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REDUCTION OF OZONE GENERATION IN ELECTROSTATIC PRECIPITATOR

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ABSTRACT

The influence of electrode shape on ozone generation in electrostatic precipitator (ESP) has been experimentally investigated. It experimented by using the two-stage-type ESP composed of a precharger and collecting section. In the precharger section, three types of high voltage electrode of a wire, a thin plate, and a saw-tooth were used to experiment. Each ground electrode used a plate. The collecting section had a parallel-plates configuration. The gases exhausted from the diesel engine were diluted with air and introduced into ESP. The electrical characteristics in a corona discharge on each electrode are summarized. The corona discharge luminescence was observed by each electrode type. In the positive corona discharge, the thin plate type electrode has shown low ozone generation compared with the wire type. In the negative corona discharge, the saw-tooth type electrode has also shown low ozone generation compared with the wire type. All current characteristics of the collection efficiency of the wire and the thin plate were almost the same. Those of the wire and the saw-tooth in negative polarity were also almost the same. These results have great practical importance for improving the performance of the two-stage type electrostatic precipitator as it allows the collecting efficiency of the unit to be increased without exceeding the ozone generation.

INTRODUCTION

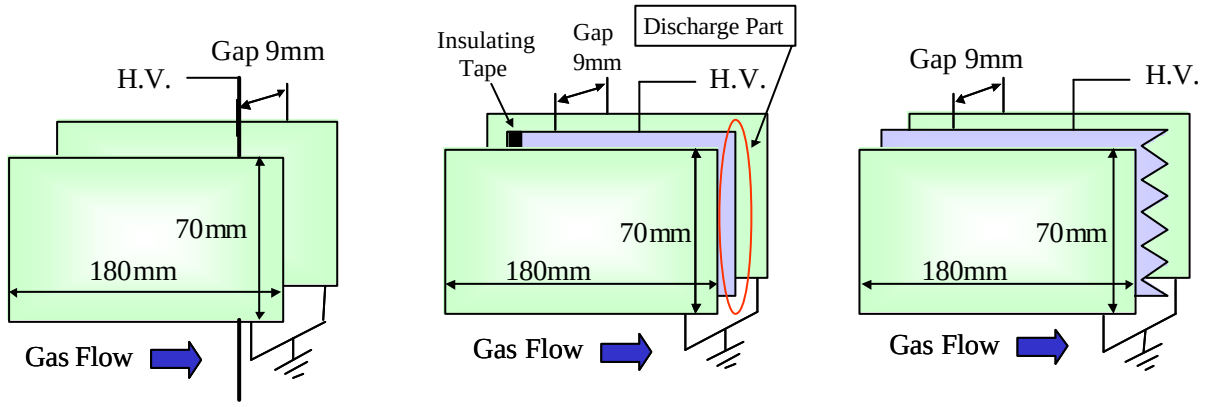
Electrostatic precipitator (ESP) is installed in a tunnel to collect particulates that principally involve diesel exhaust particles. ESP collects the particle by the corona discharge. The electron of high energy dissociates the oxygen molecule when the discharge is generated, and the oxygen atom is generated. The oxygen atom reacts with another oxygen molecule and the ozone is generated. Therefore, ESP generates harmful ozone in the human body and the environment without fail. The ozone exhausted from the tunnel causes the oxidase smog. ESP was only installed in the tunnel in the mountainous region in Japan. Recently, underground tunnel type expressways have been constructed in urban area. NO_2 removal equipment is installed behind the ESP in this type expressway because many people live in this area. Ozone oxidizes NO contained in the diesel exhaust gas, and increases the NO_2 concentration included in the atmosphere. Therefore, the decrease of the ozone generated from ESP is requested.

