Forum G Composite Materials

G01 (Invited)

Research of Nanocomposite Fatliquoring Agent based Plant Oil with Functionality

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Fatliquoring process is one of the important leather processes. Fatliquoring agent can penetrate into the skin collagen fibres. Fatliquoring agent can form oil film and play lubricating and plasticizing roles so that the molecular chain segments can easily move. With the improvement of level of consumption and development of market, traditional fatliquoring agent could not meet the requests of fatliquoring process and customers. So it is a tendency that the fatliquoring agent with new functionality was developed, such as flame retardancy, waterproofness, light fastness, anti-mold ability and low fog value. Focus on the issues of leather products such as easy to flame, easy to yellow and easy to mould. The three types of fatliquoring agent were prepared from natural plant oil and nanomaterials. Modified rapeseed oil/montmorillonite nanocomposite fatliquoring agent (MRO/MMT) with flame retardency was prepared by ultrasonic method and in-situ method. MMT can endow the composites with superior thermal stabilit y, flame retardancy, and barrier properties. The burning ratings of leather fatliquored with MRO/MMT was reduced 0.29～0.53mm/s. The Limited Oxygen Index (LOI) values of leather fatliquored with MRO/MMT was improved 6.4%～11.7%. Hydrogenated castor oil/modified TiO_2 nanocomposite fatliquoring agent (HCO/TiO_2) with yellowing-resistant was prepared through in-situ method. High saturation of hydrogenated castor oil and good ultraviolet absorbent of rutile TiO_2 nanoparticles were used in HCO/TiO_2. The index of yellowing-resistant could reach 4 ～ 5. Modified soybean phospholipid/TiO_2 nanocomposite fatliquoring agent (SBP/TiO_2) with anti-mold ability was prepared via in-situ method and blending method. The cell membranes and DNA can be damaged by reactive oxygen species produced byTiO_2.

The leather fatliquoed with SBP/TiO_2 showed that the leather had superior anti-mold activity.

G02 (Invited)

Development of Ultrasensitive Piezoresistive Strain Sensors Made from

Carbon Nanofiller/Epoxy Nanocomposites

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In this work, firstly, based on effective multi-scale numerical modeling and simulations, three possible mechanisms of piezoresistivity in polymer nanocomposites with carbon nanofiller (CNF, e.g., carbon nanotube and carbon nanofiber), i.e., 1) variation of conductive networks formed by CNFs; 2) tunneling resistance change in neighboring CNFs and 3) piezoresistivity of CNFs themselves, have been systematically explored. Based on the numerically obtained knowledge for the working mechanisms of the piezoresistivity, a set of resistance-type strain sensors has been fabricated from metal-coated CNF/epoxy nanocomposites. Two nanofillers, i.e., multi-walled carbon nanotubes (MWCNTs) and vapor growth carbon nanofibers (VGCFs) with nickel, copper and silver coatings were used. The ultrahigh strain sensitivity was observed in these novel sensors as compared to the sensors made from the CNFs without metal-coating, and conventional strain gauges. In terms of gauge factor, the sensor made of VGCFs with silver coating is estimated to be 155, which is around 80 times higher than that in a metal-foil strain gauge. In experiments, the possible mechanism responsible for the high sensitivity and its dependence with the networks of the CNFs with and without metal-coating and the geometries of the CNFs were further investigated thoroughly.

G03

Nano-engineered Strong, Durable and Multifunctional/Smart Concretes

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Micro/meso scale modification can bring big changes in macroscale property. The addition of nanofillers makes materials strong, durable and multifunctional/smart. This paper aims at studying mechanical property, durability, electrical property, electromagnetic property and piezoresistivity of concrete with nano silica(NS), carbon nanotube(CNT), botryoid hybrid carbon material (BHCBM), nano graphite platelet(NGP) and nano-tip material(spiky spherical nickel particles), respectively. Results demonstrate that the compressive and flexural strengths of concrete show significant increases with the increasing contents of NS. The addition of CNT obviously enhances the transport property of concrete. The BHCBM endows theexcellent electrical conductivity with concrete. Both shielding effectiveness and electromagnetic wave absorbing performance of concrete can be achieved by adding NGP. The concrete with nano-tip

materialhas ultrahigh piezoresistive response to stress and strain.

