دانشگاه تربیت دبیر شهید رجائی

More efficient

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10th Iranian Fuel Cell Seminar

February 20, 2019

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Collection Of Abstracts

دهمین سمینار پیل سوختی ایران

۱ اسفند ماه ۱۳۹۷

دانشگاه تربیت دبیر شهید رجائی - دانشکده علوم پایه

مرکز مطالعات اطلاع رسانی علوم و فناوری

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مکان دبیرخانه: دانشگاه تربیت مدرس، دانشکده علوم پایه، طبقه سوم، دفتر انجمن الکتروشیمی ۸۲۸۸۴۷۱۳-۰۲۱


بسم الله الرحمن الرحيم

Collection of Abstract Papers

10th Iranian Fuel Cell Seminar

Faculty of Science
Shahid Rajaee Teacher Training University

Tehran, Iran
February 20, 2019

10th Iranian Fuel Cell Seminar

Held in Shahid Rajaee Teacher Training University, Tehran, Islamic Republic of Iran, 20 February, 2019

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Abstract papers proceedings of 10th Iranian Fuel Cell Seminar, 20 February 2019, Electrochemical Society of Iran.

Organizers:

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FUEL CELL RESEARCH LABORATORY
دانشگاه تربیت دبیر شهید رجایی
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Welcome to 10th Iranian fuel cell seminar

Dear colleague,

On behalf of all members of scientific and organizing committees, it is my great honor to welcome you to the 10th Iranian fuel cell seminar. This seminar is hosted by the Electrochemical Society of Iran and Shahid Rajaee Teacher Training University, 20 February 2019. The aim of this seminar is to get together and present the latest scientific findings and to share information in the field of fuel cell systems for professionals within academia, research and industry.

Fuel cells are promising sustainable energy for human beings in this century. Much research is in progress in the world to increase performance and reduce the price of these systems. By providing the good conditions in cost and performance of the fuel cell systems, it can be hoped that in the near future to begin commercial operation of such systems.

In the 10th fuel cell seminar, the invited speakers present their own experiences in this technology and participants present their own articles in the form of poster and oral presentations. The value of the accepted papers in the form of oral and poster is the same.

This seminar would not be possible without your participation and support. We would like to thank you for your participation and also all those involved in the organization of this seminar as well as the efforts of the members of the Scientific and the Executive Committee especially the Head of Scientific Committee of the Seminar Dr. Masoumeh Ghalkhani.

Dr Rasol Abdullah Mirzaie

Seminar Chairman

10th Iranian Fuel Cell Seminar

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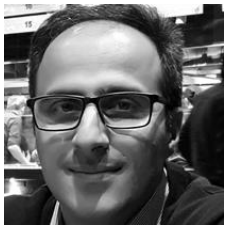
Key Speakers:

	Dr. Kazem Mohammad zadeh	Tarbiat Modares University	Volume of Fluid (VOF) Modeling of Water Management in the Anode Channel of Proton Exchange Membrane Fuel Cell
	Dr. Ali Ghaffarinejad	Iran University of Science & Technology	Application of Multi-metallic Compounds in Fuel Cells
	Dr. Seyed Majid Rahgoshay	Babol University	آخرین پیشرفت‌ها در حوزه آزمون‌های سری پیل سوختی پلیمری
	Dr. Daryosh Semnani	Isfahan University of Technology	A review on all-solid-state polymer electrolytes applicable in lithium ion batteries

Key Speakers:

	Dr. Soheila Javadian	Tarbiat Modares University	Binders as an important component of energy-storage devices
	Dr. Mahdi Kheradmand	Yasouj University	Electronic structure of metallic Hydrogen chain: Is metallic Hydrogen- Air new fuel cell type?
	Dr. Morteza Mousavi khoshdel	Iran University of Science & Technology	مطالعه واکنشهای اکسایش و احیا در سطح الکترود به روش محاسباتی DFT با نگاهی به واکنش های الکترو کاتالیستی تولید هیدروژن

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Volume of Fluid (VOF) Modeling of Water Management in the Anode Channel of Proton Exchange Membrane Fuel Cell

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Abstract: The water management plays an essential role in the anode gas flow channel of Proton Exchange Membrane (PEM) fuel cells that ensures a high performance and long life-time of the fuel cell. Water flooding in the anode channel results in a local lack of fuel and consequently, occurrence of carbon corrosion in the cathode catalyst layer. In addition, the very low flow rate of the Hydrogen gas will not be adequate to remove the accumulated liquid water from the channel. Also, the process of separating the liquid water from the residual fuel exiting the PEM fuel cell is a difficult task. Numerical modeling as a powerful tool eliminates the difficulties associated with conducting the experiments, and visualizing and measuring sophisticated processes and parameters which occurs in PEM fuel cell. In addition, Numerical modeling allows researchers to observe and describe detailed processes, which could be missed in PEM fuel cell experiments due to small scales (both time and dimension). In this presentation, a hybrid numerical model is introduced for water management in the anode channel of a PEM fuel cell. In this model, a home made PEM fuel cell computer code has been coupled with a VOF code for capturing the water and gas interface by calculating the amount of water generated by condensation on the anode gas channel. The mechanism of water condensation on the walls of the anode channel is numerically simulated using a 2D along-the-channel model. Based on the distribution of the saturated liquid water under various working conditions, the amount of produced water is evaluated. Subsequently, a relationship for the volume of the produced water is proposed as a function of current density, working temperature of the fuel cell, Hydrogen stoichiometry ratio, and relative humidity. Finally, the droplet deformation over removal time, the instantaneous and time-averaged values of pressure drop and water coverage ratio (WCR) in the anode gas channel are calculated using this model.

Application of Multi-metallic Compounds in Fuel Cells

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Abstract: Direct alcohol fuel cells are one of the interesting novel power sources has been extensively studied for stationary and portable miniature electric devices due to their high efficiency and low emissions of pollutants [1]. However, there are some challenges to developing this type of fuel cells. For example, introducing new economic and efficient catalysts [2] or reducing the poisoning and inactivation of the catalyst by impurities or products of alcohol oxidation on the anode electrode [3]. Pt and Pd are two common commercial catalysts in alcohol fuel cells. These noble metals are expensive and to reduce the loading amount and enhance the catalytic effect of them, researchers put efforts on the investigation of their bimetallic and/or trimetallic compositions. Studies show when we use these compositions, a synergic effect (according to volcano plots and d-band centre theory) could be observed and also may the poisoning of the catalyst layer be reduced. In this presentation, we focus on our recent studies on Ag-Pd bimetallic catalyst for methanol and ethanol oxidation.

Keywords: Palladium; Silver; Bimetallic; Alcohol fuel cell

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آخرین پیشرفت‌ها در حوزه آزمون‌های سری پیل سوختی پلیمری

سید مجید رهگشا

دانشگاه بابل

چکیده: امروزه پیل سوختی بعنوان یکی از مولدهای انرژی پاک در دنیا شناخته شده است. با توجه به شرایط آب و هوایی جهان، کمیته فنی اتحادیه اروپا در سال ۲۰۱۷ گزارش داده که ۱۸٪ انرژی اولیه دنیا باید تا سی سال آتی، توسط هیدروژن تامین گردد. گام‌های بسیاری در راستای تولید، استانداردسازی و تجاری‌سازی پیل‌سوختی انجام شده است. یکی از مهم ترین قسمت‌ها در این فرآیند، تست و ارزیابی آن پس از تولید می‌باشد. این گزارش مجموعه‌ای از مطالب در مورد آزمون های سری پیل‌سوختی که با سایر پژوهشکده‌های دنیا هم آهنگ شده، بصورت عمومی ارائه خواهد داد. ابتدا خلاصه‌ای از دستگاه تست و تعریف کارایی سل یا استک پیل سوختی (منحنی قطبیت) ارائه می‌شود. سپس به تعریف تست پیل‌سوختی پرداخته شده و شرایط کاری مانند فعالسازی، روشن کردن، خاموش کردن و توان نامی ارائه می‌گردد. تمرکز این گزارش بر شرایط عملیاتی استک پیل‌سوختی می باشد. آزمون‌ها سری یل‌سوختی در سه بخش کارایی، ایمنی و ماندگاری دسته‌بندی می‌شوند. با استفاده از گزارش‌های بین‌المللی و استانداردهای موجود در زمینه تست استک پیل‌سوختی پلیمری، آزمون های مورد نیاز برای ارزیابی پیل توصیف می‌شوند که شامل ۱۱ عنوان ماژول تست در بخش کارایی، ۸ عنوان در بخش ایمنی و ۴ عنوان در بخش ماندگاری می‌باشد.

A review on all-solid-state polymer electrolytes applicable in lithium ion batteries

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Abstract: In recent years, solid polymer electrolytes (SPEs) have received great attention due to wide variety of applications such as energy storage devices. Despite, favorable characteristics of SPEs, poor ionic conductivity has suppressed their applications. SPEs are basically consisted of a polymer host and a lithium salt. SPEs are commonly synthesized through film casting method. Polyethylene oxide (PEO) has been widely applied as a polymer host due to the ability to solve various salts and additives. So far, numerous attempts have been made to enhance the ionic conductivity of SPEs. Addition of various fillers and plasticizers, modification of the polymer structure, the increase of salt concentration and many more are of the common methods for the improvement of the ion conductivity. The previous researches have focused on the preparation of SPEs using the film casting method. So far, there has been little discussion regarding the electrospinning technique for the fabrication of SPEs. Compared with SPEs, nanofibrous electrolytes have shown greater ion conductivity due to their highly porous structures. In general, electrospinning can be considered as a high efficient, quick and easy method for the production of all-solid-state nanofibrous electrolytes which are applicable in lithium ion batteries.

