stability.

7. Water has dielectric properties and is thus an insulator, measuring very high resistance values the purer (or less contaminated) it gets resulting in allowing only minute currents to flow, Tera ohms in resistance and Pico ampere in current. To measure such values is beyond conventional test equipment and in particular a hybrid Conductance/Resistivity instrument like a conductance meter operating on AC. To also expect such Conductance meters to also measure non-conduction materials such as neutral metals, organics and pathogens *is wishful thinking*.

8. There is always the problem in describing the concept of dissolved solids. Some scientists just relate this to ionic matter, but the truth is that total dissolved solids can mean matter in the water DISSOLVED OR NOT can have an adverse effect on the purity or quality of the water. Processes of the water to remove ionic matter and metallic salts may still contain harmful materials such as pharmaceuticals as well as recombinations of these drugs, hormones and pathogens. For that type of contamination, knowing the Conductance factor in micro Siemens is useless. Perhaps we may have to revisit the old analogue test equipment used in the 1900s such as the Turbidity, Nephelometer and other such equipment for physical observation of some of these dissolved organic matter. I am just completing such an instrument for personal use. It uses cross polarised light scattering principles that under violet light can make very small particles visible and quantifiable.

CONCLUSION

There is a need for something better. Perhaps in the area of analogue electronics where indeed measuring instrumentation can go much lower and higher parameters of pure and unpure water by factors of millions in some areas. When testing water we simply cannot rely on just a conductance measurement and hope we measured it all. That is simply not true.