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## NANO-ELECTROCATALYSTS BASED ON CARBON NITRIDE SUPPORTS FOR THE ORR AND FOR IN PEM FUEL CELLS

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The sluggishness of the alcohol oxidation reaction (FOR) and of the oxygen reduction reaction (ORR), evidenced by its very low j<sub>0</sub> values [1,2], is a major limiting factor in the operation of polymer electrolyte membrane fuel cells (PEMFCs and DAFCs). PGM are concentrated mostly on the cathodic electrode of hydrogen-fuelled systems [3]. The resulting high costs, together with important durability issues, have effectively prevented the wide-scale application of the promising and environment-friendly PEMFC and DAFC technology. Multimetallic nano-electrocatalysts based on carbon nitride supports are currently being developed to overcome the drawbacks of state-ofthe-art electrocatalysts. This report is an overview of the development of this new family of materials. Multimetallic nano-electrocatalysts are prepared by decomposing in an inert atmosphere a homogenous precursor obtained by coordinating the desired metal centers with a suitable organic binder such as sucrose or polyacrylonitrile [4, 5]. By controlling the stoichiometry of the precursor and the parameters of the pyrolysis, it is possible to obtain materials with the desired chemical composition, both in terms of metal atoms and of nitrogen. The thermal treatment plays a crucial role in determining both the structural properties and the activity of the materials in the FOR and ORR. A systematic investigation on several families of electrocatalysts with different metal and nitrogen concentrations and the study of preparation parameters such as the thermal treatments allowed to propose a general framework to optimize the performance of carbon nitride-based electrocatalysts in the ORR. The best results were obtained in electrocatalysts with "core-shell" morphology, supporting on active carbons (core) multimetal carbon nitrides with a low nitrogen concentration (shell). In the latter, the "active" metal (Pt or Pd) is used together with one or more first-row transition metals (Fe, Co, Ni, etc...) acting as co-catalysts. Promising results were obtained: a) in the ORR processes, both in terms of ORR overpotential (up to ~30 mV lower with respect to reference Pt-based systems) and of PGM mass to achieve 1 kW (up to ~0.3-0.4 g) [5]; b) in the FOR for the methanol and ethanol oxidation processes in acid conditions.

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## THE THERMODYNAMIC LIMITS TO ENERGY CONVERSION: HOW TO JUSTIFY RESEARCH IN SEARCH FOR ALTERNATIVE ENERGY SOURCES

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#### Introduction

This presentation summarises a number of practical results from classical and renewable energy generation and demonstrates the most efficient and thermodynamically sound ways to present and justify research related to accumulators, batteries and fuel cells.

#### **Results and Discussion, Conclusions**

The uppermost efficiency of a combustion engine is given by the second law of thermodynamics, or its result, the Carnot theorem [1]. For example the maximum theoretical efficiency of a combustion engine at 500 °C, assuming heat rejection at 50 °C is 58 % and of course, due to nonidealities, this number is lower. The value becomes even lower if the energy cost expended to obtain the fuel is factored in. Such value for gasoline can be, according to one source, 83 % [2]. The theoretical efficiency of fuel cells and batteries is not limited by the Carnot theorem. Often, the efficiency of a combustion engine is compared directly to the efficiency of an electrochemical power source. An often-used argument is that a fuel cell or a battery are more efficient than a combustion engine. Although this is in general understanding true (for example a hydrogen fuel cell operating at 25 °C has maximum theoretical efficiency of 83 %), to make such a comparison is fundamentally flawed, as the energy cost of obtaining the fuel for the fuel cells is rarely included.

The second argument for beneficial use of electrochemical power sources is their non-polluting nature. The concept of a carbon footprint will be also examined. With the value of 800-1000 gCO<sub>2</sub>eq/kWh the coal fired power plants are the obvious worst culprit and wind-generated power comes victorious with perhaps 5 gCO<sub>2</sub>eq/kWh. Photovoltaic sources with value 60-100 gCO<sub>2</sub>eq/kWh [3] indicate need for improvement.

There is no doubt that batteries and fuel cells are important component in energy for the future. However, proper education to understand the role and contribution of these components to the global picture is needed and outlined.

#### Acknowledgements

Travel support from the ABAF Organizers and their Sponsors is greatly appreciated.

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## THE UNLP RESEARCH AND DEVELOPMENT PROJECT ON LITHIUM-ION BATTERIES FOR ELECTRIC CARS

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The great challenge of our times is to replace polluting oil energy sources with renewable and clean energies that are ready to be used, which requires addressing the need for proper storage solutions. Electric energy storage should be clean, economical, efficient, safe, have long useful life and high specific capacity (mass and volume). The lithium-ion batteries would fulfil most of these requirements. To expand the scope of application of these batteries, which are currently used in electric cars, we are working on the development of techniques for building electrodes with a good response to high discharge currents. Lithium iron phosphates with olivine structures would meet the requirement of energy drain at high current values. A summary of the current technology for lithium-ion batteries, as well as their future prospects, will be presented. Results will be discussed in the Innovation and Technology Transfer Project in Priority Areas of the Universidad Nacional de La Plata (UNLP) in cooperation with the laboratory of the Department of Electrotechnology, Faculty of Electrical Engineering and Communications of the Czech Republic.

## ABOUT INFLUENCE OF MEA COMPRESSION & VARIED MATERIAL PROPERTIES ON THE EFFICIENCY OF PEMFC'S

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#### Introduction

It is a known effect that the Membrane Electrolyte Assembly (MEA) of a Polymer Electrolyte Membrane Fuel Cell (PEM-FC) will be deformed during the assembly process. The gas diffusion layers (GDL), as the most elastic layers of all MEA components, will be distorted and squeezed into the gas channels. As a result the material properties in regions of higher deformation will change.

#### **Results and Discussion, Conclusions**

This paper investigates the influence of deformations and related property variations numerically. The required material properties are obtained from recently published data. A multi-physics suite of codes is extended to support anisotropic properties variations giving the possibility to calculate electrochemical performance based on stresses and straines resulting from assembly forces utilized.

Numerical implementation, numerical algorithms and results based on varied material properties, will be presented and discussed. It will be shown that considering the MEA deformation plays an important role in fuel cell electrochemical behavior.

#### Keywords

Electro-chemistry, simulation, Polymer Electrolyte Membrane Fuel Cell (PEM-FC), Membrane Electrolyte Assembly (MEA)

## HIGH CONDUCTIVITY PVA MEMBRANE FOR ELECTROLYSIS

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Electrolysis is the physico-chemical phenomenon caused by the passage of electric current liquid in which chemical changes occur at the electrodes. Electrically conductive fluid contains a mixture of cations and anions resulting in fluid dissociation. Passing an electric current is the movement of positive ions to the negative electrode and negative ions to the positive electrode. The electrodes can then lead to chemical reactions - between the ions and the electrode, ions between themselves or between ions and fluid (due to higher concentration of ions at the electrodes).

In practice, the device uses electrolysis called electrolyser. This device needs to solve the problem of separation of products resulting from electrolysis. One way is to use a membrane that separates these products. The requirements for these membranes are especially high ionic conductivity, impermeability for emerging products and long-term durability in the electrolyte used.

Membrane used in this article, is made of a mixture of PVA (SIGMA-ALDRICH, 99+% hydrolyzed,  $M_W = 89,000 - 98,000$ ), glutaraldehyde and  $H_2SO_4$ . This mixture is pressed into nonwoven polypropylene fabric (BTP Czech Republic, NT-SB-50). The resulting membrane is measured ionic conductivity, impermeability to resulting gases and durability in the used electrolyte, which in this case 5.6 mol/l KOH.

PVA membrane in this article is compared with two commercial products: fumapem® AM alcaline membrane from Fumatech company and separator 3401 from Celgard company.

#### Acknowledgements

This work was supported by the grant FEKT-S-11-7

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## ELECTROCATALYTIC PROPERTIES OF NANOCOMPOSITES FOR ELECTROCHEMICAL POWER SOURCES FROM THE STANDPOINT OF LOCALIZATION OF REACTIONS

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Catalytic electrode materials of nanocomposites based on metals (Pt, Ni, Pb), manganese, molybdenum, chromium, cobalt, niobium oxides and cadmium sulfide have been obtained by various methods of formation on the surface of multiwalled carbon nanotubes [1-3]. The nanocomposites obtained have been investigated as materials for the oxygen electrodes of electrochemical power sources in alkaline electrolytes, and their electrical characteristics have been studied. These catalysts were deposited under the same conditions on a smooth-nickel substrate to study the kinetics of molecular oxygen evolution. On the electrodes under investigation, molecular oxygen evolution polarization curves have been obtained in alkaline electrolytes, and the coefficients a in the Tafel equation have been determined. A dependence of the catalytic activity of oxygen electrodes based on catalytic nanocompopsite materials on the value of the coefficient a in the Tafel equation for oxygen evolution reaction has been discovered. It is evident from this dependence that the electrical characteristics of oxygen electrodes of nanocomposites with catalyst increase with increasing coefficient a for oxygen evolution at this catalyst. The assumption was made that oxygen adsorption and subsequent electron attachment are localized and take place simultaneously on the catalyst and on the support. On the basis of this assumption, the discovered dependence may be attributed to the fact that for the nanotubes with low oxygen adsorption energy, catalyst with high molecular oxygen adsorption energy must be used, on which oxygen molecule will be adsorbed more readily with subsequent bond stretching in it and subsequent electron attachment. It was also suggested that it is possible to predict the catalytic properties of materials, i.e. good catalysts for oxygen reduction reaction will be materials with high molecular oxygen adsorption energy and hence with large value of the coefficient a in the Tafel equation for molecular oxygen evolution reaction.

