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# A novel bipolar electrostatic ionizer for charged polypropylene granules used in a pneumatic powder transport facility

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ABSTRACT

As a method of preventing or mitigating explosion due to electrostatic discharges during the loading of polymer granules in a metal silo, we have developed a novel bipolar electrostatic ionizer. In this study, we investigated experimentally a practical version of the bipolar electrostatic ionizer with a modeling test device to measure the charge-neutralizing current, and a full-sized pneumatic powder transport facility. The electrostatic discharges generated inside a silo while loading polypropylene (PP) granules were also observed visually with/without the novel bipolar electrostatic ionizer. As a sample, 300 kg of polypropylene granules 2–3 mm in size was used in this study. The specific charge of the polypropylene granules was clearly decreased by approximately 85 percent with the novel bipolar electrostatic ionizer. The brush discharges, as well as the incendiary bulk surface discharges, completely died out inside the silo when the novel bipolar electrostatic ionizer used.



## 1. Introduction

A pneumatic conveying system transfers granules, powders and other dry bulk materials with several advantages, such as being more flexible, simple, and efficient than a mechanical conveyor. When polymer granules (or powders) are transferred, they are highly charged triboelectrically by frictional contact of the individual particles with the walls of the transfer piping. As the charged granules fills the large storage silo (or hopper), the charge inside the silo accumulates. This charging phenomenon often leads to incendiary electrostatic discharges within the silo. There is no risk of ignition by electrostatic discharge with granules that are greater than 500 μm (IEC50404, 2003). However, mixtures of granules and fine powders that are concentrated in the explosion range are potentially hazardous. In fact, dust explosions and fires related to electrostatic charges have occurred in industrial processes with pneumatic conveying systems (Pratt, 2000).

In an effort to prevent industrial accidents caused by electrostatic discharges, many studies on the development of electrostatic ionizers have been conducted. Mogami et al. (2010) developed a new feedback control ionizer system. They confirmed that the electrostatic charge during the pneumatic powder transport process was favorably self-controlled, and the powder charge was sufficiently reduced with the feedback control ionizer. However, this system is very complex and is expensive to adapt within the industry. Romay et al. (1994) designed and tested the sonic jet bipolar ionizer. The ionizer was characterized regarding the ion output, particle generation for several electrodes, and ionizer operating conditions. Tabata et al. (1997) introduced the bipolar static ionizer for neutralizing moving charged films that travel at high speeds. The surface potentials on the films decreased from 10 kV to several hundred volts in magnitude when the ionizer was used. However, neither experimented with anything related to powders. In our previous study, Choi et al. (2013) introduced an AC electrostatic ionizer to neutralize the charge of the polypropylene granules before they enter a metal silo in a pneumatic transport facility. The ability of the AC electrostatic ionizer was insufficient in neutralizing the polypropylene granules; brush discharges still occurred inside the silo. In order to improve the performance of the AC electrostatic ionizer from our previous study, we are introducing in this paper a novel bipolar electrostatic ionizer. One of our primary objective is to clarify the performance of a novel bipolar electrostatic ionizer through several tests.

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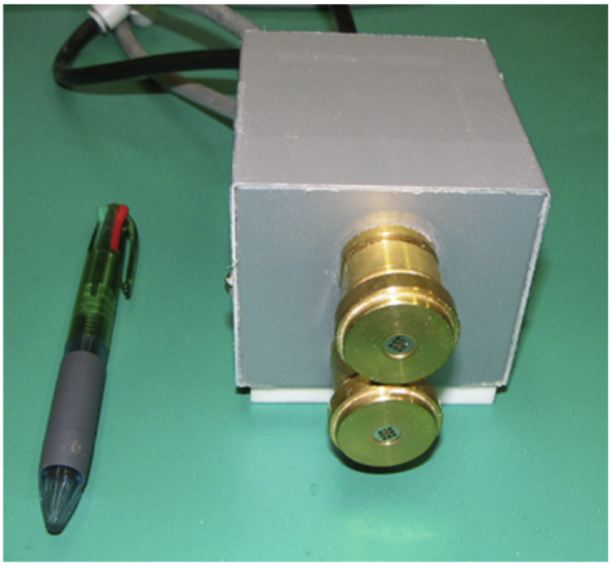

**Fig. 1.** Novel bipolar-type electrostatic ionizer.

## 2. Experimental

### 2.1. A novel bipolar electrostatic ionizer

The novel bipolar electrostatic ionizer developed in this study is shown in Fig. 1. It has an outward appearance similar to that of our previous AC ionizer (Choi et al., 2013). The novel ionizer has a dimension of 0.15 m in length, 0.07 m in width, and 0.07 m in height. It consists of one pair of corona needle electrodes situated within a grounded nozzle shield, an electrode support, a DC high-voltage power source, a punched plate (stainless steel), a slender tube 8 mm in diameter for supplying air, an air compressor (Hitachi, 250 *l*, 10.4 kgf/cm), and a fully automatic air dryer (CKD, RD-2008).

