Tuesday, 22 September 2009 (Day 1)

10:00  Formal Opening followed by Presentation and Lecture for Grove Medal
11:00  Refreshments
11:30  Plenary Session 1 - Scene Setting
12:30  Lunch
16:15  Refreshments
16:45  Parallel Session 2A continued  Parallel Session 2B continued
17:45  End of Sessions Day One

Wednesday, 23 September 2009 (Day 2)

09:00  Parallel Session 3A - Road Vehicles  Parallel Session 3B - Transport Applications
10:45  Refreshments
11:15  Parallel Session 3A continued  Parallel Session 3B continued
12:45  Lunch
14:00  Plenary Poster Session
15:00  Refreshments
16:30  Parallel Session 4A - Transport Applications  Parallel Session 3B - Transport Applications
18:15  End of Sessions Day Two

Thursday, 24 September 2009 (Day 3)

09:00  Parallel Session 5A - The Voice of the Customer  Parallel Session 5B - Induction Systems
10:45  Refreshments
11:15  Parallel Session 5A continued  Parallel Session 5B continued
12:45  Lunch
14:00  Poster Prize Awards
14:20  Plenary Session 6 - Future Challenges and Innovations
15:45  Closing remarks
16:00  Close of Symposium
In this work an attempt to develop new technology, more cheap and efficient is taken. Industrial aluminium powders are reacting with water under high temperature (up to 400°C) and pressure (up to 160 atm) conditions. Power plant prototype has been developed, assembled and tested in RAS Joint Institute for High Temperatures. System under testing produces heat (20 kW), electricity (generated hydrogen is converted by 10 kW PEMFC), nanostructured aluminium hydride (18 kgph). Last-by-product can be recuperated back to Al powders or sold as raw material for catalyst, sorption and composite materials. AIOOH transferring back to aluminium powders makes them a sort of transitional energy carrier. Important advantages of aluminium powders as energy carrier is their transportation and storage safety comparing with hydrogen high-pressure cylinders – the most traditional way for hydrogen storage. The further work is concerned with hydrogen autonomous generator for 100 mm3/h (hydrogen). This system will be able to produce also heat and AIOOH. Hydrogen can be fed to power plant (fuel cells, gas turbine or catalytic boiler) or used for technological processes or for example hydrogen transport refueling.

Economical analysis of such system has been carried out. In case when price for kg of powder and kg of hydrogen are equal, power plant operation becomes profitable even considering AIOOH and initial powders transportation for distances up to 100 km.

Keywords: Aluminium, Hydrothermal, Trigeneration

AlumOHydrogen power sources
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Traditional methods of energy production are based on use of hydrocarbon fuels. The reserves of hydrocarbon fuels are limited. Their cost cannot be prognosticated reliably. Wide use of hydrocarbon fuels leads to significant emission of greenhouse gases and other hazardous pollutions. That is why it would be reasonable to widen resource base of energy production by means of clean fuels and energy carriers of inorganic origin.

The most famous candidate for the role of universal and clean energy carrier is hydrogen. On the other hand the concept of hydrogen energy possesses some serious drawbacks. The most essential among them are the following ones:
- Technical and economy problems of transportation and distribution of hydrogen;
- Low energy density of H₂ under ambient conditions;
- Explosion hazard of hydrogen – air mixture;
- High cost and low durability of H₂ – air fuel cell stacks.

To bypass the problems of hydrogen energy we consider aluminium as alternative to hydrogen. Al may be used directly – for production of electricity in electrochemical oxidation in air. Also, Al may be used for hydrogen production during process of its oxidation in water.

In this report we described a number of AlumOHydrogen power sources which were developed and tested in our Institute (Joint Institute for High Temperature, Russian Academy of Science):
- for portable application with power range 3 – 1500 W;
- for transport application with power range 1.5 – 11 kW;
- for stationary application with power 10 kW (e) and 40 kW (h).

Test results demonstrate viability and good prospects of proposed AlumOHydrogen energy technologies.

