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Book of Abstracts

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Code	Title
0170	A PDMS BASED 3 OMEGA SENSOR FOR THERMAL CHARACTERIZATION OF POLYMER COMPOSITES WITH CARBON FIBER OH, DONG-WOOK
0178	PREPARATION OF SILICON@ POROUS CARBON COMPOSITES BY DIFFERENT CARBON SOURCES FOR LITHIUM BATTERY ANODES FU, DONGJU - MIN, JIE - ZHANG, WEILI - CHEN, JIANJUN
0179	DEVELOPING OF COMPOSITE FROM BIOMASS-DERIVED ACTIVATED CARBONS WITH CARBON NANOTUBES FOR ELECTROCHEMICAL ELECTRODES TEMIRGALIYEVA, TOLGANAY - KUZUHARA, SOKI - NODA, SUGURU - NAZHIPKYZY, MERUYERT - MANSUROV, ZULKHAIR - LESBAYEV, BAKHYTZHAN - PRIKHODKO, NIKOLAY
0180	PREPARATION OF MESOCARBON MICROBEADS/SHORT CARBON FIBER COMPOSITES DERIVED FROM DIFFERENT SIZED MESOCARBON MICROBEADS IM, UISU - LEE, BYUNG-ROK - PECK, DONG-HYUN - JUNG, DOOHWAN
0184	NANOPOROUS CARBON COMPOSITES – SYNTHESES AND CHARACTERISTICS GAWDZIK, BARBARA - SOBIESIAK, MAGDALENA - PODKOŚCIELNA, BEATA - PODDUBNAYA, OLGA I. - PUZIY, ALEXANDER
0187	THEROMCHEMICAL CONVERSIONS OF DVB-MA-TMVS TERPOLYMERS DURING THEIR CARBONIZATION PROCESS SOBIESIAK, MAGDALENA - GAWDZIK, BARBARA - PODKOŚCIELNA, BEATA - PODDUBNAYA, OLGA I. - PUZIY, ALEXANDER
0196	IMPACT OF PRIMARY AND SECONDARY BEADS OF CARBON ENTEROSORBENT ON EPR PARAMETERS OF RATS WITH CYTOSTATIC NEUTROPENIA SNEZHKOVA, ELISAVETA - PYATCHANINA, TETIANA - BURLAKA, ANATOLIY - NIKOLAEV, VOLODYMYR - MAZUR, MARIA - KOZYNCHENKO, OLEKSANDR - SHEVCHUK, OKSANA
0199	SHRINKAGE MINIMIZATION IN ORGANIC GELS OBTAINED BY MICROWAVE HEATING CANAL-RODRÍGUEZ, MARIA - VILLANUEVA, SARA F. - MONTES-MORAN, MIGUEL - MENÉNDEZ, J. ANGEL - ARENILLAS, ANA
0200	COMPARATIVE EVALUATION OF TWO FORMULATIONS OF ACTIVATED CARBON USED AS ENTEROSORBENTS IN THE TREATMENT OF EXPERIMENTAL LIVER KOZYNCHENKO, OLEKSANDR - SNEZHKOVA, ELISAVETA - T.V., DATSKO - NIKOLAEV, VOLODYMYR - SYDORENKO, OLEKSIY - BARDAKHIVSKA, KVITOSLAVA - MAZUR, MARIA - L.A, Sakhno
0202	BIOPHYSICAL STUDY OF THE EFFECTIVENESS OF TWO FORMULATIONS OF NANO/MACROPOROUS CARBON ENTEROSORBENTS IN THE TREATMENT OF EXPE KOZYNCHENKO, OLEKSANDR - SARNATSKAYA, VERONIKA - PROKOPENKO, IGOR - YUSHKO, LARYSA - SIDORENKO, ALEXEI - MASLENNY, VITALY - NIKOLAEV, VLADIMIR
