Unified expressions of the charges transferred by brush discharges and of the onset criterion of propagating brush discharges on charged insulating coats and liners

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***Abstract*—Insulating inner coats and liner bags often used for metal tanks, pipes, drums, etc., have sometimes caused electrostatic ignitions in chemical process industry. There are two types of discharge, i.e., brush and propagating brush discharges, occurring on a charged insulating coat or liner in contact with a grounded conductor when a grounded object approaches it. The brush discharges (BDs) occur at lower charged surfaces and the propagating brush discharges (PBDs) at higher ones, resulting in lower ignitability of BDs and higher one of PBDs. It is known that the charge transferred by BDs can assess the risk of their ignitability—60 nC for explosive group IIA, 25 nC for IIB, and 10 nC for IIC, and recently that BDs cannot ignite any dust flammable atmospheres without flammable gases or vapours. Therefore, finding unified expressions of the transferred charge by BDs and of the criterion of the onset of PBDs with considering coat materials (relative permittivity) and thickness can lead to easier assessments of the risks due to the BDs and PBDs. The unified criterion can also provide PBD-free coats that significantly reduce the ignition risk in powder processes. Towards these aims, we experimentally investigate the transferred charges and the minimum surface potentials where the PBDs occur with charged insulating sheets in contact with a grounded metal, in which the sheets used are polytetrafluoroethylene (PTFE: 0.05, 0.1, 0.2, 0.3 and 0.5 mm thick), borosilicate glass (BS: 0.1, 0.21, 0.3 and 0.55 mm thick) and polyethylene (PE: 0.05, 0.07, 0.08 and 0.1 mm thick) often practically used for the coats and liners. As a result, the following expressions for the charge transferred by BDs and for the onset criterion of PBDs were gained [1]:**

The charges transferred by BDs, q_{tBD}, can be expressed by

$$\frac{q_{tBD}}{\varepsilon/d} = aV_{s0}^2, \tag{1}$$

where ε and d are permittivity and thickness of the sheets, V_{s0}^2 is the initial surface potential of the sheets, $a = 1.33 \times 10^{-8}$ $\mathrm{V^{-1}m^2}$ for negatively charged surfaces, as a solid line shown in Fig. 1, and $a = 7.48 \times 10^{-9}$ $\mathrm{V^{-1}m^2}$ for positively charged surfaces.

The plots of the initial surface potential that yielded PBDs, V_{PBD}, versus the capacitance per unit area, $\frac{\varepsilon}{d}$, of different samples gained a unified criterion for the onset of the PBD, as shown in Fig. 2, in which the onset voltage of PBD can be expressed by

$$V_{PBD} = b\left(\frac{\varepsilon}{d}\right)^{-1/2}, \tag{2}$$

where $b = 5.46$ $\mathbf{VF}^{\frac{1}{2}}\mathbf{m}^{-1}$ for positively charged surfaces, and $b = 4.01$ $\mathbf{VF}^{\frac{1}{2}}\mathbf{m}^{-1}$ for negatively charged surfaces, which are expressed by solid lines in Fig. 2.

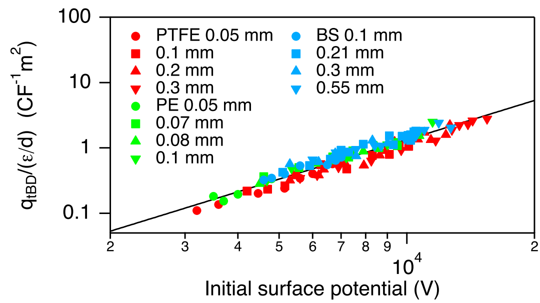

Fig. 1. Unified expression for charge transferred by BDs on negatively charged surfaces.

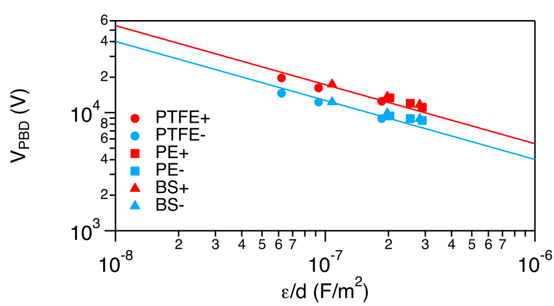

Fig. 2. PBD onset voltage (minimum initial surface potential that yielded a PBD) versus capacitance per unit area for PTFE of 0.1, 0.2, and 0.3 mm thick, PE of 0.07, 0.08, and 0.1 mm and BS of 0.21, 0.3, and 0.55 mm.

References

[1] A. Ohsawa, Brush and propagating brush discharges on insulating sheets in contact with a grounded conductor, J. Electrostat. 88 (2017) pp. 171–176.