Keywords: Lithium ion battery; Electrospun electrolyte; Polymer matrix; Ion conductivity

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Binders as an important component of energy-storage devices

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Abstract: Developing high-performance battery systems requires the optimization of every battery component, from electrodes and electrolyte to binder systems. Binders, as an important component of energy-storage devices, need to pay attention. Polyvinylidene fluoride (PVDF) has been the dominant binder in the battery industry for decades despite several well-recognized drawbacks, i.e., limited binding strength due to the lack of chemical bonds with electroactive materials, insufficient mechanical properties, and low electronic and lithium-ion conductivities. In this lecture, we present recent progress on material and structural design of binder systems. Nonconductive polymers with rich carboxylic groups have been used as binders to stabilize ultrahigh-capacity inorganic electrodes that experience large volume or structural change during charge/discharge, due to their strong binding capability to active particles. To improve the energy density of batteries, different strategies have been adopted to design multifunctional binder systems based on conductive polymers because they can play binary functions of both polymeric binders and conductive additives. Also, the development of multifunctional binders by hybridizing conductive polymers with other functional materials will be introduced.

Electronic structure of metallic Hydrogen chain: Is metallic Hydrogen- Air new fuel cell type?

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Abstract: One of the three problems of physics in the 21st century is metallic Hydrogen [1]. As we know, the hydrogen molecule H_2 is insulated and does not exhibit metal properties. In order to achieve the properties of metallic hydrogen, we must have hydrogen under high pressure and low temperature or high temperature and ambient pressure and overcome the following limitation of the strong molecular hydrogen bonding energy (4.477 eV) and Proton repulsion energy [4]. Electrical conductivity is one of the important properties to distinguish a metal but until now the electrical conductivity of solid metallic hydrogen retains an aura of ambiguity. In this work, by choosing a chain of 50 hydrogen atoms, we change the length of the chains between 25 and 60 Å and ambient temperature by utilizing the Gaussian 03 suite of programs. We calculated 66.2, 124.17, 243.96, 489.36, 1025.64, 2274.54, 4794.88 and 12323.72 GPa for their pressure that include a wide range of phases. Then we examined the effect of pressure on thermodynamic properties, Homo-Lumo gap and density of states(DOS). We showed that with increasing pressure in the chains, the hydrogen chain properties vary from diatomic to mono-atomic and the tendency to metallization is represented by using the electrical conductivity of the system by investigating the DOS.

Keywords: Metallic hydrogen; Density of states; Electrical conductivity.

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Palladium based anode nano-catalyst for isopropyl alcohol electrooxidation in DAFC

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Abstract: In the present study, electrooxidation of isopropyl alcohol was investigated on Pd based electrocatalyst by using different electrochemical techniques such as: Cyclic voltammetry (CV) and Chronoamperometry (CA). Scanning electron microscopy (SEM) and X-ray diffraction (XRD) were also employed to physicochemical survey of the electrocatalyst. The kinetic parameters of alcohol oxidation, i.e. Tafel slope and activation energy (E_a), were determined on the catalyst. This study upholds the fact that isopropyl alcohol is a promising fuel candidate for a direct alkaline alcohol fuel cell.

Keywords: Isopropyl alcohol, alkaline fuel cell, palladium, electrooxidation

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Electrocatalytic activity of Pd-Pt and Pd-Au alloy nanocatalysts for EG oxidation in alkaline medium

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Abstract: In the present study, Pd-Pt and Pd-Au alloy nanocatalysts were synthesized by using electrochemical reduction method and used for EG electrooxidation by using different electrochemical techniques such as: Cyclic voltammetry (CV), chronopotentiometry (CP) and chronoamperometry (CA). The results were compared with those obtained on Pd nanocatalyst. Scanning electron microscopy (SEM) and X-ray diffraction (XRD) were also employed to physicochemical survey of the electrocatalysts. This study showed that Pd based alloy catalysts compared with Pd catalyst have higher catalytic activity for EG electrooxidation.

Keywords: Ethylene Glycol, alkaline fuel cell, palladium, platinum, gold, electrooxidation

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Synthesis and Characterization of Fe doped $Li(Li_{0.21}Mn_{0.54}Ni_{0.125}Co_{0.125})O_2$ as the cathode materials For Battery Applications

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Abstract: In this paper, the nanoparticles of $Li(Li_{0.21}Mn_{0.54}Ni_{0.125}Co_{0.125-x})Fe_xO_2$ (x=0%, 0.01%, 0.025% 0.05%) were prepared by sol-gel method, and the structural and chemical properties of the samples were investigated .These properties of samples characterized by X-ray diffraction (XRD), field-scattering microscopy (FESEM), X-ray energy spectroscopy (EDS), thermogravimetric analysis (TGA), differential thermal analysis (DTA), infrared spectroscopy (FTIR), and the results of characterization were investigation and reveled crystalline structures for pure and impure nanoparticles. The reflection peaks indicate that the samples have standard α-$NaFeO_2$ layered structure with the space group R3m, except for the super lattice ordering between 22°-25°. The FESEM images for pure and impure samples have shown that these nanoparticles have Hexagonal structures. The particle size of nanopowders in the range of 50-80 nm the chemical analysis of EDS has proven the presence of Ni, Mn, Co and Fe in the samples. TG /DTA measurements showed weight loss in nanopowders of pure and impure. In infrared spectroscopy (FTIR), the connection bonds and chemical elements used in these nanopowders have been investigated.

Keywords: lithium-ion battery, $Li[Li_{0.21}Mn_{0.54}Ni_{0.125}Co_{0.125-x}]Fe_xO_2$, cathode, sol gel, impurity, nanopowders.

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Properties Assessment of Synthesized Sulfonated Poly (ether sulfones) Containing Coupling Agent as Proton Exchange Membranes for Fuel Cell Application

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Abstract: With respect to that in fuel cell field, researchers have focused on performance improvement and also membrane as electrolyte is one of the key components which determines fuel cell efficiency, in this study we synthesized random sulfonated copoly (ether sulfones) based on sulfonated and non- sulfonated bisfluorophenyl sulfone (BFPS), bishydroxyphenyl sulfone (bisphenol S) and decafluorobiphenyl (DFBP) as coupling agent (sulfonation degree (DS)= 35%, 45%, 55%) via nucleophilic aromatic substitution polycondensation reaction to obtain polymers with higher properties and performance. FTIR and H NMR characterizations confirmed the successful synthesis of sulfonated monomer and copolymers. TGA and DSC results showed excellent thermal properties of membranes. Mechanical properties of membranes were in accordance with molecular weight estimation from dilute solution viscometry. Ion exchange capacity (IEC), water uptake and oxidative stability measurement resulted in IEC in the range of 1.04-1.54 meq/g, (8.8-28.8)% water uptake and reasonable long life in Fenton test.

Keywords: Fuel Cell; PEM; Synthesis; Coupling agent.

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Structural and chemical properties of the layered $Li(Li_{0.21}Mn_{0.54}Ni_{0.125}Co_{0.125-x})Fe_xO_2$ as the candidate Material for Lithium Battery

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Abstract: The nanopowders of $Li(Li_{0.21}Mn_{0.54}Ni_{0.125}Co_{0.125-x})Fe_xO_2$ (x=0% , 0.01% , 0.05%, 0.075 and 0.10%) (Fe doped-LMNC) were prepared by sol-gel method. The thermal, structural and chemical properties of the samples were investigated by thermogravimetric analysis (TGA), differential thermal analysis (DTA), X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), X-ray energy spectroscopy (EDS), and infrared spectroscopy (FTIR).The TG /DTA measurements showed weight loss in nanopowders of pure and doped samples. The XRD results reveled crystalline structures for pure and Fe powder nanoparticles.doped-LMNC, It was found that the layerd structure of the Fe doped-LNNC materials were not changed up to % 0.05 Fe but for the higher Fe doping concentration the additional peak, which are related to the formation of the secondary phase of $LiMn_2O_4$, have been observed in the structure.The FESEM images for pure and doped samples have shown to be agglomerated with relatively spherical particles size of smaller than 50 nm. Image tools software was used for illustrating the distribution of particle size of nanopowders.The connection bonds and used chemical elements in these nanopowders have been investigated by The Infrared spectroscopy (FTIR),

Key words: nanoparticles, lithium-ion battery, cathode, sol gel, doping.

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Experimental Study of Water management in H_2/O_2 PEMFC Stack with Specific Design

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Abstract: PEM fuel cells have the ability to be operated with open-end and dead-end modes. At the open-end mode the extra reactants are essential for obtaining the specified current density. The extra reactants remove accumulated water in anode and cathode channel to prevent flooding. This issue at the dead-end mode that impurities remove from channels at the specified period of times is very important. Therefore, a deep understanding of the processes of accumulation of water in the channel and water transport at the time of discharge and setting of discharge time for removing the water and impurities without leaving a considerable amount of reactive gas to outlet environment is inevitable. There are different methods for investigation of water management such as: neutron radiography, gas chromatography, capturing use of X-ray and capturing use of inferred ray. Due to high cost and many hazards these methods at most cases cannot be used. In this papera transparent PEMFC stack as a simplest, cheapest and the most suitable method for investigation of water management is recommend. Designing and manufacturing this type of PEMFC stack require special techniques. In this paper, the design steps are explained with details.The performance of PEMFC stack at open-end

and dead-end mode is compared. The results have shown that for steady-state operation, the maximum time possible for closing the output valves is 5 seconds and the minimum time required to open it is 5 seconds.

Keywords: PEMFC stack; Water formation; Purge duration; Dead-end mode.