0207	ION SELECTIVE SUBNANOMETER SIZED NANOWINDOWS OF SINGLE WALL CARBON NANOHORNS TANIGAKI, NAOTO - MURATA, KATSUYUKI - HAYASHI, TAKUYA - KANEKO, KATSUMI
0211	G-C3N4/CARBON COMPOSITES FOR LITHIUM-SULFUR BATTERIES ZHANG, HAN - ZHAO, ZONGBIN - HOU, YANAN - ZHANG, ZHICHAO - WANG, XUZHEN - QIU, JIESHAN
0214	SIMULTANEOUS TAGGING AND ENHANCEMENT OF CARBON FIBER/EPOXY INTERFACE BY UPCONVERSION LUMINESCENT NANOPARTICLES LIU, DAWEI - LI, GANG - YANG, XIAOPING
0216	ADSORPTION OF CO2 ON N-ENRICHED POROUS CARBON DERIVED FROM CROSSLINKED POLYETHYLENEIMINE SPHERE CHEN, SHUIXIE - LIU, FENGLEI - SUN, PENG
0219	PRIMARY AND SECONDARY BEADS OF CARBON ENTEROSORBENT AND OXIDATIVE STRESS' INDICES IN MELPHALAN SINGLE INJECTION SNEZHKOVA, ELISAVETA - SHEVCHUK, OKSANA - MIKHAILENKO, VIKTOR - GLAVIN, ALEXEI - MAKOVETSKA, LYUDMILA - BARDAKHIVSKA, KVITOSLAVA - NIKOLAEV, VOLODYMYR - SARNATSKAYA, VERONIKA - KOZYNCHENKO, OLEKSANDR
0220	CHARPHITE PROJECT: COAL CHAR AS A SUBSTITUTING MATERIAL OF NATURAL GRAPHITE IN GREEN ENERGY TECHNOLOGIES SANTOS, ANA - BIALECKA, BARBARA - CALUS-MOSZKO, JOANNA - CRUCERU, MIHAI - FREIRE, CRISTINA - GUEDES, ALEXANDRA - LAZARO-MARTINEZ, JUAN - POPESCU, LUMINITA - PREDEANU, GEORGETA - VALENTIM, BRUNO - WAGNER, NICOLA
0224	PREPARATION OF NOVEL MATERIALS FOR ELECTRODE OF ENERGY DEVICES BY ELECTRO SPINNING AND NANOHYBRID OSHIDA, KYOICHI - MINAMISAWA, TAKUNORI - ANDO, AKINOBU - KOBAYASHI, NOZOMI - MISAWA, DAIKI - ITAYA, TOMOYUKI - OSAWA, KOZO - MURATA, MASAHIKO - MORIYAMA, MINORU - HATA, TOSHIMITSU
0227	SYNTHESIS OF BIO-COMPATIBLE GRAPHENE QUANTUM DOTS BY THERMAL DECOMPOSITION OF SILICON CARBIDE LEE, NA EUN - LEE, SANG YOON - LIM, HYUNG SAN - PARK, YANG JEONG - KIM, JUNG WOO - LEE, JU HYUK - CHO, SUNG OH - JEONG, JONG-MIN - JEONG, WON-IL - CHO, YONG-HOON
0229	THE EFFECT OF TWO FORMULATIONS OF NANO/MACROPOROUS CARBON ENTEROSORBENTS ON OXIDATIVE STRESS INDEXES OF EXPERIMENTAL ANIMALS Sanatskaya, Veronika - MIKHALENKO, VIKTOR - SHEVCHUK, OKSANA - GLAVIN, ALEXEI - MAKOVETSKA, LYDMILA - SAKHNO, LARYSA - YUSHKO, LARYSA - KOZYNCHENKO, OLEKSANDR - NIKOLAEV, VLADIMIR

