

Unique Features and Applications of Chlorine Dioxide on Disinfection

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Abstract— Disinfection is an important measure to ensure the water quality security. Chlorine dioxide -as a strong oxidizer is widely used for disinfection of drinking water and wastewater. This paper firstly introduces the basic properties of chlorine dioxide, then detailly analyses its disinfection -functionality and advantages, finally discuss the prospect of application

Keywords-Chlorine dioxide; Chlorine dioxide Disinfection; Disinfectant

I. INTRODUCTION

The distribution of water resources spatial and temporal heterogeneity, rapid population increase, expansion of production capacity, urbanization, low water resource utilization-, extravagant habits of water etc cause the serious shortage of water resources ^[1,2,3], which not only -severely restricts the economic development, but also causes infaust psychological -influence ^[4]-on the residents, even may lead to significant social and political crisis. Therefore, on the basis of saving water, it is imminent to develop the unconventional water sources from many aspects in order to address a series of serious problems caused by the shortage of water resources Compared with newly developed sources of water, wastewater reuse is an effective way of low cost, quick solution to the problem of water shortage. How to choose a highly effective disinfectant with the low cost and less disinfection by-products has become the focus of attention. Chlorine dioxide is a high chemical activity and strong oxidant, and produces less environmental pollution. Now the application of chlorine dioxide has been broadened widely, especially in sterilization.

A. Properties of chlorine dioxide disinfectant

Chlorine dioxide when disinfection is generally exists in solution form, it's usually gas is yellow, in the solution concentration was 14 ~ 17mg/L odor, achieved when 45mg/L is irritating. Chlorine dioxide gas can be compressed into a liquid at room temperature, density is 2.4kg/L, the boiling point of 11 DEG C, melting point - 59 °C. When chlorine dioxide is exposed to light or in contact with organic material with the temperature rise will explode. In industry, chlorine dioxide transport through a mixture of air, to keep the concentration of chlorine dioxide in 8% ~12%. In the dark, chlorine dioxide solution can be stored for several months.

The solubility of ClO₂ is 5 times larger than the Cl₂, redox potential is 1.15 times higher than Cl₂, but not as easy

as chlorine with water or ammonia reacts with the ^[5]. Because the ClO₂ does not with water, NH₃ and chloramine, therefore does not break point such as chlorine dosage and residual volume curve formed by ^[6]. Moreover, ClO₂ has obvious volatile, as long as the removal of ^[5] from water by simple aeration. In addition, ClO₂ exists in the resonance structure of AB₂, the electronic structure of the ClO₂ molecule was not saturated, but in the water but not to two poly or poly state exists, this is good for ClO₂ ^[6] in the rapid diffusion of water.

B. General technical characteristics of 2 chlorine dioxide disinfection

In recent years, domestic and foreign scholars have studied the exploration and validation of chlorine dioxide disinfection effect, many test results show that the application of chlorine dioxide disinfection with chlorine disinfection in water treatment practice has more ideal effect.

C. Effectively kill bacteria propagule.

Ridenour (1947) study demonstrated that, in pH 7 water, not to 0.1mg/L doses of chlorine dioxide in 5min can kill typhoid, paratyphoid, dysentery bacillus, Escherichia coli bacteria and other common enteric bacteria; in the range of pH6 ~ 10, its bactericidal effect is not affected. Benarde (1965) proved by the experiment, when pH>8.5, the disinfection effect of chlorine dioxide chlorine 20 times faster than ^[7].

In recent years, through research on the disinfection effect of chlorine dioxide, results show that under certain conditions of chlorine dioxide on Staphylococcus aureus and Escherichia coli bacteria in 1 ~ 2min, the killing rate is more than 99.9% ^[8]. On the role of Escherichia coli 2min, killing rate up to 99.99%, if the action of 10min, it can be completely kill. To make a long story short, chlorine dioxide is very powerful to kill bacteria propagule.

D. effectively kill virus

Is generally believed that the effect of chlorine dioxide on virus is stronger than the chlorine or similar. As early as in 1946, there were reports, chlorine dioxide with inactivated polio virus (Polio virus) role, its effect is similar with free chlorine. Other researchers also reported in the pH than neutral or the presence of ammonia, chlorine dioxide in the inactivation of F2 phage, Ke Saqi virus B3, ECHO virus, vaccinia virus, phage phi X174, Sendai virus Andvaccine virus than chlorine strong.

Aieta 5mg/L of chlorine dioxide and chlorine in the two grade in the sewage treatment of Escherichia coli bacteriophage phi 8 and Polio virus I virus killing effect.

The results showed that chlorine dioxide, inactivation of phage phi 8 and Polio virus I than Cl intensity. Longley has the similar reports, they compared the chlorine and chlorine dioxide in waste water of phage killing effect, the dosage of 5mg/L, contact time, 3min, chlorine inactivation of 1 log level, and chlorine dioxide inactivated phage reached 3 log^[9] and above.