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## ANISOTROPY IN CONDUCTIVITY OF SCANDIA-STABILIZED ZIRCONIA

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Earlier we found out the low-temperature anomaly in conductivity on 89 mol. %  $ZrO_2 + 10$  mol. %  $Sc_2O_3 + 1$  mol. %  $CeO_2$  ceramic composition in the range of temperatures 600-630 K for the first time [2]. It is assumed that this anomaly in conductivity is caused by ordering the crystallites which is result in the conductivity anisotropy of specimen.

Experimental proof of the assumption was performed on 89.9 mol.%  $ZrO_2$  + 9.9 mol. %  $Sc_2O_3$  + 0.2 mol. %  $La_2O_3$  ceramic composition which average grain size was less 2 mkm.

So far as ionic conductivity dependences of previously studied and present ceramic compositions (for 89 mol. %  $ZrO_2 + 10$  mol. %  $Sc_2O_3 + 1$  mol. %  $CeO_2$  and 89.9 mol. %  $ZrO_2 + 9.9$  mol. %  $Sc_2O_3 + 0.2$  mol. %  $La_2O_3$ , respectively) have the similar form it gives the ground to suggest the general character of the revealed laws of ionic conductivity. It is shown two jumps in specific conductivity. First appears in the high-temperature region (750-900 K). This jump has hysteresis character, and it is connected with phase transition from the rhombohedral phase to cubic phase. Second one appears in the low-temperature region (600-630K).

To detect the possible anisotropy effect in conductivity of specimen that was under the some sets of conductivity measurements in heating-cooling mode, we changed the surfaces on which silver contacts were coated.

It is found out that the specific conductivity of the specimen took approximately a fourth in the range of temperatures 640-740 K, and in this case the anomaly of conductivity was not appeared.

After heating up to 800 K, for the daisy-chain specimen, the kind of conductivity dependences was opposite. For the lateral connection of specimen, there it was again the low-temperature anomaly in conductivity and, for face connection of specimen, conductivity was decreased in the same value, and the low-temperature anomaly in conductivity was not found out.

Such «the effect of anisotropic properties switching» occurs only after heating up the sample, which must be mainly in the rhombohedral phase, to 800 K. Also this effect appears after every change of orthogonal specimen surfaces on which measuring contacts were coated.

From the analysis of experimental results, we can suppose that discovered anisotropy in ionic conductivity may be connected with ordering the crystallites. This ordering became possible because of display of crystal lattice instability near to a point of phase transition from the rhombohedral phase to the cubic phase. Instability of a lattice, occurrence of soft vibrational phonon modes essentially facilitate the reorganization of lattice which occurs owing to the co-operative ordered movement of doping scandium ions in the weak electric field.

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## PVA MEMBRANES FOR ALKALINE FUEL CELLS

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The field of research of low-temperature fuel cells have recently focused on new types of ionexchange membranes based on PVA. These membranes are tested for use in direct methanol fuel cells. These fuel cells require the use of expensive noble catalysts based on Ru-Pt because of the use of methanol as a fuel. For this reason, our research is focused on the application of PVAbased membranes in PEMFC (Polymer Electrolyte Membrane Fuel Cells), which allows use the cheaper catalysts instead of Pt. Stable hydroxyl anion conducting membranes have been developed using poly(vinyl alcohol). To clarify cross-linking effect on membrane performance, two series of PVA membranes were prepared by direct chemical and UV cross-linking methods. These have been characterized in detail at structural and hydroxyl ion conducting property by scanning electron spectroscopy (SEM), water sorption, pycnometry, temperature resistance stability and electrochemical impedance. MEA (Membrane electrode Assembly) structures were prepare on the base of these PVA membrane, and were measured in experimental fuel cells Quintech.

#### Acknowledgements

This work was supported by the grant FEKT-S-11-7 and the project CVVOZE CZ.1.05/2.1.00/01.0014.

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## NMR MEASUREMENT OF RELAXATION TIMES AND DIFFUSION OF GEL ELECTROLYTES BASED ON NaCIO₄ DURING POLYMERIZATION PROCESS

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#### Introduction

Nuclear magnetic resonance spectroscopy is good way to investigate the structure and the internal mobility of a wide spectrum of materials and systems from solutions, very soft and movable gels over synthetic polymers to organic and inorganic crystals [1].

#### Experimental

We focused on the gel electrolytes with conductivity based on the sodium ion Na+. The electrolyte was a solution of NaClO<sub>4</sub> in propylene carbonate mixed with methyl methacrylate with four different concentrations. Each sample was irradiated by UV radiation in fifteen minute intervals. We performed measurements of relaxation times  $T_1$ ,  $T_2$  of <sup>23</sup>Na nuclei and diffusion of <sup>1</sup>H nuclei after each of those intervals. The experiment was performed on the 4.7T NMR system at the ISI in Brno.

#### **Results and Discussion**

For calculating the relaxation times from measured data, we suppose the presence of two regions with different relaxation times ( $T_{1a}$ ,  $T_{1b}$ ,  $T_{2a}$  and  $T_{2b}$ ). We determined the exchange of the relaxation times  $T_1$  and  $T_2$  for different concentrations of salt in conductive gels during polymerization. The relaxation times of NaClO<sub>4</sub> mixed with propylene carbonate (PC) is found to be  $T_{1a} = 39$  ms and  $T_{1b} = 1.5$  ms, whereas for free sodium the time is determined at  $T_1 = 57$  ms [2]. This indicates that sodium is much more bound to the structure.

#### Conclusions

The change in the structure of polymer gels during polymerization is characterized by <sup>23</sup>Na relaxation times and by the both the relaxation and the diffusion of <sup>1</sup>H nuclei.

#### Acknowledgements

The work described in the paper was financially supported by the research project of the Czech Science Foundation, Grants No. P102/10/2091, and European Commission and Ministry of Education, Youth and Sports of the Czech Republic (project No. CZ.1.05/2.1.00/01.0017).

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## PHASE DIAGRAM FOR MIXTURES OF SULFOLANE – DIMETHYLCARBONATE FOR USING IN ELECTROLYTES FOR LITHIUM – ION BATTERIES

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#### Introduction

The aim of this work is to determine the melting point for different ratio of solvents. The solvent used for lower flammability- sulfolane, have a high melting point 27.5°C. Sulfolane would greatly limit the range of temperatures where it could be used. That's why we need to add a second solvent, which modifies the mixture properties for becoming a better use in lithium – ion batteries. Non-toxic and environmentally friendly dimethylcarbonate was selected as the second solvent.

#### Experimental, Results and Discussion, Conclusions

The melting point was estimated using cryoscopy. The sample, closed in glass bottle, was inserted into ethanol bath. The bath was cooled by liquid nitrogen with was slowly poured into the bath. The sample temperature was measured by thermocouple K type and recorded in ten second intervals. From the cryoscopic curves the melting point was determined. With increasig concentration of dimethycarbonate the melting point was changed and decreased non-liearly. The best composition for electrolytes, for lowest melting point, was 60% sulfolane and 40% dimethylcarbonate the melting point of which was -0.5°C. The melting point can by decreased even further by adding a salt to ensure conductivity of electrolyte.

#### Acknowledgements

Grant Agency of Czech Republic, Project P102/10/2091 "Increase the safety of lithium-ion batteries", project CVVOZE CZ.1.05/2.1.00/01.0014

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## NMR INVESTIGATION OF THE INTERACTION OF Li<sup>+</sup> IONS WITH SOME PRECURSORS OF THE LITHIUM BATTERY POLYMER SYSTEM

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#### Abstract

High resolution NMR has been used to reveal interactions between components in prepared electrolyte material prior to polymerization that was aimed for use in lithium polymer battery research. Previous results indicated a decrease in lithium mobility with increased amount of methoxysilyl groups contained in the sample. <sup>1</sup>H, <sup>13</sup>C, <sup>7</sup>Li, and <sup>29</sup>Si NMR spectra as well as pulsed field-gradient (PFG NMR) measurements of the self-diffusion of lithium ions were obtained and a preferred coordination of lithium ions to the methoxysilyl groups was proved. Although this interaction seems quite weak, based on the small shifts observed in the spectra, a clear decrease in lithium diffusion dependent on the increased content of methoxysilyl groups was shown.

#### Acknowledgements:

This research is financed by the GACR Foundation as a part of project nr. P102/11/1092

## GEL POLYMER ELECTROLYTES WITH HIGHER THERMAL STABILITY

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This work deals with preparation of thermally stable PMMA based gel polymer electrolytes (GPE) for lithium batteries. with aprotic solvents. Variety of aprotic solvents based on sulfolane was tested to obtain suitable properties for lithium batteries. These GPEs have been chracterized in ionic conductivity and thermal stability by scanning electron spectroscopy (SEM), electrochemical impedance spectroscopy (EIS) and thermogravimetry (TGA).