Code	Title
0235	NITROGEN-DOPED MESOPOROUS CARBONS PREPARED BY USING COPOLYMER TEMPLATES FOR ENHANCED ADSORPTION OF HEAVY METAL IONS YE, GANG - SONG, YANG
0238	MOS2 DECORATED HOLEY GRAPHENE BASED CORE-SHEATH FIBERS FOR SUPERCAPACITORS WITH HIGH ENERGY DENSITY AND RATE CAPABILITY WANG, CHAOJUN - ZHAI, SHENGLI - CHEN, YUAN
0241	PREPARATION OF CARBON FIBER USING ASH FREE COAL PYROLYSIS RESIDUE LEE, SEON HO - LEE, SONG MI - PECK, DONG-HYUN - LEE, BYUNG-ROK - SHUL, YONG GUN - JUNG, DOO-HWAN
0242	FLEXIBLE VOC SENSORS USING CONDUCTIVE POLYMERS AND CARBON FIBER ELECTRODES FOR APPLICATION TO TEXTILES KIM, TAEKYEONG - JEONG, EUIGYUNG - BAE, JINSEOK - LEE, JUNHEON - PARK, JIHOON - LEE, JAEWOONG
0243	ULTRAFAST HYDROTHERMAL ASSEMBLY OF NANOCARBON MICROFIBERS IN NEAR-CRITICAL WATER FOR 3D MICROSUPERCAPACITORS ZHAI, SHENGLI - CHEN, YUAN
0245	VERTICAL MOS2 NANOSHEETS/HYDROGENATED GRAPHENE HYBRID CATALYSTS FOR EFFICIENT AND STABLE HYDROGEN EVOLUTION REACTION TONG, XILI - HAN, XIUXIU - GUO, XIANGYUN
0246	INVESTIGATION ON CHEMICAL STRUCTURE EVOLUTION OF REDUCED GRAPHENE OXIDE UNDER SUPER-HIGH TEMPERATURE KONG, QINGQIANG - CHEN, CHENGMENG
0254	THE EFFECT OF CNTS FOR CFRTPS MADE WITH POLYAMIDE 6 SHIBATA, MASATAKA - IRISAWA, TOSHIHIRA - TANABE, YASUHIRO
0255	ELASTIC REARRANGEMENT OF STACKED NANOGRAPHENES UNDER HIGH PRESSURE COMPRESSION CHOTIMAH, NURUL - PUTRI, AUSTINA D - ONO, YUJI - HATTORI, YOSHIYUKI - WANG, SHUWEN - FUTAMURA, RYUSUKE - URITA, KOKI - VALLEJOS-BURGOS, FERNANDO - NEIMARK, ALEXANDER V - KANEKO, KATSUMI
0259	MACROPOROUS MONOLITHIC CARBON XEROGEL VIA TEMPLATE-FREE METHOD FROM RESORCINOL AND FORMALDEHYDE CHOI, GUN - LEE, JAE YOUNG - YOON, TAE-HO
0260	CARBON FIBERS SUPPORTED NISE NANOWIRE ARRAYS AS EFFICIENT AND FLEXIBLE ELECTROCATALYSTS FOR THE OXYGEN EVOLUTION REACTION GUO, XIANGYUN - TONG, XILI - GUO, XIAONING
