

Killing of Invasive Marine Species in Ship's Ballast Water Using Hydroxyl Radicals

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Until now, no any effective method is used in the treatment of ship's ballast water on board. With the Strong ionization discharge method, the strong electric field ($E_d \geq 400 \text{Td}$, $1 \text{Td} = 10^{-17} \text{Vcm}^2$) is formed with the thinner $\alpha\text{-Al}_2\text{O}_3$ dielectric layer in the micro-gap at a high pressure ($P \geq 0.1 \text{Mpa}$ or $n = 2.6 \times 10^{-19} / \text{cm}^3$). The electrons achieve the average energy of above 12eV. As a result, O_2 in air and H_2O in seawater are ionized and dissociated into a number of activated particles such as OH , O_2^+ , $\text{O}(^1\text{D})$, HO_2 radicals, and then dissolved into a part of seawater to form the dissolved hydroxyl radicals. The ratio concentration of OH^\cdot is 23.4mg/L in 20t/h pilot-scale system and injected into the main pipeline of ballast water discharge. The experimental results are as following:

- [1] OH^\cdot radicals are dominantly produced from the positive ions O_2^+ reacting with H_2O to form the water cluster ions.
- [2] The concentration of killing organisms in ship's ballast water is only 0.63m/L.
- [3] The duration to kill mono-cell algae, bacteria and protozoan are very fast only 2.67s.
- [4] The hydroxyl radicals have much stronger oxidized and decomposed actions to the photosynthesis pigments of phytoplankton. The contents of chl-a, chl-b, chl-c and carotenoid are decreased to 35%-64% within 8.0s further to the lowest limit of test after 5 minutes.
- [5] The lipid peroxide degree of cell is increased three times. The basic life substances, monose, amylose, protein, DNA and RNA of cell, are greatly destroyed. Also CAT, POD and SOD of antioxidant enzyme system are obviously destroyed. Biochemistry processes is the main reasons of organism cell death.
- [6] The quality of ballast water is greatly improved. With the duration of 2.67s, the decrease rates of COD, nitrite and ammonium salt are 100%, 98.3% and 99.5% respectively, and the turbidity is decreased to 50%. DO is increased 77% due to the decomposition of residual OH^\cdot .
- [7] The equipment of hydroxyl solution has some advantages such as small volume, simple operation and low running cost, which is only 1/30 cost in comparison with the open-ocean- exchange of ship's ballast water.

In a word, the treatment of ship's ballast water using OH^\cdot radicals is a kind of advanced oxidation method, which realizes Atom Economy, Zero Emission and Zero Pollution in the process of the production of OH^\cdot radicals and the kill of organisms of ship's ballast water. Invasive marine species can be killed in ship in the process of the discharge or inputting ballast water.