G04

Mechanical and Thermomechanical Properties of Hybrid Nanocomposites Reinforced by Nanotubes and Nanoplatelets

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A theoretical study on the mechanical and thermomechanical properties of hybrid nanocomposites reinforced by nanotubes (NT) and nanoplatelets (NP) is presented. The stiffness and coefficient of thermal expansion (CTE) are derived via an approach based on Mori-Tanaka method. The influences of hybrid ratio, reinforcement volume fraction, aspect ratio and orientation on the stiffness and CTE are discussed.

G05

High Efficient Large-scale Synthesis and Electromagnetic Property Control of Silica/Metal Double Shell Composite Hollow Microspheres

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For the formation of hollow structures, most of the synthetic strategies are usually tedious and costly, involving expensive sacrificial templates, complicated multi-stages, time-consuming reaction processes, and the excess use of organic solvents. More importantly, the elimination of templates may inevitably leads to composition and structure variation of the shells. Meanwhile, the elimination of templates may also result in less robust shells and make the hollow structures easy to collapse, which can bring tremendous performance decline in practical applications. Therefore, for both practical application and academic study, it is of great importance to develop simple, controllable, and industrial acceptable strategies to achieve large scale fabrication and fine property control of hollow structures with high stability.

Double shell composite hollow microspheres (DSCHMs) with silica (inner shell) and magnetic metal (outer shell) shells were prepared in large scale through a novel cost effective strategy involving spray drying, simultaneously silicification and surface decoration with active sites, and finally directed growth of magnetic metal shells. Micron sized spherical particles with silicate shell were prepared firstly by spray drying of low-coast water glass. The silica shell formed through silicification of silicate possesses good chemical durability and thermostability. The spherical shape and hollow structure were well reserved during the silicification and calcination at a high

temperature of 1200 ℃ (in which the phase component of the silicate shell varies from amorphous to high crystalline α-cristobalite). It should be noted that, with properly controlled processing condition and reaction solution, the decoration with active sites of the newly formed silica surface can be achieved simultaneously during the silicification treatment. Afterwards, light weight DSCHMs with the outer (second) shell composed of various metals were fabricated through in situ chemical reduction of metal ions and directed assembly of the as-formed metallic nanocrystals. And the thickness of the metallic shell can be tailored simply and reliably by varying the experimental conditions. The electromagnetic properties of the DSCHMs were studied and the results demonstrate that the as-obtained materials have excellent microwave absorption performances depending on the shell composition and thickness. For example, DSCHMs with Ni-Fe-P alloy shell exhibited a maximum reflection loss of -45.92dB at 15.92GHz and a broad effective absorption bandwidth (bandwidth with the reflection loss value lower than -10dB) of 4GHz with a thin absorbing layer thickness 1.5mm. The electromagnetic properties were believed to depend largely on the synergism of dielectric polarization absorption and magnetic coupling absorption arisen from the codeposition of Fe and Ni instead of single metal. On the other hand, the strong multiple scattering of electromagnetic waves of the metal shells and the extra electromagnetic waves trapped and attenuated in the hollow structure could contribute to the excellent microwave absorption. The new strategy reported here holds the potential to be extended to the controlled preparation of various double or multishell composite particles with robust hollow silica as support and various metal, alloy or metal oxides as functional shells.

G06

Simulation of the Engagement of Carbon Fabric Reinforced Phenolic-Based Wet Friction Materials

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To make clear the friction characteristic and service ability of carbon fabric reinforced phenolic-based wet friction materials applied to wet clutch and then provide evidence for the design of carbon fabric wet clutch, the comprehensive evaluation system was developed by fuzzy comprehensive evaluation method and the influences of operating conditions on tribology properties were investigated. Based on the characteristics of porosity and compressibility/recovery, the friction torque model and temperature field model were developed. Finally, the essence of wet engagement was illustrated, which can lay a solid theoretical foundation for the application of carbon fabric friction materials.