When a positive voltage is applied to the wire of the discharge electrode, ozone generation is very low [1]. However, the main problem of this system is breaking of wire. In this study, it proposes the ESP systems that can be equal to the wire electrode collection efficiency, and decrease ozone. First, a thin plate was used instead of the wire as a discharge electrode, the corona discharge is generated at the edge of the plate. Secondly, the edge of the plate was transformed into saw-tooth. Finally, three types of discharge electrodes of the wire, thin plate, and saw-tooth were valued at ozone concentration and collection efficiency in both positive and negative voltage.

EXEPERIMENTAL

Electrode Structures of ESP

The experiment is conducted by two-stage-type ESP composed a precharger and collecting section. In the precharger section, three types of high voltage electrode of a wire, a thin plate, and a saw-tooth were used to experiment. Each ground electrode used a plate. The collecting section had a parallel-plates configuration. Electrode structures of the precharger in ESP are shown in Fig. 1. In wire type, a wire electrode of 0.4mm diameter was used as a discharge electrode. In plate type, a plate electrode of 0.1mm thickness was used. In saw type, a saw-tooth electrode of 0.1mm thickness was used.



(a) Wire type *(b) Plate type* *(c) Saw type*

Figure 1: Precharger sections in ESP

Experimental Methods

The gases exhausted from the diesel engine were diluted with air and introduced into ESP. Gas flow velocity was 7m/s. Discharge current in the precharger section was 0.02, 0.04, 0.06, 0.08mA. DC 7.5kV was applied to high voltage electrode in the collecting section. Ozone concentration behind ESP was measured. The corona discharge luminescence was observed from the front of the precharger by a digital camera as shown in Fig. 2. Discharge current was 0.06mA in either electrode. Shutter speed of the camera was 8sec.

Current waveform of discharge was measured with a digital microscope as shown in Fig. 3. Measuring was based on fall-of-potential method by serially inserting resistance 10k. into ground side in the precharger. Discharge current was 0.005mA in moving-coil ammeter.

RESULTS AND DISCUSSION

Wire type ESP

Current-voltage characteristic in the precharger of wire type is shown in Fig. 4. Both discharge currents increase with increasing discharge voltage. Discharge current in the negative voltage was higher than that in the positive. Photographs of discharge luminescence

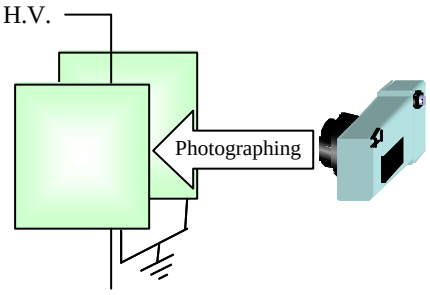


Figure 2: observation of discharge luminescence

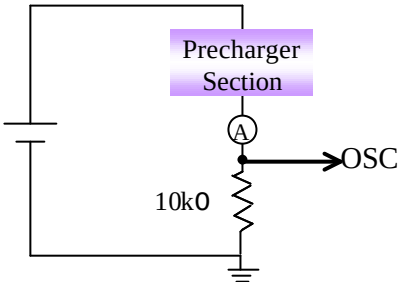


Figure 3: Measuring circuit of discharge current waveform

are shown in Fig. 5. In the positive voltage, wire was covered with filmy luminescence. In the negative voltage, an innumerable point that emitted light frequently were ignited, and disappeared. Current waveforms of the discharge in the precharger are shown in Fig. 6. In the positive voltage, most of discharge pulses were very small. In the negative voltage, a large discharge pulse is observed significantly.

Collection efficiencies of wire type are shown in Fig. 7. Collection efficiency in the positive voltage was almost as same as that in the negative voltage. Ozone concentration is shown in Fig. 8. Ozone concentration in the positive voltage was lower than that in the negative voltage. This characteristic of the concentration of ozone is corresponding to the discharge pulse waveform well.