Keywords: Aluminium-Hydrogen, Transport, Portable, Stationary

Surface modification and performance of inexpensive Fe-based bipolar plates for PEMFC
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This study is to develop inexpensive and high-performance Fe-based metal bipolar plates for PEMFC systems. A new surface modification technique, reforming pack chromization at low temperature, was carried out on the Fe-based alloys (SS 440, SS 430, and SS 316 stainless steels) with malleable and superior mechanical properties to allow the design of mass production. A low temperature pack chromization (LTPC) combined with rolling processes was performed not only to generate a coating possessing excellent conductivity and corrosion resistance on the steels, but also to reduce the chromizing temperature and fabricating cost. The power efficiencies of rolled-chromized and simple chromized BPPs were compared with graphite BPP employed in PEMFC. Experimental results showed that the rolled-chromized BPPs had corrosion current (i corr) of 7.87×10⁻⁹ A/cm² and interfacial contact resistance (ICR) of 12 mΩ·cm². Moreover, the power density of the single cell assembled by rolled-chromized BPP is 0.45 W/cm², which is very close to that of graphite (0.47 W/cm²). In the tested conditions of this study, the ranking of coated stainless steels for power density, from large to small, is as follow: SS 420-rolling-LTFC, SS 432-LTFC, SS 436-rolling-LTFC, SS 436-LTFC, SS 430-rolling-LTFC, SS 430-LTFC.

Keywords: Fe-based alloys, Rolling, Bipolar plates (BPPs), Low temperature pack chromization (LTPC)

A study on the self-humidification of the anode side using the pulse injection effect in PEMFC
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This paper describes some experimental results performed on the basic purging characteristics, how to increase the purging period using the pulse effect, and self-humidification method using the pulse effect of the anodic dead end and modes in PEMFC. The outlet of the anode channel was equipped with a purga solenoid valve, which can operate on/off mode by voltage signal of the current loader. In the dead end mode fuel cell, the purga is essential for avoiding the flooding effect which can block the porous media, and then prevent the chemical reaction process. However, the un-reacted hydrogen can be discharged in purging process. Therefore, the number of times of purge should be investigated and decreased. In this study, it decreased when the current density decreases and operation pressure increased. Additionally, when the pulse effect such as various frequencies or amplitudes in the anode outlet was applied, the number of times of purge was alleviated up to one third. Finally, the pulse injection can be an auxiliary humidifier using the back diffusive water vapor in the anodic dead end mode, which is a novel concept of the humidification.

Keywords: Polymer electrolyte membrane fuel cell, anodic dead end, purga period, back diffusive water flux

Preparation of doped PBI-xerolite membranes for high temperature PEMFCs
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Inorganic-organic hybrid membranes are promising systems because they have special physicochemical properties arising from the synergic characteristics of the raw materials. However, incorporation of inorganic particles into polymer gels, as a consequence, higher stiffness in the polymer matrix and the appearance of interfacial voids. It has been verified that the most effective strategy to obtain an ideal interface is to maintain flexible membrane formation. For this reason, plasticizers, i.e., sorbitol, which are able to decrease the glass transition temperature of the membrane, increase the flexibility and reduce the voids at the interface during solvent evaporation are often used to prepare hybrid membranes.

The aim of this work is to prepare inorganic-organic hybrid membranes from three different microporous materials: sodium mordenite (MOR) and amora (BEA) zeolites and ETS-10 type thosilicates. The polymer solution is polyvinylidene fluoride (PVDF) in N,N-dimethylacetamide (DMAc) 5 w.t., and D-sorbitol is incorporated as plasticizer. The membrane preparation is based on the following steps: i) mixture of the components to obtain an homogeneous suspension; ii) casting and drying of the membrane and iii) phosphoric acid doping.