(1) In order to synthetically evaluate the wet tribological properties of friction materials,

fuzzy comprehensive evaluation model was developed. The analytic hierarchy process was introduced into the model to establish weight function. The wet friction materials with different CNTs content were chosen as the six projects. It is found that the comprehensive evaluation indexes were increased by 126%~307% for the samples with 4~15wt.% of CNTs compared with the sample without CNTs. The judgment matrix has high consistency by consistency checking. And the evaluation results are also in accordance with the results obtained through the friction torque, surface structure and temperature.

(2) The effects of operating conditions on the tribological properties were investigated by statistics method. The results of curve fitting shows that the dynamic friction torque linearly increases and the dynamic friction coefficient (u) inversely decreases with the rise of interface pressure. To demonstrate the results, the contact model was presented based on Gaussian surface asperity height distribution and the assumption of elastic deformation. Meanwhile, the asperity contact area is considered as the critical factor. Moreover, u firstly increases and then decreases as the rotating speed and total inertia increase. However, the friction stability and shudder phenomenon become gradually poor. The influence of braking pressure on u is the largest, followed by the total inertia among the above three operating conditions.

(3) Studying the wet clutch engagement more efficiently makes it necessary to simulate the wet clutch behavior. So, based on the modified Reynolds equation and torque balance equation, the modified numerical model was developed by introducing the carbon fabric contact coefficient and the surface pattern parameter for the carbon fabric wet clutch. It is found that there is a good agreement between computational results and experimental measurements. Subsequently, the influences of the applied pressure, the permeability and the fluid viscosity on the engagement characteristics were explored with the proposed numerical model.

(4) The temperature plays a significant role in the tribology properties and failure of friction materials during engagement of wet clutch. In order to obtain the temperature field of carbon fabric wet clutch, the thermal model was developed and the finite element analysis was conducted with the heat flux, convective and conductive heat-transfer taken into account. The predicted temperatures of thermometer hole were compared with experimental values. The effects of the thermal parameters on the temperatures of engagement and the damage of carbon fabric composites were investigated. Results show the thermal model is evaluated as effective and can well predict the temperature field. The lower skeletal density, lower specific heat capacity and higher thermal conductivity are indispensable for the purpose of lowering the temperature of engagement. The highest temperature appears at R=0.0509m, where the damage of friction lining easily occurs.

G07

Fabrication of 2D/3D Graphene/Cu Composites by In-situ CVD and the Study of its Strengthening Mechanism

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In this research, Cu matrix composites are synthesized reinforced by in-situ 2D/3D graphene grown through chemical vapor deposition (CVD). Cu powders and polymethylmethacrylate (PMMA) are employed as matrix and carbon source repectively. PMMA is dispersed on Cu powders after ball-milling. During the CVD process, carbon atoms from pyrolyzed PMMA diffuse and precipitate on Cu powders. By inheriting the morphology of Cu powders, carbon atoms build a 2D/3D in-situ on Cu powders. Bulk graphene/composites are obtained by vacuum hot-press sintering. The favorable interfaces that crucial to the achievement of exceptional mechanical properties of a bulk composite are verified by TEM and SEM characterizations. A yield strength and tensile strength of 290 MPa and 308 MPa respectively are achieved of the composite. The structure of 2D/3D graphene is well preserved in the bulk composites. We demonstrate that the 2D/3D graphene serves as an effective obstacle to the propagation of dislocations by TEM further.

