

time clinical intervention in acute situations. It also can be used for daily measurement of hematocrit for patients on anticoagulant drugs, or to detect acute myocardial damage outside a hospital.

*This work was done by Eugene Y Chan and Candice Bae of DNA Medicine Institute for Glenn Research Center.*

*Inquiries concerning rights for the commercial use of this invention should be ad-*

*ressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18391-1.*

## Microfluidic Extraction of Biomarkers Using Water as Solvent

### Terahertz modulation of permittivity of water would enable solvation of molecules of interest.

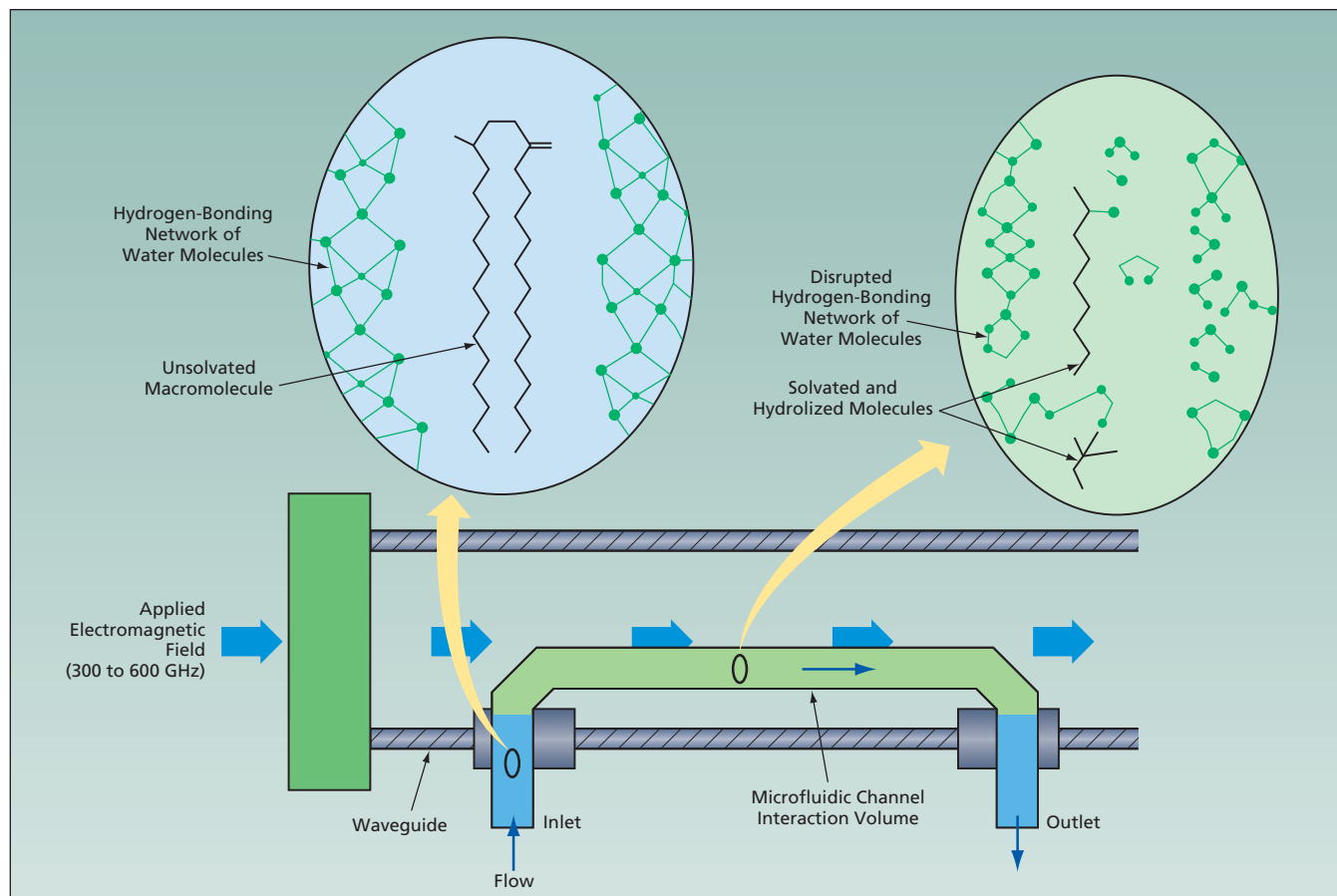
NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed device, denoted a miniature microfluidic biomarker extractor ( $\mu$ -EX), would extract trace amounts of chemicals of interest from samples, such as soils and rocks. Traditionally, such extractions are performed on a large scale with hazardous organic solvents; each solvent capable of dissolving only those molecules lying within narrow ranges of specific chemical and physical characteristics that notably include volatility, electric charge, and polarity. In contrast, in the  $\mu$ -EX, extractions could be performed by use of small amounts (typically between 0.1 and 100  $\mu$ L) of water as a universal solvent.