#### Acknowledgements

This work was supported by the grant FEKT-S-11-7, the project CVVOZE CZ.1.05/2.1.00/01.0014

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## CONDUCTING POLYMERS AS ELECTRODE MATERIALS FOR ELECTROCHEMICAL CAPACITORS

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The electrochemical properties of asymmetric supercapacitors based on active carbon and polyaniline or polypyrrole and poly(3,4-ethylenedioxythophene) are discussed. The electrically conductina polvmers such polyaniline (PANI). polypyrrole (PPv) and as polv(3.4ethylenedioxythiophene) (PEDOT) were prepared using chemical method of oxidative polymerization of the suitable monomers. The active carbon (AC) was prepared by carbonization of commercial lignine (Aldrich) and then activated in KOH with a C:KOH ratio of 1:4. The morphology of the materials was observed by SEM. The electrochemical performance of obtained materials in symmetric capacitors was studied in two and three electrode Swagelok® systems using 1 M H<sub>2</sub>SO<sub>4</sub> as an electrolyte. The electrochemical measurements have been carried out using cyclic voltammetry, galvanostatic charge/discharge and impedance spectroscopy. The results showed that PANI provided the highest value of capacity as positive electrode while the other materials (PPy, PEDOT and AC) should be used as negative electrodes due to their electrochemical properties. The highest value of capacity in asymmetric device was obtained for PANI/AC configuration, which can additionally work in wide potential window 1.4 V. The considerable growth of energy is connected with such asymmetric system of capacitor. The results of cycleability showed that such configuration provided high value of capacitance (comparing to the pristine materials) but the drop of capacity after 3000 cycles with high current regime 2 A/g (in potential window 1.2 V) is also high ca. 40 percent. For the PANI/PEDOT configuration the potential window of 1.2 V was obtained while PANI/PPy arrangement has worked well only in the potential window of 0.8 V.



*Fig. 1:* Voltammetry characteristics of asymmetric capacitor PANI/PEDOT. The CV curves are made for 2-electrode cell at 10 mV/s.

#### Acknowledgements

The authors acknowledge the financial support from the European Fund of Regional Development within the frameworks of the operating program –"Innovative Economy 2007–2013", under Project No. POIG.01.01.02-00-015/09.

## ELECTROCHEMISTRY OF SULFOLANE AT LOW TEMPERATURES

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Properties of sulfolane SL and of mixture sulfolane with propylene carbonate PC were investigated at temperature close and below the freezing point of SL down to +20 °C. The viscosity  $\eta$  is fairly increased and parallel to it, the electric specific resistivity  $\rho$  increased simultaneously. This is shown for a 0.5 M LiClO<sub>4</sub> in SL and in a mixed solvent consisting of SL and PC. The data could be described by an empirical equation  $\eta = const \cdot \rho^{0.7}$  (see figure).

The impedance of pure solvent containing SL and PC is fairly complex. At frequencies up to 1 MHz, the permittivity approached the value corresponding to optical values corresponding to refractive index. The impedance of the mixture SL + PC at lower frequency showed strong and slow polarization with relaxation time of the order of milliseconds.



## A VIABLE PATH TOWARD A HIGH ENERGY DENSITY ANODE FOR LITHIUM-ION BATTERIES

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It is well known that tin could be a suitable material for a high energy density anode in lithium-ion batteries, owing to its theoretical capacity (994 mAh/g). Unfortunately, like other elements alloying with lithium (Si, Sb, Al, etc.), tin suffers high swelling and relaxing processes during charge and discharge of the battery, respectively. Volume expansion up to 260 % can be observed, and this induces stresses whitin metal up to its crumbling which brings battery going off even after few cycles only.

In the present work it is demonstrated that electrodeposition inside pores of a nanostructured membrane can be a suitable path to fabricate an array of nanowires made of tin amorphous binary alloy with increased electrochemical performances both in term of high C-rate and capacity compared to those of carbonaceous anodes.

The right choice of the inert component to alloy with tin allows relaxing stresses induced by strain. Changing electrolytic bath composition it is possible to control alloy composition and crystalline structures, reaching the right compromise between a higher specific capacity (due to tin content) and a higher duration of performance (also due to the amorphous structure of the sample). Moreover, the particular shape of nanowires addresses strain mainly lengthwise, avoiding tin agglomeration.

Electrochemical characterization has been performed galvanostatically in a three electrode cell, with lithium both as counter and reference, by deep charge and discharge in the potential range from 0.020 to 2.000 V vs. Li<sup>+</sup>/Li, at different C-rate in dimethyl carbonate:ethylene carbonate 1:1 – 1 M LiPF<sub>6</sub>, at 30 °C. Figures below show the delivered capacity (mAh/cm<sup>2</sup> and mAh/g<sub>Sn</sub>) of nanostructured SnCo alloy electrodes over cycling at C/2.

![](_page_22_Figure_10.jpeg)

## SUPERCAPACITORS AT THE DEPARTMENT OF ELECTRICAL AND ELECTRONIC TECHNOLOGY

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At our department are made experiments with electrode materials, liquid and gel electrolytes suitable for supercapacitors. A lot of measurements are done in the test cells ECC-Std from ELL-CELL.

In the field of electrodes materials are tested electric conductivity, diffusion properties, porosity. Viscosity, ionic conductivity, flash point and working potential tests are done with suitable electrolytes

#### Acknowledgements

This work was supported by the grant FEKT-S-11-7 and the project CVVOZE CZ.1.05/2.1.00/01.0014.

# THIN-LAYER ELECTROLYTIC NICKEL- HYDROXIDE, - OXIDE COMPOUNDS IN MODEL ELECTROCHEMICAL CAPACITOR

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Electrolytic nickel hydroxides and that additionally oxidized by anodic polarization were produced on stainless steel foil from aqueous electrolytes comprising nickel sulfate and nickel nitrate [1]. Cycling voltagrammes were performed on VoltaLab PJZ 301 at the scan rate from 1 to 100 mV/s. The solutions of 0.01; 0.05; 0.10; 1.00; 3.00; 6.00 mol/l KOH were used as an electrolyte in model electrochemical capacitor. Electrolytic  $\alpha$ -Ni(OH)<sub>2</sub> and  $\alpha$ -Ni(OH)<sub>2</sub> +  $\beta$ -Ni(OH)<sub>2</sub> were obtained in thin layers and their cycling voltagrammes reflect the behavior of one or two redox-pair respectively. The behavior of model capacitor dependences on KOH concentration, potential scan rate, temperature treatment of synthesis object, substrate material nature, electrolysis technology, etc. A linear  $i_{max}$ - $\sqrt{\nu}$  (peak current  $i_{max}$ - potential scanning rates  $\nu$ ) dependence of electrode process is in agreement with the occurrence of the diffusion control Ni(OH)<sub>2</sub>/NiOOH redox-pair electrode reaction. The analysis of Ni(OH)<sub>2</sub>/NiOOH cycling voltagrammes proposed by us allows separate the deposits of the principal capacitor reaction (Ni(OH)<sub>2</sub>+OH<sup>-</sup>→NiOOH+ē) and the parasitic oxygen evolution reaction on dependence KOH concentration in capacitor (potential window is 0.65 V vs. Ag/AgCI).

It was established that oxygen evolution decreases and potential window extends with the decrease of KOH concentration in model capacitor. Best reversibility of Ni(OH)<sub>2</sub>/NiOOH system achieved in (0.10 mol/l) KOH solution.

Cycling voltagrammes of Ni(OH)<sub>2</sub>/NiOOH system obtained at  $\upsilon$ =10 mV/s in solution of 1 mol/l KOH show the dependence of peak current on Ni(OH)<sub>2</sub> mass. Optimal mass is established as 1-3 mg/cm<sup>2</sup>.

In XRD patterns synthesized with additional anode polarization it was identified oxide NiO. The specimens with additional anode polarization have advantages over those anodeless polarizations that are expressed in the stabilization of synthesis product at the storage.

The temperature treatment of synthesized electrolytic products in the temperature range more than 150°C is the negative influences on their electrochemical characteristics. The potential window became narrower, the current density decreases.

Ni(OH)<sub>2</sub> film maximum reversible capacity achieves of 427- 457 F/g.

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## **ELECTRODEPOSITED THIN LAYERS OF TiO<sub>2</sub>**

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The preparation of thin layer oxidic electrodes by electrodeposition has been studied in our department extensively. We have preprade layers of manfganese, tungsten and/or vanadium oxides. The attempt to prepare titanium dioxide layers is the subject of this contribution.

The layers were deposited cathodically from a solution of titanium potassium oxalate  $C_4K_2O_9Ti$  on ITO glasses. Layers of thickness 200 – 400 nm were prepared easily in this way, as confirmed by QCM.