0262	APPLICATION OF THE SI-B-C-O COATING ON POROUS CARBON BODIES FOR HIGH TEMPERATURE THERMAL PROTECTION LI, TONG-QI - ZHANG, DAH-AI - JIAO, XING-JIAN - FENG, ZHI-HAI
0263	ACTIVATED CARBON FROM GRAPE SEEDS UPON HYDROTHERMAL CARBONIZATION AND CHEMICAL ACTIVATION MANZANO, JAVIER - VILLAMIL, JOHN - F. MENA, ISMAEL - DIAZ, ELENA - F. MOHEDANO, ANGEL - RODRIGUEZ, JUAN J.
0267	HYDROPHOBIC CARBON MATERIALS AS BIPHASIC MICRORREACTOR FOR CATALYTIC APPLICATIONS IN AQUEOUS MEDIA CALVO-CASTAÑERA, FELICIANO - ALVAREZ-RODRIGUEZ, JESUS - CANDELA, NURIA - MAROTO-VALIENTE, ANGEL
0269	NOVEL HYBRID MATERIAL BASED ON BIMETAL OXYHYDROXIDES (FE:CE)-GAC FOR SUPERIOR AS(V) REMOVAL VENCES-ALVAREZ, ESMERALDA - RANGEL-MENDEZ, RENE
0272	FLEXIBLE AND ULTRASENSITIVE FABRICS-BASED CARBON COMPOSITES SENSOR FOR DETECTING HUMAN MOTIONS LIANG, JINGJING - ZHAO, ZONGBIN - TANG, YONGCHAO - ZHANG, HAN - WANG, XUZHEN - QIU, JIESHAN
0273	N-DOPED MESOPOROUS CARBON NANOSHEETS DERIVED FROM MOFS FOR HIGH-RATE SUPERCAPACITORS HOU, YANAN - ZHAO, ZONGBIN - ZHANG, HAN - WANG, XUZHEN - QIU, JIESHAN
0274	SYNTHESIS OF GRAPHENE-CNT HYBRID MATERIALS AND THEIR ELECTROCHEMICAL APPLICATIONS SONG, JUN HO - RYU, JAE SEUNG - WOO, SANG CHEOL - LEE, CHURL SEUNG - PARK, JI SUN - KIM, YOUNG KWON
0278	VARIABLE TEMPERATURE RAMAN SCATTERING ON MICROMECHANICS OF CARBON FIBER REINFORCED POLYIMIDE/CNTS COMPOSITES RAN, MIN - SONG, YUNJIA - WU, QILIN
0280	ON THE RELIABILITY OF SODIUM CO-INTERCALATION IN EXPANDED GRAPHITE PREPARED BY DIFFERENT METHODS AS ANODES FOR SODIUM-ION BAT CABELLO, MARTA - BAI, XUE - CHYRKA, TARAS - ORTIZ, GREGORIO - LAVELA, PEDRO - ALCANTARA, RICARDO - TIRADO, JOSE
0282	THE STUDY OF INTERFACIAL ADHESION OF CFRTP MADE WITH IN-SITE POLYMERIZABLE THERMOPLASTICS KOBAYASHI, SARASA - TANABE, YASUHIRO - IRISAWA, TOSHIHIRA

