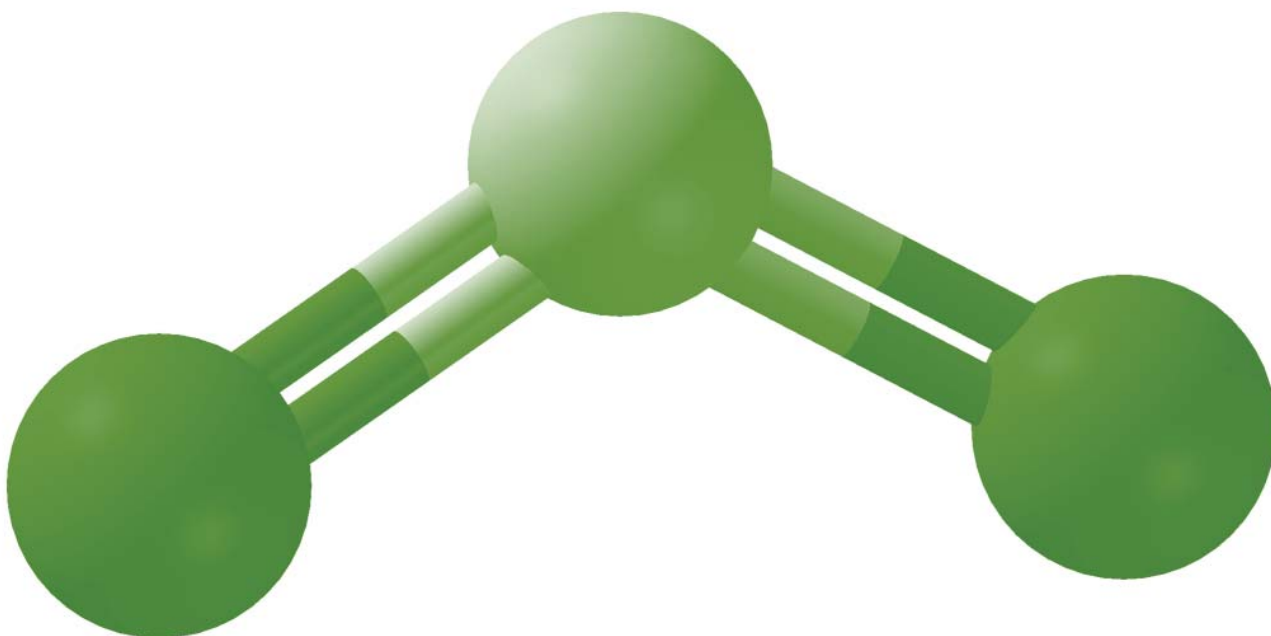


Innovation

CHLORINE DIOXIDE



atomes

3485 Ashby, Ville Saint Laurent

Quebec, H7W 2N9, Canada.

Tel: +1 (514) 745 2597

Fax: +1 (514) 745 5176

www.atomesbio.com

I. GENERAL INFORMATION

- Chlorine dioxide (ClO_2) is a synthetic, green-yellowish gas with a chlorine-like, irritating odor. Chlorine dioxide is a neutral chlorine compound.
- Chlorine dioxide is very different from elementary chlorine, both in its chemical structure as in its behavior. It is a small, volatile and very strong molecule.
- In diluted, watery solutions chlorine dioxide is a free radical. At high concentrations it reacts strongly with reducing agents.
- Chlorine dioxide is an unstable gas that dissociates into chlorine gas (Cl_2), oxygen gas (O_2) and heat.
- When chlorine dioxide is photo-oxidized by sunlight, it falls apart. The end-products of chlorine dioxide reactions are chloride (Cl^-), chlorite (ClO^-) and chlorate (ClO_3^-).
- At -59°C , solid chlorine dioxide becomes a reddish liquid.
- At 11°C chlorine dioxide turns into gas.
- Chlorine dioxide is 2.4 times denser than air. As a liquid chlorine dioxide has a bigger density than water.
- One of the most important qualities of chlorine dioxide is its high water solubility, especially in cold water. Chlorine dioxide does not hydrolyze when it enters water; it remains a dissolved gas in solution. Chlorine dioxide is approximately 10 times more soluble in water than chlorine. Chlorine dioxide can be removed by aeration or carbon dioxide.

AT – 7070 DESCRIPTION & ADVANTAGES

AT-7070 comes in two separate chemicals, **Enhance I (A) and Enhance II (B)**.