After rinsing and drying, the layers were transferred to a solution of  $LiClO_4$  in propylenecarbonate and tested for the possibility to intercalate lithium. This was fairly successful. The layers accept lithium in the amount 1 Li to 2 atoms of Ti approximately and their color changed reversibly to light brown and colorless and perfect voltammograms were observed. The layers were nanoporous.

![](_page_25_Figure_9.jpeg)

#### Acknowledgements

Grant Agency of Czech Republic, Project P102/10/2091 "Increase the safety of lithium-ion batteries" and Project CVVOZE No. CZ.1.05/2.1.00/01.0014. The Electrochemical Society assisted to cover the publication costs of this article and in preparation of this meeting.

## COBALT DOPED LiFePO<sub>4</sub> / C COMPOSITE MATERIAL FOR Li-ion ANODES

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High temperature solid state synthesis was used for preparation of LiFePO<sub>4</sub>/C composite material and cobalt doped LiFePO<sub>4</sub> composite material. Glycine assisted combustion method was involved as a carbon coating procedure. It uses glycine as a carbon precursor for conductive coating and connecting of active material nanoparticles. Two different samples were prepared and investigated – clear LiFePO<sub>4</sub>/C material and LiFePO<sub>4</sub>/C doped with 1% of cobalt. The aim of this work is to show how supervalent ions if cobalt influences parameters of cathode material. Electrochemical characterization by galvanostatic cycling, electrochemical impedance spectroscopy and rate capability was made and physical characterization by x-ray diffraction was provided.

#### Acknowledgment

This work was supported by the Ministry of Education. Project No. CZ.1.05/2.1.00/01.0014, and by Czech Science Foundation, project No. P102/11/2091.

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## IMPROVING LIFePO<sub>4</sub> CATHODE MATERIAL BY CONDUCTING PPY-MWCNTS COATING

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#### Abstract

A novel network composite cathode was prepared by mixing LiFePO<sub>4</sub> (LFP) particles with multiwalled carbon nanotubes. LFP particles were connected by multiwalled carbon nanotubes and polymer binder polypyrrole-polyethylene glycol (PPy-PEG) to form a three-dimensional network wiring. The surface morphology and thermal stability of LiFePO<sub>4</sub>-MWCNTs composite materials blended with PPy-PEG coating were investigated by scanning electron microscopy (SEM), thermogravimetric analysis (TGA) and pyrolysis capillary gas chromatography (Py-cGC). The smaller particle size and most homogeneous structure were observed for LFP-PPy-PEG-MWCNTs sample. Particles are homogeneous with average diameter 100 nm. Pyrolysis capillary gas chromatography measurements at 500 °C showed minimal thermal decomposition of organic species contained in cathode material. Our results proved that MWCNTs addition was an effective way to increase homogeneity and thermal stability of LFP-PPy-PEG-MWCNTs cathode material.

#### Aknowledgements

We acknowledge the financial support from DAAD (grant No. 03042007/SMS) and Slovak Grant Agency VEGA (grant No. 1/0043/08 and No. 1/0011/11).

## **NEGATIVE ELECTRODE OF LITHIUM SECONDARY CELLS**

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#### Abstract

This paper deals with study of the various carbon materials for negative electrode of lithium-ion accumulators. Advantage of Lithium is a great specific capacity 3860 Ah.g<sup>-1</sup>, however lithium have a lot of disadvantages, e.g. growing up dendrites and low lifetime of Lithium accumulators. Theses and other reasons was stopped using lithium for negative electrode, as a substitute can be considered carbonaceous materials.

Main differences between Lithium and Carbon materials are in cost, longer lifetime and especially in safety. The most often using materials are based on graphite. Our research investigated following kinds of graphite soots, natural graphite, expand graphite and CNT (Carbon Nano Tube) and were analyzed their propertis. Like the most appropriate material was evaluated oxidized expand graphite that allows higher current density along with minimal defects.

Further research should deal with oxidation time and temperature in CO<sub>2</sub> or O<sub>2</sub> atmosphere.

#### Acknowledgments

The investigations were supported by Czech Science Foundation, grant No. P102/11/2091, Center of Research and Utilization of Renewable Energy Sources CVVOZE project No.Cz.1.05./2.1.00/01.0014 and project MEB 111010, bilateral cooperation berween Czech republic and Argentina.

## EFFECT OF MULTIELEMENTS INTRODUCING INTO LDH STRUCTURE ON PERFORMANCE STABILITY OF ALPHA NICKEL HYDROXIDE

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#### Introduction

The paper relates to research focused on utilization of alpha nickel hydroxide in alkaline batteries and verifying of ways how make it stable in strong alkaline electrolyte. Reffered-to work was aimed at clarifying of reasons for its transformation tendency with the aim of finding proper inhibition method. Based on our former experience with an individual-element's doping, simultaneous incorporation of selected elements into brucite type lattice of nickel hydroxide appears to be suitable solution for fulfilment of the purpose.

#### Acknowledgements

This article was supported by the Ministry of Education, Youth and Sports, Czech Republic

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## EFFECTS OF ADDITION OF DIFFERENT CARBON-BASED COMPOSITE MATERIALS ON THE ELECTROCHEMICAL PROPERTIES OF A NICKEL HYDROXIDE ELECTRODE

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The electrochemical properties of the pasted nickel hydroxide electrode with different carbonbased composite materials additions were examined. The cobalt hydroxide composites were obtained by chemical impregnation of graphite flakes (KS 5-75 µm (Lonza)) and two types of multiwalled carbon nanotubes (MWNT with outer diameter 10 - 15 nm and MWNT with outer diameter 110 – 170 nm (Aldrich)) with cobalt hydroxide. The cobalt oxide composites were prepared by thermal treatment of mentioned cobalt hydroxide composites. The standard carbon materials were added to the active mass of positive electrode for comparison (Fig. 1). The electrochemical performance of electrodes with those additions was conducted to determine the best composition for the positive active mass of nickel-metal hydride batteries (Ni-MH). The electrochemical properties such as: specific capacity, charge efficiency, percentage of utilization and cycleability, were defined by: cyclic galvanostatic charge/discharge, cyclic voltammetry and electrochemical impedance spectroscopy methods, in a half-cell system. The electrochemical measurements were carried with a classical three-compartment glass cell, containing 6M KOH solution as electrolyte. The addition of MWNT (110-170 nm diameter) with Co<sub>x</sub>O<sub>y</sub> presented the best electrochemical properties such as chargeability, specific discharge capacity, active material utilization, discharge voltage and cycling stability (Fig. 2).

![](_page_30_Picture_7.jpeg)

**Fig. 1:** SEM images of: a) flake graphite 5-75 μm; b) flake graphite 5-75 μm + Co(OH)<sub>2</sub>; c) MWNT 10-15 nm; d) MWNT 10-15 nm + Co(OH)<sub>2</sub>.

![](_page_30_Figure_9.jpeg)

**Fig. 2:** Cycling stability of the nickel electrodes with addition of different carbon-based composite materials calculated on the mass of nickel hydroxide.

#### Acknowledgements

The authors acknowledge the financial support from the European Fund of Regional Development within the frameworks of the operating program –"Innovative Economy 2007–2013", under Project No. POIG.01.03.01-00-086/09.

## EFFECTS OF ADDING DIFFERENT QUANTITIES OF CARBON NANOTUBES ON THE ELECTROCHEMICAL PROPERTIES OF METAL HYDRIDE ELECTRODE

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The AB<sub>5</sub>-type alloy (with LaMmNi<sub>3.55</sub>Al<sub>0.3</sub>Mn<sub>0.4</sub>Co<sub>0.75</sub> formula) was examined to determine the influence of various quantities of carbon nanotubes additions on the structural parameters and the sorption of hydrogen. The multicomponent alloy of the mentioned formula was prepared in an arc furnace, in argon atmosphere, using the mixture of pure metals (with minimal purity of 99.5%) in proper atomic proportions. The electrode material was produced via cyclic hydrogen absorption/desorption, from gaseous phase. The metal hydride electrodes were prepared by mixing the alloy powder with addition of various quantities of carbon nanotubes with outer diameter of 110-170 nm (from 0 to 10 wt.% CNTs (Aldrich)) (Fig.1). To predict the electrochemical behaviour of the prepared alloys as negative electrodes for Ni-MH cells, the electrochemical pressurecomposition (EPC) isotherms were estimated from the rest potential of the alloy electrode. For preliminary assessment of practical use of the samples, the electrodes prepared from the alloy were subjected to charge/discharge measurements in a half-cell system, in 6M KOH solution as the electrolyte. The discharge capacities were estimated. The highest discharge capacities were presented by the electrode with addition of 10 wt.% CNTs (260 mAh/g), while the sample without any addition of CNTs, showed lower discharge capacities (160 mAh/g). The increase of capacity for these electrodes is parallel to the increase of the hydrogen concentration determined from EPC isotherms (Fig. 2).

![](_page_31_Picture_7.jpeg)

![](_page_31_Figure_8.jpeg)

Fig. 1: (left). SEM images of metal hydride electrode with addition CNTs.

*Fig. 2:* (right) Electrochemical pressure-composition isotherm for absorption and desorption of metal hydride electrodes with addition of different quantities of carbon nanotubes (CNTs).

