PolyFuel Receives Broad Patents on Key Portable Fuel Cell Technology

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Hydrocarbon Membranes Gaining Momentum as "The Heart of the Fuel Cell"; Enable Efficient Micro Power Fuel Cells for Portable Electronics Applications

MOUNTAIN VIEW, CA --The United States Patent and Trademark Office recently issued two broad patents for fundamental fuel cell technology to PolyFuel, Inc, a leader in engineered membranes for fuel cells. The patents, with the unassuming titles of "Ion Conductive Block Copolymers" and "Sulfonated Copolymer", cover some of the sophisticated chemistry and breakthroughs behind PolyFuel's broadening family of high performance, hydrocarbon-based polymer fuel cell membranes.

The patents are significant because such membranes, which resemble flexible sheets of cellophane, are the critical technology behind portable fuel cells, and to a large degree dictate their size, cost, power and efficiency. Such "micro power" fuel cells are widely expected to begin supplanting batteries as the primary power source when extended runtimes are desired for increasingly power-hungry portable electronic devices such as laptop computers, PDAs, and smart phones. On the strength of its membrane technology, PolyFuel is moving into the dominant market and technology position, and these broad patent grants are expected to secure PolyFuel's state of the art position in hydrocarbon membranes for portable fuel cell applications.

To date, PolyFuel has filed 23 patent applications, and these are the first of several "composition of matter" applications to be granted. Says PolyFuel president and CEO Jim Balcom, "In any new field, there are ultimately a few, benchmark patents from which much future technology springs. We believe that this is one of those situations, and our investors and customers should be encouraged that we now have such key intellectual property protection in place, and are free to exploit our technology for the benefit of the industry."

PolyFuel's membranes have garnered much interest in the portable electronics industry as they continue to raise the bar on fuel cell performance, in spite of the tremendous technical challenges in nano-engineering the exotic plastic films. Such increased performance is causing PolyFuel's hydrocarbon membranes to displace alternative technologies, particularly fluorocarbon membranes, in much of the new and existing portable fuel cell development around the world.

State of the Art
There are essentially two alternative technologies for the design of portable direct methanol

fuel cells (DMFCs), based upon the type of polymer used to create the plastic film-like membranes that make fuel cells possible. One technology, pioneered by DuPont®, uses membranes based on fluorocarbon polymers, similar to the ones used to manufacture the non-stick Teflon® coating on frying pans, and fibers for Gore-Tex® water-resistant fabrics. DuPont originally developed the so-called fluorocarbon membranes, now marketed under the trade name Nafion®, in the late 1960s, for the early U.S. space program.

The other technology, significantly newer in origin, has been pioneered by PolyFuel, SRI, Honda, and others. Instead of fluorocarbon polymers, the technology uses hydrocarbon polymers – long chains of organic molecules of varying composition – to form extremely stable films with carefully engineered properties.

Literally decades of research, and by some estimates hundreds of millions of dollars, have been expended on these exotic membranes – tens of millions by PolyFuel alone. Although there continues to be active development work on fluorocarbon-based fuel cells, in recent years, the most active and promising developments have come from hydrocarbon membranes, many of them from PolyFuel, because of the widening performance gap between the two fundamental technologies. Samsung, for example, recently characterized PolyFuel's latest membrane as "a breakthrough" in their efforts to develop portable fuel cells (see: "PolyFuel Sets New Record for Portable Fuel Cell Performance – Again", November 7, 2006). Much of the technology behind that breakthrough membrane is protected by these two new patents.

How It All Works – A Layman's View

Fuel cells can be thought of as refillable batteries. Unlike batteries, which when exhausted must be discarded or recharged over a number of hours, fuel cells will keep producing power indefinitely, as long as there is fuel. In fuel cells being designed for portable consumer electronics devices, snap-in cartridges – the size of disposable cigarette lighters in several handheld designs – can be carried in pocket or purse, and popped into the fuel cell as required. One such cartridge, containing just a few ounces of methanol (CH3OH) and water (H2O), might power a laptop computer for 8 hours or more.

A portable, "direct methanol" fuel cell (DMFC) works by extracting energy directly from just such a mixture of methanol and water. The energy is extracted electrochemically, in the form of electricity, without combustion.

The heart of the fuel cell is the fuel cell membrane, and it is the membrane that determines many of the key properties of the fuel cell, such as size, weight, cost and runtime. The membrane is coated with a thin layer of catalyst, typically platinum, which helps increase the rate at which the electricity is produced.

