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Preparation and Application of Microneedles for Transdermal Delivery Across Skin

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Background

The most common routes for human drug delivery are oral administration, hypodermic injection and transdermal delivery. Transdermal delivery is painless, unlike hypodermic injection, and does not generate dangerous medical waste or pose a risk of disease transmission from needle reuse which is common in developing countries. It has a number of advantages over the oral route in cases of poor drug absorption or enzymatic degradation in the gastrointestinal tract or liver. Transdermal drug delivery is non-invasive / minimally invasive and is self-administered with a high degree of patient compliance. It is thus an inexpensive drug delivery system with long-term controlled release.

A new drug transdermal delivery system is a hybrid of transdermal microneedles and drug storage & delivery patches. They administer drugs via narrow and shallow injections. Microneedles are a new transdermal drug delivery system that have the advantages of small dimensions, the ability to non-invasively penetrate the skin tissue and minimal risk of trauma and infection. A microneedle is typically around 100-200 microns in length, which is long enough to penetrate the stratum corneum skin barrier but not to reach the nerves in the dermis layer. Therefore, microneedles may provide a painless injection, and patients may be able to operate them safely on their own. Most transdermal systems are coupled with passive infusion (i.e., drug delivery through the barrier by diffusion), which may not be applicable when a significant and precise amount of drug release is required. Active infusion, a drug delivery method that forces drug-containing liquid out to tissues by mechanical means, is a preferred solution in such cases.

Technology Overview

Firstly, the present invention provides a method of making zeolite microneedles. A polymer template is prepared for the needles by a photolithographic process, wherein a layer of photo-sensitive polymeric material is coated on a substrate such as silica, glass, quartz or metal. The fabrication of zeolite microneedles involves precise control of the conditions for front exposure photolithography. To achieve polymeric microneedles (refer to Demonstration Sample 1) with different degrees of tapering, the exposure time and development time in the microfabrication process are varied.

Secondly, the invention provides a method of fabricating hollow zeolite microneedles by removing the polymer needle template from the zeolite shell by (i) air calcination or (ii) ozonation.

Thirdly, the invention provides a method of obtaining either closed-tip or open-tip microneedles (refer to Demonstration Sample 2) by varying the seeding methods and the growth conditions of the zeolites.

Fourthly, the potential applications of microneedles in the present invention include drug delivery, body fluid extraction and cosmetic purposes.

Finally, the invention describes the design and manufacture of transdermal patches and devices (refer to Demonstration Sample 3) for the delivery of therapeutic drugs and/or cosmetic formulations across the skin barrier at a controlled rate by nonelectronic means. The patch and device consist of a nonelectronic actuating device and a volume of a therapeutic drug and/or cosmetic formulation in separate compartments that are connected by a membrane. The actuating device consists of an expanding hydrogel that expands at a fixed rate to deliver a therapeutic drug and/or cosmetic formulation at a fixed dosing rate. The patch or device can be further attached to a microneedle for skin poration to enhance delivery across skin.

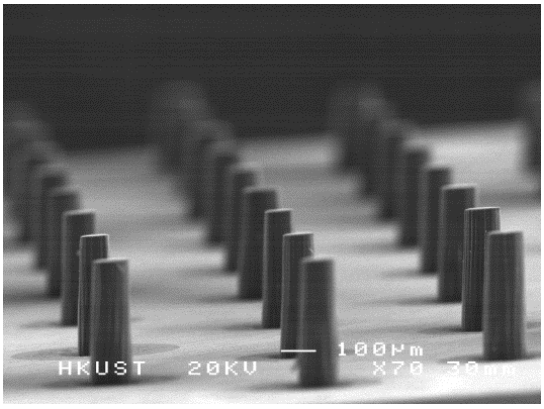
Applications

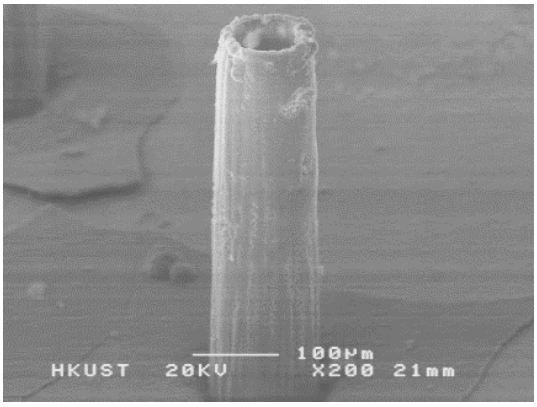
- Drug delivery
- Body fluid extraction
- Cosmetic applications

Patents

- US Patent no.: 11/674881
- US Patent no.: 14/432634
- China Patent no.: 200780006266.5
- China Patent no.: 201380051498.8

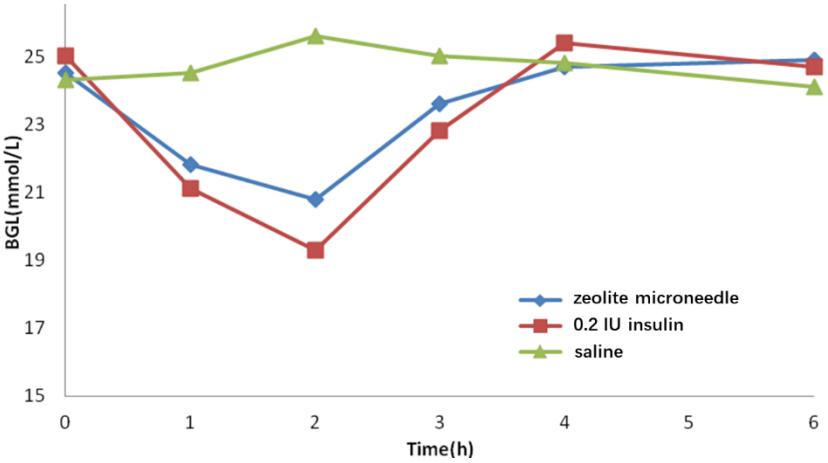
Figures





Array of microneedles with closed and open tips

The transdermal microneedle patch can be worn as a watch for convenience



Insulin was delivered by transdermal patches to diabetic rats, and the rats' blood glucose level (BGL) was monitored and compared. The figure shows that zeolite microneedles can produce a therapeutic effect similar to that of the direct hypodermic injection of insulin, indicating effective drug delivery