#### Acknowledgements

The authors acknowledge the financial support from the European Fund of Regional Development within the frameworks of the operating program –"Innovative Economy 2007–2013", under Project No. POIG.01.03.01-00-086/09.

## INFLUENCE OF CARBON ON THE NEGATIVE ACTIVE MASS ON THE LIFE OF THE LEAD-ACID BATTERY

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#### Introduction

Much effort has been spent in the development of lead-acid batteries for various types of hybrid electric vehicles [1,2]. A probable mechanism of the action of carbon in the negative lead-acid battery electrodes, based on experiments and on thorough measurements including the active mass and contact resistances, has been proposed in our preceding publications [3,4]. Thus, it has turned out that the effect of carbon is due to steric hindrance of the sulphate crystallization rather than the electric conductivity of graphite. Our aim was to investigate what happens when the carbon concentration in the negative lead electrode is changed.

#### **Experimental, Results and Discussion, Conclusions**

We prepared six experimental electrodes with a discontinuous system of parallel ribs, pasted with negative active mass according to the common industrial method. Concentrations of its admixtures in the electrodes were chosen 0,15%, 0,46%, 0,78%, 1,4%, 2,65% and 5,15%. The process of formation consisted of 26 cycles, each consisting of charging with 0,2A for 4 h and stand for 2 h. The final voltage showed a distinct tendency to drop with increasing concentration of graphite. The rate of formation decreased with the rising carbon content. The cell capacity was then determined by one conditioning cycle, the cells were discharged to 50% capacity and cycled as follows: charging with 2A constant current for 25 s, 3 s stand, discharging with 2A constant current for 25 s, and 3 s stand. The last PSoC run was finished at a voltage drop below 1,5 V. In total, three PSoC runs were carried out. The electrode containing 0,78% graphite attained the longest cycle life. Maximum of the cycle life was at low graphite concentrations between 0,6 and 1,1%.

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## THE EFFECT OF MECHANICAL PRESSURE ON CYCLE LIFE OF LEAD-ACID ACCUMULATOR FOR HEV

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#### Introduction

We studied set of cells containing expanders and additives carbon and titanium dioxide. Cells were under compression and were subjected to PSoC accelerated cycling [1].

#### **Experimental, Results and Discussion, Conclusions**

We prepared six experimental electrodes with a discontinuous system of parallel ribs, pasted with a negative active mass according to the common industrial method with the pressures of 2, 4, and 6 N.cm<sup>-2</sup>. The initial capacity of the negative electrodes was around 3 Ah. Then cells were subjected to PSoC accelerated cycling by using symmetrical 25 s current pulses followed by 3 s stand. Cells containing expanders and additives (1% of milled N134 carbon or with 1% of titanium dioxide) were cycled by using 2,5 A current. During the experiment there were measured the contact resistance,  $R_k$ , and the active mass resistance  $R_m$ . Electrodes under test showed the best cycle life at a pressure close to 4 N.cm<sup>-2</sup>. Compression caused loss in porosity and hence loss in capacity, whereas expansion caused loss in mechanical strength of NAM. It is interesting to note that the same value of the optimum pressure was found in our previous study of lead-acid cells with electrodes without the present additives [2].

Accelerated PSoC cycling cells revealed that electrodes doped with carbon perform in the first PSoC run better cycle life than those doped with  $TiO_2$  since they reached about 30,000 cycles regardless of the applied pressure. Mechanical pressure of 4 N.cm<sup>-2</sup> has a pronounced favourable effect on the cycle life of negative electrodes with expanders in the accelerated PSoC regime. Higher pressures are not recommended.

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## IMPROVING OF THE NEGATIVE LEAD-ACID BATTERY ELECTRODES BY USING EXTRA ADDITIVES

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#### Introduction

In this study, the effects of additives on the negative electrode of lead-acid batteries have been measured mainly in partial state of charge. Many additives such as carbon particles or titanium dioxide particles etc. have been proposed to reactivate the deteriorated lead-acid batteries due to sulfatation although the working mechanism is not clear.

#### **Experimental, Results and Discussion, Conclusions**

We employed six experimental electrodes of specific dimensions pasted with negative active mass prepared according to the industrial recipe. One mass per cent of a special additives were added into each electrode. The complete electrode packs were inserted into cells that could be hermetically closed.

The cells were subjected to 23 formation cycles (consisting from 4 h charging at 0.2 A and 2 h stand). Our present results confirm our recent finding [1] that addition of carbon to the negative active mass causes an increase of the time of effective formation. Probably, the added material blocks some pores in the active mass thus interfering with the electrolyte transport. It is interesting that the time of formation increases with the decreasing particle size of the additive.

The electrodes were subjected to accelerated cycling in the hermetic state and the cell voltage measured in every discharge half-cycle was plotted against the cycle number.

The positive effect of carbon and titanium-dioxide additives on the cycling life of electrodes is evident, whereby the electrode with carbon additives has in the course of the first PSoC run better properties than the electrode with  $TiO_2$ .

After finishing first PSoC run, the cells were subjected to several refreshing cycles and the second run was started. The positive effect of both carbon and titanium dioxide additives on the electrode cycling life is evident, whereby in the second PSoC run the electrode with carbon additive does not feature a markedly better performance that the electrode with the  $TiO_2$  additive. It seems that the cycle life of the electrodes shows some correlation with the rate of attainment of the second charging step in refreshing cycles.

#### Acknowledgements

This work was supported by the EU project CZ.1.05/2.1.00/01.0014 and by the specific graduate research of the Brno University of Technology No. FEKT–S–11–7.

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## NICKEL HYDROXIDE PREPARED IN VARIOUS CONCENTRATION

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#### Introduction

Nickel hydroxide is the basic material for positive electrode of alkaline accumulators as Ni-Cd, Ni-MH and Ni-Fe. The three modifications of nickel hydroxide are known, these are alpha, beta and gama.

Nickel hydroxide can be prepared by mixing of Nickel salt and Hydroxide as KOH or NaOH. Other way of preparing Nickel hydroxide is electrochemical deposition from Nickel nitrate.

#### Experimental, Results and Discussion, Conclusions

Thin layers of Nickel hydroxide were prepared by electrodeposition from Nickel nitrate. The concentration of solution was  $0,1M - 2M \operatorname{Ni}(\operatorname{NO}_3)_2$  in  $H_2O$ . The samples were measured in 6M KOH solution with by cyclic voltammetry for 150 cycles. Scan rate 10 mV/s, potential window 0-600 mV to Hg/HgO reference electrode.

The best capacity was measured on Nickel hydroxide layer prepared from 0,2M Ni(NO<sub>3</sub>)<sub>2</sub>. Higher concentrations made more Beta modification in Nickel hydroxide structure and the measured capacity were lower. For Preparation of Alpha nickel hydroxide by electrodeposition from nickel nitrate is necessary to use low concentration of solution, maximally 0,2M Ni(NO<sub>3</sub>)<sub>2</sub> in H<sub>2</sub>O

#### Acknowledgements

The investigations were supported by Ministry of Education of Czech Republic, Project MSM0021630516

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## SEPARATORS FOR ALKALINE ACCUMULATORS

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Separators play a key role in all batteries and accumulators. Their main function is to prevent electrical short circuits between positive and negative electrodes while permitting free ion flow necessary to complete the circuit between electrodes. Separators don't participate in battery reactions, but structure and properties considerably affect the battery performance, including the energy and power densities, cycle life and safety.

Our work deals with commercial microporous separators, several types of woven and non-woven fabrics suitable for alkaline accumulators. Electronic insulating properties, electrolyte (ionic) conductivity and chemical resistance were examined.

#### Acknowledgements

This work was supported by the grant FEKT-S-11-7 and the project CVVOZE CZ.1.05/2.1.00/01.0014.

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## CONCENTRATOR PHOTOVOLTAIC SYSTEMS

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#### Abstact

This paper deals with experimental concentrator photovoltaic system build in cooperation with Solartec s.r.o. company. The system is used to test hypotheses and study the behavior during its operation. The aim is to measure concentration ratio, temperature and electrical characteristics and to compare advantages of active and passive cooling of photovoltaic cells.

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## SPECTRAL DEPENDENCE OF LUMINESCENCE OF SOLAR CELLS

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#### Introduction

This study is focused on new possibilities with luminescence of solar cells. Basic principles of luminescence as a tool in defining quality are already known. It is necessary to improve testing methods for better analyzing defects during cells production. Electroluminescence method is one of the favorite diagnostic tools. It is based on using forward voltage connected to solar cell. In dark box as a workplace it is possible to see current density as darker and lighter areas. This radiation from luminescence is highly dependence on current going through the cell. But in experimental measurements was observed that the radiation has a wide range and depends on the degree of luminescence solar cell. From the spectral analysis luminescence it is possible to better indentify individual defects in whole area of the cell. For spectral analyzing it is use the Linear Array Spectrometer, type VS140. It can work with spectral range from UV trough visible light to infrared area. Data obtained from spectral analysis are comparing with results from Matlab software, used to define the total brightness of the final image from CCD camera used for first analyze the solar cell. With this new approach to the testing method we can better improve produce of solar cells and reduce counts of defects.