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Potential Electrocatalysts for Fuel Cells

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Abstract: Electrooxidation of several fuel compounds was studied using metallic nanoparticles such as Au, Pd, Pt, AuPd and AuPt synthesized by electrodeposition. Scanning electron microscope (SEM) images and X-ray diffraction (XRD) data showed that monometallic (Au, Pd and Pt) and alloys of bimetallic nanoparticles of AuPd and AuPt were formed. The catalytic performance of the prepared electrodes was investigated in acidic, alkaline and neutral media (100 mM phosphate buffer, pH 7) by cyclic voltammetry and the results were compared. The performance of the electrocatalysts towards electrooxidation of most common fuels that use in fuel cell were studied.

Keywords: Nanostructure; Electrodeposition; Fuel cell; Electrooxidation; Acidic medium.

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Studies of Polyaniline Thin Layer Presence in Electrocatalytic Properties Pt-Sn/GC Electrode Modified by MWCNT for Methanol Oxidation

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Abstract: Electrocatalytic activities Pt and Pt_Sn nanoparticles supported on Multiwall carbon nanotubes and Vulcan carbon were examined for methanol oxidation reaction. The Pt/C, Pt_Sn/C, Pt/MWCNT, Pt_Sn/MWCNT catalysts were synthesized using a deposition_ reduction technique with sodium borohydride. The electrocatalysts were characterized by EDS, XRD, FESEM and cyclic voltammetry. The Pt_Sn/MWCNT electrocatalyst with an atomic ratio Pt/Sn (3:1) in MOR exhibited a higher forward peak current density and a lower peak potential during cyclic voltammetry compared to other electrocatalysts. Then the effect of glassy carbon electrode (GC) surface modification by a thin layer of polyaniline was investigated. The results showed that in present a thin layer of polyaniline and platinum-tin electrocatalytic particles supported on multiwall carbon nanotube (GC/polyaniline/Pt-Sn/CNT) the oxidation of methanol in aqueous acid media is considerably enhanced.

Keywords: Electrocatalyst; Platinum; Polymer; Tin; Methanol Oxidation

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Investigation of parameters affective on MFC operation

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Abstract: Bioenergy is a renewable energy that plays an indispensable role in meeting today's ever-increasing energy needs. Unlike biofuels, microbial fuel cells (MFCs) convert energy harvested from redox reactions directly in to bioelectricity. MFCs can utilize low-grade organic carbons (fuels) in waste streams. In recent years, MFCs have also been used in the electrolysis mode to produce bioproducts in laboratory tests. Micro-organisms actively catabolize substrate, and bioelectricities are generated. MFCs could be utilized as power generator in small devices such as biosensor. Besides the advantages of this technology, it still faces practical barriers such as low power and current density. In the present article different parts of MFC such as anode, cathode and membrane have been reviewed and to overcome the practical challenges in this field some practical options have been suggested MFCs research has intensified in the past decade and the maximum MFCs power density output has been increased greatly and many types of waste streams have been tested. However, new breakthroughs are needed for MFCs to be practical in wastewater treatment and power generation beyond powering small sensor devices. To reduce capital and operational costs, simple and robust membrane less MFCs reactors are desired. This review is an update on the recent advances on MFCs designs and operations.

Keywords: Microbial fuel cell; Biosensor; Biocatalyst; Anaerobic anode; Bioelectricity

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Optimization of the contact pressure distribution in PEM fuel cells

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Abstract: A finite element model is developed to investigate the influence of the assembly pressure of proton exchange membrane fuel cell (PEMFC) single cell components especially the membrane electrode assembly (MEA). A new design end plate consists of two separate plates like a cylinder and a piston and the applied pressure exerted pneumatically to the fuel cell assembly. This end plate distributed the contact pressure more uniform than the conventional bolts and nuts clamping mechanism and causes to reduce the stress concentration. The contact pressure distribution over the MEA for some different pneumatic chamber size is investigated and optimized using finite element method. The results are compared with the contact pressure distribution achieved by simple steel end plate. It is obvious that the pneumatic clamping mechanism acts better that those of simple conventional bolts and nuts clamping mechanism.

Keywords: PEM fuel cell; Finite element method; Contact pressure; Clamping Mechanism.

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New designing of microbial fuel cell stack by approach to green energy production and wastewater treatment

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Astract: Microbial fuel cells (MFCs) are bioelectrochemical systems which can degrade organic materials and are increasingly seen as potential contributors to low carbon technologies, particularly in energy recovery from and treatment of wastewater. In the last years, noticeable growths in MFC technology have been seen, although, significant challenges still exist before the MFC can be ready to commercialization. Towards MFC commercialization different scale-up studies were performed and these studies indicate that scaling-up MFCs is possible, but it is important to improve power output with new designs that can be used in large scale applications. The present work deals with the design stacked microbial fuel cell (MFC) to generate electricity from wastewater.

Keywords: MFC Stack, Renewable Source, Design, Membrane

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Investigation of oxidation activation energy of Ni-Co-CeO_2 composite coating on Crofer 22 APU steel used in SOFCs

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Abstract: The oxidation resistance of interconnect plates used in solid oxide fuel cells (SOFCs) can be improved by using a protective/conductive coating layer. In this study, a Ni-Co-CeO_2 composite coating was deposited on Crofer 22 APU steel substrate through the electroless method. Inorder to evaluate the oxidation resistance and measuring the oxidation activation energy, coated and bare samples were exposed at 700, 800, 900 and 1000°C temperatures for 50 hours. The results showed that Ni-Co-CeO_2 composite coating improved the oxidation resistance of Crofer 22 APU steel. Also, the results showed that Ni-Co-CeO_2 composite coating during oxidation, reduced the oxidation activation energy of coated samples (75 KJ mol^{-1}) compared to bare samples (126 KJ mol^{-1}).

Keywords: Activation energy, Solid oxide fuel cell, Ni-Co-CeO_2 composite coating, Oxidation

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Study of parabolic rate constant of Mn-Co-CeO_2 coated AISI 430 steel for SOFC interconnect application

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Abstract: Oxidation resistance of solid oxide fuel cells interconnects can be ameliorated by use of a protective, effective, relatively dense and well adherent spinel coating. In this study the electrodeposition method was employed to coat AISI 430 ferritic stainless steel. Isothermal oxidation and cyclic oxidation were applied to evaluate the parabolic rate constant (k_p). The formation of Mn-Co oxides during oxidation improved oxidation resistance. The Mn-Co-CeO_2 coated samples demonstrated lower k_p in each test and it indicate that the coating layer has acted as a mass barrier against the outward diffusion of cations specially Cr.

Keywords: Solid oxide fuel cell; AISI 430 ferritic stainless steel; Mn-Co-CeO_2; parabolic rate constant

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Study of Cr_2O_3 oxide layer thickness of AISI 430 steel with a Mn-Co-CeO_2 composite coating for SOFC interconnect applications

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Abstract: Most current research has concentrated on solid oxide fuel cells (SOFCs) to resolve the contact resistance and cathode-chromium-poisoning problems associated with application of ferritic stainless steels as interconnects. In this study AISI 430 ferritic stainless steel was coated through electrodeposition method. Isothermal oxidation and cyclic oxidation were applied to evaluate the oxide layer thickness which was created during these tests. Results showed Mn-Co-CeO_2 composite coating improved oxidation resistance. The increase of oxidation time and cycle number enhanced the oxide thickness. Also the Mn-Co-CeO_2 coated substrate oxide thickness (0.83 µm) was lower compared with uncoated ones (3.57 µm) during isothermal oxidation test.

Keywords: Solid oxide fuel cell; AISI 430 steel; Mn-Co-CeO_2 coating; Cr_2O_3 thickness

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Preparation and evaluation of sulfonated polysulfone membrane for proton exchange membrane fuel cells

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Abstract: Polysulfone is known as one of the most suitable polymers to use instead of commercial fluorinated membranes in proton exchange membrane fuel cells (PEMFCs). In this paper, a sulfonated polysulfone (SPSU) membrane was prepared and its physicochemical properties were investigated. To achieve this goal, at first, the polymer was sulfonated with chlorosulfonic acid in the presence of nitrogen at 50°C. The degree of sulfonation was obtained by H-NMR analysis. Sulfonated polysulfone membrane was prepared by a solution casting method using NMP as a solvent. Different properties of the prepared membrane were investigated by ion exchange capacity (IEC), water uptake (WU), and swelling ratio, and proton conductivity. The obtained results showed the prepared SPSU had appropriate properties to use as proton exchange membrane for fuel cell applications.

Keywords: Proton exchange membrane, Polysulfone, Sulfonation degree, Water uptake.

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Application of Ni-doped Zn-based metal organic framework as an electrode material for supercapacitors

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Abstract: Metal-organic frameworks (MOFs) have attracted intense attention due to their various application in the energy storage and conversion field. Herein, Ni-doped TMU-22 was synthesized through sonochemical method as an electrode material for supercapacitor. The supercapacitive behavior of synthesized material was evaluated using cyclic voltammetry (CV) and galvanostatic charge/discharge measurements in 0.5M K_2SO_4 as electrolyte. The Ni-doped TMU-22 exhibited outstanding specific capacitance of 25.28 $F.g^{-1}$ at a discharge current density of 1 $A.g^{-1}$. The specific capacitance retention is about 80.22 % after 300 cycles. We expected that this work would open up a new door for MOF applications in the supercapacitors electrode material.

