Injection of Drug-Infused Nanoparticles Through the Skin Using Electrostatic Pulse

Cassandra A. Browning, David H. Sherr, and Mark N. Horenstein

We are developing a new device for the transdermal delivery of drugs and vaccines via electrostatic pulsing of nanoparticles. If successful, the method will be rapid and will not require invasive skin puncture. We are also investigating *in vivo* the biological transport of a specific protein in mice to demonstrate the role that layer-specific transdermal drug delivery can play in targeting the immune system. Proteins are encapsulated within nanoparticles of *poly(lactic-co-glycolic acid* (PLGA), a common, body-tolerant, biodegradable polymer. The intent of the electrostatic pulse is to force the PLGA nanoparticles to a 10-µm depth into the epidermis where dendritic cells reside. The latter are intimately tied to the body's lymph node system, presenting the body's first line of defense against pathogens. The long term goal is to develop a clinical instrument for the widespread, inexpensive, and hygienic dosing of a broad spectrum of medications and vaccines.

The PLGA nanoparticles are produced via a sonication and centrifuging process and range from 20 nm to 500 nm in diameter. To help track their penetration depth and *in vivo* transport, they are infused with one of the fluorescent proteins GFP or FITC-OVA. After fabrication, the nanoparticles are dry mixed with 170-µm glass shot bead in a small tumbler that rotates axially and reciprocally at about 120 rpm. Air is injected into the rotating vessel at about 1 cfm via a 6-mm inside-diameter inlet tube. The air exits the vessel carrying airborne PLGA nanoparticles via a second tube aligned collinearly with the first. The heavy glass beads do not become airborne during cylinder rotation, but they help break up nanoparticles agglomerates, and their tumbling action facilitates the lifting of the nanoparticles into the inlet-to-outlet air stream, where they become entrained.

Nanoparticles leaving the tumbler enter a unipolar-corona diffusion charging station containing an array of axially directed needles energized to about 10 kV. A removable, nylon-mesh covered planar electrode (the "patch") covers the open end of the cylinder. Nanoparticles charged by diffusion deposit on the electrode. The particle laden "patch" is then placed on the skin and pulsed at about 10 Hz and up to 2 kV to porate the skin and drive the nanoparticles into the stratum-corneum epidermal layer.

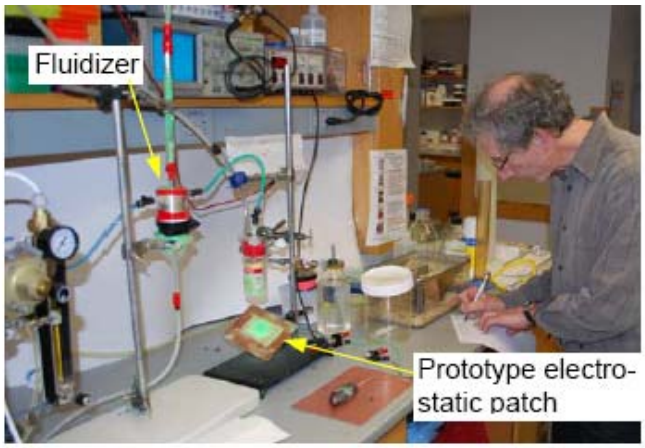

Figure 3 – Particle charging apparatus in the laboratory.