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Fluidization Electrolysis Treatment on the Control of Water Quality

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Abstract: The assurance of good-quality raw water and environmental protection are important to be solved. This study was conducted, directing major attention to the fact that some of the ceramics produced from silicate minerals as raw material have electrical functions such as electrical insulation, dielectric and piezoelectric properties. Stable granular ceramics having electrical charges at the surface were developed, using the natural raw materials of silicate minerals that have excellent moldabilities and sintering properties. Production of water having functions was attempted by effective use of the electrochemical energy of the ceramics with an efficient water treatment apparatus in which the granular ceramics were fluidized in water. In the experimental results, for the ceramics-treated water, it was clear that the surface activity increased and the volatilization speed of the chlorine was slow and also the ingredient of the irritation was controlled.

Key words: Electrochemical energy, fluidization electrolysis, granular ceramics, residual chlorine, surface activity

INTRODUCTION

In recent years, the consciousness for life, health and safety, attributed to global environmental problems, has increased. Especially, the assurance of good-quality water is a very important problem to be solved. Based on the protection of water quality, the development of innovative water circulation systems may contribute to the environmental protection^[1]. In this study, in expectation of the decrement of running costs such as electrical rates etc. on the water treatment system, rationalization for the water treatment system and its practical application were attempted, differently from water treatments with chemicals. That is, rocks (silicate minerals) were finely crushed and granular ceramics with an electrical charge at the surface were produced^[2]. The granular ceramics have abilities to enhance activation for large amounts of water by electrochemical energy of the ceramics, which is always fluidized in a circling current^[3]. Fukumoto *et al.*^[4] evaluated the effects of ceramics in water in promising as a means of improving water quality. Tamura *et al.*^[5] considered that the water treatment system using granular ceramics could change the state of water. In this paper, the reaction of surface activities and the change in concentration of the residual chlorine for the water passed through the fluidization layer of the granular ceramics were discussed.

MATERIALS AND METHODS

Granular ceramics: The granular ceramics of 0.8 mm in diameter with non-porosity, the coefficient of shape 0.89, the angle of repose 24.2°, the absolute gravity 2.62 and the moh's hardness 6.8 were developed by using the powder of quartz porphyry and natural soil as the bonding agent and sintering at 1200°C^[6]. The zeta potentials (by fluidization potential method) of granular ceramics were -10 to -12 mV as the pH was 5 to 10.

Water treatment apparatus: The experimental apparatus shown in Fig. 1 was used to treat the raw water^[3]. In the ceramics treatment section, 300 g of the granular ceramics was inserted into the fluidization layer (packing layer) of 50 mm in diameter. With the help of magnetic pump, water flows from the lower side to the upper side and the granular ceramics that have an expansion ratio of 1.5 were fluidized in a water flow rate of 10 L min⁻¹. In the control section, the granular ceramics were not inserted into the fluidization layer and the raw water passed through the packing layer at 10 L min⁻¹.

Emulsification experiments: In order to reveal the factors on change in structure of water by the ceramics treatment, the emulsion phenomena of an anionic surfactant on a benzene-water system were compared. That is, for the