#### Acknowledgements

This paper is based on the research supported by the Grant Agency of the Czech Republic, grant No. 102/09/0859, Internal Grant of University of Technology No. FEKT-J-11-3/1363 and FEKT-S-11-7.

## **MEASURE APPARATUS FOR HYDROGEN ENERGY STORAGE**

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#### Introduction

Environmental changes and global warming are most discussed topics nowadays. Main causes therefore should be solved at this century. Renewable sources are probably the right way out from today's problems. Hydrogen storage is a promising option for future storage of large amounts of energy [1].

#### **Experimental, Results and Discussion, Conclusions**

New measure apparatus is built within FRVŠ grant. Main aim of it is to measure efficiency of electric energy first stored in a form of hydrogen gas and then changed back to electric energy and used in resistor load. Measure apparatus consists of solar panel or power source, electrolyser, hydrogen storage, fuel cell and resistor load.

There are two devices used to measure voltage and current (power) going to and from system and computer to record measured data. Hardware is controlled by program written in Agilent VEE Pro 8.0, that is object programming language.

Students attending subject "Renewable power sources" will have chance to familiarize themselves with functioning of solar panel, electrolyser and fuel cell. Practical approach should make students to be interested in this topic in the future.

#### Acknowledgements

This work was supported by the EU project CZ.1.05/2.1.00/01.0014 and by FRVŠ project 31228.

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## SURFACE DIAGNOSTIC OF ELECTRODES USED IN ELECTROCHEMICAL POWER SOURCE

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#### Abstract

The electrochemical power sources based on the Ni - Zn system have good electrical properties. They are highly recyclable and represent a promising replacement for the Ni - Cd accumulators. The commercial deployment of the Ni - Zn batteries is limited due to their short lifetime caused by the Zn electrode degradation in the KOH electrolyte. The degradation of Ni-Zn electrodes during overcharging processes have impact on the shape changes of the Zn electrode and formation of dendrites, which can lead to the short - circuits of the cell and destroy its effectiveness. The lifetime of the Ni - Zn batteries can be improved by suppressing formation of the zinc dendrites with using additives in the active mass of the zinc by modification of the electrolyte, which improve morphology of the zinc electrode during the recharging as well as by usage of the separators. [1]

This work deals with diagnostics of the influence of the aging process on the surface morphology of the zinc electrodes. Scanning electron microscopy and atomic force microscopy as the diagnostics methods were used.

The technique of the scanning electron microscopy (SEM) allows studying topography and material composition of a wide range of the samples by detection of the signal electrons emitted from the surface during interaction between focused beam of primary electrons and sample. Atomic Force Microscope (AFM) works with a special scanning tip on or above the sample surface. For the sample surface diagnose of the zinc electrode in AFM, the contactless acoustic AC mode (AAC) was used.

#### Acknowledgements

This work was supported by the project no. FEKT-J-11-3/1363, project no. FEKT-S-11-7 and by project CVVOZE CZ.1.05/2.1.00/01.0014.

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## EFFECT OF ENVIRONMENTAL TEMPERATURE ON THE BRITTLE-FRACTURE CHARACTERISTICS UNDER DYNAMIC LOADING AND ASSESSMENT OF DEFORMATION ON LOW-ALLOY STEEL DEVICES USED IN CONTAINERIZATION

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#### Abstract

This paper examines the influence of test temperatures, which lead to deformation of brittlefracture characteristics under dynamic loading of extra-hard low-alloyed steel ARMOX 500T and ARMOX 600T. For the analysis of effects on fracture surfaces a fractographic analysis was used. Temperatures for the experimental investigation were in the temperature range of -80 °C to +100 °C.

Dynamic fracture toughness is a characteristic of steel resistance to brittle deformation initiation under dynamic loading conditions. The examination of the possible formation of degradation processes leading to the onset of a marginal status in ultra-low-alloy steel, meant the implementation of experimental measuring of brittle-fracture-dynamic characteristics of fracture toughness in the temperature range -80 °C to +100 °C, which corresponds to the operating temperatures, to which this type of material is exposed. The basis of the tests was to determine dynamic fracture toughness under impact-loading of samples until failure occurred [1, 2]. In the specimen under a cyclic pulsating load, with the coefficient of asymmetry of the oscillations in the range of C = 0.1 - 0.25, there occurred at the root of a notch a fatigue crack by using a highfrequency pulsator RUMUL Cracktronic 8204 with the following parameters: a dynamic bending moment of up to ±35 Nm, static torque of up to 35 Nm, bending moment of up to 70 Nm max. The sample was loaded by degrees using less torgue and the cycle was terminated at such a low load in order to achieve the required number of cycles and crack length. During the cycling experiment the cycle asymmetry coefficient R = 0.1 (ratio of upper and lower  $\sigma$ ), the nominal voltage  $\sigma_{0,nom} = 6M/B (W - a)^2$  was utilised. Loading declined gradually from the momentum of M = 22 Nm up to M = 5.6 Nm. The total length of the crack (including the notch) had to be such that the ratio of crack length a to the height of the specimen W ranged from a/W = 0.45 to 0.55.

#### Acknowledgements

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## THERMO-MECHANICAL SIMULATION OF SOLID MICROBATTERIES

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#### Introduction

Micro-batteries are gaining a lot of interest in recent times due to their size and efficiency. Several issues related to thermal management and life duration do however remain unaddressed. This paper introduces an innovative 3D modelling technique to capture the electrochemistry of the battery and related heat dissipation.

#### **Results and Discussion**

Validation work was pursued to ensure the validity of the numerical algorithms. The Lithium ion diffusion in solid state electrodes and separator as well as in liquid electrolyte batteries is modelled. The electrochemistry is resolved using the Bulter-Volmer equation. State of charge and property changes proportional to Li+ concentration distribution in all regions of the battery are described to provide reliable predictions about battery hysteresis.

#### Conclusions

Comparisons with experiments will be presenting showing that numerical models are sufficiently reliable offering a reliable platform for 3D modelling. Preliminary results showing heat dissipation will also be presented; validation work is still ongoing and might be available by the time this paper is published.

#### Keywords

Electro-chemistry, simulation, micro-battery, solid state battery, Butler Volmer, Hysteresis, Heat dissipation

## ANALYSIS OF THE CONDITIONS OF SURFACE ROUGHNESS MEASUREMENTS ON STRATIFIED SURFACES BY OPTICAL AND INDUCTIVE METHODS

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#### Abstract

The article describes the conditions of surface roughness measurements by optical and inductive methods and the use of instruments for measuring profile and surface topography. It is a reference to their analysis and analysis of the influence of changes in the measurement conditions on the surface roughness parameters in 2D and 3D methods of surface texture measurements.

Surface quality control uses specific measuring instruments and it is clear that the development of measurement technologies not only increases the technical level of existing instruments, but also introduces new measurement systems. One of the present trends in measurement technologies is focused on introducing non-contact optical methods for surface quality measurement. The second trend of surface metrology is focused on wider use of the space measurement, called 3D topography, which provides a more description of the surface.

Measurements were carried out on the stratified surface (surface formed as a result of two consecutive technological operations, for example by grinding and polishing or coating) [1]. Base influents of measurement conditions on surface roughness parameters of contact and non-contact methods are showed in [2]. The conditions can be selected by operator as well as measurement instrument and evaluation method of optical and inductive profilometer.

The effect of spacing of scanning data on surface roughness is practically analyzed by using the parameters SaR, SaP, Ra, RSm a PSm [3]. The spacing of scanning data has a significant influent on the parameters RSm and PSm, but a less influent on the parameters Sa and Ra. According to the type of instrument the spacing of scanning data also affects measurement time and data set size for processing and evaluating the parameters.

#### Acknowledgements

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## ACCUMULATORE MASS OBSERVATION IN ESEM

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#### Abstract

The presence of gases in ESEM or vapors enables observation of moisture or of water containing specimens, phase interfaces etc [1]. Another great advantage is, regarding the effectiveness of ionization of  $H_2O$  by electrons, a considerable amplification of signal level obtained by ionization detector (which is used most frequently at ESEM) in the environment of water vapors, We observed the structures of accumulator mass in our microscope.

#### Acknowledgment

This work was supported by the grant projects GA CR 102/05/0886 and SM 0021630516.

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## PRODUCTION OF BATTERIES LiFePO₄ FOR ELECTRIC VEHICLES AND ACCUMULATION SYSTEMS

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Our company have been looking into research and development of batteries for six years. We focus on batteries which are intended for electric vehicles and accumulation resources. System based on the material LiFePO4 seems to be promising taking into account the demands on the life and safety.

Initial experiment was runing without necessary equipment, but even so we managed to produce functional patterns. After this partial succes, we began to solve the necessary machinery. At present we have a complete manufacturing line and we have everything prepar for start with small series production.

Our final mission on which we work before commercial sale, is to finalize the necessary legislation and certification.