G08

Elevated Conductivity and Electromagnetic Interference Shielding Effectiveness of Pvdf/Petg/Carbon Fiber Composites through Incorporating Carbon Black

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Along with the electronic products entering people's life, the electromagnetic radiation is becoming a serious problem threatening human health. Consequently, the aim of this paper is fabricating the electromagnetic shielding materials containing carbon fiber (CF), carbon black (CB), poly(vinylidene fluoride) (PVDF) and poly(ethylene terephthalateco-1,4-cylclohexylenedimethylene terephthalate) (PETG). By adjusting CB content, the composite with high electromagnetic interference shielding effectiveness (EMI SE) was achieved. Additionally, the effects of CB on the rheological, dynamic mechanical properties, and electrical resistivity of PVDF/PETG/CF composites were investigated in detail. That CB formed the conductive networks in the PVDF/PETG/CF/CB composite at 5 % of CB and above led to the

reduction in electrical resistivity and the augment of the modulus as well as the glass transition temperature of PETG. From the electrical resistivity and storage modulus points of view, the short CF exhibited the better synergistic effect with CB than the long CF did. But the lowest electrical resistivity (0.39 Ω.cm) occurred in the long CF based composites containing 15 % of CB, and its EMI SE is determined to above 30 dB over a frequency of 0.1 to 1500 MHz.

G09
Characteristics of the Tensile Mechanical Properties of Fresh and Dry Forewings of Beetles

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Based on a tensile experiment and observation with scanning electron microscopy (SEM), this study demonstrated the characteristics of the tensile mechanical properties of the fresh and dry forewings of two types of beetles. The results revealed obvious differences in the tensile fracture morphology and characteristic of tensile mechanical properties of fresh and dry forewings of*Cybister* and*Allomyrina dichotoma*. There occurred a viscous, flow-like, polymer matrix plasticdeformation on the fracture surface of fresh forewings of the two beetles, with the morphology soft and many fibers being pulled out, whereas on the dry forewings,the tensile fracture surface was straightforward and there were no features resembling those found on the fresh forewings. The fresh forewings exhibited a greater fracture strain than the dry forewings, which was caused by the relative slippage of hydroxyl inter-chain bonds due to the presence of water in the fibers and proteins in the fresh forewings. Our study is the first to demonstrate the phenomenon of sudden stress drops caused by the fracturing of the lower skin because the lower skin fractured before the forewings of *A. dichotoma* reached their ultimate tensile strength. We also investigated the reasons underlying this phenomenon.This research provides a much better understanding of the mechanical properties of beetle forewings and facilitates the correct selection of study objects for biomimetic materials and the development of the corresponding applications.

G10 (Invited)
High-Capacity Spinel Cathode for Future Li-Ion Batteries Through Domain Engineering

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Spinel cathode is one of promising candidates for high-performance lithium-ion batteries due to its high voltage and hence high energy. This kind of material has excellent rate performance with 3D lithium diffusion pathway and it is inexpensive, stable and environmentally friendly. Although $LiMn_{1.5}Ni_{0.5}O_4$ suffers from its limited capacity above 3 V, doubled capacity can be obtained when it is cycled in a wider potential window of 2-5 V. However, in this case, Jahn-Teller distortion cannot be ignored and results in a fast capacity fade. The present study attempts to embed the layered Li_2MnO_3 with good cycling stability into the spinel structures to extend its capacity. The resultant composite crystallized in both a layered and spinel structure with nano-domain structure. When it is used as a cathode material for lithium-ion batteries, it exhibits superior cycle stability with a high capacity after some conditioning cycles and no Jahn-Teller distortion can be identified.

G11 (Invited)

Functional Composite Materials with Ordered Micro-Structure

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Colloidal crystal is an ordered array of monodispersed colloidal submicrospheres, analogous to a standard crystal whose repeating units are atoms or molecules. A natural example of colloidal crystal can be found in the gem opal. The ideal opal structure is a periodic close-packed three-dimensional array of silica microspheres. There are some examples of colloidal crystals in nature, for example, butterfly, which show beautiful iridescent colours due to sub-micron scales on their wings. Other examples are peacock feathers and beetle cuticles.

