Bromate free disinfection by high voltage pulse

I-S Chang*, J-H.Lee**

*Hoseo University, Dept. of Environmental Engineering, Asan, south Korea, cis@hoseo.edu
**Hoseo University, Dept. of Electrical Engineering, Asan, south Korea, jhlee@hoseo.edu

ABSTRACT

Ozonation for the purpose of disinfection of drinking water usually produces various kinds of disinfection byproducts (DBPs). Among the DBPs, bromate (BrO_3^-) is notorious for its potential carcinogenic nature. World health organization (WHO) limits the bromate to 10 ppb in drinking water. To reduce this bromate formation during the disinfection processes, a high voltage impulse (HVI) technique was applied in this study. HVI has been used as one of disinfection process for non-thermal sterilization of foods. The HVI system consisted of power supply, high voltage generator, capacitors and impulse generator. HVI with 10 to 20 kV/cm of electric fields was introduced to sample waters in order to monitor if bromates are formed or not. As the precursor of bromate, i.e., bromide (Br^-) spiked into the sample waters by 1,000 ppb, bromate was not generated at all times, indicating that the bromate formation was completely inhibited. A model microorganism, *Escherichia coli* is inoculated to the sample waters to test the disinfection efficiency. More than 2-log reduction (99 %) of *E.coli* was achieved after HVI treatment with 20kV/cm, 100Hz, 4μs pulse width. Consequently, HVI technique could be used for alternative strategy for bromate free-disinfection procedure for water disinfection

Keywords: bottled water, bromate, disinfection, high voltage, pulse

1 INTRODUCTION

Ozonation, the most common disinfection practices for the bottled drinking water, produces various kinds of disinfection byproducts (DBPs). Among the DBPs, bromate (BrO_3^-) is notorious for its potential carcinogenic nature [1]. It has been known that bromate is generated by the oxidative reaction between ozone and bromide (Br^-). World health organization (WHO) limits the bromate to 10 ppb in drinking water [2].

In orer to reduce or minimize this bromate formation during the disinfection processes, a high voltage impulse (HVI) technique was applied in this study. HVI has been used as one of an alternative disinfection process for non-thermal sterilization of foods because it does not alter the nutritional properties of foods such as avoiding loss of flavors and vitamins. Cell membranes of the microorganisms exposed to HVI are damaged and thus, their cells are torn leading to disinfection and/or sterilization [3, 4]. Therefore, the purpose of this study is to verify if the HVI could be used for bromate-free disinfection of the bottled water. The level of microbial inactivation and bromate formation were investigated according to two important operating parameters of HVI, electric field strength (E) and contact time (t).

2 MATERIALS AND METHODS

In this study, we designed and assembled high voltaged pulse generating system in our laboratory. As shown in the Fig. 1, the HVI system is consisted of power supply, high voltage generator, capacitors and pulse generator. The pulses generated from the HVI system were monitored by oscilloscope equipped with current and voltage probes. In order to monitor if bromate is formed or not, the pulses with 10 to 20 kV/cm of electric fields were introduced to the sample waters where was in the HVI reactor.

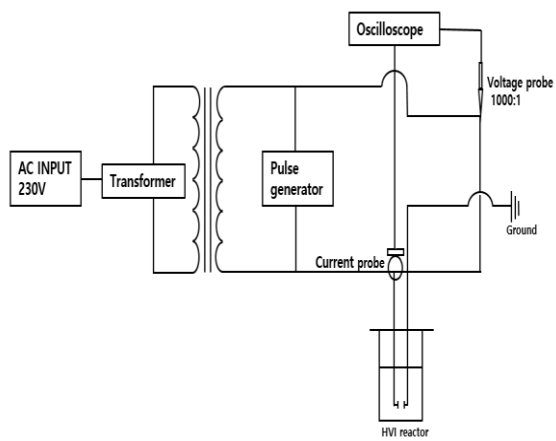

Figure 1: Ion chromatogram of the HVI disinfected samples spiked with 100 and 1,000 ppb of bromide

As the precursor of bromate, i.e., bromide (Br^-) was spiked into the sample waters by 100 and 1,000 ppb. Bromate was analyzed using ion chromatography (Metrohm Inc., Swiss).