Keywords: Ni-doped TMU-22; supercapacitor; metal-organic frameworks; MOFs

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The effect of polymer concentration on ion conductivity of the all-solid-state nanofibrous electrolytes applicable in lithium ion batteries

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Abstract: In recent decades, solid polymer electrolytes (SPEs) have appeared as a safe alternative for liquid electrolytes of lithium ion batteries (LIBs) which provides fabrication of all-solid-state and flexible LIBs. SPEs are basically consisted of a host polymer and a lithium salt which are commonly prepared through a film casting technique. Herein, fabrication of all-solid-state nanofibrous electrolytes by using an electrospinning process was reported. Polyethylene oxide (PEO) and Lithium perchlorate ($LiClO_4$) were applied as polymer matrix and lithium salt, respectively. The effect of PEO concentration (7 %, 8/5 % and 10 % wt.) on morphology and ion conductivity of the electrospun electrolytes was evaluated. SEM images showed increase of average diameter of the nanofibers with the increment of polymer concentration. This can be assigned to the improvement of solution viscosity and so more entanglement between the polymer chains which lead to the formation of thicker electrospun fibers. FTIR spectra confirmed the complexation between the PEO and $LiClO_4$. The Nyquist plot revealed decrease of impedance with the reduction of PEO concentration. The highest conductivity of 0/0167 $mS.cm^{-1}$ was obtained for the electrospun electrolyte containing 7 % wt. PEO. This could be attributed to the difference between fiber diameters, leading to various porosities and pore sizes. With the reduction of nanofiber's diameter, porosity increases while the

size of pores decreases. Thus, the lithium ions will go through tiny pores as well as PEO segment that gives rise to higher ionic conductivity. Notably, the as-spun electrolyte showed 10 times greater ion conductivity than the SPE synthesized by film casting method. The obtained results suggest that further optimization might lead to practical uses of nanofibrous electrolytes in lithium ion batteries.

Keywords: Lithium ion battery; Electrospun electrolyte; Polymer matrix; Ion conductivity

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Plasticized electrospun PEO-based nanofibers as electrolyte applicable in lithium ion batteries

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Abstract: The development of lithium ion conducting solid polymer electrolytes (SPEs) is of current interest for use in portable devices and electric vehicles. Film casting method is a common process for the fabrication of the SPEs. In this study, all-solid-state PEO-based nanofibrous electrolytes were fabricated by using an electrospinning method. $LiClO_4$ and ethylene carbonate (EC) were applied as lithium salt and plasticizer, respectively. The effect of EC concentration (0, 4/5% and 9% wt.) was studied on the characteristics of the as-spun electrolytes. SEM and FTIR analysis were applied to investigate the effect of EC concentration. Impedance spectroscopy was conducted at room temperature on the resulted electrospun electrolytes. The SEM results showed the reduction of average diameter of the nanofibers with the addition of EC plasticizer. The obtained result can be attributed to the enhancement of salt dissociation with the addition of EC plasticizer and so increment of solution conductivity which leads to the formation of thinner fibers. The FTIR spectra confirmed complexations between the polymer host matrix and the additives. In addition, the FTIR spectrum showed the enhancement of the fraction of free ions from 65 % to 82/62 % with the addition of 9 % wt. EC into the PEO/$LiClO_4$ nanofibers. The highest ion conductivity of 0/16 $mS.cm^{-1}$ was obtained with the addition of 9% wt. EC. The impedance of the as-spun electrolyte was

10 times smaller than the impedance of the film polymer electrolyte synthesized by film casting method with similar chemical composition. In fact, the highly porous structure of the nanofibers, facilitates ion path and enhances ion conduction. Therefore, the results showed that the electrospun structures can be great candidates as SPEs in lithium ion batteries.

Keywords: Lithium ion battery; Electrospinning; Nanofibrous electrolyte; Plasticizer; Ion conductivity

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The Effect of Different Metal Dopands ZnO Nanostructures on Glucose Oxidation Reaction

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Abstract: ZnO nano particles was prepared by hydrothermal method and doped with 1% Cr,Mn,Fe,Co,Cu,Ni in hydrothermal process. In second part, we used our synthesized Nano particles to determine glucose in acidic, alkaline and neutral media.

In this work we obtained an efficient electro-catalyst to determine glucose oxidation reaction in optimized condition with cyclic voltammetry and other electro chemical techniques.

SEM and PL detected that this nano particles have rice shape and are photo active. We suggest this kind of electro-catalyst to use for glucose fuel cell.

Keywords: Fuel cell, Glucose, ZnO Nano structures , oxidation reaction , acidic and alkaline and neutral media

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Pt-Ni-Cu nanoparticles decorated glassy carbon electrode for glucose electro oxidation process

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Abstract: Platinum and nickel-copper nano particles were electrodeposited on glassy carbon electrode using cyclic voltammetry-based electroplating technique. Morphology and chemical composition of the newly designed electrode was studied via SEM, EDX and elemental mapping analysis. This electrode was eventually employed to electro-oxidize of glucose using cyclic voltammetry and electrochemical impedance spectroscopy (EIS) techniques. The results revealed high catalytic activity of the Pt-Ni-Cu/glassy carbon electrode. Compared to the other electrodes reported in the literature, Pt-Ni-Cu/glassy carbon electrode shows a better potential as an anode for direct glucose alkaline fuel cells.

Keywords: Electroplating, Platinum, Nickel, Copper, Electrocatalyst, Direct glucose alkaline fuel cell.

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Graphene quantum dots decorated Ag-MnO_2 elecro-catalysts for oxygen reduction reaction in alkaline media

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Abstract: Electrocatalysts for oxygen reduction reaction (ORR) play a fundamental role because this reaction is very slow. In this paper, we synthesis of Ag-MnO_2 catalyst by electro deposition method and preparation of graphene quantum dots (GQDs) by hummer method and then we prepared composite of GQDs@Ag-MnO_2 and we investigated behaviour of composite for ORR. Also, this composite was compared with Ag-MnO_2 and showed better performance against Ag-MnO_2. The performance of both catalyst was considered with linear sweep voltammetry (LSV), electrochemical impedance spectroscopy (EIS) and choronoamperometry (CA) of catalysts in 0.5 M KOH solution. The cathodic current density of GQDs@Ag-MnO_2 was 6.74 mA/cm^2 while the cathodic current density of Ag-MnO_2 was 3.60 mA/cm^2. CA for both two catalyst was showed the same durability and EIS for GQDs@Ag-MnO_2 was showed that GQDs enhanced the electrical conductivity of composite and low electrochemical charge transfer resistance was obtained on the GQDs@Ag-MnO_2 electrode compared with Ag-MnO_2.

Keywords: Ag-MnO_2, Graphene quantum dots, Oxygen reduction reaction, Alkaline media

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Silica Protection of Zeolitic Imidazolate Framework (ZIF)/GO Composite as High Activity Electrocatalysts for Oxygen Reduction Reaction

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Abstract: The oxygen reduction reaction (ORR) is the common cathode reaction in many important electric energy devices, such as fuel cells and metal air batteries. The ORR is four electron process with sluggish kinetics and thus requires catalysts to enhance. So far Pt-based catalysts are still the most efficient catalysts. But the scarcity and high costs of platinum, together with instability and deactivation by CO poisoning and crossover effects, limit the application of fuel cells. Currently there are tremendous efforts to develop efficient low cost ORR catalysts to replace Pt based noble metal catalysts to reduce the cost of these advanced electric energy devices. Metal–organic frameworks (MOFs) have received increasing attention due to their potential applications in many areas such as gas adsorption and separation, catalysis, photoluminescence, drug delivery, photoelectrochemistry and ionic conductivity.

In this work we report a highly efficient Co based catalyst for the oxygen reduction reaction (ORR) with highly dispersed Co-N_x sites on N-doped carbon. We synthesized the core-shell GO-ZIF8/ZIF-67 and silicon- core-shell GO-ZIF8/ZIF-67. Silicon protection strategy proved highly effective in preventing the irreversible fusion and aggregation of GO-Co,N-CNF during the high-temperature pyrolysis step used in GO-Co,N-CNF manufacture. Compared to unprotected core-shell GO-ZIF8/ZIF-67 an enhanced electrocatalytic activity was obtained in the case of the silicon-core-shell GO-ZIF8/ZIF-67 with optimized composition and nanostructure. In alkaline media cyclic

voltammetry and linear sweep voltammetry was conducted to compare the electrochemical activities for the samples. The onset Potential for silicon-core-shell GO-ZIF8/ZIF-67 (-0.1V vs AgAgCl) is better than core-shell GO-ZIF8/ZIF-67(-0.06V vs AgAgCl).

Keywords: Oxygen Reduction Reaction (ORR), Silica-Protection, Zeolitic Imidazolate Framework (ZIF)/GO, core-shell

Iron-Nitrogen co-Doped Porous Carbon Derived from ZIFs as an Effective ORR Electrocatalysts

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Abstract: Oxygen reduction reaction has been one the challenging reactions in the energy conversion and storage systems [1]. The reason behind this matter is ORR sluggish reaction and its urgent need to the high cost Pt catalyst. Hence, the widespread application of such devices is limited primarily because of the high price of Pt beside its scarce reserve, poor durability, and low poison resistance [2]. These issues have encouraged researchers to substitute Pt-based catalysts with nonprecious metal catalysts (NPMCs) especially metal-nitrogen-carbon. These catalysts have promising properties such as low cost, good activity and stability comparable or even better than those of Pt-based catalysts in both alkaline and acidic electrolyte [3]. Recently, Fe-based catalysts have emerged as one of the most promising NPMCs [4]. Many reports have been published in the domain of pyrolyzed carbon materials obtained of subclass of MOFs named zeolitic imidazolate framework (ZIF) especially ZIF-8 nanocrystals, composed of imidazole linkers containing carbon and nitrogen atoms and Zn^{+2} ions. A feature that makes these templates more applicable for fabrication of different catalysts with unique and special properties is their ability to mix with other precursors contain different metals (e.g., Co, Fe, Ni) [5]. Because the boiling point of Zn atoms is low (mp 420 ℃, bp 907 ℃), they can evaporate away at high temperatures over 800 ℃, and second added metal (Fe) nodes is reduced in situ by carbonization of the organic linker. When the molar ratio between two metals was adjusted precisely, the resulted catalyst after high thermal treatment

can have single metal atoms anchored on N-doped porous carbon. Such single-atom catalysts (SACs) represent the lowest size limit to obtain the maximum atom efficiency and expose the most active sites in catalysts [6]. On the other hand, adjusting the selected thermal treatment is crucial to maintain this single atom dispersion on the N-doped carbon matrix. Highly dispersed FeNx active sites on the carbon matrix make excellent ORR performance in both acidic and alkaline media. In this report, the obtained Fe-Nx-900 single sites exhibited superior ORR performance with onset potentials (0.887 V_{RHE}, 1.017 V_{RHE}) in acidic and alkaline environments, respectively that the obtained results for commercial Pt/C were 0.937 V_{RHE} and 0.987 V_{RHE}, respectively. As can be seen, in the acidic media, the performance of SAC was appropriate rather than Pt/C but in the alkaline media, a better performance was obtained for SAC. On the other hand, when the temperature of heat treatment process was increased to 1000 ℃, Fe NPs prevailed. In this temperature, likely the Fe SAs would sinter and Fe-N bonds braked for facile formation of Fe NPs. This conclusion was based on the current density drop than that of Fe-Nx-900 in which is because of decrease effective active sites.

