Фарбування в електричному полі

Приклад аналізу розмірності

Car painting in electric field

The attraction of the oppositely charged objects is the core of electrostatic painting, which uses electrostatic fields to paint metal objects quickly, efficiently and with practically no cleanup.

Let us consider a droplet of liquid with surface tension coefficient σ and charge q in the external electric field E. How the critical radius r_{cr} of its brake in smaller ones depends on E ?

Electrostatic painting uses some very specific tools in order to paint a metal object using the attraction of oppositely charged electrostatic fields. First of all, specially formulated paint is mixed with a chemical catalyst and is then given a positive charge. The metal object that's going to be painted (and it must be a metal object for this process to actually work) is then grounded by having a wire attached to it. Since the paint and the metal object are now oppositely charged, with the paint being positive and the object being negative, the paint will be attracted to the metal object as if it were a magnet.

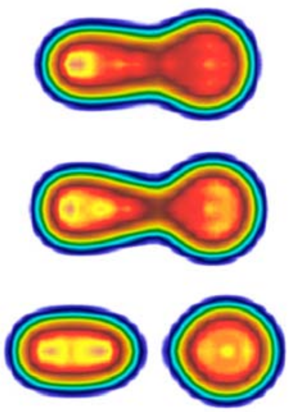
The positively charged paint is sprayed toward the metal object, which draws the paint toward its surface. This attraction is so strong that if an object (say a metal rail) is only sprayed from one side, the charge will actually pull the paint around so that it covers the entire metal surface.

Car painting in electric field

The attraction of the oppositely charged objects is the core of electrostatic painting, which uses electrostatic fields to paint metal objects quickly, efficiently and with practically no cleanup.

1. Let us consider a neutral droplet of liquid with surface tension coefficient σ in the external electric field E. How the critical radius r_{cr} of its brake in smaller ones depends on E ?

$$E \sim r_{cr}^{\alpha} \cdot \sigma^{\beta} \qquad [E] = [r_{cr}]^{\alpha} [\sigma]^{\beta}$$



$$[E] = \frac{[F]}{[q]} = \frac{g \cdot cm \cdot s^{-2}}{[q]}$$

Dimensionality of the charge in CGSE is Franklin (Wikipedia)

$$[q] = cm^{3/2} g^{1/2} s^{-1}$$

$$\frac{g \cdot cm \cdot s^{-2}}{cm^{3/2} g^{1/2} s^{-1}} = [cm]^{\alpha} \left[g \cdot s^{-2}\right]^{\beta}$$

$$cm^{-3/2} g^{-1/2} s^{1} = cm^{\alpha-1} g^{\beta-1} s^{-2\beta+2}$$

Car painting in electric field

$$\alpha - 1 = -3/2$$
$$\beta - 1 = -1/2$$
$$1 = -2\beta + 2$$

$$\alpha = -1/2$$
$$\beta = 1/2$$

$$E = \sqrt{\frac{\sigma}{r_{cr}}} \quad \Rightarrow \quad r_{cr} = \sigma / E^2$$

U=300 V → U=1 unit CGSE. Corresponding E=U/d=1 unit CGSE.

$$\sigma \sim 10^2 dyn/cm$$

$$r_{cr} \sim 100cm$$

Impossible !!!

Hence, our model is wrong! Charge is important!

Now let us suppose that the droplet is charged and its electric potential is ϕ.

$$q = C\phi = r\phi$$

The electrostatic repulsion competes with the surface energy:

$$q\phi = \sigma r^2$$
$$r\phi^2 = \sigma r^2$$
$$\phi = \sqrt{\sigma r}$$

This could be obtained from our formula

$$E = \sqrt{\frac{\sigma}{r_{cr}}}$$

Yet, assuming E as the field of charged sphere of radius r

If one needs to have droplets of the size 0.1 mm

Hence $\phi = \sqrt{100 \cdot 0.01} = 1$ CGSE unit=300V