To one of the corona needle electrodes, DC + 7 kV was applied with a high-power DC source. To the other, DC − 7 kV was applied. Thus, it make no difference whether the powder (and/or granules) particle is negatively or positively charged. Compressed air with zero relative humidity is supplied to the nozzle to blow ionized air toward the charged powder and to protect the needle electrode from the deposition of powder particles. A punched plate with a hole size of 0.9 mm and 9 holes was inserted into the nozzle opening of the ionizer. The punched plate prevents the ingress of solid foreign objects into the ionizer. The distance between the punched plate and the corona needle electrode was 3 mm.

### 2.2. Modeling test to measure the charge-neutralizing current

We examined the charge-neutralizing current, $I_e$ [A], of the novel bipolar electrostatic ionizer with several air pressures using a modeling test. Fig. 2 is a schematic diagram of the modeling test. The modeling test is typically adapted to charged materials such as granules, powders, and films that are moving (Kodama et al., 2002). The $I_e$ is the current supplied from the bipolar electrostatic ionizer when the electrostatic field generated by charged material is 100 kV/m. This was also used to investigate the performance of our previous AC electrostatic ionizer (Choi et al., 2013). The model consists of the novel bipolar electrostatic ionizer, a metal plate (0.45 m × 0.45 m), a high-voltage DC power source (Trek, Model No. 664A) with an amplifier (Trek, Model No. 662), an ammeter (Yokogawa, Model No. 2011), an air pressure regulator, an air compressor (Hitachi, 250 *l*, 10.4 kgf/cm), a fully automatic air dryer (CKD, RD-2008), and other auxiliary devices.

The novel bipolar electrostatic ionizer was fixed toward the center of the metal plate attached to the high-voltage DC power source. The separation distance, $d$ [m], between the nozzle opening of the ionizer and the metal plate was 0.05 m. Compressed air, $A_p$ [Pa], was maintained in the range of 0.05–0.2 MPa. The charge-neutralizing current, $I_e$ [A], was measured with an ammeter connected between a metal plate impressed with high DC voltage, $V_e$, of 5 kV in negative polarity and the ground. It is noteworthy that, in the present study, since the polypropylene granules used in this experiment in the pneumatic powder transport facility were negatively charged, the polarity of the high voltage impressed on the metal plate was negative.

### 2.3. Pneumatic powder transport facility and polymer sample

A full-sized pneumatic powder transport facility was used to evaluate the performance of the novel bipolar electrostatic ionizer. The facility had an earthen cylindrical silo (stainless steel; diameter, 1.5 m; straight body length, 2 m; capacity, 4.8 $m^3$), as shown in Fig. 3, a pipeline (stainless steel; diameter, 0.1 m; total length, 23 m), an air blower (10 $m^3$/min) driven by an inverter motor, and an air-conditioning unit controlling the temperature (30 °C) and humidity (30% RH) of the blowing air. The silo was provided with a rotary valve (13 rpm) driven by an inverter motor to discharge powder from the bottom of the silo. The polymer granules

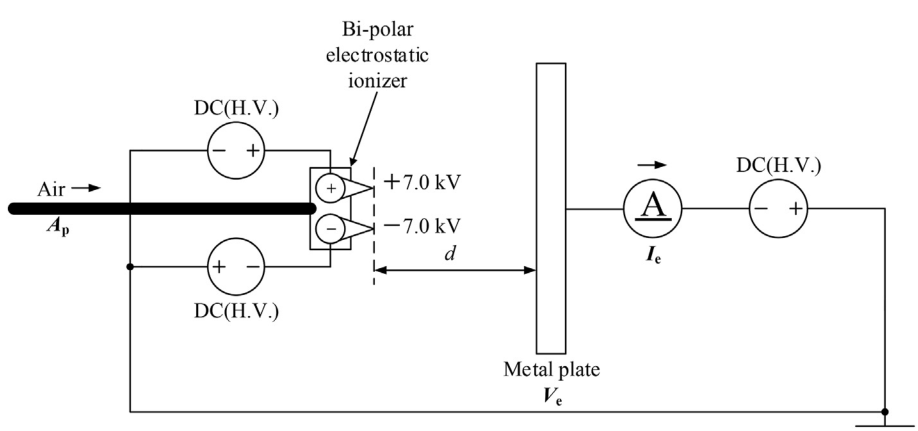


**Fig. 2.** Schematic of the model test used in this study.