We have developed method to self-assemble 2D and 3D colloidal crystals. 2D colloidal crystals are monolayer arrays of colloidal microspheres or nanospheres. They are usually assembled on planar substrates or at air/water interface with ordered arrangement. For the preparation of 3D colloidal crystals, the vertical deposition by evaporation technique has been used; the method relies on the balance between sphere sedimentation and evaporation of the colloidal suspension. Evaporation of solvent from the meniscus region draws colloidal spheres into the area of film formation and inter-particle capillary forces assemble the spheres into close packed arrays. By using spray method, large area PCs could be self-assembled. Colloidal crystals are employed as the templates to structurally direct the formation of inverse opal structures. In recent years the fabrication and characterization of

three dimensionally ordered macroporous(3DOM)materials have become one of the most hot and exciting areas.

We prepared 3DOM materials that included Ge, Si, Ni; oxides such as WO_3, ZrO_2, b_2O_5, Ta_2O_5, CeO_2, V_2O_5 etc. Ge photonic crystal was particularly first synthesized at room temperature in the world, which conquered the problem of lower filling rate, lower degree of order and higher energy consumption. Two sets of photonic crystal assembly systems had been built, which can provide a variety of substrates with high ordered, fast and large area assembly, offering technical support for their applications. Related research results were published in Angew. Chem. Int. Ed. (Hot Paper), J. Mater. Chem, Sol. Energy Mater. Sol. Cells, Phys. Chem. Chem. Phys. Opt. Express, Appl. Phys. Lett. and other renowned journals internationally.

G12 (Invited)
Multi-scale Simulation on the Compaction of Composite Powders

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In present work, the packing densification of binary composite powders (the mixture of hard and soft particles) subjected to single action die compaction was simulated by using FEM continuous modeling from macro scale and multi-particle FEM (MPFEM) discrete modeling from particulate scale, where the MPFEM incorporates the characteristics of DEM (discrete element method) and traditional FEM to realize their coupling. Different initial packing structures with hard particles of certain size and content distributed in various ordered and amorphous soft particle packings were all generated by DEM modeling. During compaction, the morphology evolution of the composite compacts with the compaction pressure was monitored and the relationship between the relative packing density of the composites and the pressure was identified. Meanwhile, the dynamics based on the interactive forces between the soft and hard particles were analyzed and the densification mechanism such as the evolution of pore size and structure, pore filling mode was studied as well. The results show that different initial packing structures of the particulate composites correspond to different densification behaviors. For the ordered initial packings, the force chains in the compacts are ordered with uniform distributions at each height and the deformation of soft particles is regular. While for the amorphous initial

packings, the force chains in the compacts are disordered which are mainly determined by the contacts between hard particles and the deformation of soft particles is irregular. The initial packing structure of hard particles, particle size, and content in the composite can to a large extent influence the densification of the composite compact and its subsequent properties. Therefore, for the binary composite powder packing mixture, to properly control the distribution of hard particles, relative particle size and content in initial packing is the prerequisite to obtain the high performance composite compacts.

G13

Ultrasonic Effect on Fabrication of Intercalated MgAl-LDH/PVA Nanocomposite Via Exfoliation-adsorption Route

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Preparation for Glycine-Mg/Al-Layered double hydroxide (LDH-G)/PVA nanocomposites was carried out via exfoliation-adsorption route based on exfoliation of LDH-G in formamide. The effect of ultrasonic treatment on the fabrication of LDH-G/PVA nanocomposites was investigated, and the thermal stability of PVA containing the nano-scale dispersed LDH-G was analyzed. The results of XRD suggest that chains of PVA with double layer arrange into the galleries of restacking LDH platelets with the formation of intercalated-type nanocomposite. Experiments present that ultrasonic treatment on the colloid of LDH-G/PVA increases the amount of platelet which forms the intercalated phase, and improves the regularity of LDH-G arrays in the c direction. It is demonstrated that the exfoliated LDH platelets orient in its normal paralleling the flow direction at the high shear rate induced by ultrasound. Simultaneously, under the enhanced temperature caused by long term of ultrasonic treatment, PVA chains extend more and the interaction between PVA chains and LDH layers is reinforced. A model was proposed for various stages of LDH platelets and PVA chains in their mixed colloid during ultrasonic treatment which describes the fabrication of improved hybrid structure. Thermo-gravity analysis reveals that the presence of LDH-G nanolayers promotes catalytically the first stage of PVA decomposition, while hinders the second-stage degradation of PVA due to barrier effect of LDH-G layers and the decreasing mobility of PVA chains intercalated into LDH-G layers.

