Hydrocarbon processors for hydrogen production using micro and nanotechnology

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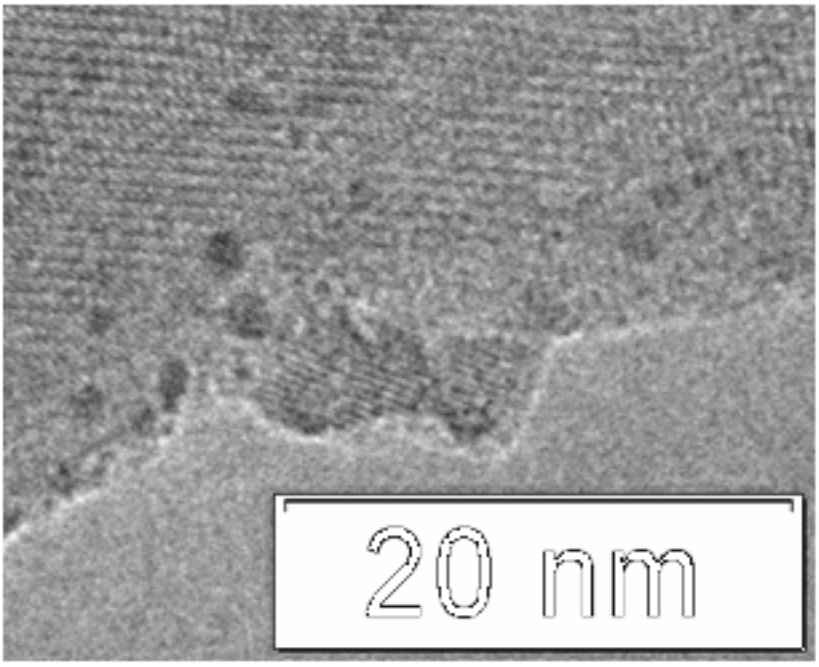
Application of the fuel cells, which use the hydrogen as a fuel and realize electrochemical generation of electrical power, will change the design of electrical generators and their technical qualities. Especially it concerns with the local electrical generation where fuel cells application need to compact hydrogen production systems with different purity degree. The hydrocarbon conversion to hydrogen is complex multistage process and traditional chemical reactors can not be applied due to their size and complexity in a management. The fundamental solutuon of the problem of compact hydrogen generators is application of microchannel hydrocarbon processors based on the nanocatalyst of new generation, which combined heat and product species flows to obtain the high total efficiency.

Microchannel processor is the assemblage of compact microchemical reactors with channels of micron size, which define their total efficiency. Nanotechnology allows create the catalyst with optimal structural and dimensional characteristics for these reactors for increasing the activity, selectivity and productivity. Nanodesign of the catalyst, which covers the walls of the microchannels, make possibility the reduction of total activation barrier and management of the selectivity by reduction of the individual reactions barriers.



Nanoparticles with the size less then 10 nm is characterized by increased surface energy, coordinating unsaturation and high absorption capacity, which is conditioned on commensurable particle size and the radius of intermolecular force action as far as the presence of unrequited chemical bonds in surface atoms. When the size of the particles decreases the number of surface defects increases, which are active sites of the reactions. The procedure of manylayer nanostructure production is developed

which contains the nanoparticles of precious metals with large reaction interface and high surface diffusion of the reactants. Based on synthesis of multinuclei coordinating compound and its following thermo destruction up to high dispersed nanosized oxides, and mechanochemical methods the manycomponent nanocatalysts were obtained, which are characterized by high homogeneity of the phase composition. The catalyst has uniform fraction of the nanoparticles of precious metals with average size of 1 nm and optimal oxygen mobility in the lattice of carrier. It allows avoid fast carbonization of the catalyst surface due to hydrocarbon decomposition and exclude high oxidation rate of the hydrocarbon fragments with formation of a water and carbon dioxide.

Synthesized catalysts were applied for production of hydrogen contained gas at methane partial oxidation, methane and methanol steam reforming, autothermal methane reforming, catalytic methane combustion and showed high efficiency. The temperature range was defined where methane reforming characterized by high hydrogen and carbon monoxide selectivity, the kinetic of elementary reaction was studied for synthesized catalysts. The main regularity of hydrocarbon chemical conversion in microchannel systems when the reactions are activated in nanocatalyst were obtained as far as data on the kinetics of manystage reactions in conditions of essential un-homogeneity of temperature and concentration fields /1, 2/. It allows define the operation conditions of the elements of fuel processor with high hydrogen production when the temperature and concentration fields are controlled. For designed conditions the residence time is less then 10 ms, it allows to obtain the considerable mole flux even for length of microchannels in some centimeters.

Developed manylayers nanostructures showed their high efficiency for hydrogen production, they were used for design of the hydrocarbon processors of block architecture for feeding of low temperature fuel cell. The scheme of the processor for reforming of liquid fuel includes the microchannel evaporators for water and fuel, reactor for hydrocarbons reforming, reactor for carbon monoxide purification and reactor for final hydrogen cleaning. After then the pure hydrogen comes to fuel cell. Using the channel architecture allows to co-ordinate the exothermic and endothermic reactions in the elements of the processor to increase its total energy efficiency. Proposal design of methane processor permits to obtain the hydrogen content in dry product gas up to 73 percentages for one stage process, and up to 87 percentages with carbon monoxide content less then 1 percentage when the shift microreactor is used. For feeding of high temperature fuel cell the one stage processors for methane partial oxidation and autothermal methane reforming are designed. To increase energy efficiency the processor is combined with fuel cell. Anode gas, which contains the residual hydrogen, finish combust in the evaporator to produce heat needs to fuel and water evaporation, and cathode gas direct to condenser to separate water and use it in processor cycle. For designed prototype of hydrocarbon processors the specific productivity was defined, it is not less then for best foreign samples. It clears the way for manufacturing of energy efficient hydrocarbon processors based on micro and nanotechnology for prospective systems of electrical energy production.

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Literature

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