

strated using both suspension (HL-60) and adherent (BHK-21) cells.

Novel features associated with this development are twofold. First, novel designs that execute needed processes with improved speed and efficiency were developed. These primarily encompass electric-field-driven lysis of cells. The configurations include electrode-containing constructs, or an “electrode-less” chip design, which is easy to fabricate and mitigates fouling at the electrode surface; and the “fluidized” extraction format based on electrokinetically as-

sisted mixing and contacting of microbeads in a shape-optimized chamber. A secondary proprietary feature is in the particular layout integrating these components to perform the desired operation of RNA isolation.

Apart from a novel functional capability, advantages of the innovation include reduced or eliminated use of toxic reagents, and operator-independent extraction of RNA.

This work was done by Shivshankar Sundaram, Balabhaskar Prabhakarbandian, Kapil Pant, and Yi Wang of CFD Research

Corp. for Johnson Space Center. 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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Refer to MSC-24375-1, volume and number of this NASA Tech Briefs issue, and the page number.

Enabling Microliquid Chromatography by Microbead Packing of Microchannels

Goddard Space Flight Center, Greenbelt, Maryland

The microbead packing is the critical element required in the success of on-chip microfabrication of critical microfluidic components for in-situ analysis and detection of chiral amino acids. In order for microliquid chromatography to occur, there must be a stationary phase medium within the microchannel that interacts with the analytes present within flowing fluid. The stationary phase media are the microbeads packed by the process discussed in this work. The purpose of the microliquid chromatography is to provide a lightweight, low-volume, and low-power element to separate amino acids and their chiral partners efficiently to understand better the origin of life.

In order to densely pack microbeads into the microchannels, a liquid slurry of

microbeads was created. Microbeads were extracted from a commercially available high-performance liquid chromatography column. The silica beads extracted were 5 microns in diameter, and had surface coating of phenyl-hexyl. These microbeads were mixed with a 200-proof ethanol solution to create a microbead slurry with the right viscosity for packing. A microfilter is placed at the outlet via of the microchannel and the slurry is injected, then withdrawn across a filter using modified syringes. After each injection, the channel is flushed with ethanol to enhance packing. This cycle is repeated numerous times to allow for a tightly packed channel of microbeads.

Typical microbead packing occurs in the macroscale into tubes or channels by

using highly pressurized systems. Moreover, these channels are typically long and straight without any turns or curves. On the other hand, this method of microbead packing is completed within a microchannel 75 micrometers in diameter. Moreover, the microbead packing is completed into a serpentine type microchannel, such that it maximizes microchannel length within a microchip. Doing so enhances the interactions of the analytes with the microbeads to separate efficiently amino acids and amino acid enantiomers.

This work was done by Manuel Balvin and Yun Zheng of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16514-1

On-Command Force and Torque Impeding Devices (OC-FTID) Using ERF

This technology is applicable as a rehabilitation or exercise device.

NASA's Jet Propulsion Laboratory, Pasadena, California

Various machines have been developed to address the need for countermeasures of bone and muscle deterioration when humans operate over extended time in space. Even though these machines are in use, each of them has many limitations that need to be addressed in an effort to prepare for human missions to distant bodies in the solar system.

An exercise exoskeleton was conceived that performs on-demand resistiv-

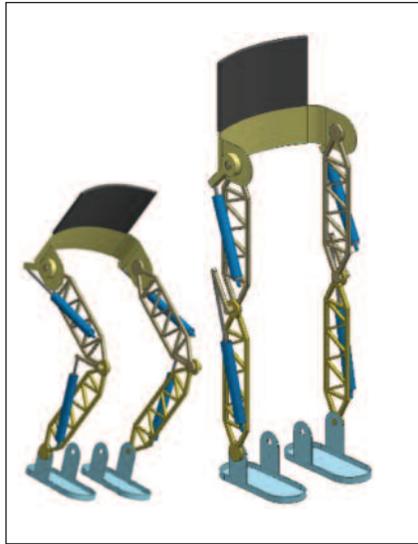
ity by inducing force and torque impedance via ElectroRheological Fluid (ERF). The resistive elements consist of pistons that are moving inside ERF-filled cylinders or a donut-shaped cavity, and the fluid flows through the piston when the piston is moved. Tests of the operation of ERF against load showed the feasibility of this approach.

The inside of the piston consists of parallel electrodes with alternating po-

larity that increase the ERF viscosity when activated. This increase leads to the formation of a virtual valve inside the piston creating impeding force to the piston motion. The cross-sectional area of the piston is mostly hollow to allow low piston resistance to the motion when the electrodes are not activated, and produce high impedance when the electrodes are activated. A balanced volume is created on the two

sides of the piston so that pushing it will only involve fluid flow against the effect of the increased viscosity in the gaps between the electrodes.

The elements are shaped as a cylinder or donut with a piston that is moved inside the internal cavity containing ERF. The elements have a piston inside the cavity with shafts on its two sides. The piston is pushed or pulled inside the chambers and consists of parallel electrodes with opposing polarity wired through one of the shafts. When the electrodes are subjected to electric field, they form a virtual valve causing increased viscosity and impeded flow. Using ERF offers the ability to proportionally (as a function of the voltage) increase the viscosity of the fluid with a very fast reaction time on the order of milliseconds. The feasibility of this approach is straightforward from the nature of ERF materials and preliminary tests made in the lab.



The **Exoskeleton** and the required elements that control the mechanical impedance are shown. The elements are shaped as a cylinder or donut with a piston that is moved inside the internal cavity containing ERF.

ERF properties of high yield stress, low current density, and fast response (less than one millisecond) offer essential characteristics for the construction of the exoskeleton. ERFs can apply very high electrically controlled resistive forces or torque while their size (weight and geometric parameters) can be very small. Their long life and ability to function in a wide temperature range (from -40 to 200 °C) allows for their use in extreme environments. ERFs are also non-abrasive, non-toxic, and nonpolluting (meet health and safety regulations).

The technology is applicable as a compact exercise machine for astronauts' countermeasure of microgravity, an exercise machine for sport, or as a device for rehabilitation of patients with limb issues.

This work was done by Yoseph Bar-Cohen, Mircea Badescu, and Stewart Sherrit of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).. NPO-48393