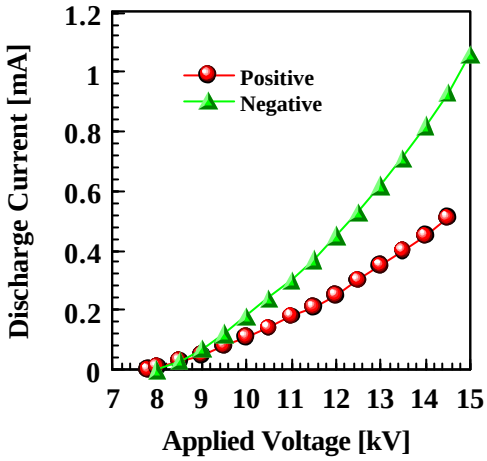
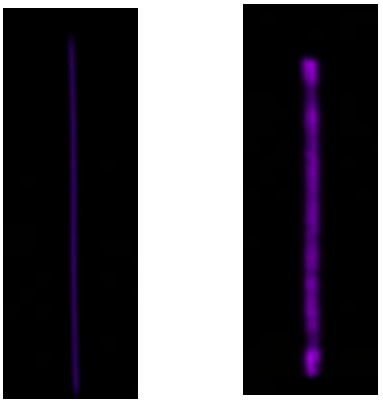
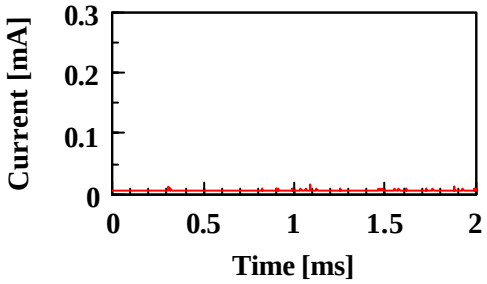


Figure 4: Current-voltage characteristics

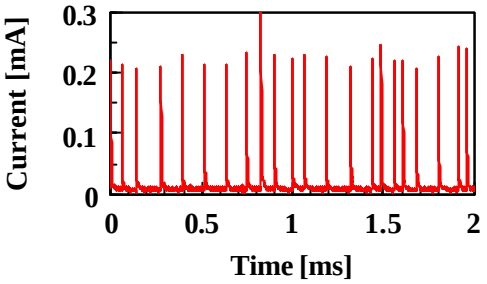


(a) Positive *(b) Negative*

Figure5: Discharge luminescence



(a) Positive



(b) Negative

Figure 6: Waveforms of discharge current of wire type

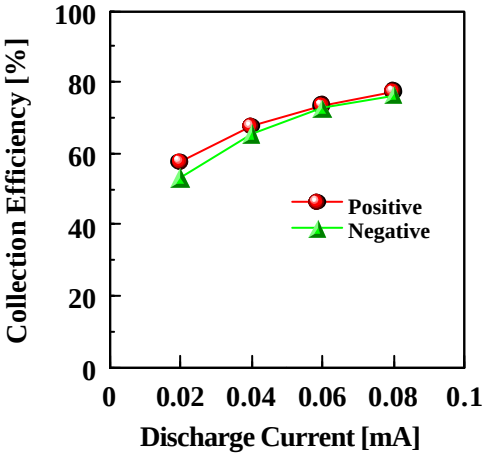


Figure 7: Collection efficiency of wire type

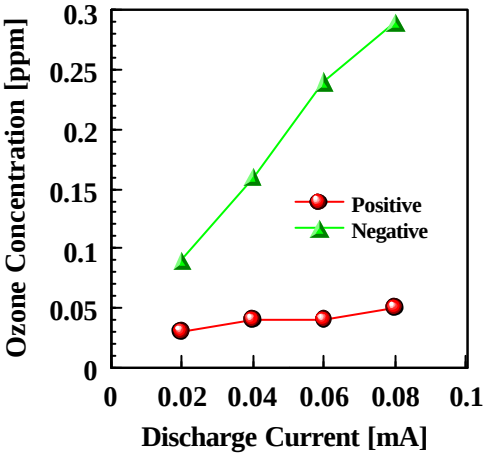


Figure 8: Ozone concentration of wire type

Plate type ESP

Current-voltage characteristic in the precharger of plate type is shown in Fig. 9. Discharge current in the negative was higher than that in the positive voltage as in the case of the wire. Photographs of discharge luminescence are shown in Fig. 10. In the positive voltage, the discharge form in the plate type was similar to that in the wire type. In the negative voltage, some points that emitted light frequently were ignited, and disappeared.