G14

The Fabrication of Silver/Poly(Methyl Methacrylate) Nanocomposite with Size-Controlled In-Situ Synthesis Method

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The Ag/poly (methyl methacrylate) (PMMA) nanocomposite materials have been intensively studied owing to its superior mechanical, optical and electrical properties. In this paper, Monodispersed silver nanoparticles with controllable size have been successfully in situ synthesized in PMMA matrix. CF_3COOAg, NaHS, HCl and poly(vinyl pyrrolidone) (PVP) were used to optimize the nucleation and growth of silver nanocrystalline. UV–vis analysis and transmission electron microscopy (TEM) were used to characterize the size and dispersion of silver nanoparticles in the Ag/PMMA nanocomposites. The results reveal that silver nanoparticles (NPs) homogeneously distribute in PMMA/DMF sol and the particle size of silver NPs increased with the increase of time. It is suggested that the nucleation of Ag atoms can be facilitated through the addition of a trace amount of NaHS to generate Ag_2S clusters as heterogeneous nuclei. Introducing a trace amount of Cl^- into the reaction system can effectively reduce the growth rate of the nanoparticles and thus generating more uniform silver nanoparticles in PMMA matrix.

G15

Mechanical and Electromagnetic Shielding Properties of Carbon Fiber Reinforced Multilayered (PyC-SiC)n Matrix Composites

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Carbon fiber reinforcedmultilayered (PyC-SiC)n matrix (C/(PyC-SiC)n) composites were prepared by means of layer-by-layer deposition of PyC and SiC and varying PyC-SiC sequences via isothermal chemical vapor infiltration.

Effects of the number of PyC-SiC layer (n=1, 2 and 4) on the matrix microstructure, electrical conductivity, mechanical and electromagnetic interference (EMI) shielding properties of C/(PyC-SiC)n composites were investigated.

The results show that the flexural strength and fracture toughness increase from 121 ± 17 to 193 ± 18 MPa and from 3.0 ± 0.1 to 4.2 ± 0.3 MPa m1/2 with increasing n, respectively. The enhanced mechanical properties of C/(PyC-SiC)n composites are attributed to the increasing number of interfaces, supplying more channels for crack deflection and propagation, which is

favorable to more fracture energy dissipation. The total shielding effectiveness of as-prepared composites increases from 34 to 42 dB in the frequency range of 8.2-12.4 GHz with the increase of n due to the increasing electrical conductivity and number of interfaces within the multilayered matrix.

Therefore, the mechanical and EMI shielding properties of C/(PyC-SiC)n composites can be tailored by controlling n, serving as structural and functional materials in various environments.

G16

Monitoring Three-point Bending Behavior of Carbon/Carbon Composites Using Electrical Resistance Change Methods

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Damage behavior of unidirectional carbon fiber reinforced carbon (C/C) composites under three-point bending load by electrical resistance change (ERC) methods was presented.

Staticbending tests and ERC tests were examined simultaneously to obtain the relationship between damage types and electrical resistance changes. In order to identify the occurring time and types of damages, specimens with defects produced in different loading time were observed as well.

The results show that trends of flexural load-flexural displacement curves can be reflected by ERC rate-flexural displacement curves. Every dramatic decrease of flexural load is accompanied by a sudden increase of ERC rate. The relationship between electrical resistance changes and damage types in unidirectional C/C composites is obtained: fiber breakages, matrix cracking and fiber/matrix debonding are major factors for the increase of electrical resistance. Meanwhile, inter-bundle defects and delamination results in the decrease of the electrical resistance.