E. Effective in killing bacterial spores

As the chlorine dioxide has strong oxidation, so it on the spores of bacteria also has a strong bactericidal effect. Compare it with the same concentration of chlorine, and concluded that chlorine dioxide sporicidal effect is stronger than chloride. Experimental conclusion, it to be anthrax spore inactivation ability is 5 times stronger than chlorine. A study of chlorine dioxide with a 15min concentration of 1000mg/L, the spores of Bacillus subtilis var.niger killing rate of up to 100%^[10].

F. Kill fungus

Chlorine dioxide effect of 5min 500mg/L 100%, can kill to Trichophyton; but the role of 200mg/L 60min, of Aspergillus fumigatus by calf serum protection 0.03% of the killing rate reached 99.9999%; 100mg/L 60 seconds, with 0.03% calf serum protection of Candida albicans in the killing rate was 99.99999%. Be11 Research Report 2min, chlorine dioxide, the acrylic resin with 10% horse serum protection of Candida albicans killing rate reached 100%^[11]. There are reports containing 4.5 ~ compound disinfectant of chlorine dioxide and chlorine 5.0mg/L available chlorine for Candida albicans of 1 ~ 2min, the killing rate is more than 99.9%.

G. Effectively kill algae and plankton

Tests show, killing effect of chlorine dioxide on filamentous algae, Chlorella, ankistrodesmus, prismatic desmids, Cladophora algae increases with the concentration of the disinfectant, and basically is better than or equal to the liquid chlorine.

In pH=7.0, to kill 20min, experiments show that with the increase of the amount of disinfectant, killing of protozoan and metazoan more. Liquid chlorine dosage increases to 7.0mg/L, all protozoa and metazoa were killed, and the chlorine dioxide to achieve the same result is only 5.0mg/L.

H. Remove part of organic matter

Chlorine dioxide oxidation ability is very strong, has good removing effect on phenolic compounds in water, but also on the polycyclic aromatic hydrocarbons, nitrosamines, griseofulvin, aflatoxin and mustard gas and other mutagens and carcinogens oxidation degradation product has good removal capability. According to reports in the literature, chlorine dioxide can be carcinogenic BaP oxidized quinone, non carcinogenic, when water is added 8.4mg/L ClO₂, the BaP removal rate can reach 80%, which is the chlorine disinfection is not up to^[6]. In addition, the ability of chlorine dioxide caused by the removal of organic matter in water color taste is also very strong, water can be 2, 3, 6- 2-

three chlorobenzene ether, methyl isoborneol, 2- isopropyl -3- methoxy pyrazine and 2- isobutyl -3- methoxypyrazine and odor removal. These compounds in water even PPT level will also have great taste.

II. DISINFECTION CHARACTERISTIC OF DISINFECTANT

Some researchers the disinfection effect of chlorine dioxide and chlorine were compared, as shown in table 1. Can be seen that under the same conditions, disinfection effect of chlorine dioxide is obviously better than that of chlorine; to achieve the same effect, shorter contact time of chlorine dioxide disinfectant required dosage less^[13]

TABLE I. COMPARISON OF CHLORINE DIOXIDE AND CHLORINE DISINFECTION

Disinfection Effect	Chlorine dioxide disinfection (concentration and action time) dioxide disinfection	Chlorine disinfection (concentration and action time)	document
One of the water source of Shanghai city Minhang bacteria in raw water reached 100% of the inactivation	2.5mg/L, 15min	3.0mg/L, 60min	Mo Xingkang, 2000[14]
On E.coli inactivation rate reached 99%	1.4mg/L, 20min	1.8mg/L, 20min	Huan g Junli, 2002[6]
Staphylococcus aureus reached 98% of the inactivation rate	2.5mg/L, 2min	2.5mg/L, 3.5min	
The prismatic desmids reached 85% and the killing rate Engineering	4mg/L, 30min	5mg/L, 30min	
The Cryptosporidium oocysts inactivation rate reached 90% Management	1.3ppm, 60min	80ppm, 90min	Korich et al, 1990[12]

III. SUMMARY AND OUTLOOK

Due to the high-effective and broad-spectrum bactericidal effect of chlorine dioxide, it works long lasting, and its diffusion speed in water and penetration ability are faster than chlorine, especially in low concentrations exhibiting the more obvious effect. In addition, using chlorine dioxide as a disinfectant, there is almost no disinfection by-products to form, and the process is rarely affected by pH value and organism. It has been widely used in the drinking water.

Moreover, the long-term practice also proved that chlorine dioxide is the most ideal chemical disinfectant in the present. There are more extensive applications in the catering, food, medical, aquaculture industry disinfection^[17].

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