- Once mixed together at a ratio **1:1 for 5 minutes**¹, they **instantly**² generate **80'000 ppm**³ of Chlorine Dioxide Stable for at least **100 hours**⁴ in the dilution tank. AT-7070 is effective as low as **0.1 ppm**⁵.
- **A** is an acid replacement technology, specialty chemical, derived from a reaction of 12 safe, non-harsh, environment friendly ingredients. **B** is a state of the art unactivated oxidizing agent, with 5 ingredients. Once diluted with **A** will generate precursors leading to a chemically reacted Chlorine Dioxide.
- Enhance Chlorine dioxide is not classed as a chlorine-based disinfectant, as it acts in a different way and does not produce free chlorine. Chlorine dioxide breaks down to chlorite and chlorate, which will remain in solution; the WHO health-based drinking-water provisional guideline value for chlorite is 0.7 mg/l (0.7ppm) (based on a TDI of 0.03 mg/kg of bodyweight) (WHO, 2004), and this is also the provisional guideline for chlorate.
- Enhance Chlorine dioxide makes it an ideal choice to meet the microbial and oxidative challenges of today's environmentally concerned world. It is an ideal replacement for chlorine, providing all of the benefits of chlorine and more, but without any of its weaknesses and detriments. Chlorine dioxide is a broad spectrum biocide with 2.6 times the oxidizing capacity of chlorine. It is a selective oxidizer that is effective across a broad pH range.
- Chlorine dioxide is an effective tool for the treatment of pool and recreational water. It is a powerful disinfectant that nicely balances purification performance against



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disinfection by product formation. It is one of four EPA approved disinfectants for drinking water with CT values second only to ozone in biocidal efficacy but without the ozonation by-products or high capital expense.

- Enhance (Chlorine Dioxide) is manufactured by Atomes Canada. Atomes products comply with the highest regulatory purity standards for drinking and pool water.

- Does AT-7070 produce byproducts ⁶?

AT-7070 applied to water produces less disinfection byproducts than oxidators, such as chlorine. Contrary to ozone (O₃), AT-7070 does not produce bromide (Br⁻) ions into bromate ions (BrO₃⁻). Additionally AT-7070 does not produce large amounts of aldehydes, ketones, ketone acids or other disinfection byproducts that originate from the ozonisation of organic substances. Simply AT-7070 does not form toxic by-products

- AT-7070 is **effective over a wide pH range** ⁷ between 4 & 10, in both hard and soft water.

Contrary to chlorine, AT-7070 is effective at a pH of between 4 and 10. The efficiency increases at high pH values, while the active forms of chlorine are greatly influenced by pH. Under normal circumstances AT-7070 does not hydrolyze. This is why the oxidation potential is high and the disinfection capacity is not influenced by pH.

- Both **temperature and alkalinity of the water do not influence the efficiency** ⁸. At the concentrations required for disinfection, AT-7070 is not corrosive. AT-7070 is more water-soluble than chlorine.

- ⁹ AT-7070 will eliminate both planktonic and sessile bacteria, disinfect surfaces and rapidly destroy problematic biofilm. These properties make it ideal for use in a wide

range of water sterilization, disinfection, environmental hygiene, industrial and process water treatment activities.

- **10** Our range of advanced technology chlorine dioxide products deliver **fast acting**, superior microbiological control in a safe, convenient form. Our ClO₂ products include innovative two component liquids.
- **11** Ideal and very cost effective for small to medium users of chlorine dioxide
- **12** Effective against all water related microorganisms (bacteria, viruses, protozoa, fungi, yeast), No resistance building by micro-organisms.
AT-7070 is a very effective bacterial disinfectant and it is even more effective than chlorine for the disinfection of water that contains viruses. **AT-7070** has regained attention because it effectively deactivates the chlorine-resistant pathogens Giardia and Cryptosporidium.
- **13** Very cost effective method of generating chlorine dioxide.
- **14** The smell, taste and color of drinking water improves.
- **15** Less load on sewage.
- **16** Reduction of residue in water.
- **17** **AT-7070** removes and prevents Prophylaxis on biofilms.
- **18** Disinfection with **AT-7070** does not cause odor nuisance. It destroys phenols, which can cause odor and taste problems. **AT-7070** is more effective for the removal of iron



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and manganese than chlorine, especially when these are found in complex substances.

- **19 How can AT-7070 be stored and transported?**

- a. A and B could be stored at room temperature for a long period, shelf-life contrary to regular chlorine dioxide gas that is as a liquid at 4 °C and cannot be stored for too long, because it slowly dissociates into chlorine and oxygen.
- b. A and B are not explosive contrary to the regular gas form, because it is explosive under pressure. When concentrations are higher than 10% chlorine dioxide in air, there is an explosion hazard.
- c. In a watery solution, AT-7070 remains stable and soluble.
- d. AT-7070 is safely transported contrary to regular chlorine dioxide that is rarely transported, because of its explosiveness and instability and which is usually manufactured on site.

- **20** Regular liquid chlorine dioxide are produced from mixing harsh and hazardous ingredients such as acids. AT-7070 is very safe because it is produced from non-harsh, safe, environment friendly actives.

AT-7070 showed 20+ advantages over regular chlorine dioxide gas or any other liquid components simply by producing instantly in less than 10 minutes 80'000 ppm of chlorine dioxide and stable for at least 100 hours.

