ORP

Oxidation-Reduction-Potential (ORP) Explained

By MHI February 5, 2023

OXIDATION-REDUCTION POTENTIAL ORP BASICS*

One of the characteristics of water containing dissolved **molecular hydrogen** (such as **ionized water**) is that it exhibits a negative **oxidation-reduction potential** (O.R.P.).[1]Chemical reactions occurring in an aqueous solution are called redox reactions.[2] The ORP measures the capacity of a solution to either release or accept electrons from chemical reactions. The ORP value, much like pH, is important for determining water quality and for water treatment processes.[3]

Just as pH determines the water's relative state in receiving or gaining protons (i.e. **hydrogen ions, H^+**), ORP indicates the water's relative state to receive or gain electrons. A solution with a higher (more positive) ORP has the potential to oxidize a solution with a lower ORP. For example, +700 mV is an antioxidant to +900 mV, which is an antioxidant to +1100 mV.

OXIDATION & REDUCTION

Oxidation occurs when electrons are removed,[4] such as when a **free radical** steals an electron from a cell. The cell is oxidized (an increase in its oxidation state), whereas, the free radical is reduced.

Therefore **reduction** means a receiving or gaining of electrons (decrease in its oxidation state),[4] such as when an **antioxidant** donates an electron to a free radical. The free radical is reduced and the antioxidant is oxidized. The antioxidant is said to be the "reducing agent"; it reduces the free radical. Whereas the free radical is called the "oxidizing agent"; it oxidizes the antioxidant. [4]

KEEPING IT STRAIGHT

One way to keep this straight is by using the common mnemonic, OILRIG.[5] **O**xidation **I**s **L**oss, **R**eduction **I**s **G**ain. *(of electrons)*.

The figure to the left is also very descriptive and informative of this process. Remember that you can't have an oxidation reaction without a corresponding reduction reaction.[4] The converse is also true.

POTENTIAL

The potential is a characteristic of the chemical species to undergo an oxidation-reduction reaction. It is not the actual reaction. Rather, it is stored energy that has the ability to do work and is measured in volts; thus, the greater the voltage potential, the greater the ability and propensity to undergo a redox reaction.[6]

The higher the specie's positive potential, (i.e. free radical) the greater affinity it has for electrons, and thus a higher tendency to oxidize (steal electrons) from another species, like a cell membrane. Conversely the lower the specie's redox potential (i.e. antioxidants) the lower its affinity for electrons, and thus a higher tendency to donate its electrons and be a reducing agent (neutralize a free radical).

TWO IMPORTANT POINTS

- It is important to note that just because something has a high ORP (negative or positive) does not mean a reaction will take place.[4] Just like the depiction with the ball at the top of the hill, it has the "potential" to go down the hill, but someone still needs to give it the initial "push" (this is called activation energy, $E_{a)}$). If the required activation energy is too high, the reaction may never occur. In fact, although we hear that diamonds last forever, they actually have a favorable potential to spontaneously convert to graphite (Gibbs free energy = -2.90 kJ/mol.);[7] but, the E_a is so high that the reaction doesn't readily occur.[7]

- It is also important to note that just because something has a negative ORP doesn't mean that it has any physiological antioxidant value. It is the chemical species responsible for producing the ORP value that determines whether or not it can act as a biological antioxidant. For example, a negative ORP can be produced by the addition of vitamin C, molecular hydrogen or aluminum metal to water, but only vitamin C and molecular hydrogen have physiological benefits—even though small amounts of aluminum (Al) in different oxidation states (i.e. Al^{+} to $Al^{3+)}$ can give an ORP of over -700 mV. In fact, the metal can actually act as an oxidant, causing the very thing you're trying to prevent. This is important to keep in mind with many commercial products now tauting the benefits of –ORP water. The question must be "what is the chemical species responsible for producing the negative ORP, and does that have physiological value?"

SUMMARY

The ORP value only tells you if an oxidation-reduction reaction CAN happen. It does not tell you how fast or even if it will happen. It also does not tell you if it has physiological and biological antioxidant value if consumed internally. Make sure you know what chemical species is responsible for producing the negative ORP value.

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