

Electrolyzed Oxidizing Water Generation Methods

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Electrolyzed oxidizing (EO) water, also known as Denkaisui in Japan, or electro-chemically activated water (ECA or ECAW), is a solution generated by passing a dilute salt solution (NaCl and KCl are commonly used) through an electrolytic cell. The anode side of an electrolytic cell, from which acidic EO water is obtained, produces various chlorine compounds and ions such as hypochlorous acid (HOCl), hypochlorite ion (OCl⁻) and chlorine gas (Cl₂), which are all collectively known as free chlorine. HOCl is the main antimicrobial agent present in EO water. EO water generally has a low pH (2.3 – 2.7) and a high oxidation – reduction potential (ORP) (> 1000 mV).

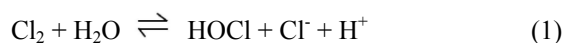
On the cathode side of the electrolytic cell, a dilute solution of NaOH is generated, and this is sometimes referred to as electrolyzed reducing (ER) water. Unlike EO water, the principal use of ER water is not in the reduction of microbial numbers. Instead, ER water is mainly used as a degreaser and cleanser¹. Additionally, work has been done on the health benefits of ER water in terms of cancer prevention, wound care, skin care and also as drinking water for improving digestion and cow milk production². Chemically, ER water is characterized as having a high pH (10-11.5) and a low ORP (-800 to -900 mV)³.

Properties of EO water

EO water is primarily a solution consisting of HOCl, OCl⁻, and dissolved Cl₂, that when in contact with organic materials, variable amounts of organic chlorides, such as trihalomethanes (THMs), chloramines and haloacetic acids (HAAs), all often referred to as bound (or combined) chlorine, are formed. The sum total of HOCl, OCl⁻, Cl₂, and chloramines is known as the total chlorine concentration of an EO water solution.

Ultimately, the concentration and ratio of the species of free chlorine, combined chlorine and chloride ion are dependent on method of generation, and pH of EO water.

In its pure form, chlorine (Cl₂) is a poisonous yellow-green gas. However, chlorine exhibits a pH-dependent chemistry. In other words, the pH of the solution that chlorine is dissolved in will play a dominant role in what compound chlorine will assume. From pH 3 to 7, HOCl is the dominant chlorine species. HOCl is a strong oxidant (ORP > 900 mV), and is the preferred free chlorine species for disinfection. HOCl is generated by the hydrolysis of dissolved Cl₂, as demonstrated in the following equation:



Due to the high molar concentration of water in aqueous solutions, this reaction proceeds via 1st order kinetics ($k_1 = 22.3\text{s}^{-1}$)⁴. Disregarding the effects of all other factors (i.e. product concentrations, temperature, catalysts), the concentration of Cl₂ is the most important factor in determining forward reaction rate in equation 1.

Below pH 3, Cl₂ becomes increasingly dominant. One major cause of free chlorine loss from water at low pH (< 4) is due to off-gassing of Cl₂. The solubility of chlorine gas at 20°C is about 7g/l pure water, and it is reasonable to assume that this solubility can be altered by temperature changes and changes in partial pressure over the surface of the liquid (as Henry's Law states). At low pHs, the reverse reaction of equation 1 predominates, and it is a 3rd order reaction ($k_{-1} = 4.3 \times 10^4 \text{ M}^{-2}\text{s}^{-1}$)⁴. As evident, this reaction proceeds at a much greater rate than the forward reaction described previously. However, it is important to understand that since this reaction relies on the availability of free protons and hypochlorous acid, a low pH is necessary to shift the