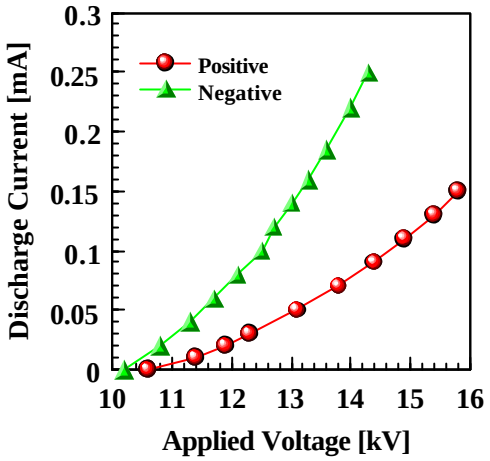
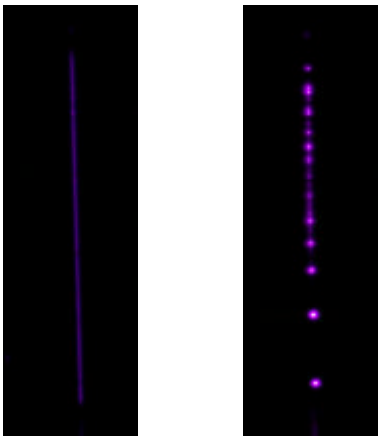
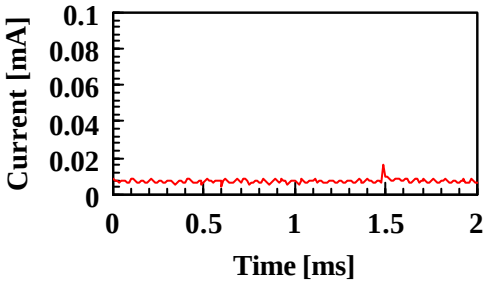