Keywords: Fuel cell, Carbon-doped with heteroatom, Cathode, MOF, Transition metal.

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ZIF(Fe/Zn)-derived Hierarchically Porous Carbon Nanotubes as Oxygen Reduction Reaction Electrocatalysts

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Abstract: In fuel cells as energy conversion device, the oxygen reduction reaction (ORR) as a cathodic reaction is one of the most challenging sections in the researches and commercialization processes [1]. Although Pt-based materials have been extensively used to overcome the sluggish kinetic of ORR, problems such as the scarce reserve, high cost, poor durability, and low poison resistance of Pt significantly prohibit their large-scale commercial application [3]. Vast variety of novel carbon catalysts as substitute to Pt have been developed in the last few decades [2]. Nonporous carbons with various dopant species (e.g., N, S) as supporting materials can effectively improve the ORR catalytic activity owing to high surface area, highly porous structure, excellent electrical conductivity, and increased catalytic active sites [4]. Specifically, it has been illustrated that the carbon catalysts coordinated with transition metals (Co, Fe) and nitrogen (N) are emerging as the most promising substitute for Pt toward the ORR [5]. However, an aggregation of loaded metal nanoparticles is often observed following in high thermal treatment can be attributed to the lack of rational nanostructure engineering of the carbon catalysts and it usually leads to a decrease in the number of catalytically active sites. Therefore, improved catalytic activity of such catalysts depends on abundant and uniformly distribution of metal and N dopant on the carbon matrix [6]. Recently, metal organic frameworks (MOFs) derived carbon materials have attracted a lot of interests. The first interesting point is existence of an inherent coordination between metals, heteroatoms and carbon into one framework. Moreover, a homogeneous dispersion of metal-heteroatom doping throughout

framework can serve as active sites and increase ORR performance. It has been reported that a special class of MOFs named zeolitic imidazolate framework (ZIF) can be directly converted to carbon framework homogeneously doped with a transition metal (e.g., Co, Zn, Fe) and nitrogen [7]. In this study, a new ZIF-composite assembly strategy for achieve a new nonprecious metal catalyst based on nanoparticles encapsulated in porous pod-like N-doped carbon nanotubes is reported. This metal-N-doped carbon was prepared by mixing the as prepared Fe-doped ZIF-8 with pyrrole and $FeCl_3$ precursors, followed by pyrolysis at 1000°C for 3h. The main aim to surrounding nanoparticles inside carbonaceous structures was the increasing of the metal NPs protection against corrosion especially in acidic media. It has been demonstrated that this active cites encapsulating strategy make indirectly facilitate the ORR. Because a charge transfer from the metal NPs clusters to the carbon nanotubes takes places, this modification is expected to decrease the local work function and increase the chemical reactivity of the functionalized regions of the CNTs exterior to augment the ORR. In summary, the synthesized electrocatalyst exhibited good and comparable ORR activity to that of the commercial Pt/C in both acidic (0.81 V_{RHE} & 0.95 V_{RHE}) and alkaline (0.92 V_{RHE} & 1.00 V_{RHE}) solution, respectively.

Keywords: Fuel cell, Carbon-doped with heteroatom, Cathode, MOF, Transition metal.

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Differences Between Electrochemical Tests on Synthesized MOF Precursor with and without Sonication for ORR

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Abstract: Nowadays, Feul cells are technology that have major potential to develop renewable energy. The bottleneck of this technologies lies in the high expense of platinum group metal (PGM) electrocataysts for catalyzing the oxygen reduction reaction (ORR) at the cathode [1]. with plan on this issue, transition-metal and nitrogen codoped nanocarbons (TM-N-C, TM: Fe, Co, Ni, Cu, etc.) are inseparable part of researches on ORR electrocatalysts because of their outstanding electrocatalytic activity, superior electrochemical stability, and methanol tolerance. Fuel cells are the suitable items to be a promising vehicle of energy generation. Recently, one of the most promising candidates to replace commercial catalyst (Pt/C) in cathode is using metal organic frameworks, where metal and nitrogen embedded in carbon matrix are regarded active site for oxygen reduction reaction . However, the high temperature will reduce the amount of heteroatoms doping (e.g., nitrogen), which decreases the number of active sites. Therefore, the determination of a suitable temperature is a key factor to prepare the high efficient porous carbon catalysts derived from different MOF precursors [2].

Herein, we report the preparation of ultraSonic Fe nanoparticles embedded in nitrogen-doped by direct pyrolysis of Fe-based zeolitic imidazolate frameworks (Fe-ZIF) at 1000 ^{o}C in Ar.

Keywords: Metal Organic Framework(MOF) , Fuel cell, Oxygen Reduction Reaction (ORR).

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Influence of different functionalized graphene oxide and ionic liquids in electrocatalytic activity and charge storage performance of conductive polymer modified electrodes

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Abstract: In this paper firstly, different functionalized graphene oxide (FGO) and ionic liquids (ILs) were synthesized using chemical approach and then fabricated hybrid conductive polymer/ FGO and conductive polymer/ILs films by electro- polymerization of conductive polymer in the presence of FGO and ILs to serve as the active electrode for electrochemical energy storage materials [1-3]. Different electrochemical methods including galvanostatic charge–discharge experiments, cyclic voltammetry and electrochemical impedance spectroscopy are carried out in order to investigate the performance of the system. This work introduces new most efficient materials for electrochemical energy storage materials and electrocatalyst towards oxidation of different alcohols with advantages including ease synthesis, high active surface area and stability in an aqueous electrolyte.

Keywords: conductive polymer, composite, pseudocapacitor, electrocatalyst, ionic liquid

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Glucose Photoelectrochemical Oxidation at Modified Electrode with ZnO Based Nano Catalysts

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Abstract: In this investigation, we try to synthesis two different simple and cheep photoactive and electroactive nano structures based on ZnO to develop glucose photo-electrochemical oxidation in a photo-fuel cell. At first, we separately doped 1% Pt and 1% Ag in ZnO nano-structure with hydrothermal method. Regarding photo-electrochemical activation of synthesized materials, we selected them for facilitating the glucose oxidation reaction. In this process, we used mono-saccharides as template for growing hexagonal sheets based nano-materials. Then, the effect of the dopants percentage and synthesis conditions such as temperature on the structural morphology and electro-catalytic properties of the final products was studied and optimized. The surface of a pyrolytic graphite electrode was modified by synthesized Pt and Ag doped ZnO nanostructures and it was used for further voltammetric studies. The effect of various parameters such as the amount of modifier deposited on the electrode surface, type, pH and concentration of electrolyte and voltammetric sweep rate was investigated on the electro-oxidation response of glucose. Obtained results revealed improvement of glucose electro-oxidation response on the modified electrodes compared to the bare electrode in the both case of over-potential reduction and current density enhancement. The applicability of the prepared synthesized ZnO doped nanostructures for the glucose oxidation in biofuel cells was confirmed.

Keywords: Fuel cell, Electrocatalyst, Hydrothermal, ZnO, Glucose, Electro oxidation.

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The investigation of platinum electrocatalyst deposited on a gold electrode for glucose oxidation reaction in the body media

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Abstract: Nowadays, glucose oxidation reaction has attracted myriads of scientists, as for its performance in biofuel cells. In as much as the specific conditions of the living organisms' body make the possibility of utilizing a catalyst face with many ordeals, catalysts must not be harmful to the body. Accordingly, the present study emphasizes the exploit of safe and non-toxic metals; in consequence, the results could be used in living organisms' body. In the present study, a gold substrate is used as an electrode in glucose electro-oxidation reaction. Platinum as electrocatalyst is used at this work. For preparing modified electrode, cyclic voltammetry (CV) is carried out from -0.2 to 0.5 V versus the saturated calomel electrode (SCE) at a scan rate of 10 mVs^{-1} for electrodeposition of platinum as simple technique. The working electrode is designed to examine the glucose oxidation reaction in the body media using electrochemical techniques such as cyclic voltammetry (CV) and linear sweep voltammetry (LSV). The results demonstrating the prepared electrode has favorable performance for glucose oxidation reaction in neutral media. The results of the cyclic voltammetry representing the glucose oxidation reaction is executed on the electrode surface based on related peaks in CV diagram. Besides, linear sweep voltammetry data (-1 to 0.2 V versus SCE and at a scan rate of 1 mVs^{-1}) shows that glucose oxidation reaction, with a relatively fast kinetics, is carried out on the optimized electrode with the current density of 0.367 mA cm^{-2} at -0.158 V versus SCE. This issue is further discussed in this article.