The influence of PBI/zeolite and zeolite/sorbitol ratio, type and particle size of the microporous inorganic fillers on the conduction properties of the as prepared hybrid membranes has been analyzed by a percolation theory of temperature and relative humidity. As an example, Figure 1 shows the variation in ionic conductivity with temperature of PBI/zeolite membranes with a 40 w.t% of inorganic loading at dry conditions. As can be seen, the addition of BEA particles (around 2 microns in size) does not affect the conductivity of the PBI membrane. On the other hand, the most significant improvement in conductivity is exhibited by MOR/PBI membranes, in accordance with its pronounced hydrophilic character (S/K value=0.5).
The kinetics of ORR was investigated by cyclic voltammetry and linear sweep voltammetry techniques, at the rotating ring-disk electrode. These results showed the existence of two $E_{1/2}$ regions, at low current densities with the slope of $-2.37 \text{RT/F}$ and at high current densities with the slope of $-2.30 \text{RT/F}$, usually referred for ORR of polypyrrole $\text{Pi}$ in acid solution, as well as for Pt nanoparticles. It was proposed that the main path in the ORR mechanism on PtNBTiO$_x$ catalysts was the direct four electron process with the transfer of the first electron as the rate-determining step. Cyclic voltammetry, expressed in terms of kinetic current density at 0.85 V vs RHE, per real surface area or per mass of loaded Pt, was found to be much higher (five times enhancement per mass of loaded Pt) in comparison with Pt/C nanocatalyst. The increase in catalytic activity for ORR on PtNBTiO$_x$ catalysts, in comparison with Pt/C catalyst, was explained by synergic effects due to the formation of the interface between the platinum and oxide materials and by a splitter due to the surface diffusion of oxygen reaction intermediates.

Keywords: oxygen reduction reaction, PtNBTiO$_x$ catalyst, nanoparticles, acid solution

P2.06
Study of hydrogen redox reactions on platinum nanoparticles in concentrated HBr solutions
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Polycrystallite platinum nanoparticles (2-3nm) are mainly used as catalysts in the field of PEM fuel cells. Platinum-group metals are known for their underpotential deposition (UPD) of hydrogen which associates with their activity in the hydrogen redox reactions (HCR and HRR). Catalyst poisoning by the above-listed impurities (such as halides, sulfides, and others) is a phenomenon affecting the activity of these nanoparticle catalysts and degrades fuel-cell performance.

The adsorption of bromides on platinum-group metals is a complex process, not well understood, which is affected by several factors, including the metal itself and its crystal facets, the concentrations of the bromide species, the pH and the temperature. Most publications focus on platinum at low bromide concentrations (generally in the mM range), whereas for practical applications such as fuel cells and electrolysers, adsorption at higher concentrations (5-7M) is most important. In this work, the adsorption of bromides and the hydrogen redox reactions were studied on platinum nanoparticles in concentrated HBr solutions with the use of cyclic voltammetry. The ECSA and the exchange-current density ($i_C$) were measured as a function of the number of HCR and HRR cycles between -0.1 and 0.1 V on the hydrogen scale. Up to 7,000 cycles were carried out. Degradation attributable to bromide poisoning was observed. When the concentration of HBr in the supporting electrolyte (0.5M H$_2$SO$_4$) was increased, the characteristic voltamogram of platinum charged: the height of the more negative HBr peak (weakly bonded) increased and the more positive peak (strongly bonded) became smaller. At high HBr concentrations the strongly-bonded HBr peak disappeared and the weakly-bonded peak increased in height and moved closer to zero volts. The H$_2$O oxidation/reduction peaks became smaller as the HBr concentration was increased until they vanished at high HBr concentrations. The charge measured under the Pb oxidation peak at 3M HBr solution is greater than that measured in sulfuric acid solution. This indicates another reaction taking place on the electrode surface, apparently adsorption/desorption of bromides.

Keywords: Hydrogen redox, Platinum, catalysis, HBr

P2.07
Experimental study of the various effects on the performance of PEM fuel cell operated at elevated temperature
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In order to reduce the effect of CO poisoning, simplify the heat rejection and have more useful waste heat, operating PEM fuel cell at elevated temperature is believed to be a promising approach. Therefore, a PEMFC with a polymer membrane is tested at elevated temperature (100°C-120°C) in the present study to observe the effects of both different relative humidity and different back pressure of the reactant gases on the fuel cell performance.

The facility used for the E-I measurement of the present fuel cell is shown in Fig. 1. The current collectors of the single cell are made of gold-plated copper plates. Graphite plates with the fuel flow channel are used as gas flow field plates for both anode and cathode. The MEA of the present fuel cell is obtained by hot pressing of two gas diffusion electrodes (E-Tek, LT120EGW) with catalyst loading of 0.5 mg Pt/cm$^2$ and a polymer membrane (NRE 212) at 130°C under pressure of 100 atm for 80 sec. The effective area of three electrodes is 25 cm$^2$. Finally, the cell was tightened with bolts and nuts clamped to 70 kg/cm$^2$ of torque for subsequent experimental tests. Besides E-I curve measurement, the electrochemical impedance is also measured.