At the interface between the catalyst and the membrane on the fuel side of the fuel cell, the hydrogen atoms in the methanol and water molecules spontaneously split into negatively charged electrons and positively charged protons – which are simply hydrogen atoms missing their usual, single electron. The protons pass through small channels in the membrane from the fuel side of the fuel cell to the air side. The electrons, by contrast, travel outside the fuel cell as electricity and do useful work such as powering a laptop. On the air side of the fuel cell, returning electrons recombine with protons that have crossed through the membrane, and with oxygen present in the air, to complete the reaction, creating water vapor as a byproduct.

For many years, and prior to the widespread availability of hydrocarbon membranes from PolyFuel, developers of DMFC fuel cells had no choice but to use fluorocarbon membrane

materials, which were originally developed for hydrogen fuel cells. However, fluorocarbon membranes have some significant performance drawbacks when used in direct methanol fuel cells. First their protonconducting channels tend to be somewhat larger than is optimal. Second, fluorocarbon membranes have a soft, rubbery consistency, and in the presence of methanol, they tend to swell, making the proton channels even larger still.

The net effect of these drawbacks is that the water and methanol from the fuel supply practically pour through the channels, along with the protons, however without making any electricity. This significantly reduces the efficiency of a fluorocarbon membrane-based fuel cell and requires that the fuel cell have a larger fuel tank. Additionally, when the unwanted water and methanol arrive at the air side of the fuel cell, they essentially "drown" the catalyst, by preventing ambient oxygen from reaching the protons and electrons to complete the fuel cell reaction. To make matters worse, the uninvited methanol itself reacts with the air and creates heat, even more water, and carbon dioxide (CO2) – reducing the efficiency of the fuel cell even further.

PolyFuel's now-patented hydrocarbon membrane material self-assembles proton channels that are nano-engineered to be significantly smaller than those in fluorocarbon membranes. The polymer matrix is also much tougher and stronger so that it does not swell to the same degree as fluorocarbon membranes do. The net result is that more of the water and methanol remain on the fuel side of the fuel cell, where they can be used to create useful electricity. The fuel cell is also able to breathe easier, and doesn't create as much heat, water and CO2. This in turn enables the fuel cell to be smaller, lighter, less expensive, and longer running.

These characteristics of the PolyFuel-based fuel cell are critically important to portable fuel cell system developers, and environmentally conscious consumers.

PolyFuel's composition of matter patents, US 7,094,490, and 7,202,001 describe the chemistry behind these concepts. Together the patents are broad in their scope, and describe a nearly infinite number of permutations of hydrocarbon membranes, which gives the company outstanding protection in such an important, commercially imminent field.

About PolyFuel
PolyFuel (http://www.polyfuel.com) is a world leader in engineered membranes that provide significantly improved performance in direct methanol fuel cells (DMFC) and hydrogen fuel cells, particularly for portable electronic and automotive applications. The state of the art of fuel cells is essentially that of the membrane, and PolyFuel's best in class, hydrocarbon-based membranes enable a new generation of fuel cells that for the first time can deliver on the long-awaited promise of clean, long-running, and cost-effective portable power.

PolyFuel has an unmatched capability to rapidly translate the system-level requirements of fuel cell designers and manufacturers into engineered polymer nano-architectures. Such capability – based on PolyFuel's over 150 combined years of fuel cell experience, world-class polymer nano-architects, and a fundamental patent position covering more than 23 different inventions – also makes PolyFuel an essential development partner and supplier to any company seeking to advance the state of the art in fuel cells. Polymer electrolyte fuel cells built with PolyFuel membranes can be smaller, lighter, longerrunning, more efficient, less expensive and more robust than those made with other membrane materials.

PolyFuel is working with most of the world's leading portable fuel cell system developers, the majority of whom are household brand name consumer electronics manufacturers. Several of the largest Japanese and Korean consumer electronics companies rank PolyFuel's membrane as the best portable fuel cell membrane available in the world today. To date, NEC, Sanyo

and Samsung have disclosed they are using PolyFuel membranes.

PolyFuel was spun out of SRI International (formerly Stanford Research Institute) in 1999, after 14 years of applied membrane research. The company is based in Mountain View, California, and is publicly listed on the AIM market of the London Stock Exchange.