Escherichia coli (*E.coli*) was selected as a model microorganism for HVI disinfection because *E.coli* can be grown and cultured easily in laboratory and used as an indicator organism for bacteriological analysis in water. *E.coli* solution had been cultivated in nutrient broth at 35°C. To prepare a good concentration of *E.coli* solution, a series

of dilution of the cultivated *E.coli* stock solution was carried out using saline (0.85 % NaCl) solution.

3 RESULTS AND DISCUSSION

A typical pulse waveforms of current and voltage are shown in Fig. 2. Square-typed wave pulse ranged 12.5 kV was formed for the first 4 micro-seconds and thereafter decayed exponentially to zero. The current at the very initial stage of the pulse formation looks like a surge current.

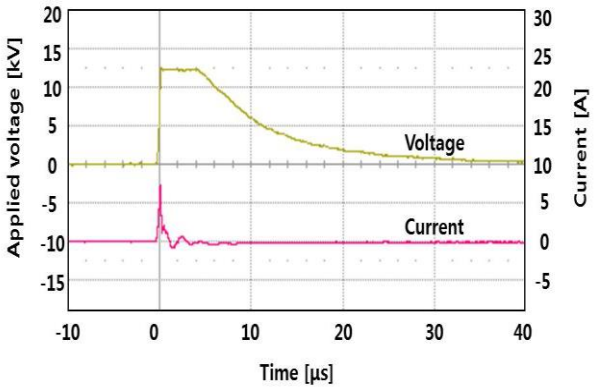

Figure 2: Captured images of the waveforms of the pulse

A model microorganism, *E. coli* is inoculated to the sample waters to test the disinfection efficiency. Fig. 3 shows that more than 4-log reduction (99.99 %) of *E.coli* was achieved after HVI treatment for 60 minutes with 20kV/1.8cm of electric fields. As the applied voltage increasd, disinfection efficiency increased.

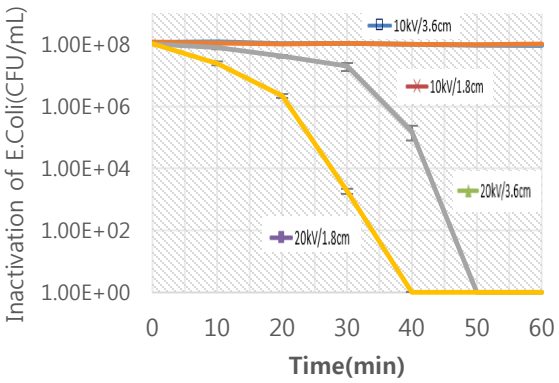

Figure 3: Inactivation of *E.Coli* with respect to the applied voltage of HVI

After the HVI disinfection, bromate was not generated at all times, indicating that the bromate formation was completely inhibited (Fig. 4). Consequently, the HVI technique could be used for alternative strategy for bromate free-disinfection procedure for water disinfection.

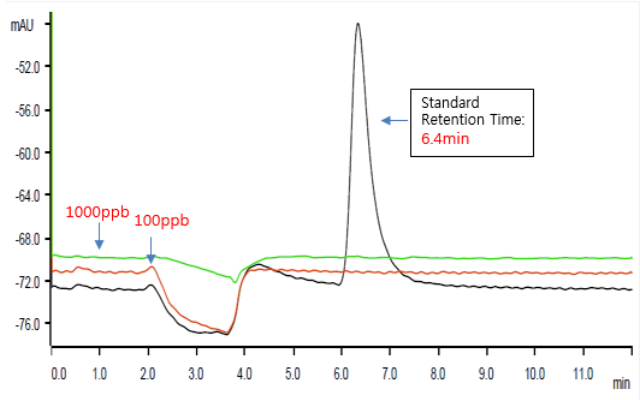

Figure 4: Ion chromatogram of the HVI disinfected samples spiked with 100 and 1,000 ppb of bromide

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