Improved Devices for Collecting Sweat for Chemical Analysis

Unlike prior devices, these would enable measurement of volumes of specimens.

Lyndon B. Johnson Space Center, Houston, Texas

Improved devices have been proposed for collecting sweat for biochemical analysis — especially for determination of the concentration of Ca^{2+} ions in sweat as a measure of loss of Ca from bones. Unlike commercially available sweat-collection patches used previously in monitoring osteoporosis and in qualitative screening for some drugs, the proposed devices would not allow evaporation of the volatile chemical components (mostly water) of sweat. Moreover, the proposed devices would be designed to enable determination of the volumes of collected sweat. From these volumes and the quantities of Ca^{2+} and/or other analytes as determined by other means summarized below, one could determine the concentrations of the analytes in sweat.

A device according to the proposal would be flexible and would be worn like a commercial sweat-collection patch. It would be made of molded polydimethylsiloxane (silicone rubber) or other suitable material having properties that, for the purpose of analyzing sweat, are similar to those of glass. The die for molding the silicone rubber would be fabricated by a combination of lithography and electroplating. The die would reproducibly form, in the silicone rubber, a precisely defined number of capillary channels per unit area, each channel having a precisely defined volume. Optionally, electrodes for measuring the Ca^{2+} content of the sweat could be incorporated into the device.

The volume of sweat collected in the capillary channels of the device would be determined from (1) the amount of light or radio waves of a given wavelength absorbed by the device and (2) the known geometry of the array of capillary channels. Then, in one of two options, centrifugation would be performed to move the sweat from the capillary tubes to the region containing the electrodes, which would be used to measure the Ca^{2+} content by a standard technique. In the other option, centrifugation would be performed to remove the sweat from the device to make the sweat available to other analytical instruments for measuring concentrations of substances other than Ca^{2+}.

This work was done by Daniel L. Feeback of Johnson Space Center and Mark S. F. Clarke of the University of Houston. Further information is contained in a TSP (see page 1).

Refer to MSC-23625-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Tissue Photolithography

This method for extracting pure DNA from single cancer cells enables high-specificity cancer identification.

NASA's Jet Propulsion Laboratory, Pasadena, California

Tissue lithography will enable physicians and researchers to obtain macromolecules with high purity (>90 percent) from desired cells in conventionally processed, clinical tissues by simply annotating the desired cells on a computer screen. After identifying the desired cells, a suitable lithography mask will be generated to protect the contents of the desired cells while allowing destruction of all undesired cells by irradiation with ultraviolet light. The DNA from the protected cells can be used in a number of downstream applications including DNA sequencing. The purity (i.e., macromolecules isolated form specific cell types) of such specimens will greatly enhance the value and information of downstream applications.

In this method, the specific cells are isolated on a microscope slide using photolithography, which will be faster, more specific, and less expensive than current methods. It relies on the fact that many biological molecules such as DNA are photosensitive and can be destroyed by ultraviolet irradiation. Therefore, it is possible to "protect" the contents of desired cells, yet destroy undesired cells. This approach leverages the technologies of the microelectronics industry, which can make features smaller than 1 μm with photolithography.

A variety of ways has been created to achieve identification of the desired cell, and also to designate the other cells for destruction. This can be accomplished through chrome masks, direct laser writing, and also active masking using dynamic arrays. Image recognition is envisioned as one method for identifying cell nuclei and cell membranes. The pathologist can identify the cells of interest using a microscopic computerized image of the slide, and appropriate custom software.

In one of the approaches described in this work, the software converts the selection into a digital mask that can be fed into a direct laser writer, e.g. the Heidelberg DWL66. Such a machine uses a metalized glass plate (with chrome metallization) on which there is a thin layer of photoresist. The laser transfers the digital mask onto the photoresist by direct writing, with typical best resolution of 2 μm. The plate is

then developed to remove the exposed photoresist, which leaves the exposed areas susceptible to chemical chrome etch. The etch removes the unprotected chrome. The rest of the photoresist is then removed, by either ultraviolet organic solvent or overdevelopment. The remaining chrome pattern is quickly oxidized by atmospheric exposure (typically within 30 seconds).