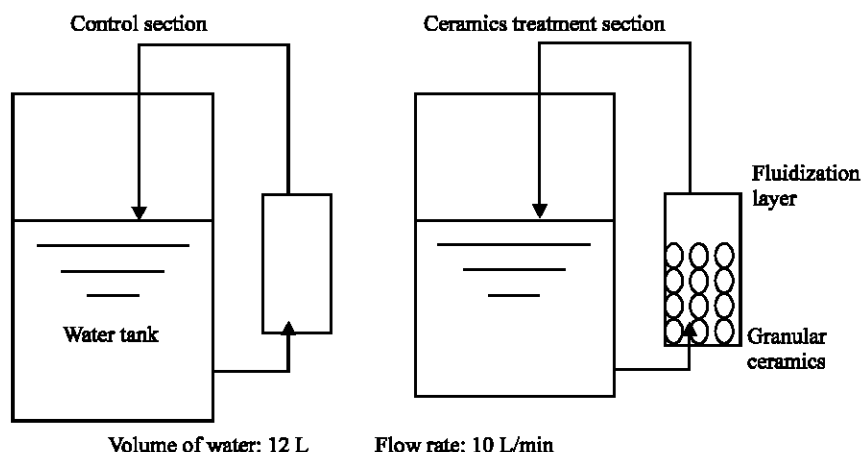


Fig. 1: Experimental apparatus

preparation of water, tap water, distilled water and ceramics-treated water were used as samples and the change in the EC with the addition of 0.1% sodium dodecyl sulfate solution, by stirring with a magnetic stirrer was studied. Furthermore, for each sample of 20 ml, benzene of 5 ml and 0.1% sodium dodecyl sulfate solution of 1 ml were added and after they were stirred for 5 min they were allowed to stand for 5 minutes and the surface and the state of emulsion were recorded in detail. In this case, 0.1% sodium dodecyl sulfate solution was added by 1 ml until benzene was being suspended homogeniously in water.

Comparison of residual chlorine concentration: In the production of raw water, two kinds of chlorine concentration solution were prepared, that is, i) nearly 1 mg L^{-1} concentration solution: 5 ml of NaClO (effective chlorine 5%) was added into 300 L distilled water, ii) nearly 25 mg L^{-1} concentration solution: 12 ml of NaClO was added into 30 L distilled water. The raw water was treated by the water treatment apparatus and was allowed to stand in an incubator at 30°C . A spectrophotometer (DR 2000) was used for measurement of the residual chlorine concentration.

RESULTS AND DISCUSSION

Emulsification experiments: 0.1% sodium dodecyl sulfate solution was added for each sample. As for the results, the relation between amounts of the addition and the EC values were expressed as a linear regression and the EC rose with an increment of the addition. However, significant difference was not recognized at a significant level of 5% or lower for each test section. For emulsification, amounts of the surfactant were studied for each benzene concentration (Table 1). The emulsification

Table 1: Solubilization of benzene

Benzene concentration (%)	Amount of surfactants (ml)			
	Distilled water	Ceramics-treated distilled water	Tap water	Ceramics-treated tap water
9	10	9	12	10
16	20	18	18	14
28	20	20	18	18

Table 2: Change in residual chlorine concentration

Hours after one-pass treatment	Residual chlorine concentration (ppm)	
	Control section	Ceramics-treatment section
0	0.85	0.92
2	0.76	0.88
4	0.71	0.84
6	0.67	0.84
24	0.44	0.66

Residual chlorine concentration before treatment: 1 ppm

Table 3: Change in residual chlorine concentration

Hours after one-pass treatment	Residual chlorine concentration (ppm)	
	Control section	Ceramics-treatment section
0	22.74	22.74
2	22.54	22.69
4	22.33	22.59
6	22.03	22.43
24	16.20	18.22
48	9.04	13.66
72	4.68	10.11

Residual chlorine concentration before treatment: 25 ppm

speed was higher for the ceramics treatment section (one-pass treatment), with the amount of addition 16 to 22% less than that of the control section. This means that the micelle was formed easily for the ceramics-treated water when the surfactant was solubilized in water and thus materials hardly soluble in water were solubilized easily.

Comparison of residual chlorine concentration: The experiment was performed in an open system. Thereby, after water was treated with one-pass (about 20 seconds),

the residual chlorine concentration in both sections gradually decreased with the elapse of time. In the case of treatment for low concentration solution (Table 2), the residual chlorine concentration showed about $\frac{1}{2}$ at 24 h after a one pass treatment for the control section. However, the change in the residual chlorine concentration was smaller for the ceramics treatment section. In the case of treatment for a high concentration solution (Table 3), the change in the residual chlorine concentration in both sections was slow and the residual chlorine concentration decreased, but the decrement rates were higher after each segment of experimental time in compare to the low concentration solution. The residual chlorine concentration for the ceramics treatment section was 1 to 2 times higher as compared with that of the control section.

Generally, chlorine is used as a disinfectant and reacts with water so that statistically dissociation takes place^[7]. About $\frac{1}{2}$ the amount of added chlorine became ineffective as chlorine ion when the pH was nearly 7.0 and reacted with the matter, contained a reductant in water. For the ceramics-treated water, it was clear that the surface activity increased and the volatilization speed of the chlorine was slow and also the ingredient of the irritation was controlled.

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