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Need to Know ClO_2 versus the others

This Need to Know describes the main differences between the active substances conventionally used for water disinfection.

1. General overview

	Chlorine	H_2O_2	Stabilized H_2O_2	ClO_2 generator (HCl)	Pure ClO_2 (Diox)
Required dosage active substance	High	High	High	Low	Low
Biocidal activity	Intermediate	Intermediate	Intermediate	Good	Good
Resistant microorganisms	Yes	Yes	Yes	No	No
Biofilm removal and prevention	Poor	Poor	Poor	Good	Good
Residual concentration	Good	Poor	Intermediate	Intermediate	Intermediate
pH-effect	High	Intermediate	Intermediate	Low	Low
Corrosive	Yes	Yes	Yes	Intermediate	No
Cost per liter	Low	Intermediate	Intermediate	Intermediate	Intermediate
Total cost of ownership	High	High	High	Intermediate	Low
Environment	Bad	Good	Intermediate	Intermediate	Good

2. Required dosage active substance

Chlorine and H_2O_2 have a high oxidation strength, implying they not only attack microorganisms, but also most materials as eg stainless steel.

Chlorine dioxide is a weak oxidizer. This might sound as a disadvantage but it is actually a big advantage. It means that it is sufficiently strong to kill off quickly and completely all micro-organisms, but leaves the lion's share of the materials unaffected.

This has as a consequence that less chlorine dioxide is required for a same disinfecting effect.

3. Biocidal activity and increased microbial resistance

   Chlorine has somewhat a limited biocidal spectrum. For example, chlorine is not active against the parasite *Cryptospordium*, one of the leading causes of waterborne diseases. H_2O_2 shows also tendency to decreased biocidal spectrum, eg against crazy roots, caused by the bacterial species *Agrobacterium rhizogenes.*

   To date, no organism has proven chlorine dioxide resistant.

4. Action against biofilm

   A biofilm is a complex ecosystem of microorganisms, their products and nutrients. Treating biofilms with strong oxidizers like chlorine or H_2O_2 burns the outer layer of a biofilm, but in meantime, warns the more shielded microorganisms to harness themselves. Hence it becomes more and more difficult to get rid of a biofilm in a system.

   Chlorine dioxide is a gas under normal conditions. For water disinfection, it is used as a water-dissolved gas. Well, the gas chlorine dioxide is capable of penetrating the biofilm. Instead of only affecting the outer surface of the biofilm, it removes it at the roots.

5. Residual concentration

   Chlorine shows the best residual concentration, whereas stabilized H_2O_2 and chlorine dioxide score intermediate. Regular H_2O_2 quickly disappears in water systems.

6. pH effect

   The activity of chlorine is strongly affected by pH. Chlorine is best applied at pH < 7. At higher pH, a much higher dose is required. H_2O_2 also shows a tendency to be affected by the pH of the water.

   Chlorine dioxide shows the required biocidal activity in a pH-range of 4-9,5.

7. Corrosivity

   Since chlorine and H_2O_2 are both strong oxidizers, they both are highly corrosive for pipes, reactors, ... If chlorine dioxide is produced by a generator (HCl, strong acid), an excess of HCl is used, which makes the dosed chlorine dioxide solution more acid than necessary. Diox represents an alternative chlorine dioxide production method, not using the strong acids. Hence, Diox is much softer for materials.

8. Cost per liter

   Chlorine is the cheapest product, expressed per liter. H_2O_2 will be the most expensive. Chlorine dioxide has an intermediate cost.

9. Total cost of ownership

   Taking into account the required investments and product costs for the disinfection and the costs for the monitoring and the maintenance of the water system, chlorine dioxide will often show the lowest total cost of ownership. Despite the higher product cost as compared with chlorine, the quality of the water will be secured and the maintenance costs for the water system will strongly decrease.

10. Environmental impact

    Chlorine produces toxic by-products such as AOX. Stabilized H_2O_2 sets silver ions free in the environment. Chlorine dioxide produced with strong acids creates significant amounts of chlorate. When using high quality chlorine dioxide, the final reaction product are small amounts of chloride (as found in kitchen salt).

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