Electrostatic charging during electrospray deposition of polymer granular coatings

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Electrospray is a liquid atomization technique which has been applied to form thin coatings over solid substrates from a wide range of starting solutions (Jaworek, 2007). Highly charged droplets are formed, which repel each other, forming a spray which travels towards a collection electrode. When the droplets contain non-volatile solutes, either a continuous film or a granular coating made of dry residues can be collected.

The electrode configuration and the applied needle voltage (needed for a stable cone-jet mode) determine the electric field and the spray geometry, which in turn define the collection area of the film on the conductive substrate. Therefore, such films are generally considered to be uniform and to grow linearly with deposition time. However, in this study, we have noticed that granular polymer films grow wider during the deposition process.

We have studied the film growth dynamics and the degree of uniformity of the film thickness, as a function of factors which influence the rate of charge accumulation during coating, such as needle-plate separation and ambient relative humidity (RH).

The granular polymer films shown in Figure 1, for example, show radial variations not only in thickness but also in film morphology (size segregation of primary and satellite particles). At the 6.4 mm location, the buried layer of residues from satellite droplets (S) must have been collected earlier than the top layer of residues from primary droplets (P).

Figure 2 shows that these films grow wide faster at low than at high RH. We believe that electrostatic charges accumulate on the film during collection of polymer particles, and contribute a repulsive electric force (pointing towards the droplet emission zone) which acts to slow down the droplets and the dry particles that define the electrospray plume. As a result, the lifetime of the dry particles in the spray is increased, and the spray widens by electrostatic expansion before its particles reach the collector.

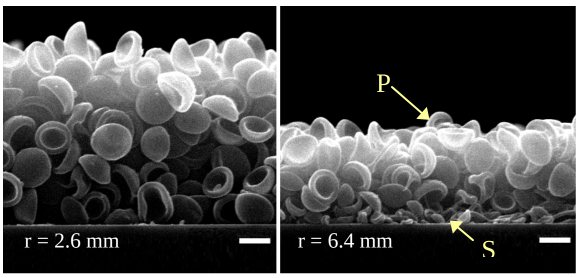

Figure 1. Cross section views by SEM of an ethyl cellulose granular film at different radial locations, collected at 10% RH. Scale bar 1 μm.

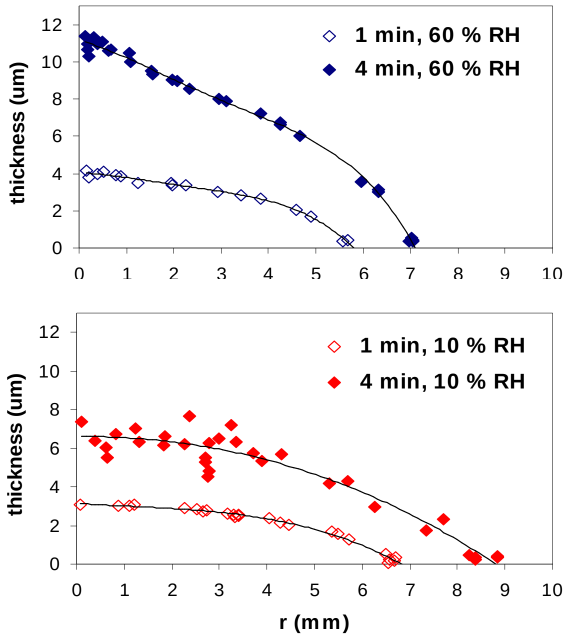

Figure 2. Thickness radial profiles of deposited ethyl cellulose films at fixed inter-electrode separation.

This model explains the observed trends of the radial profile of film thickness versus RH (Fig. 2) and inter-electrode separation (not shown here).

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