DEVELOPING OF COMPOSITE FROM BIOMASS-DERIVED ACTIVATED CARBONS WITH CARBON NANOTUBES FOR ELECTROCHEMICAL ELECTRODES

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Introduction

Electrochemical capacitors, which known as supercapacitors, are a unique type of high-power devices being developed for a different type of applications as consumer electronics, medical devices, transportation and military defense systems[1].Activated carbon (AC) is a porous material with high surface area and can exhibit good adsorptive capacities[2]. The high specific surface area (SSA) of 1000-3500 m^2g^{-1} and the porous structure of AC let charge storage at the electrode/electrolyte interaction, the capacitance of mentioned interaction is equal to 10 $\mu F\ cm^{-2}$. Activated carbon can be synthesized from vegetable raw materials as apricot stone, rice husk, coconut shell.

Another group of carbon materials which can be used in supercapacitor electrodes are carbon nanotubes. Carbon nanotubes have properties as tensile strength, flexibility, electrical conductivity and high specific surface area. In[3] was synthesized few-wall CNTs (FWCNTs). Difference of FWCNTs from SWCNTs are low cost, high electronic conductivity (~100 S/cm) because of long length (~400 μm) and ease to manipulation.

In this study, capacitive AC particles obtained from waste of agricultural industry RH and AS at the Institute of Combustion Problems in the Laboratory of Carbon Nanomaterials and Nanobiotechnologies, were integrated with conductive, flexible FWCNT to fabricate conductive electrodes with high-electrochemical capacity. The electrochemical characteristics of AS-FWCNT, RH-FWCNT hybrid electrodes were compared with YP-80F-FWCNT (Kuraray Chemical Co., Osaka, Japan) electrodes.

Materials and Methods

To prepare AC-FWCNT hybrid electrodes, 0.5 mg of FWCNTs were mixed with YP-80F activated carbon for supercapacitors (5-20 μm diameter, 1900-2200 m^2g^{-1}), activated carbons which was obtained from apricot stones, rice husk in AC:FWCNT weight ratios of 9:1. Both carbon materials were added to ethanol (EtOH) and dispersed in a bath-type sonicator with a cooling unit to keep the temperature at 20 ^{0}C. The electrodes were obtained by vacuum filtration over polytetrafluoroethylene (PTFE) membrane filters (5 μm pore size). The final product was a mechanically-robust matrix of interwoven FWCNTs that held the YP-80F, AS, RH. Residual solvent was removed by drying at 90 ^{0}C for 2 hours.

To evaluate the performance of the FWCNT 3D collector matrix, Ti-mesh (200 L *200 S) connected to the carbon electrodes were prepared. Electrode cells were used to run cyclic voltammetry.

The three-electrode cell consisted of an YP80F-FWCNT, AS-FWCNT, RH-FWCNT as a working electrode, a YP-80F-FWCNT counter electrode and a Ag/AgCl electrode (in saturated NaCl aqueous solution) reference electrode; the electrolyte was 1M Na_2SO_4 aqueous solution.

Results and Discussion

Preparation of electrodes from CNTs with AC in hybrid electrodes has been developed to improve electrical conductivity of common electrodes, and to replace ordinary conductive additives. It is desirable to combine the high surface area of ACs with the conductivity of CNTs to obtain an electrode with enhanced capacitive performance as high electrolyte-accessibility. AS-FWCNT, RH-FWCNT hybrid electrodes are prepared without using binders and it has self-supporting flexible nature.

The results of electrochemical measurements were obtained from CV tests in a three-electrode cell in the range -1–0.6 V vs. Ag/AgCl, using the full-contact Ti-mesh configuration.

The specific capacitance was calculated from the CV plots using the expression:

$$C = \frac{q}{\nu} = \frac{1}{\nu} \frac{\int_{E_1}^{E_2} i(E)dE}{E_2 - E_1} \quad (1)$$

where C is capacitance, q is electric charge, ν is the scan rate, E is voltage and i is current. The mass of AC, AS was used in the capacitance calculation[4].

The specific capacity for the AC-FWCNT elelctrodes are summarized in Table 1. An increase of specific capacitance was observed for the AS-FWCNT hybrid electrodes. Hybrid electrode which were made with RH particles show lower rate performance than other electrodes.

Table 1. Electrochemical performance of hybrid electrodes

Electrodes	Specific capacitance (F g^{-1}) (at 1–100 mV s^{-1})	Volumetric capacitance (F cm^{-3}) (at 1–100 mV s^{-1})
AS-FWCNT	**139-103**	**30-25**
RH-FWCNT	**106-85**	**24-20**
YP80F-FWCNT	**119-100**	**41-35**

Conclusions

We obtained self-supporting carbon hybrid electrodes by enclosing highly-capacitive activated carbon particles within an electrically conductive 3D collector made of FWCNTs. Hybrid electrodes were prepared from biomass derived ACs obtained from apricot stones and rice husk with sub-millimeter long FWCNTs. The FWCNTs provides mechanical stability and fewer contact and junction resistances, making it possible to produce self-supporting electrodes with no additional binder materials. The fabrication method followed in this work can rapidly and easily produce lightweight electrodes with controlled thicknesses for varied applications, given its important advantage over other, more complicated procedures.

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