Key words: Glucose oxidation reaction, Body media, Gold, Platinum electrocatalyst.

N-doped Graphene Quantum Dot Supported Pt Catalyst as an Oxygen Reduction Activity

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Abstract: Fabricating efficient and long-lasting platinum catalysts as oxygen reduction reaction (ORR) catalysts is still a most important obstacle of fuel cell commercialization. In this work, facile hydrothermal and impregnation method were employed to synthesize platinum Pt nano-catalysts supported on N doped graphene quantum dot. The prepared catalysts physico-chemically were characterized by X-ray diffraction (XRD), Raman spectroscopy, transmission electronmicroscopy (TEM), and X-ray photoelectron spectroscopy (XPS). The electrochemical evaluation was carried out in three electrode half-cell system to investigate the catalyst activity for oxygen reduction reaction (ORR),. In comparison to commercial Pt/C (ETEK, 20 wt%), the Pto/ N-GQD with lower weight percentage catalyst (~8 wt%) displayed comparable electrocatalytic activity toward ORR. To investigate the role of catalyst support, catalytic activities of Pt/NGQD and Pt/C were compared. The results demonstrated superior catalytic activity of Pt/NGQD which could be related to cocatalytic role of N-GQD due to the presence numerous of active sites exposed to the reactants.

Keywords: Oxygen reduction, -N-doped graphene quantum dot

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چکیده

مقالات فارسی زبان

مدل‌سازی تامین آب موردنیاز نیروگاه سیکل ترکیبی شهید کاوه قاین با استفاده از نیروگاه پیل سوختی

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چکیده

امروزه به دلیل کاهش شدید سوخت‌های فسیلی و آلودگی ناشی از این سوخت‌ها استفاده از منابع تجدیدپذیر تولید انرژی مانند پیل سوختی بسیار گسترش یافته است. تنها محصولات جانبی پیل سوختی آب و گرما است. بنابراین می‌توان از پیل سوختی برای تولید همزمان برق و آب استفاده کرد. در این مقاله طراحی یک نیروگاه پیل پلیمری جهت تامین آب موردنیاز سیکل ترکیبی کاوه قائن بررسی شده است. طراحی بر مبنای دبی آب موردنیاز این نیروگاه (۱۹ لیتر بر ثانیه) انجام شده است. بر اساس نتایج حاصله، نمودار تغییرات جریان الکتریکی پیل بر حسب دما زیگزاگی است که این رفتار با توجه به نحوه‌ی تغییرات رطوبت نسبی با دما توجیه می‌شود. بر اساس این مطالعه، بهترین دمای عملیاتی پیل پلیمری ۸۶°C تعیین شده است. همچنین مشخص شد که با افزایش فشار تا ۱/۵ بار، جریان حاصل از پیل افزایش یافته و با افزایش بیشتر فشار جریان ثابت می‌ماند. بنابراین در شرایط فعلی ۱/۵ بار فشار بهینه است.

واژگان کلیدی: پیل پلیمری، نیروگاه سیکل ترکیبی، تولید آب

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مطالعه نظری بهبود الکترود آنزیمی بوسیله ساختارهای گرافنی برای بیوسنسورهای الکتروشیمیایی

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چکیده

امروزه استفاده از نانوساختارهایی که قابلیت کاتالیزوری و حد واسط دارند در ساخت نسل سوم بیوسنسورها افزایش چشم گیری پیدا کرده اند. ویژگی های منحصر به فرد گرافن در بالا بودن هدایت الکتریکی بالا، قدرت کشسانی ، مقاومت مکانیکی، سطح ویژه و سرعت انتقال الکترون باعث کاربردهای متنوع آن شده است. لبه های گرافنی دارای دو شکل هستند، یک طرف به صورت زیگزاگ و طرف دیگر به صورت دسته ی صندلی هستند. با بهینه کردن ساختارهای آنتراسن و فناترون به عنوان مدلی از لبه های زیگزاگی و دسته صندلی و محاسبه سطوح انرژی اوربیتالی آنها و فاصله نوار ظرفیت و رسانش ، مشاهده شد که گرافن با لبه زیگزاگی می تواند به عنوان رسانای خوب الکتریکی در نسل سوم بیوسنسورها به کار برده شود.با مقایسه سطوح انرژی اوربیتال مولکولی آنتراسن با مولکولهای پایرن و کرونن نیز نتایج مشابهی بدست آمد.

واژگان کلیدی: بیوسنسورها، گرافن، باند رسانش، باند ظرفیت، نظریه اوربیتال مولکولی.

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آشنایی با پیل سوختی میکروبی(MFC)

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چکیده

محدودیت و مشکلات زیست محیطی سوخت‌های فسیلی سبب اهمیت استفاده از روش‌های تبدیل انرژی با راندمان بالاتر و همچنین امکان تولید منابع انرژی از منابع تجدیدپذیر و تجدیدناپذیر شده است. از بین انواع مختلف انرژی، تولید انرژی الکتریکی از منابع تجدیدپذیر به شدت مورد توجه قرار گرفته است و تلاش‌های بسیاری جهت جایگزینی روش‌های تولید الکتریسیته در حال انجام می‌باشد. در این میان، تکنولوژی پیل سوختی با قابلیت تبدیل مستقیم سوخت به انرژی الکتریکی، راه حل مناسبی برای عبور از مشکلات انرژی و زیست محیطی می باشد. یکی از انواع پیل‌های سوختی(FC)، پیل سوختی میکروبی(MFC) می‌باشد که اولین بار در سال ۱۹۱۰ توسط پاتر پروفسور گیاه شناس برای تولید الکتریسته معرفی شد، به‌طور جدی از سال ۲۰۰۳ به بعد امکان بالقوه‌ی تولید الکتریسیته با

استفاده از پیل‌های سوختی میکروبی مورد بررسی قرار گرفت، به همین منظور به معرفی و اساس کـار MFC در ایـن مقاله می‌پردازیم.

واژگان کلیدی: پیل سوختی، پیل سوختی میکروبی، محیط زیست، MFC، تولید برق

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تاثیر دوپندهای مختلف نانو ساختارهای اکسید مس روی الکترواکسیداسیون گلوکز

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چکیده

در این پژوهش، نانو ذرات اکسید مس، منگنز دوپ شده با نانوذرات اکسید مس و نیکل دوپ شده با نانوذرات اکسید مس برای اندازه گیری اکسایش گلوکز به روش هیدروترمال سنتز شد. اکسایش گلوکز در محیط قلیایی صورت گرفت. الکتروکاتالیست‌های سنتز شده روی سطح الکترود کربن شیشه‌ای (GCE) قطره نشانی شد. نانو ذرات سنتز شده به عنوان الکتروکاتالیست فعالیت بالایی در الکترواکسیداسیون گلوکز از خود نشان دادند. سنجش‌های الکتروشیمیایی در این پژوهش با استفاده از تکنیک ولتامتری چرخه‌ای صورت گرفت. با توجه به اندازه گیری‌های انجام شده نیکل دوپ شده با نانو ذرات اکسید مس بالاترین جریان و پاسخ را برای اندازه گیری اکسایش گلوکز نشان داد؛ هم‌چنین این الکتروکاتالیست توانست حساسیت، انتخاب پذیری و پایداری بالاتری را نسبت به دو الکتروکاتالیست دیگر در طول الکترواکسیداسیون گلوکز از خود نشان دهد.

با توجه به نتایج ولتامتری چرخه‌ای نانو ساختارهای سنتز شده از جمله نشان دادن حساسیت بالای گلوکز به این الکتروکاتالیست‌ها می‌توان از این ساختارها در پیل سوختی گلوکز استفاده کرد.

واژگان کلیدی: الکترواکسیداسیون گلوکز، نانوذرات اکسید مس، منگنز دوپ شده با نانوذرات اکسیدمس، نیکل دوپ شده با نانو ذرات اکسید مس، ولتامتری چرخه‌ای.

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مدل‌سازی ترمودینامیکی، تحلیل ریسک و قابلیت اطمینان پیل سوختی کربنات مذاب با در نظر گرفتن فاکتورهای مختلف سوخت ورودی به سیستم

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چکیده

پیل‌های سوختی از جمله سیستم‌های همزمان تولید حرارت و برق می‌باشند که میتوانند در صنایع بزرگ مورد استفاده قرار گیرند. پیل های سوختی بر اساس دمای کارکرد تقسیم بندی میشوند. یکی از کارامدترین این پیل‌ها، کربنات مذاب میباشد. در این پژوهش مدلسازی ترمودینامیکی تولید حرارت و برق پیل سوختی کربنات مذاب انجام شده است و سیستم به ترتیب 3171.2 و 2885.2کیلوات برق و حرارت تولید کرد. همچنین برای اولین‌بار تحلیل ریسک و قابلیت اطمینان بر روی پیل سوختی کربنات مذاب بررسی شده است و نتایج اصلی این بررسی نشان داده است که با افزایش سن پیل سوختی کربنات مذاب، احتمال کارد سیستم به درستی، به مراتب کاهش میابد و با توجه به اینکه پیل سوختی یک سیستم تعمیرپذیر در نظر گرفته شده است، سیستم مذکور تا پاین عمر خود حداقل ۴ بار خرابی را تجربه خواهد کرد.