![](_page_45_Picture_9.jpeg)

Fig. 1: Stacking machine

## BATTERY MONITORING SYSTEM FOR THE AIRPLANE VUT 051 RAY

Klima, B.<sup>1</sup>, Hutak, P.<sup>1</sup>, <u>Cipin, R.<sup>1</sup></u>, Knobloch, J.<sup>1</sup>, Nouman, Z.<sup>1</sup>, Vondrus, J.<sup>1</sup>

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#### Introduction

This paper deals with the battery monitoring system for the airplane VUT 051 RAY. This monitoring system contains several blocks which take complex care of the lithium ion battery pack operation used in the airplane. It also contains balancing circuit which ensures uniform distribution of voltage on the individual batteries, it prevents overcharging and discharging below allowed limit. Balancing system operates in two different modes – charging mode, and discharging mode. The monitoring system measures voltage and temperature of each cell of battery pack (serial-parallel combination). Each monitoring device has its own processor and serial flash memory for the subsequent data processing at superior unit. The communication with superior unit is done by the CAN bus.

#### **Experimental, Results and Discussion, Conclusions**

In this time, the battery monitoring system is putting into operation. All important measurements will be done. And operation of the system will be verified.

#### Acknowledgements

This work was solved in the frame of the faculty project FEKT-S-11-14 "Utilization of new technologies in the power electronics"; of the project MSM 0021630516 "Power sources, accumulation, and optimization of the energy utilization"; and of project MPO FR-TI1/061 "Application of VUT 001 Marabu for hydrogen fuel cells propulsion".

- Yuang-Shung, L.; Ming-Wang, Ch. Intelligent control battery equalization for series connected lithium-ion battery strings. IEEE Transactions on Industrial Electronics, 2005, vol. 52, no. 5, p. 1294-1307. ISSN: 1 0278-0046.
- [2] Cadar, D.V.; Petreus, D.M.; Orian, C.A. A method of determining a lithium-ion battery's state of charge. 5th International Symposium for Design and Technology of Electronics Packages, 2009, p. 257-260. ISBN 978-1-4244-5132-6.

## **BATTERY SYSTEM OF ELECTRIC AIRPLANE VUT 051 RAY**

Klíma, B.<sup>1</sup>, Červinka, D.<sup>1</sup>, <u>Pazdera, I.<sup>1</sup></u>, Píštěk, A.<sup>2</sup>, Hlinka, J.<sup>2</sup>

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#### Introduction

The paper deals with an accumulator for experimental fully electric airplane VUT051RAY with rated power 55kW. The preliminary requirements on accumulator capacity and its weight were defined according to a precisely specified flight profile.

#### **Experimental, Results and Discussion, Conclusions**

After assuming of all accumulator types available on the market the Panasonic NCR-18650A Li-Ion accumulators were chosen. These accumulators have most advantageous capacity/weight ratio. But they have higher internal resistance in comparison with the other types of accumulators.

Individual cells are serial-parallel connected to the battery with nominal voltage approx. 330V and capacity approx. 100Ah (90cells in series and 34cells parallel). The voltage and temperature of every single cell is measured. These critical data are collected via quick system of multiplexers and transmitted to a central unit. The central unit provides the diagnostic and displays important operating data to the pilot. On board installation of the batteries is a very complex and interdisciplinary issue. There are a lot of demands put on mechanical connections of the batteries due to expected vibrations and due to other specific issues in aviation technics.

#### Acknowledgements

This research has been supported by the ENIAC project CA-E3Car-2008-120001 E3CAR - Nanoelectronics for an Energy Efficient Electrical Car and by the faculty project FEKT-S-11-14 Utilization of new technologies in the power electronics.

- [1] P. Vorel, D. Červinka, I. Pazdera: Practical experience with Li-Ion traction accumulator in an electric bike. Proceedins of 11<sup>th</sup> ABAF Brno 2010, 26-27.
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## **DESIGN OF ELECTRIC PROPULSION SYSTEM FOR A RACING CAR**

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#### Introduction

The paper deals with a description of design procedure used in construction of pure electric vehicle based on the frame of the well-known Formula Student race car. The functional principles of electric vehicles and the main parts of the electric drive system are described. Optimal system components are proposed according to computed values of drive drags to meet required performance criteria. The whole concept of electric formula race car is verified by simulations, where basic performance parameters of the electric formula are calculated.

#### Tractive System of the Formula Race Car

An automotive power train consists of a power plant (electric motors), energy source (batteries), transmission (final gear), differential, drive shafts and driven wheels [1]. Tractive system of the Formula Student Electric race car designed by Stuba Green Team consists of high voltage and low voltage part. The system operates at alternating current -AC voltage, so it is needed to use inverter. The electric motor converts the electric energy into mechanical energy to propel the vehicle, or, vice versa, to enable regenerative braking. Brusa hybrid synchronous motor was chosen as tractive motor and EWT high power Li-Polymer accumulator cells were chosen as energy supply. The system have to be designed with respect to high safety [2].

#### Acknowledgements

The paper was prepared with support of the Internal grant of STU in Bratislava within the Programme for Support of Young Researchers, name of the Project: Podpora modelovania a simulácií alternatívnych energetických zdrojov v mechatronických systémoch. Authors of the paper would also like to thank to the sponsors and partners of the Stuba Green Team for their support. All the support is gratefully acknowledged.

- P. Benkovský, V. Staňák: Implementation of Electric Propulsion in Small Race Car; in: ELITECH'10 12th Conference of Doctoral Students, FEI STU Bratislava, (2010) CD-rom. ISBN 978-80-227-3303-8.
- [2] Formula Student Electric 2011 rules : http://www.formulastudentelectric.de/uploads/media/FSE\_Rules\_2011\_v1.1.0.pdf

## **POWERFUL FAST CHARGER 16KW FOR ELECTRIC VEHICLE**

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#### Introduction

This contribution describes a development of a fast charger. Useful modular conception of the power part was chosen. The modules can be serial-parallel reconfigured - for various battery voltage levels. Single-module output parameters are 160V/16kW. The charger is based on a DC/DC transistor converter using CoolMOS transistors and SiC diodes. A non-usual topology of the power circuit, especially construction of power pulse transformers and output choke coils is performed. Now this circuitry is designed (first version), realized and it is just tested. High switching frequency is used at the large output power (80kHz -16kW). This way the dimensions of the device are minimised.

#### **Experimental, Results and Discussion, Conclusions**

1	Output (charging) current	100A
U	Output voltage	160V
Ρ	Output power	16kW
<b>U</b> <sub>in</sub>	Input AC RMS voltage	3x400V
f	Switching frequency	80kHz
т	Mass	ca 15kg

All important measurements must be done. A fully new digital control circuitry instead of the simple analogue solution must be created. Some EMI problems of the power circuit and EMS problems of the control circuits must be solved. Implementation of over-current and other protections is necessary. Then a redesign of the power circuit is necessary (especially the mechanical construction, PCBs etc.).

#### Acknowledgements

This research has been supported by the ENIAC project CA-E3Car-2008-120001 E3CAR - Nanoelectronics for an Energy Efficient Electrical Car and by the faculty project FEKT-S-11-14 Utilization of new technologies in the power electronics.

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 KUZDAS, J.; VOREL, P. Rychlonabíječka trakčních akumulátoru s novými polovodičovými prvky. Elektrorevue - Internetový časopis (http://www.elektrorevue.cz), 2011, roč. 2011, č. 20, s. 1-4. ISSN: 1213- 1539.

## INFORMATION ABOUT THE ELECTROCHEMICAL SOCIETY

![](_page_50_Picture_1.jpeg)

#### Introduction

ABAF 2011 is co-sponsored by the Electrochemical Society, Inc (ECS). ECS was founded in 1902 as an international nonprofit, educational organization concerned with a broad range of phenomena relating to electrochemical and solid-state science and technology.

The Electrochemical Society has over 9,000 member scientists and engineers in over 75 countries worldwide, as well as roughly 100 corporations and laboratories, which hold corporate membership. ECS objectives are:

- to advance the theory and practice of electrochemistry, solid-state science, and allied subjects;
- to encourage research and dissemination of knowledge in these fields;
- and to assure the availability of adequate training and education of fundamental and applied scientists and engineers in these fields.

First founded as the American Electrochemical Society in 1902, the name of the Society was changed to The Electrochemical Society already in 1930 to more accurately reflect its international activities and membership. Presently, more than 50 % of members reside outside USA. ECS has grown and continued to respond to the changing technical needs and interests of its members; and in 2000, adopted the official acronym of ECS. The tag-line name of ECS is "The society for solid-state and electrochemical science and technology," encompassing its long tradition to advance these fields. ECS continues to disseminate information through individual membership, corporate membership, student services, technical journals, a quarterly news magazine, books, technical meetings, and awards; and to provide networking contacts through ECS thirteen Divisions. Geographically, members can also associate with Sections. For example, most members in Europe are members of the European Section.

ECS bridges the gaps among academia, research, and engineering—bringing together scientists from around the world for the exchange of technical information. This unique blend provides an unparalleled forum for the integration of these areas of science and technology. The ECS staff can provide support to you in learning more about ECS and its many activities.

The Society actively recruits students and gives them the opportunity to get organized in student chapters. One of the active chapters is also in Brno, the site of this year's ABAF meeting. Student membership can be obtained at significant discount.

ECS maintains digital library of its collection of publication. Access to the library, with certain number of downloads, is part of the membership benefits package. Full information can be obtained at www.electrochem.org.

