Electrosprays: Chaos and Chemistry in the Electrified Dripping Faucet

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When the high voltage is turned off on an electrospray source it starts to behave like a dripping faucet. The leaky faucet is a central problem in non-linear dynamics because it exhibits order-chaos transitions as the liquid flow rate is increased. Based on spray current measurements and fast imaging of the Taylor cone region in electrosprays, we demonstrate that droplet and jet production in these sources exhibit a fundamental analogy with a dripping faucet. Using phase Doppler anemometry, we also characterize the droplet size and velocity distributions in the spray plume. Mass spectrometric analysis of the produced droplets provides information on the variations in ion chemistry as a function of spraying mode changes. Order-chaos-order transitions were demonstrated in the transitions between spraying modes. The frequency of the spray current oscillations was found to decrease with increasing wetted area at the tip of the capillary. The pulsation frequency for small wetted areas was utilized to determine the net charge on the Taylor cone. A significant change in droplet size was observed for axial mode I in both the axial and radial directions. Uniform droplet size distributions were noticed for the pulsating Taylor cone mode. Ion yields and fragmentation were compared in the axial spraying modes for reserpine, leucine enkephalin and thermometer ions. Correlations between spraying modes, electrochemical redox processes and ion fragmentation reactions due to internal energy changes were established.