



Digital Microfluidics Sample Analyzer

Combined innovations enable portable analyzers for medical diagnostics, bioterrorism pathogen detection, and food supply analysis.

Lyndon B. Johnson Space Center, Houston, Texas

Three innovations address the needs of the medical world with regard to microfluidic manipulation and testing of physiological samples in ways that can benefit point-of-care needs for patients such as premature infants, for which drawing of blood for continuous tests can be life-threatening in their own right, and for expedited results. A chip with sample injection elements, reservoirs (and waste), droplet formation structures, fluidic pathways, mixing areas, and optical detection sites, was fabricated to test the various components of the microfluidic platform, both individually and in integrated fashion. The droplet control system permits a user to control droplet microactuator system functions, such as droplet operations and detector operations. Also, the programming system allows a user to develop software routines for controlling droplet microactuator system functions, such as droplet operations and detector operations.

A chip is incorporated into the system with a controller, a detector, input and output devices, and software. A novel filler fluid formulation is used for the transport of droplets with high protein concentrations. Novel assemblies for detection of photons from an on-chip droplet are present, as well as novel systems for conducting various assays, such as immunoassays and PCR (polymerase chain reaction).

The lab-on-a-chip (a.k.a., lab-on-a-printed-circuit board) processes physiological samples and comprises a system for automated, multi-analyte measurements using sub-microliter samples of human serum. The invention also relates to a diagnostic chip and system including the chip that performs many of the routine operations of a central lab-based chemistry analyzer, integrating, for example, colorimetric assays (e.g., for proteins), chemiluminescence/fluorescence assays (e.g., for enzymes, electrolytes, and gases), and/or conductometric assays (e.g., for hematocrit on plasma and whole blood) on a single chip platform.

Microfluidic control is essential for a successful lab-on-a-chip. This innovation is capable of analysis of bodily fluids such as blood, sweat, tears, serum, plasma, cerebrospinal fluid, sweat, and urine. It can be configured as a mobile or handheld instrument for use at bedside, ICU (intensive care unit), ER (emergency room), operating rooms, clinics, or in the field. Alternatively, it can be configured as a benchtop system. The chip can be configured to perform on-chip all-electrical micropumping; i.e., the chip can be configured to operate with no off-chip pressure sources or syringe pumps. Additionally, it can perform many simultaneous, parallel operations on nanodroplets, thereby expediting production of results.

To aid in processing the microfluidic samples, an improved design for loading a droplet actuator includes a top substrate that combines glass with one or more other materials that are easier to manufacture. Examples of such materials include resins and plastics. The glass-plate portion covers the droplet operations area of the droplet actuator, providing a flat, smooth surface for facilitating effective droplet operations. The plastic portion has one or more openings that provide a fluid path, from an exterior well, into the gap of the droplet actuator. The substrates are associated with electrodes for conducting droplet operations such as droplet transport and droplet dispensing.

This work was done by Michael G. Pollack, Vijay Srinivasan, Allen Eckhardt, Philip Y. Paik, Arjun Sudarsan, Alex Shenderov, Zhis-han Hua, and Vamsee K. Pamula of Advanced Liquid Logic, Inc. 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-24283-1/553-1/4-1, volume and number of this Medical Design Briefs issue, and the page number.

Radiation Protection Using Carbon Nanotube Derivatives

This technology can be used in clinical oncology and in nuclear disaster response.

Lyndon B. Johnson Space Center, Houston, Texas

BHA and BHT are well-known food preservatives that are excellent radical scavengers. These compounds, attached to single-walled carbon nanotubes (SWNTs), could serve as excellent radical traps. The amino-BHT groups can be associated with SWNTs that have car-

bolyx acid groups via acid-base association or via covalent association.

The material can be used as a means of radiation protection or cellular stress mitigation via a sequence of quenching radical species using nano-engineered scaffolds of SWNTs and their deriva-

tives. It works by reducing the number of free radicals within or nearby a cell, tissue, organ, or living organism. This reduces the risk of damage to DNA and other cellular components that can lead to chronic and/or acute pathologies, including (but not limited to) can-

cer, cardiovascular disease, immunosuppression, and disorders of the central nervous system. These derivatives can show an unusually high scavenging ability, which could prove efficacious in protecting living systems from radical-induced decay.

This technique could be used to protect healthy cells in a living biological system from the effects of radiation therapy. It could also be used as a prophylactic or antidote for radiation exposure due to accidental, terrorist, or wartime use of radiation-containing weapons; high-altitude or space travel (where radiation ex-

posure is generally higher than desired); or in any scenario where exposure to radiation is expected or anticipated.

This invention's ultimate use will be dependent on the utility in an overall biological system where many levels of toxicity have to be evaluated. This can only be assessed at a later stage. *In vitro* toxicity will first be assessed, followed by *in vivo* non-mammalian screening in zebra fish for toxicity and therapeutic efficacy.

This work was done by Jodie L. Conyers, Jr., Valerie C. Moore, and S. Ward Casscells of the University of Texas Health Science Center at Houston for Johnson Space Center. For fur-

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Refer to MSC-24565-1, volume and number of this NASA Tech Briefs issue, and the page number.

Process to Selectively Distinguish Viable From Non-Viable Bacterial Cells

NASA's Jet Propulsion Laboratory, Pasadena, California

The combination of ethidium monoazide (EMA) and post-fragmentation, randomly primed DNA amplification technologies will enhance the analytical capability to discern viable from non-viable bacterial cells in spacecraft-related samples. Intercalating agents have been widely used since the inception of molecular biology to stain and visualize nucleic acids. Only recently, intercalating agents such as EMA have been exploited to selectively distinguish viable from dead bacterial cells.

Intercalating dyes can only penetrate the membranes of dead cells. Once through the membrane and actually inside the cell, they intercalate DNA and, upon photolysis with visible light, produce stable DNA monoadducts. Once the DNA is crosslinked, it becomes insoluble and unable to be fragmented for post-fragmentation, randomly primed DNA library formation. Viable organisms' DNA remains unaffected by the intercalating agents, allowing for

amplification via post-fragmentation, randomly primed technologies. This results in the ability to carry out downstream nucleic acid-based analyses on viable microbes to the exclusion of all non-viable cells.

This work was done by Myron T. La Duc, James N. Benardini, and Christina N. Stam of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-47218