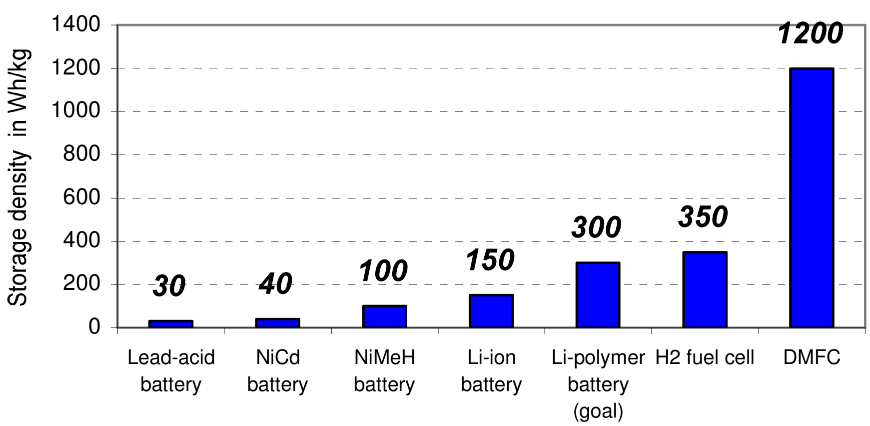
The ideal fuel for portable fuel cells - hydrogen or methanol?

Since several years fuel cells have been developed as power sources for small, portable devices. It is generally accepted that, because of the cost structures, mass production of fuel cell products will start in the portable sector, probably below 100 W. Key questions for such products are: What is the ideal energy carrier for the fuel cell? How can a safe, convenient and low-cost fuel infrastructure be established?

The electrical capacity of batteries has not kept up with the increasing power consumption of electronic devices. Features such as W-LAN, higher CPU speed, "always-on", large and bright displays and many others are important for the user but severely limited by today's battery life. Lithium ion batteries and lithium-polymer batteries have almost reached fundamental limits. A laptop playing a DVD today has a runtime of just above one hour on one battery pack, which is clearly not acceptable. Such limitations have led to an enormous interest in alternative power sources, of which the fuel cell is the most promising candidate. Storage density, i.e. the electrical capacity available per unit mass of energy storage means, is one of the most important parameters. Figure 1 shows several energy storage and conversion technologies and their respective storage densities.



Storage densities of energy conversion / storage systems

Assumptions: H_2 fuel cell efficiency: 40 %, DMFC efficiency: 25 %.
Source: Samsung / SFC Smart Fuel Cell

About a dozen companies and institutions world-wide are active in the field of miniaturized fuel cell systems, which can be divided in two different technological concepts: Hydrogen and methanol. Hydrogen (H_2) is stored in metal hydride canisters, and liquid methanol is stored in more or less ordinary containers or plastic cartridges for use in the direct methanol fuel cell (DMFC). Both fuel cell concepts are technically different, but the most important differences exist in the area of fuel logistics, cost and re-fuelling infrastructure.

Hydrogen fuel cells. This "traditional" type of fuel cell has been demonstrated as prototypes to power many applications from laptops up to buses. However, market traction is still lacking, although a H_2 fuel cell system is inherently very simple. It requires "only" a hydrogen storage means, a valve, a fuel cell, an air supply and some electronics. The fundamental disadvantage is the low storage density, and hence high cost, of commercially available hydrogen storage means. State-of-the-art H_2 storage canisters store hydrogen as metal hydrides, whereby hydrogen occupies certain lattice sites in exotic metal alloys. The best possible storage density – including the efficiency loss of the fuel cell system – is about 350 Wh/kg. This is only a marginal improvement over advanced batteries – not even taking into account the weight of the fuel cell itself. This means that the main customer benefit that fuel cells promise simply does not exist with hydrogen-based fuel cell systems. Additionally, there are massive problems concerning the cost of the metal hydride canisters, those of the apparatus used for refilling, and restrictions in the regulatory environment. Because of the low energy density, very large numbers (volumes) of storage canisters would be required, which means a huge investment into the required infrastructure. Such investment is problematic in light of highly questionable customer benefit.
Some people are trying to compare this situation with CO_2 gas bottles used in so-called "Soda Streamers", for which a working infrastructure has been established. However, such a comparison is highly misleading. The average "Soda Streamer" bottle lasts for about one month, whereas a hydrogen canister lasts only a few hours. CO_2 is not a hazardous material, whereas for hydrogen canisters very strict transportation regulations apply.
Conclusion: The setup of a cost-effective, appropriate infrastructure for hydrogen canisters is a major challenge for which most hurdles are unlikely to be overcome in the foreseeable future.

DMFC: This infrastructure problem is elegantly solved by the direct methanol fuel cell (DMFC). Its striking advantage is the use of a cheap liquid fuel that can very easily be handled, stored, and distributed, and which has an extremely high energy density. In several areas a working methanol infrastructure exists already down to the consumer level, e.g. windshield washer fluid. SFC Smart Fuel Cell AG has successfully established an initial world-wide infrastructure for the distribution of methanol cartridges. These are already certified by leading safety organizations and have reached clearance for transportation onboard aircraft. A cartridge containing about 140 Wh of electricity equivalent (about 100 g methanol) can be mass-produced for less than 1 EUR, so that sticker prices of about 2-3 EUR can be reached.
The only disadvantage of the DMFC vs. H_2 fuel cells is a higher system complexity. Besides a somewhat larger fuel cell, micro pumps and some controller functions are required. Miniaturization of these systems has shown dramatic progress in the last two years.

Which is the ideal fuel for portable fuel cells? The important disadvantages of hydrogen are of fundamental nature. They will not be overcome in the foreseeable future, even if R&D efforts were dramatically increased. Hydrogen storage is generally accepted to be already close to its theoretical limits. These limits render H_2

fuel cell technology not competitive with advanced batteries. Even in mass production, the costs of metal hydride canisters are prohibitively high for consumer products. As a result, H_2 fuel cells will not enter consumer markets in which runtime and cost are important criteria.

And the winner is … The challenges of marketing DMFC technology are relatively easily overcome by engineering and miniaturizing the DMFC system. Prototypes already presented, and commercial products already launched by SFC Smart Fuel Cell AG clearly prove that this technology is viable and competitive to batteries. The first working infrastructure for methanol cartridges shows that in this respect, which is essential for commercial success of fuel cell products, methanol is the clear winner of the game.

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