Carbon Nanotube Membranes for Transdermal Drug Delivery of Nicotine and Other Compounds

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Cigarette smoking continues to be the leading cause of premature death and illness in every industrialized country in the world, and in the U.S. alone leads to more than 400,000 deaths each year. Quitting smoking leads to immediate health benefits, but is difficult to achieve because people become addicted to nicotine, the active ingredient in tobacco. The nicotine patch is a widely recognized over-the-counter treatment device for use in smoking cessation that delivers a constant dose of nicotine through the skin to help relieve the symptoms associated with tobacco withdrawal. Success rates for smokers using the patch to quit, while better than those who try to quit by cessation alone, have been less than optimal (<20%). Some have proposed that this may be due to the constant steady-state pattern of nicotine delivered by the patch, which does not match the intraday peaks and valleys of nicotine blood levels associated with smoking. Dr. Hinds and his colleagues have developed a novel skin patch device for delivering nicotine based on an active layer of aligned carbon nanotubes (CNT) approximately 1.5-7 nm in diameter crossing through a solid polymer film (Fig 1). The ends of the CNTs are modified chemically so that they can be opened or closed at any time by applying or removing a small electric current, respectively. Dr. Hinds has shown that in the open state, small molecules are actively pumped across the membrane five times faster than simple diffusion. In other words, the CNT patch is a programmable system that can be controlled by the physician or the patient to mimic the rapid attainment of high nicotine plasma levels similar to those associated with smoking a cigarette, and then closed to allow a slow return to normal. The usefulness of the CNT patch is not limited to nicotine; many other skin absorbable compounds could be used as well. He and his colleagues have proposed that opioid withdrawal symptoms could be relieved in a similar manner by the use of the alpha-adrenergic agonist clonidine in the CNT patch. Currently, such treatment requires multiple injections per day over the 3-5 day opioid withdrawal period in sick and often uncooperative patients.

The CNT patch represents a major step forward in developing a programmable, transdermal drug delivery system that can usefully treat a variety of syndromes and be tailored to an individual patient's needs in a manner that will both improve therapeutic administration and efficacy.

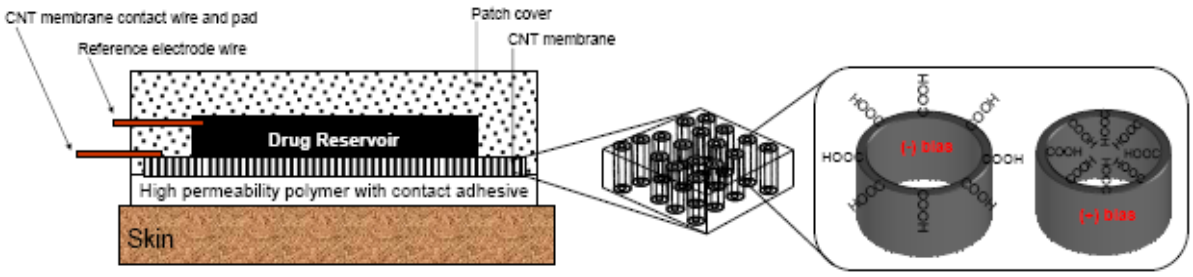

Figure 1. Incororation of functionalized nanotubes into a patch delivery system, and application of electrical bias to open or close tubes, thereby controlling drug distribution to the skin.

References/Publications

Strasinger, C.L., N.N. Scheff, J. Wu, B.J. Hinds and A.L. Stinchcomb. 2009. Carbon Nanotube Membranes for use in the Transdermal Treatment of Nicotine Addiction and Opioid Withdrawal Symptoms. *Substance Abuse: Research and Treatment* 3: 31-39.