low temperatures while being itself thermally stable.

The Johnson Matthey fuel processor combines these three new catalytic systems and novel reactor designs into a single efficient unit and enables SPFCs to be used successfully for micro-cogeneration applications, see Figure 2.

Micro-cogeneration

Micro-cogeneration is the simultaneous generation of electric power and heat by a generating device at the site where both are required. All generators produce waste heat, so producing one small enough to be located in residential or light commercial environments, means that the byproduct heat can be immediately used, thus improving the overall efficiency. Many different types of conventional combustion-engine cogeneration systems exist, but few are practical or economical at such micro-scales. Fuel cell and fuel processor technologies are highly suitable technology for micro-cogeneration systems, being compact, quiet, efficient, responsive, inherently low-maintenance and non-polluting.

The development of novel fuel cell-fuel processing technologies is expected to increase the number of micro-scale distributed generation sites. Regions where price differences between electricity and natural gas, especially where electricity costs 4 times or more than gas, where natural gas, LPG and compressed natural gas (CNG) are more readily available and where there is a lack of an extensive electrical transmission and distribution infrastructure are likely beneficiaries.

Micro-scale fuel cell generation and cogeneration systems of output less than 50 kW are expected to be used for small units, for example, as backup power, uninterruptible power and high quality power, for sensitive sites such as computer data centres, hospitals and power generation in remote sites, while mass use is expected, for residential and light commercial use.

Conclusions

Fuel processing enables the potential of SPFCs to be realised. The Johnson Matthey fuel processor has been successfully tested with a number of fuel cells and supplied to developers of fuel cell systems for transportation and stationary applications. The fuel processor has been developed to a much smaller scale than previously thought possible, and can be used in a range of applications not previously accessible with conventional technology. These advances in micro-scale fuel processing technology are expected to encourage the development of further catalysts and catalyst systems to exploit the benefits of fuel cell technology. The system is now in the advanced development phase, with a commercial product planned in the near future.

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Cryo-Imaging of Palladium Colloids

A team of researchers from Lund University in Sweden have succeeded in imaging the aggregation behaviour of palladium nanoparticles in solution, at different values of pH and ionic strength, by low-electron dose cryo energy-filtered transmission electron microscopy (cryo-EFTEM) (J.-O. Bovin, T. Huber, O. Balmes, J.-O. Malm and G. Karlsson, *Chem. Eur. J.*, 2000, 6, (1), 129–132).

Palladium colloids, covered by sodium sulfanilate protective ligands, were rapidly cooled by plunge-freezing to avoid particle rearrangement. Elemental mappings were taken at low energy and short exposures to prevent damage. Shapes, sizes, structural defects and distances between the agglomerated colloids were visible. A two-window method (jump ratio imaging) identified the palladium colloids. The colloids were always present as a mixture of single nuclei and aggregates in solution. The number of single particles in solution could be increased by lowering the ionic strength and raising the pH, but some agglomerates of two (or more) nuclei still remained.

This technique may be used to determine the best deposition conditions for the palladium/ligand and other metal/ligand systems and to study the chemistry of solids interacting with liquids.