Nicotine delivery via programmable carbon nanotube membrane transdermal delivery devices

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Abstract:

Transdermal nicotine patches currently have low success rates in smoking cessation therapy, but coupling psychological counseling with replacement therapy is expected to dramatically improve cessation rates. This could be achieved with a low-power switchable nicotine delivery device that can automatically couple psychological counseling with dosing. Carbon nanotube (CNT) membranes are energy efficient electroosmotic pumps that can be used to control drug delivery rates through the skin for a variable-rate transdermal dosing system. In particular, this would be applied to nicotine addiction treatment via nicotine replacement therapy (NRT) where dosing rate (between therapeutically used rates) is set through counseling on a smartphone using Bluetooth communications with the membrane device. This system is highly favorable for compact devices due to its low power consumption and ability to be switched by small applied biases.

We evaluated the performance of switchable CNT devices for transdermal nicotine delivery by measuring variable fluxes of nicotine through CNT membranes. CNT membranes were placed over a flow-cell and nicotine levels collected in the cross-flow increased ~6-8 times when the CNT membrane was turned from OFF to ON state by application of -1.0V bias, and ~12-13 times with a -1.5V bias. To evaluate the transdermal performance of the CNT membranes, we developed an *in-vitro* microdialysis method that allows us to detect variable transdermal fluxes of nicotine through the CNT devices and can be applied directly to *in-vivo* studies. Fluxes in the ON state were approximately 3 times that of commercial Nicoderm patches and switching times were less than 2 hours, thus showing improved therapeutic potential of our device.