Shrimp disease disinfection and phytoplankton control of intensive shrimp pond water by electro-oxidation process

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INTRODUCTION

Recently, shrimp culture in many countries have been confronted with outbreaks of diseases and environmental problems. Phytoplankton die-off and consequent proliferation of pathogenic bacteria remain to be one of the serious problems in intensive shrimp cultivation.¹⁾ During cultivation, mass mortality of shrimp was observed to coincide with the blooms of some species of *Oscillatoria*.²⁾ Severe mortality of juvenile shrimp occurred due to luminous vibrios. Although some phytoplankton are beneficial in shrimp ponds, some species can produce compounds that are extremely toxic to aquatic animals. Sub-lethal levels of toxins weaken the prawns causing predisposition to secondary infection by pathogenic bacteria.²⁾ Thus the control of the number of phytoplankton is necessary in intensive shrimp farm. Electrolytic oxidation (EO) treatment has been found to be effective for controlling phytoplankton overbloom, as well as the proliferation of pathogens in shrimp pond water. In this study, the influence of anode type, energy input and water quality on *Vibrio* inactivation and phytoplankton reduction was investigated.

MATERIALS AND METHODS

Shrimp pond water, either as natural shrimp pond water or artificial seawater containing *Skeletonema* (from NIES, Japan) as the model phytoplankton, and *Vibrio harveyi* (from Dept. of Fisheries, Thailand) as the model shrimp pathogen, were used for electrolysis experiments. Electrolytic oxidation experiments were conducted in a batch reactor with working volumes of 3 L and 8 L using a DC power source (GSV 3000, Diamond Company, Japan) controllable between 0 to 15 volts. Mixing was done either with a magnetic stirrer or a submerged jet aerator. Different electrode materials such as titanium base metal sintered with platinum, iridium or ruthenium, or coated with TiO₂, were tested; stainless steel was used as cathode. The total *Vibrio* counts (TVCs), phytoplankton level as chlorophyll *a* concentration, total residual oxidants (TROs)³⁾,

ammonia and chemical oxygen demand (COD)⁴⁾ were monitored.

RESULTS

Fig. 1 shows the time course of phytoplankton concentration (in terms of chlorophyll *a*) during EO using different types of anodes. Complete removal of chlorophyll *a* was achieved within 5 min for all anodes tested. The anode type had no significant effect on phytoplankton removal. In succeeding experiments, the Ti coated with TiO₂ anode was used.

Fig. 1. Changes in chlorophyll *a* during EO with different anode types; (Δ)Ti/Ir, (□) Ti/Pt, (◇) Ti/TiO₂, (○) Ti/Ru; Operate with 0.5 A.

Efficiencies for the removal of phytoplankton, *Vibrio* and COD by EO was affected by the amount of energy input as shown in Fig. 2. Higher volumetric energy input increased the removal efficiency. The increase in removal efficiency was highest for *Vibrio*, and followed by chlorophyll *a*. The increase in removal efficiency for COD by EO was relatively slow. The removal rates per energy input are shown in Table 1. The amount of energy in an actual process will depend on which target is chosen for removal (phytoplankton, *Vibrio* or COD) and how much they are present in the water. Fig. 3 shows the relationship between TROs and electric quantity during electrolysis with 2.8 cm² area

of Ti/TiO₂ anode. The graph shows that 13.6 mg of oxidants (as TROs) are formed for every coulomb of electricity.

Fig. 2. Changes in phytoplankton, *V. harveyi*, and COD in artificial seawater after electro-oxidation with different specific energy consumption; Ti/TiO₂ and stainless plate were anode and cathode, respectively; (□) *V. harveyi*, (○) Chlorophyll *a*, (Δ) COD. The operating condition was 60 watts power supply and 0 to 3 minutes of electro-oxidation time.

Table 1. Removal rate of *Vibrio*, phytoplankton and COD after EO

Parameter	Removal rate
<i>Vibrio harveyi</i>	>5 x 10 ⁴ CFU/watt hour
Chlorophyll <i>a</i>	276 μg/ watt hour
COD	10.3 mg/watt hour

Fig. 3. Relationship between TRO and electric quantity during electrolysis with 0.05 (◇), 0.10 (□) and 0.20 (Δ) ampere; 2.8 cm² area of Ti/TiO₂ anode

DISCUSSION

Electro-oxidation process involving the electrolysis of seawater is categorized as an indirect type of environmental electrolysis. The oxidation of COD, and the removal of phytoplankton and *Vibrio* do not occur mainly on the electrode, but by the oxidants/disinfectants produced at the anode. These oxidants/disinfectants are mainly forms of hypochlorous and hypobromous acids which are formed by reaction of water with chlorine and bromine formed from the oxidation of chloride and bromide at the anode. Therefore, the removal of *Vibrio*, phytoplankton and COD in shrimp pond water is a direct action of the oxidants formed at the anode. For practical application of this process, it will be necessary to know how much of oxidants are formed, and how much of oxidants are required for the removal of unit amounts of phytoplankton, *Vibrio* and COD. Once the "oxidant doses" for the removal of these elements are known, and if the relationship between oxidant formation and electrolysis conditions (i.e. electric current) are known, then the operating condition for an actual process can be calculated from the relationship between TROs and operating current at the different electrolysis times (Fig. 3). The oxidant doses for removal of unit amount of phytoplankton, *Vibrio* and COD were calculated to be about 1.6 x 10⁻² mg TRO/μg chl-*a*, 8.8 x 10⁻⁵ mg TRO/CFU *Vibrio* and 0.4 mg TRO/ppm COD. The laboratory conditions obtained will be evaluated and applied for testing in actual shrimp ponds.

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