Figure 9:Current-voltage characteristic

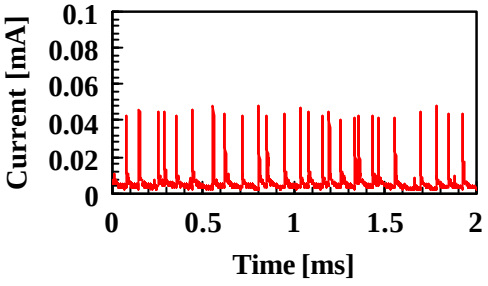


(a) Positive *(b) Negative*

Figure 10: Discharge luminescence



(a) Positive



(b) Negative

Figure 11: Waveforms of discharge current of plate type

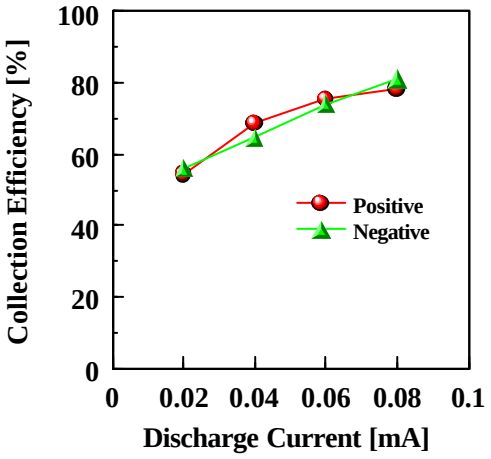


Figure12: Collection efficiency of plate type

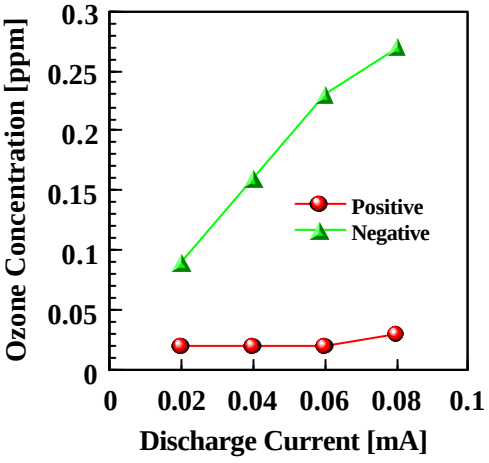


Figure 13: Ozone concentration of plate type

Current waveforms of discharge in the precharger are shown in Fig. 11. In the positive voltage, most of discharge pulses were very small as in the case of the wire. In the negative voltage, the discharge pulse of plate type is smaller than the wire type though a large discharge pulse is considerably observed.

Collection efficiency is shown in Fig. 12. Collection efficiency in the positive was almost as same as that in the negative voltage. Ozone concentration is shown in Fig. 13. Ozone concentration in the positive voltage was lower than that in the negative voltage as in the case of the wire.

Saw type ESP

Current-voltage characteristic in the precharger of saw type is shown in Fig. 14. Discharge current in the negative voltage was higher than that in the positive voltage. It sparked when a positive voltage of 11kV or more was applied to the saw type electrode. Photographs of discharge luminescence are shown in Fig. 15. The luminescence is observed both polarities in the point of the saw blade.

Current waveforms of discharge in the precharger are shown in Fig. 16. Discharge pulses in the negative voltage are slightly larger than that in the positive voltage, and are much smaller than that of the wire and plate type.

Collection efficiency is shown in Fig. 17. Collection efficiency in the negative voltage was higher than that in the positive voltage. Ozone concentration is shown in Fig. 18. Ozone concentration in the negative voltage was slightly higher than that in the positive voltage.

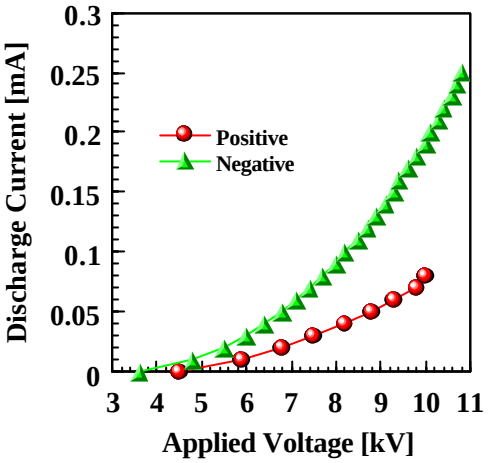
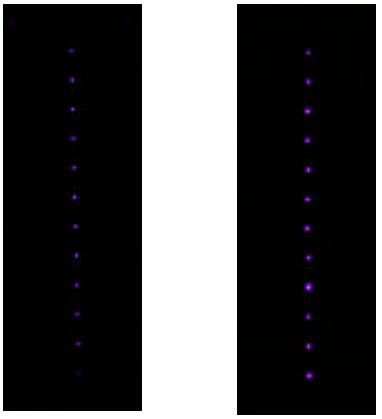
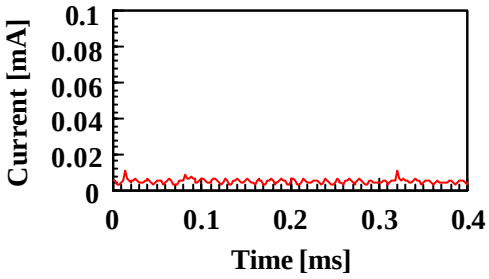