As a rule of thumb, in order to enable solvation and extraction of molecules, it is necessary to use solvents that have polarity sufficiently close to the polarity of the target molecules. The  $\mu$ -EX would make selection of specific organic solvents unnecessary, because  $\mu$ -EX would exploit a unique property of liquid water: the possibility of tuning its polarity to match the polarity of organic solvents appropriate for extraction of molecules of interest. The change of the permittivity of water would be achieved by exploiting interactions between the translational states of water molecules and an imposed electromagnetic field in the frequency range of

300 to 600 GHz. On a molecular level, these interactions would result in disruption of the three-dimensional hydrogen-bonding network among liquid-water molecules and subsequent solvation and hydrolysis of target molecules. The  $\mu$ -EX is expected to be an efficient means of hydrolyzing chemical bonds in complex macromolecules as well and, thus, enabling analysis of the building blocks of these complex chemical systems.

The  $\mu$ -EX device would include a microfluidic channel, part of which would lie within a waveguide coupled to an electronically tuned source of broadband electromagnetic radiation in the fre-



**Water Flowing in a Microfluidic Channel** would be exposed to electromagnetic radiation, causing the solvation of biomarker macromolecules that would otherwise be insufficiently soluble in water.

quency range from 300 to 600 GHz (see figure). The part of the microfluidic channel lying in the waveguide would constitute an interaction volume. The dimensions of the interaction volume would be chosen in accordance with the anticipated amount of solid sample material needed to ensure extraction of suffi-

cient amount of target molecules for detection and analysis. By means that were not specified at the time of reporting the information for this article, the solid sample material would be placed in the interaction volume. Then the electromagnetic field would be imposed within the waveguide and water would be pumped

through the interaction volume to effect the extraction.

*This work was done by Xenia Amashukeli, Harish Manohara, Goutam Chattopadhyay, and Imran Mehdi of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact [iaoffice@jpl.nasa.gov](mailto:iaoffice@jpl.nasa.gov). NPO-46150*

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## Microwell Arrays for Studying Many Individual Cells

*Lyndon B. Johnson Space Center, Houston, Texas*

“Laboratory-on-a-chip” devices that enable the simultaneous culturing and interrogation of many individual living cells have been invented. Each such device includes a silicon nitride-coated silicon chip containing an array of micro-machined wells sized so that each well can contain one cell in contact or proximity with a patch clamp or other suitable single-cell-interrogating device. At the bottom of each well is a hole, typically  $\approx 0.5 \mu\text{m}$  wide, that connects the well with one of many channels in a mi-

crofluidic network formed in a layer of poly(dimethylsiloxane) on the underside of the chip. The microfluidic network makes it possible to address wells (and, thus, cells) individually to supply them with selected biochemicals. The microfluidic channels also provide electrical contact to the bottoms of the wells.

*This work was done by Albert Folch and Turgut Fettah Kosar of the University of Washington 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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*Refer to MSC-24046-1, volume and number of this NASA Tech Briefs issue, and the page number.*

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## Droplet-Based Production of Liposomes

*Lyndon B. Johnson Space Center, Houston, Texas*

A process for making monodisperse liposomes having lipid bilayer membranes involves fewer, simpler process steps than do related prior methods. First, a microfluidic, cross-junction droplet generator is used to produce vesicles comprising aqueous-solution droplets contained in single-layer lipid membranes. The vesicles are collected in a lipid-solvent mix that is at most partially soluble in water and is less dense than is water. A layer of water is dispensed on top of the solvent. By virtue of the difference in densities, the water sinks to the bottom and the solvent floats to

the top. The vesicles, which have almost the same density as that of water, become exchanged into the water instead of floating to the top. As there are excess lipids in the solvent solution, in order for the vesicles to remain in the water, the addition of a second lipid layer to each vesicle is energetically favored.

The resulting lipid bilayers present the hydrophilic ends of the lipid molecules to both the inner and outer membrane surfaces. If lipids of a second kind are dissolved in the solvent in sufficient excess before use, then asymmetric liposomes may be formed.

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*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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## Identifying and Inactivating Bacterial Spores

*NASA's Jet Propulsion Laboratory, Pasadena, California*

Problems associated with, and new strategies for, inactivating resistant organisms like *Bacillus canaveralius* (found at Kennedy Space Center during a survey of three NASA clean-rooms) have been defined. Identifying

the particular component of the spore that allows its heightened resistance can guide the development of sterilization procedures that are targeted to the specific molecules responsible for resistance, while avoiding using un-

duly harsh methods that jeopardize equipment.

The key element of spore resistance is a multilayered protein shell that encases the spore called the spore coat. The coat of the best-studied spore-forming mi-