(contributed by Petr Vanýsek, pvanysek@niu.edu)

![](_page_51_Picture_0.jpeg)

Bochemie Group is a leading Central European manufacturer of branded household products and owner of SAVO label and other brand labels. On a global scale it is a successful manufacturer of specialty chemicals for market niches.

![](_page_51_Picture_2.jpeg)

Bochemie has been developing its know-how for more than 100 years. Management team privatized the company in 1994 and in mid-1990's created Bochemie Group which was sold to Benson Oak Capital. At the end of 2007 Bochemie s.r.o. mergered with acquisition vehicle Bochemie a.s. The group headquarter is located in the Czech Republic, the branches are in the Slovak Republic, Poland, Hungary,

Bulgaria, Romania and Russia.

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- SBU FUNGI range of fungicidal and insecticidal products for wood protection and masonry
- **SBU ACCU** various products for Ni-Cd and Ni-Fe accumulators, perforated bands, accumulator massses and electrodes
- **SBU Feropur** production of Feropur, a unique chemical for pre-pickling of the stainless steel long products (wire rod, bars)

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**SBU Green projects** – developing new strategic competences in the area of green economy and focusing on: recycling, new materials and new technology.

Bochemie is seeking projects in diverse areas of "GREEN ECONOMY"

- Green buildings
- Green transportation
- ➢ Green energy
- > Agriculture, Forestry, Water Management, Air pollution and others

![](_page_51_Picture_18.jpeg)

www.bochemie.cz www.savo.eu

Bochemie a.s., Lidická 326, 735 95 Bohumín Tel: 596 091 111, e-mail: bochemie@bochemie.cz

## AFM mikroskopie Agilent Technologies

![](_page_52_Picture_1.jpeg)

Technologie AFM/SPM mikroskopů umožňuje zobrazování v atomárním měřítku s rozlišením až na desetiny nanometrů. Zásadní výhodou těchto mikroskopů je, že vzorky lze zobrazovat v libovolných podmínkách. Je možné měřit při různých teplotách nebo i přímo v kapalinách. Konstrukce AFM mikroskopů Agilent umožňuje přímý optický přístup ke vzorkům - mikroskopy jsou vybaveny videokamerou. AFM/SPM systémy Agilent jsou používány v celé řadě oborů jako jsou například:

- výzkum a vývoj materiálů
- mikroelektronika
- nanolitografie
- aplikace s polymery
- biotechnologie
- medicína

Základním principem je snímání povrchu miniaturním hrotem, který měří konkrétní vlastnosti povrchu. Vyhodnocovací jednotka měří signál z fotodetektoru dle polohy hrotu. Držáky snímacích hrotů (tzv. nose cone) urychlují a zjednodušují změny zobrazovacích režimů. Modulární koncepce přístrojů umožňuje rozšířit schopnosti mikroskopického systému dle aktuálních potřeb.

![](_page_52_Picture_11.jpeg)

Společnost H TEST a.s. je výhradním distributorem Nanomeasurement Division Agilent Technologies, která zahrnuje AFM a SEM mikroskopii.

![](_page_52_Picture_13.jpeg)

H TEST a.s. Šafránkova 3 155 00 Praha 5 Tel: 235 365 207 info@htest.cz www.agilent.com/find/nano

![](_page_52_Picture_15.jpeg)

Agilent Technologies

-Authorized Distributor

## www.maxwell.com

![](_page_53_Picture_1.jpeg)

## Vlastnosti

# Superkondenzátory

- Velký výkon v celém rozsahu pracovních teplot
- Široký rozsah pracovních teplot -40°C to +65°C
- Počet pracovních cyklů až 1 000 000
- Dlouhá životnost mín.10 let
- Dlouhodobě jednoduše předvídatelné chování
- Netoxické

Vlastnost	Řada PC	Řada HC	Řada D	Řada K2
Pouzdro	Antonional astronomy Methodology astronom	S. MARTIN	Manmen	Manager
Napětí	2,5 V	2,7 V	2,7 V	2,7 V
Kapacita	10 F	5 – 150 F	310 – 350 F	650 – 3000 F
Hmotnost	6,3 g	2,2 – 35 g	62 – 63 g	200 – 550 g
ESR	180 m $\Omega$	$14-200~\mathrm{m}\Omega$	$2,2-3,2~\mathrm{m}\Omega$	$0,8-0,29~\mathrm{m}\Omega$
Zbytkový proud	0,04 mA	0,015 – 0,5 mA	0,3 – 0,45 mA	1,5 – 5,2 mA

![](_page_53_Picture_11.jpeg)

Modul pro vozidla 63F / 125V

Modul pro výkonové UPS 130F / 56V

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![](_page_53_Picture_17.jpeg)

![](_page_54_Picture_0.jpeg)

![](_page_54_Picture_1.jpeg)

Rukavicové boxy

![](_page_54_Picture_3.jpeg)

Vývěvy a vakuové systémy

Vakuové napařovací a naprašovací aparatury

## Hledače netěsností

Nanášení monomolekulárních vrstev (metoda Langmuir-Blodgett)

252 10 Mníšek p. Brdy Lhotecká 594 Tel.: 318 599 08 EDWARDS

![](_page_54_Picture_10.jpeg)

![](_page_54_Picture_11.jpeg)

![](_page_54_Picture_12.jpeg)

634 00 Brno Plachty 2 Tel.: 547 246 683

info@chromspec.cz www.chromspec.cz

![](_page_55_Picture_0.jpeg)

#### Historie

Společnost Mart s.r.o. byla založena v roce 1997. Začínala jako výrobce vzduchotechnického potrubí se sídlem v Hodoníně. V následujících letech společnost dynamicky rozšiřovala své výrobní kapacity i portfolio výrobků. V roce 2001 zahájila činnost i v oblasti instalací vzduchotechnických systémů.

#### Současnost

Společnost Mart je rozdělena na dvě základní části – výroba vzduchotechnických prvků a instalace vzduchotechnických systémů. Společnost se zabývá také výrobou prvků na zakázku. Samozřejmou součástí je i výroba prvků do velmi čistých a zdravotně sterilních prostředí či pro různé architektonické potřeby..

V současné době je Mart předním evropským producentem vzduchotechnického potrubí a příslušenství. Měsíčně vyrobí společnost více než 40 000 m2 čtyřhranného potrubí.

Naše výrobní závody jsou vybaveny nejmodernější technologií, umožňující zákazníkům nabídnout široké portfolio výrobků a služeb. Tyto technologie jsou pravidelně modernizovány a doplňovány, dle požadavků trhu. Společnost Mart se zapojila také do projektů EU pro modernizaci technologií pro výrobu. Výrobní pobočky naleznete v Praze, Hodoníně a Bratislavě. Na stejných místech naleznete dobře vybavené velkoobchodní sklady k okamžitému odběru zboží. Obsluhovat Vás budou profesionálové, kteří Vám rádi pomohou a poradí s Vašimi případnými dotazy.

Aktuálně využíváme 4 250 m2 výrobních ploch a 11 300 m2 skladovacích ploch, zaměstnáváme více než 160 zaměstnanců. Svým významem a velikostí patříme k nejvýznamnějším firmám nejen na Hodonínsku. Společnost si své postavení uvědomuje a snaží se podpořit spoustu zajímavých seskupení, např. mistryně ČR ve stolním tenise, klub SKST Hodonín.

Společnost Mart exportuje přibližně 50 % své produkce do zahraničí.

Divize Realizace dnes nabízí komplexní služby v oblasti dodávek systémů vzduchotechnika, chlazení, topení, MaR, a to pro všechny druhy a rozsahy projektů. Projekty jsou realizovány vlastními kvalifikovanými zaměstnanci s důrazem na přípravu projektu a kvalifikované projektové řízení.

Divize Realizace se orientuje výhradně na český, popř. slovenský trh.

#### Vize:

Společnost Mart s.r.o. si klade několik jednoznačných cílů:

- finančně zdravá firma, s dostatečným počtem zákazníků a přidanou hodnotou v našich produktech,
- profesionální přístup všech zaměstnanců na všech pozicích,
- upevňování a zlepšování pozice na trhu,
- rozšiřování výrobních kapacit,
- rozvoj a vývoj produktů, který přinese užitek našim zákazníkům.

Společnost se snaží svou činností také motivovat a stimulovat zaměstnance k co nejlepším a nejpřesnějším výsledkům. Velkou roli Mart s.r.o. přikládá také svému sociálnímu postavení v Hodoníně a blízkém okolí.

Title:	Advanced Batteries Accumulators and Fuel Cells – 12 <sup>th</sup> ABAF
Edited:	Jiří Vondrák Vítězslav Novák Petr Bača
Publishing Office:	Vítězslav Novák Petr Bača
Deadline:	August 15 <sup>th</sup> 2011
Publisher:	Brno University of Technology Faculty of Electrical Engineering and Communication Department of Electrotechnology
Press: Year:	Tribun EU s.r.o., Cejl 892/32, Brno 602 00 2011
Number of Copies:	85

The autors are fully responsible for the content and language of their contribution

## ISBN 978-80-214-4310-5