Figure 14: current-voltage characteristic

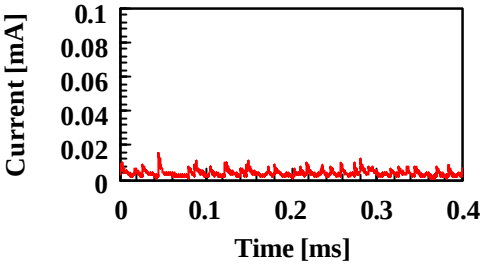


(a) Positive *(b) Negative*

Figure 15: Photographs of discharge



(a) Positive



(b) Negative

Figure 16: Waveforms of discharge current of saw type

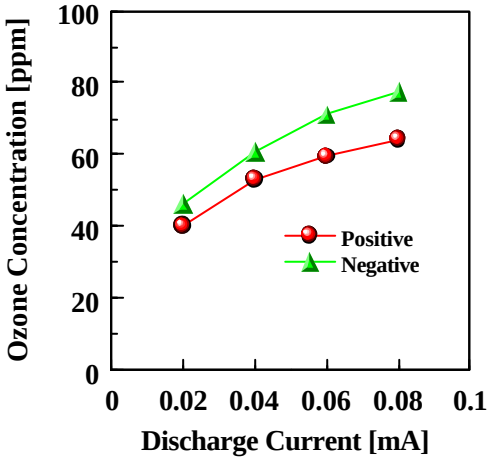


Figure 17: Collection efficiency of saw type

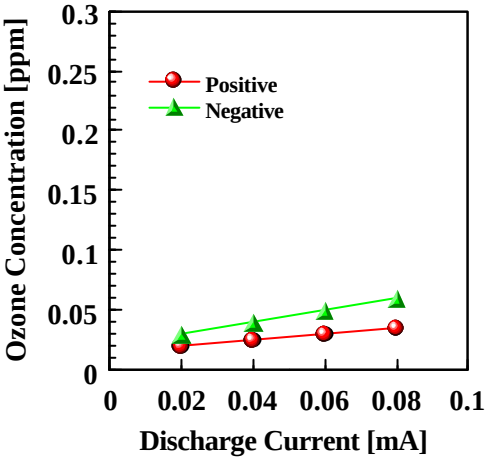
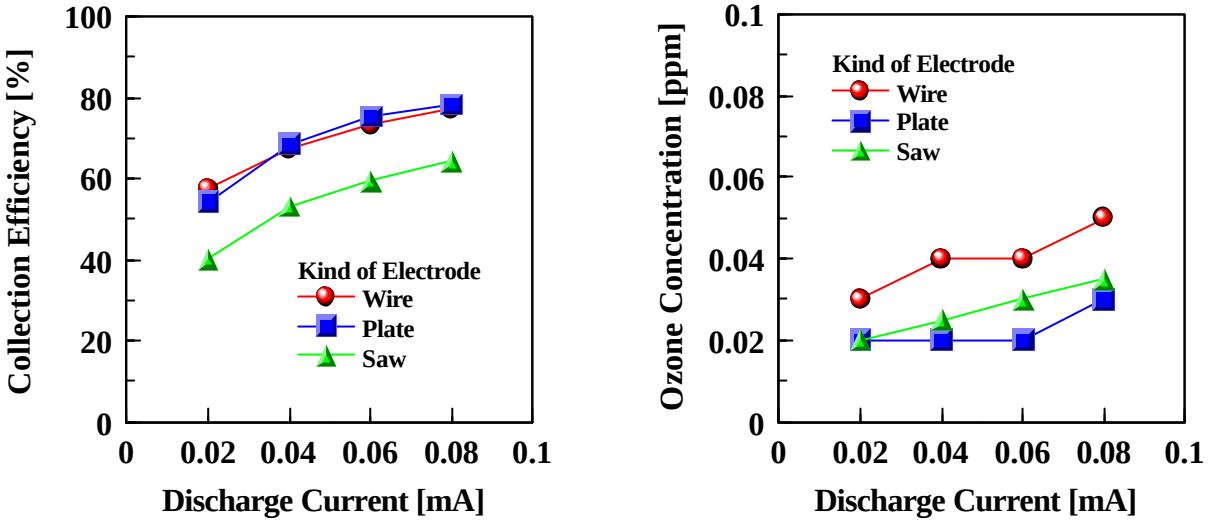