واژگان کلیدی: کربنات‌مذاب، تولید برق-حرارت، تحلیل ریسک-قابلیت اطمینان

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بررسی تاثیر دما بر رفتار خوردگی پوشش کامپوزیتی $Ni\text{-}Co\text{-}CeO_2$ بر روی فولاد Crofer 22 APU استفاده شده در صفحات پیل سوختی اکسید جامد

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چکیده

یکی از اجزاء پیل های سوختی اکسید جامد صفحات اتصال دهنده هستند که دونقش را ایفا میکنند. ۱- فراهم کردن ارتباط الکتریکی بین سل های مجاور. ۲-توزیع سوخت به آند و هوا به کاتد. این صفحات چون در تماس با هردو محیط اکسید کننده و احیا کننده هستند باید مقاومت در برابر خوردگی بالایی داشته باشند. یکی از روش های مفید برای بهبود خصوصیات صفحات اتصال دهنده ایجاد یک لایه پوشش محافظ برای کاهش رشد پوسته اکسیدی و تبخیرکروم و جلوگیری از خوردگی است. در این تحقیق پوشش کامپوزیتی $Ni\text{-}Co\text{-}CeO_2$ به روش رسوب الکترولس بر روی فولاد Crofer 22 APU رسوب داده شد. میزان خوردگی در دما های مختلف با استفاده از تست پلاریزاسیون وطیف نگاری امپدانس الکتروشیمیایی مورد بررسی قرار گرفت. نتایج نشان داد که در دمای 75°C کمترین میزان خوردگی برای این پوشش بدست آمده است.

واژگان کلیدی: خوردگی، پیل سوختی، پوشش کامپوزیتی $Ni\text{-}Co\text{-}CeO_2$، دما، پلاریزاسیون پتانسیودینامیک

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چکیده

امروزه توسعه دست ساخته‌های بشر موجبات آلودگی شدید محیط زیست را فراهم نموده و محققین و دانشمندان نسبت به افزایش بی رویه این آلاینده ها هشدار می‌دهند. این آلاینده ها اعم تخلیه پسابهای صنعتی، فاضلابهای شهری و کشاورزی، انواع فلزات سنگین و سموم را به محیط زیست وارد می‌نماید. آلودگی آب و خاک به صورت مستقیم و غیر مستقیم با سلامت انسان و سایر جانداران رابطه دارد. یکی از روشهای کاهش آلودگی ناشی از فاضلابها استفاده از پیل های سوختی میکروبی است. پیل های سوختی میکروبی روشی جهت تصفیه فاضلابهای ورودی به محیط زیست و همچنین تولید انرژی سبز هستند. در واقع با حذف هزینه های مربوط به ساخت و تجهیز و راه اندازی تصفیه خانه ها، دستیابی به انرژی پاک ممکن می‌گردد. در این تحقیق به بررسی روشهای تلفیقی با پیل سوختی میکروبی در جهت افزایش راندمان پاکسازی محیط زیست پرداخته شد.

واژگان کلیدی: پیل سوختی میکروبی، الکتروکینتیک، انرژی خورشیدی،

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مروری کوتاه بر الکتروکاتالیست‌های کامپوزیت کربن- فلزات غیرگرانبها برای واکنش احیای اکسیژن در پیل‌های سوختی

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چکیده

پیل‌های سوختی الکترولیت پلیمری یکی از جایگزین‌های اصلی سوخت‌های فسیلی به شمار می‌روند. اما یکی از مهم‌ترین چالش‌های پیش‌رو بحث تجاری شدن این پیل‌های سوختی می‌باشد؛ چرا که بکارگیری کاتالیست پلاتین برای انجام واکنش‌های الکتروشیمیایی مربوط هزینه‌های گزافی را برای ساخت و نگه‌داری این پیل‌ها تحمیل می‌کند. از این رو محققین بسیاری تمرکز خود را روی معرفی جایگزین‌هایی برای کاتالیست پلاتین معطوف کرده‌اند. در مقاله مروری پیش رو کاتالیست‌های کامپوزیتی کربن-فلزات غیرگرانبها و تأثیرات آن‌ها برای واکنش احیای اکسیژن در پیل‌های سوختی مورد بررسی قرار گرفته‌اند و نتایج حاکی از آنند که این کاتالیست‌ها می‌توانند جایگزین مناسبی

برای پلاتین باشند.

واژگان کلیدی: پیل سوختی الکترولیت پلیمری، احیای اکسیژن، کاتالیست فلزات واسطه، کربن.

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بررسی اثر پیش‌پخت در دماهای مختلف بر خواص $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ به عنوان کاتد پیل سوختی اکسید جامد

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چکیده

در این پژوهش ترکیب کاتد $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$ (BSCF) به روش سل-ژل احتراقی تولید شده است. به منظور اطمینان از رسیدن به فاز مورد نظر، کلیه ترکیبات تهیه شده با استفاده از آنالیز پراش پرتو اشعه ایکس مورد ارزیابی قرار گرفتند. در ادامه، ریز ساختار و خواص الکتریکی ترکیب کاتدی در دماهای پخت متفاوت، مورد بررسی قرار گرفت. به منظور بررسی رسانایی الکتریکی قطعات کاتدی از روش هدایت‌سنجی چهار پروب استفاده شد. نتایج حاصل نشان داد که کلیه ترکیبات تولید شده در این پژوهش به صورت خالص بوده و هیچ گونه فاز ناخالصی مشاهده نشد، در دمای پیش‌پخت بالاتر ساختار بلوری‌تر بوده هر چند رسانندگی الکتریکی آن کاهش می‌یابد.

واژگان کلیدی: BSCF، کاتد، پیل سوختی اکسید جامد، رسانندگی الکتریکی

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الکتروکاتالیست‌های کبالت فسفید به‌منظور تولید هیدروژن جهت استفاده در پیل‌های سوختی

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چکیده

پیل سوختی برای تولید انرژی پاک و تجدید پذیر از ترکیب سوخت و اکسیدکننده، انرژی الکتریکی تولید می‌کند. یکی از انواع پیل سوختی، پیل سوختی غشای تبادل پروتونی (PEM[۱]) است که سوخت اصلی آن هیدروژن خالص است. سوخت هیدروژن خالص به روش‌های متفاوتی به دست می‌آید که یکی از مهم‌ترین آن‌ها فرآیند آزادسازی هیدروژنHER[۲] و واکنش شکافت آب[۳] است. به دلیل سینتیک پایین، این فرایند نیازمند یک الکتروکاتالیست است تا پتانسیل مازاد[۴] را به حداقل برساند. پلاتین مهم‌ترین الکتروکاتالیست HER به‌حساب می‌آید اما به دلیل قیمت بالا و فراوانی کم به‌طور گسترده صنعتی نشده است؛ بنابراین استفاده از الکتروکاتالیست‌های ارزان، فراوان و البته کارآمد یکی از چالش‌های کنونی محققان است. تحقیقات زیادی در این زمینه بر روی مواد مختلف صورت پذیرفته که ازاین‌بین، ترکیبات فلزات واسطه[۵] از اهمیت بالایی برخوردار است. یکی از انواع این ترکیبات که امروزه چشم‌انداز روشنی را با توجه به هدایت الکتریکی عالی، پایداری بالا و خواص الکتروکاتالیستی مناسب در تولید هیدروژن و نیز

[1] Proton Exchange Membrane
[2] Hydrogen Evolution Reaction
[3] Water splitting
[4] Over potential
[5] Transition metal

اکسیژن رقم‌زده است، ساختارهای فسفیدی و به‌ویژه کبالت فسفید است. در این مقاله سعی شده است تا ضمن بررسی تأثیر افزودن ناخالصی فسفر به فلز کبالت، خواص الکتروکاتالیستی کبالت فسفید گزارش‌شده توسط محققان مختلف در شرایط سنتزی و عملکردی مختلف گردآوری و مقایسه شود تا چشم‌اندازی از خواص الکتروکاتالیستی آن جهت تحقیقات آتی ارائه گردد.

واژگان کلیدی: پیل سوختی، تولید هیدروژن، کبالت فسفید، کاتالیست

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فرآیندهای تلفیقی با پیل سوختی میکروبی در جهت ارتقاء کیفیت محیط زیست

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چکیده

امروزه توسعه دست ساخته‌های بشر موجبات آلودگی شدید محیط زیست را فراهم نموده و محققین و دانشمندان نسبت به افزایش بی رویه این آلاینده ها هشدار می‌دهند. این آلاینده ها اعم تخلیه پسابهای صنعتی، فاضلابهای شهری و کشاورزی، انواع فلزات سنگین و سموم را به محیط زیست وارد می‌نماید. آلودگی آب و خاک به صورت مستقیم و غیر مستقیم با سلامت انسان و سایر جانداران رابطه دارد. یکی از روشهای کاهش آلودگی ناشی از فاضلابها استفاده از پیل های سوختی میکروبی است. پیل های سوختی میکروبی روشی جهت تصفیه فاضلابهای ورودی به محیط زیست و همچنین تولید انرژی سبز هستند. در واقع با حذف هزینه های مربوط به ساخت و تجهیز و راه اندازی تصفیه خانه ها، دستیابی به انرژی پاک ممکن می‌گردد. در این تحقیق به بررسی روش تلفیقی با پیل سوختی میکروبی در جهت افزایش راندمان پاکسازی محیط زیست پرداخته شد. در واقع ترکیب فرایند پیل سوختی میکروبی

و روشهای الکتروشیمیایی جهت حذف فلز سنگین و سمی کروم از محیط رسوب انجام گرفت. مطابق این مطالعه، بیشترین میزان دانسیته توان ۱/۱۲ وات بر متر مکعب و ۴۰/۲۲ آمپر بر مترمکعب به دست آمد. همچنین نتایج آزمایشگاهی نشان داد که مهاجرت فلز کروم به محیط کاتولیت انجام گردیده است.