AT – 7070 AREAS OF APPLICATION

This versatile chlorine dioxide liquid delivery system has a range of applications including:

- Food processing environments - very effective, food safe hard surface cleaner.
- General industrial and process water treatment applications including cooling systems, cooling towers (Legionella control), water storage tanks etc.
- Re-circulating cooling water systems.
- Reverse osmosis plant and membrane sterilization.
- Emergency drinking water purification.
- Highly effective odour control.
- Water softeners.
- Vehicle and car washing facilities, controlling microbiological activity in recycled water systems.



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AT – 7070 FOR SWIMMING POOLS.

Enhance Chlorine Dioxide has several advantages over chlorine, bromides and ozone in swimming pools.

- It is more effective as a disinfectant than chlorine in most circumstances against water borne pathogenic microbes such as viruses, bacteria and protozoa – including the cysts of Giardia and the oocytes of Cryptosporidium.
- Recommended by WHO as safest disinfectant
- Fully operational on pH levels between 4-10
- Temperature independent
- No taste, smell and odour
- Long term residual disinfection effectiveness
- No reaction with ammonia, thus no release of THM recommended for human
- No corrosive effects
- Very flexible in dosing rates and combined disinfection
- No release of free chlorine
- Only limited investment cost
- Does not change the smell, taste and colour of drinking water
- Easy to transport
- Ready to use by mixing 1 L Enhance I with 1 L Enhance II to make a stock solution
- Cost effective, Made in Canada
- Most diseases related with water contamination can be controlled



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AT – 7070 FOR REVERSE OSMOSIS.

The function of adding Enhance I&II after the active coal and before the membrane is simple: by adding Enhance I&II mixture in low dosage rates the water contains disinfection power at low dosage contributing positively to face the undesired fouling of RO systems. The degree and frequency of fouling varies widely from one membrane system to another. Fouling to the point of cleaning begin required can occur as limited as once per year or as frequently every day.

The foul-ants can be classified into four main categories: dissolved solids, suspended solids, biological, and non-biological organics. Biological fouling continues to be a major unresolved problem for membranes and systems as the most common RO-membrane types in use today are attacked and degraded by chlorine and according to public literature by other oxidizing agents. Chlorine is commonly used as a feed water disinfectant. However it must be removed from the feed water prior to entering the RO system. Without a disinfectant present in the water, microorganism colonizes and forms a biofilm in the RO system. Ultimately the RO membranes have to be removed from service and cleaned. Thus the biofilm causes a reduction in membrane performance and membrane damage leading to higher maintenance and system operating cost.

The main object of Atomesbio is to efficiently treat a membrane separation system to control microbes and biofilm formation by extremely low levels of Enhance I&II solution by not adversely affecting the RO membrane.

The minimization of the biofilm in the membrane system includes the biofilm formation on the surface of the membranes. By dosing extreme low levels of Enhance I&II solution in the feed water the depositing and growing of biofilm on membranes can be significantly



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reduced without damaging the membranes leading to increased salt passage.

The dosage rate of Enhance I&II to the feed water will vary per RO system depending on the available biofilm in the RO system as well as the composition of the feed water (e.g. enzymes)

In various cases we have seen that a dosage rate of 5 ppb of Enhance I&II provided a desired result. To avoid the growth of biofilm a dosage rate of 100 ppb or 0.1 ppm on average as proven to be effective.

Further a dosage rate above 500 ppb will provide a critical level of Enhance I&II where the membrane possibly might be affected by the oxidizing power of Enhance I&II (this variation depends on the feed water composition and quality and therefore an appropriate dosage rate must be determined by test).

To summarize:

- A dosage rate of Enhance I&II should never exceed the level of 0.1 ppm and have a minimum of 50ppb.
- While using Enhance I&II the salt passage will not increase (a true and valid indicator that the membrane is not damaged)
- An appropriate sensor should control the Enhance I&II level in the system (chlorine dioxide sensor or potentiostatic analyzer) at ppb level
- The dosing system that injects Enhance I&II in the feed water should be controlled by the monitoring sensor and stop dosing if levels exceed the maximum value to avoid damage to the membrane.
- Appropriate testing by the customer is advisable.

- You can also dose in after the RO system. A lot of problems occur in the waterlines after the RO system as biofilm will still be present.

Further Enhance I&I can be used with the permeate for normal disinfection control and replace existing disinfectants (e.g. chlorine). Standard dosing rates are around 0.06ppm

To sterilize an RO system a dosage a dosage rate of 50-100ppm chlorine dioxide is required with a circulate sterilization solution for 10-15 minutes. After that the system needs to be rinsed several times with tap water. The tap water needs to be renewed between rinses. After that the system needs to be rinsed 3-4 times with de-ionized water. Once drained, the system is ready for use and the membrane can be installed.



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