The ready chrome mask is now applied to the tissue slide and aligned manually, or using automatic software and pre-designed alignment marks. The slide plate sandwich is then exposed to UV to destroy the DNA of the unwanted cells. The slide and plate are separated and the slide is processed in a standard way to prepare for polymerase chain reaction (PCR) and potential identification of cancer sequences.

This work was done by Lawrence A. Wade of Caltech and Emil Kartalov, Darryl Shibata, and Clive Taylor of the University of Southern California for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Method for Impeding Degradation of Porous Silicon Structures

This method tailors degradation of a drug delivery system to enable controlled release of therapeutic agents.

Lyndon B. Johnson Space Center, Houston, Texas

This invention relates to surface modification of porosified silicon (pSi) structures with poly(alkylene) glycols for the purpose of controlled degradation of the silicon matrix and tailored release of encapsulated substances for biomedical applications. The pSi structures are currently used in diverse biomedical applications including bio-molecular screening, optical bio-sensoring, and drug delivery by means of injectable/orally administered carriers and implantable devices.

The size of the pores and the surface chemistry of the pSi structure can be controlled during the microfabrication process and thereafter. A fine regulation of the degradation kinetics of mesoporous silicon structures is of fundamental importance. Polyethylene glycols (PEGs) represent the major category of surface modifying agents used in classical drug delivery systems and in pharmaceutical dosage forms. PEGylation enables avoidance of RES uptake, thus prolonging circulation time of intravenously injectable nanovectors. PEG molecules demonstrate little toxicity and immunogenicity, and are cleared from the body through the urine (molecular weight, MW<30 kDa) or in the feces (MW>30kDa).

The invention focuses on the possibility of finely tuning the degradation kinetics of the pSi nanovectors and other structures through surface conjugation of PEGs with various backbone lengths/MWs. To prove the concept, pSi nanovectors were covalently conjugated to seven PEGs with MW from 245 to 5,000 Da and their degradation kinetics in physiologically relevant media (phosphate buffer saline, PBS pH7.4, and fetal bovine serum) was assessed by the elemental analysis of the Si using inductive coupled plasma atomic emission spectroscopy (ICP-AES). The conjugation of the PEG with lowest MW to the nanovectors surface did not induce any change in the degradation kinetics in serum, but inhibited degradation and consequently the release of orthosilicic acid into buffer. When PEGs with the longer chains were evaluated, Si mass loss from the nanovectors was slowed down, and the PEGylated structures were almost fully degraded within 18–24 hours in serum and within 48 hours in PBS. The most dramatic effect was observed for high MW PEGs 3,400 and 5,000 Da, which prominently inhibited the degradation of the systems, with complete degradation achieved only after four days. For these PEGs, during the early stages of the degradation, there was a "lag" period of little or no Si mass loss from the nanovector.

The obtained profiles were in agreement with the erosion of the nanovector surface as observed by scanning electron microscopy.

This work was done by Biana Godin Vilentchouk and Mauro Ferrari of the University of Texas Health Science Center at Houston, Biomedical Engineering, for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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External Cooling Coupled to Reduced Extremity Pressure Device

The use of reduced-pressure boots and gloves may mitigate the effects of stroke and heart attacks.

Lyndon B. Johnson Space Center, Houston, Texas

Although suited astronauts are currently cooled with a Liquid Cooled Ventilation Garment (LCVG), which can remove up to 85 percent of body heat, their effectiveness is limited because cooling must penetrate layers of skin, muscle, fat, bone, and tissue to reach the bloodstream, where its effect is prominent. Vasoconstriction further reduces the effectiveness by limiting arterial flow when exposed to cold (the frostbite response), resulting in a time constant on