

### **The Advantages of Neutral Anolyte Biocide over Chlorine Dioxide**

CLO<sub>2</sub> is a powerful oxidizing agent which has greater killing power than hypochlorites. It was discovered in 1811 and is made in a pH neutral solution by combining NaOCl, HCl, and sodium chlorite. High purity CLO<sub>2</sub> contains no chlorine gas which is very poisonous. CLO<sub>2</sub> leaves long lasting residuals. Unlike hypochlorites, CLO<sub>2</sub> does not react with ammonia to any large extent. Its greater killing power is traced to its oxidizing power, meaning it is a better electron receiver. For example, chlorine itself can accept two electrons while chlorine dioxide can accept up to five electrons. CLO<sub>2</sub> does not combine readily with aromatic compounds and in fact can actually break these bonds (rings) apart. Chlorine, on the other hand, actually attaches itself to the rings in these compounds.

Since chlorine dioxide acts through oxidation, it will not form harmful chlorinated by-products known to be carcinogens. It does not create hydrochloric acid when mixed with water which means it is less corrosive than hypochlorites. Of note, chlorine dioxide is not particularly pH dependent. It is thus effective at all levels of pH. Chlorine dioxide also has a reputation as being able to burst through biofilms and kill the underlying bacteria.

Biofilms are a complex grouping of microorganisms on solid surfaces submerged in water solutions. They often create havoc within gas formations and upon the production tubulars (pipe) and some equipment. They are known to develop increased resistance to chemical biocides. Biofilms attach to surfaces through the operation of an electrical charge. Therefore, the best way to dislodge them is to disrupt that charge. In this case electrochemically activated water such as Neutral Anolyte is as effective as chlorine dioxide in removing biofilms.

One of the major drawbacks of chlorine dioxide is that it is unstable and often has to be generated onsite with heavy equipment. This fact makes chlorine dioxide very expensive compared to hypochlorites. Another challenge is that typical flowback water contains large amounts of organics and minerals. These constituents turn chlorine dioxide into an oxidizer and consume much of the product before it ever gets to act as a disinfectant. Thus, it can take twice as much of the product to be effective. Since chlorine dioxide is already quite expensive, even if made in a factory and shipped to the frac location, its cost becomes prohibitive in many frac pits.

In contrast to chlorine dioxide Neutral Anolyte is very stable and has a six month to one year shelf life. It can be made at a processing plant and shipped to the frac location. It can be used without the need for gowns, masks, or gloves. It is very cost competitive and is as deadly to pathogens as chlorine dioxide.

Neutral Anolyte's eco-friendly foot print and its efficacy and safety are well documented around the world. It is so safe that in other parts of the world it is used in hospitals in pre-operative and post-operative surgical settings. It has proven ability to kill both public pathogens such as e. coli and non-public pathogens such as sulfate reducing bacteria. In short Neutral Anolyte Biocide overcomes all of the challenges presented by virtually every other chemical and non-chemical biocide.