واژگان کلیدی: پیل سوختی میکروبی، الکتروشیمی، الکتروکینتیک، تصفیه فاضلاب

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اکسیداسیون الکتروکاتالیتیکی گلوکز در سطح الکترود مس اصلاح شده با تیواوره در محیط قلیایی

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چکیده: در این کار الکترود مس اصلاح شده توسط تیواوره برای اکسیداسیون الکتروکاتالیتیکی گلوکز در محلول سدیم هیدروکسید ۰/۱ مولار مورد استفاده قرار گرفت. خصوصیات فیزیکی سطح الکترود اصلاح شده توسط روش میکروسکوپ الکترونی روبشی (SEM) مورد بررسی قرار گرفت و نتایج نشان دهنده ی پوشش خوب سطح الکترود مس با ذرات تیواوره است. در مقایسه با الکترود اصلاح نشده، الکترود مس اصلاح شده با تیواوره ویژگی های الکتروکاتالیتیکی خوبی برای اکسیداسیون گلوکز با کاهش در اضافه ولتاژ و افزایش در شدت جریان آندی نشان می دهد. پارامترهای سنتیکی از قبیل ضریب انتقال الکترون (α) و تعداد الکترون‌های در گیر در مرحله تعیین کننده سرعت (n_α) برای اکسایش این ترکیب با استفاده از ولتامتری چرخه‌ای محاسبه شد. الکترود اصلاح شده با تیواوره، حساسیت بالا، انتخاب پذیری و پایداری خوبی دارد، بنابراین می تواند در پیل سوختی گلوکز مورد استفاده قرار گیرد.

واژگان کلیدی: اکسیداسیون الکتروکاتالیتیکی، گلوکز، تیواوره، ولتامتری چرخه ای

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ساخت و کاربردالکترود مس اصلاح شده با تیواوره برای الکترواکسیداسیون اتیلن گلیکول

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چکیده: در این پژوهش اکسیداسیون الکتروکاتالیتیکی اتیلن گلیکول در سطح الکترود مس اصلاح شده با فیلم تیواوره در محیط قلیایی بررسی شده است. فیلم تیواوره عملکرد الکتروکاتالیتیکی الکترود مس را در مقایسه با الکترود اصلاح نشده افزایش می دهد. خصوصیات فیزیکی سطح الکترود اصلاح شده توسط روش میکروسکوپ الکترونی روبشی (SEM) مورد بررسی قرار گرفت و نتایج نشان دهنده ی پوشش خوب سطح الکترود مس با ذرات تیواوره است. الکترود اصلاح شده فعالیت کاتالیتیکی خوبی را برای اکسایش اتیلن گلیکول نشان می دهد، به طوریکه جریان پیک اکسیداسیون به صورت خطی با غلظت اتیلن گلیکول متناسب است. پارامترهای سنتیکی از قبیل ضریب انتقال الکترون (α) و تعداد الکترون‌های در گیر در مرحله تعیین کننده سرعت (n_α) و تغییرات چگالی جریان(J_0) برای اکسایش این ترکیب با استفاده از ولتامتری چرخه‌ای محاسبه شد. الکترود اصلاح شده با تیواوره، حساسیت بالا، انتخاب پذیری و پایداری خوبی دارد، بنابراین می تواند در پیل سوختی مورد استفاده قرار گیرد.

واژگان کلیدی: اکسیداسیون الکتروکاتالیتیکی، اتیلن گلیکول، تیواوره، ولتامتری چرخه ای

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بررسی کاتالیست های جدید در واکنش کاهش اکسیژن

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چکیده: هدف از نوشتن این مقاله ارائه یک دیدگاه نسبت به وضعیت فعلی الکتروکاتالیست‌های رایج برای واکنش کاهش اکسیژن و انواع امیدوارکننده آن برای آینده بوده است. در ابتدا وضعیت ذخیره سازهای انرژی، به خصوص باتری های فلز-هوا و سلول سوختی بیان شده سپس نیاز مبرم این ذخیره سازها به الکتروکاتالیست های واکنش کاهش اکسیژن توضیح داده شده است. نحوه عملکرد سلول سوختی و مکانیسم واکنش کاهش اکسیژن نیز به اختصار بیان شده است. در ادامه دو دسته از کاتالیست های واکنش کاهش اکسیژن که از نظر قیمت، طول عمر و کارایی قابلیت رقابت و جایگزینی با پلاتین را دارند مورد بررسی قرار گرفته‌اند.

یک دسته الکتروکاتالیست هایی هستند که عملکرد آنها بر اساس پلاتین است اما سعی شده است با آلیاژ کردن فلزات دیگر با پلاتین و استفاده از ساختار هسته-پوسته مقدار پلاتین مورد استفاده در ساخت آن‌ها را کاهش دهند تا قیمت و کارایی آنها هم زمان بهبود یابد. دسته دیگر الکتروکاتالیست‌هایی بر پایه کربن هستند که در آنها از پلاتین یا دیگر فلزات گران قیمت استفاده نشده است اما با دوپ کردن هترواتم ها در ساختارشان به خواص الکتروکاتالیستی مناسبی دست یافته اند.

واژگان کلیدی: واکنش کاهش اکسیژن، سلول سوختی، الکتروکاتالیست، آلیاژ پلاتین، دوپ کردن هترواتم

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بررسی اثر واشرهای آب بندی بر عملکرد پیلهای سوختی متانولی غیرفعال

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چکیده: در این مقاله اثر محل قرارگیری و تعداد واشدهای آب بندی بر عملکرد پیل متانولی غیرفعال بررسی شد. نتایج بدست آمده حاکی از این واقعیت بودند که محل و تعداد واشرهای آب بندی تاثیر بسزایی بر عملکرد پیل های سوختی متانولی غیرفعال دارند بگونه ای که با تغییر تعداد واشرهای درون پیل، توان خروجی پیل تا حدود ۴برابر افزایش پیدا کرد. این تغییر عملکرد بخاطر تغییر در مقاومت تماسی (اهمی) و در نتیجه تغییر در مقاومت داخلی پیل بود. لذا باتوجه به شرایط نشتی و کاهش مقاومت داخلی پیل، بهترین ترکیب برای دستیابی به بهترین عملکرد، وقتی حاصل می‌شود که فقط دو واشر درون پیل قرار گیرد، یعنی یک واشر بین مخزن و جمع کننده جریان آندی و دیگری بین جمع کننده جریان آندی و MEA و در سمت کاتد دیگر واشری وجود نداشته باشد.

کلیدواژه: پیل سوختی متانولی غیرفعال ، توان خروجی، مقاومت داخلی، واشرآب بندی

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بررسی تحلیلی وضعیت مقالات منتشره در فناوری پیل سوختی در ایران و جهان

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چکیده: فناوری پیل سوختی نویدبخش تلاشی نو در راستای تامین انرژی مبتنی بر واکنش های الکتروشیمیایی در مسیر پیشرفت پایدار با درنظرگرفتن الزامات محیط زیستی می باشد. امروزه کاربرد این فناوری در جهت تامین رفاه و آسایش برای انسان از جهات گوناگون مورد توجه محققین این حوزه قرار گرفته که برونداد علمی و پژوهشی فعالیت های انجام شده به منظور تجاری سازی آن، از طرق مختلف از قبیل انتشار مقالات علمی، ثبت اختراع و ... در اختیار جامعه قرار گرفته است. در کار حاضر به منظور تحلیل فرایند فوق الذکر، موضوع انتشار مقالات در حوزه فناوری پیل سوختی مورد توجه قرار گرفته و جهت استخراج داده های لازم از پایگاه SCOPUS استفاده گردید. بررسی مقالات منتشره نشان می دهد که با معرفی الکترودهای گازی نفوذی جهت واکنش اکسایش و کاهش، این موضوع مورد توجه محققین قرار گرفت و تلاش های زیادی برای بهینه سازی الکتروکاتالیست های گوناگون جهت واکنش های یاد شده در پیل های سوختی انجام شد که بررسی کمی تجمعی مقالات منتشره در طول سال های مختلف نشان می دهد که تمرکز بیشتر محقیقن در این فناوری بر روی پیل های سوختی پلیمری و اکسید جامد بوده است از طرف دیگر بررسی داده های حاصل نشان می دهد که در سال های اخیر نرخ رشد مقالات منتشره در جهان در این فناوری کاهش یافته است. در کشور ما نیز تمرکز بیشتر مقالات منتشره بر روی پیل های سوختی پلیمری و اکسید جامد بوده که بررسی کمی مقالات منتشره کشور با کلید واژه پیل سوختی در عنوان، چکیده و کلمات کلیدی در پایگاه جهانی SCOPUS تا ماه فوریه ۲۰۱۹ وضعیت مطلوبی را نسبت به سایر کشورها در جهان نشان می دهد (رتبه سیزدهم). با این حال توجه به کاهش نرخ رشد مقالات منتشره در این حوزه فناوری نشان می دهد که توسعه فناوری پیل سوختی نیازمند نگاهی متفاوت و خلاقانه از طرف محققین به طراحی و ساخت اجزای سیستم های پیل سوختی از قبیل الکتروکاتالیست، الکترود و ... می باشد تا در مسیرهای پژوهشی جدید بتوان شاهد نرخ رشد افزایشی

در بروندادهای علمی و پژوهشی به منظور تجاری سازی این فناوری بود که می تواند کاربردهای جدیدی را هم برای آسایش انسان ها تعریف نماید. در مقاله حاضر این موضوع بیشتر مورد تحلیل قرار گرفته است.

کلمات کلیدی: فناوری پیل سوختی، مقالات منتشره، ایران، جهان، تجاری سازی، پیل سوختی پلیمری، پیل سوختی اکسید جامد.