Figure 18: Ozone concentration of saw type

Comparison in all type ESP

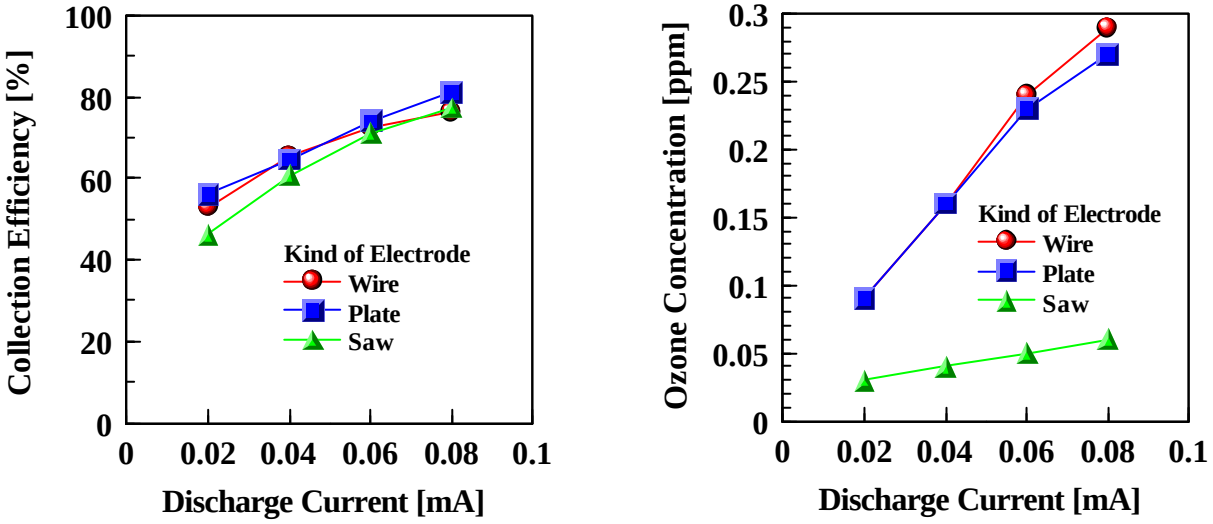
The wire, the plate, and the saw type of each polarity were compared for the collection efficiency and the ozone concentration. Performance of ESP in the positive voltage is shown in Fig. 19. Collection efficiency in the plate type is the same as the wire type. Collection efficiency in the saw

type is the lowest. Ozone concentration in the plate type was lowest of all. Therefore, it is considered that the plate type is the best system in a positive polarity.



(a) Collection efficiency *(b) Ozone concentration*

Figure 19: Performance of ESP in the positive



(a) Collection efficiency *(b) Ozone concentration*

Figure 20: Performance of ESP in the negative

Performance of ESP in the negative voltage is shown in Fig. 20. Collection efficiency in either type was almost the same. Ozone concentration of the saw type was lowest. Therefore, it is considered that the saw type is the best system in a negative polarity.

CONCLUSIONS

In this study, it proposes the ESP systems that can be equal to the wire electrode collection efficiency, and decrease ozone. Three types of discharge electrodes of the wire, thin plate, and

saw-tooth were valued at ozone concentration and collection efficiency in both positive and negative voltage. Consequently, the plate type is the best in a positive polarity and the saw type is best in the negative voltage.

REFERENCES

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