Thus, depending on the results, ERC methods can be used to reveal the relationship between the occurring time and types of damages produced by flexural load and predict the service safety of C/C composites.

G17 (Invited)

Review on Thermal Properties of Graphene Filled Polymer Composites

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The paper reviews the development of the research work on thermal properties of graphene filled polymer composites. It contains dispersed graphene sheets, 3D graphene foam and oriented graphene films filled polymer composites and their thermal conductivity, expansion,

weight loss and stability, etc. It also indicates the existing problems and possible orientation in the future.

G18 (Invited)

Mechanical Properties of Cellular Graphene and Their Sensor Applications

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In this talk we focus on the mechanical properties of cellular graphene (CG), and the applications of graphene, and cellular graphene for sensors. We report a novel, facile, two-step, adaptable and scalable method of preparing free-standing CG with tunable densities and adjustable shapes and sizes. The CG samples fabricated possess some interesting mechanical behaviors as well as excellent electrical conductivities, reaching 160 S/m, and show insignificant decrease in electrical conductivities when infiltrated with high viscosity PDMS. The GF-PDMS composite was tested for its application as strain/pressure sensor. The composite loaded in compression shows large changes in resistance in response to application of small strains or pressures. Different densities of GF show different sensitivity to applied compressive strain/pressure; therefore, these GF-PDMS composite can be used for a range of low and high strain/pressure sensing applications.

We also report that simple sewing thread fibers and fiber mats such as Nylon® can be used as supersensitive and durable pressure and strain sensors after a slight modification with reduced graphene oxide (rGO). Pristine Nylon® fibers were coated with rGO by a novel electrostatic coating method. The rGO coated fabric show smooth coating discretely wrapping every fiber downright. The in situ twisting of the fiber observed under a scanning electron microscope shows that the rGO coating remains intact even after twisting the fiber to angles as high as 1800°.These electrically conductive fabrics have several potential applications in wearable electronic devices. We show that these rGO coated fabric and fibers are highly sensitive to external perturbation such as force or strain. The fabric's response to applied compressive and bending stresses is recorded as the change in resistance. Single rGO coated single fibers, about 15µm in diameter, were isolated from the fabric and were tested for their response to flexural strains. These fibers were found to sense small strains by changing the resistance in several kilo ohms. With the help of a simple circuit it is also demonstrated that the individual rGO coated fibers, arranged in a 2x2 grid and insulated from each other, can also sense the position of the applied force.

G19

Development of NiOOH Nanosheet/Graphene Hydrogels for Asymmetric Supercapacitors

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NiOOH nanosheet/graphene hydrogels (H–NiOOH/GS), with mesoporous NiOOH nanosheets uniformly dispersed within the highly interconnected 3D graphene network, are constructed and studied for the first time by a mixed solvothermal and hydrothermal reaction. The effect of solvent composition on the morphology, phase, and dispersibility of nanocrystal and hydrogel strength is systematically studied. As binder-free electrodes of supercapacitors, H–NiOOH/GS delivers high capacitance of 1162 F/g at 1 A/g with excellent rate capability (981 F/g at 20 A/g). The charge-storage mechanisms of H–NiOOH/GS are in-depth investigated by quantifying the kinetics of charge storage, which reveals that NiOOH exhibits both capacitive effects and diffusion-controlled battery-type behavior during charge storage. Additionally, solvothermal-induced pure graphene hydrogels (H-GS) are also prepared and used as the negative electrode for the first time, which show an impressive specific capacitance of 425 and 368 F/g at 5 and 40 mV/s, respectively. Benefitting from the synergistic contribution of both positive and negative electrodes, the assembled H–NiOOH/GS//H-GS asymmetric supercapacitors achieve a remarkable energy density of 66.8 Wh/kg at a power density of 800 W/kg, and excellent cycling stability with 85.3% capacitance retention after 8000 cycles, holding great promise for energy storage applications.

G20

Multifunctional Wearable Device Based on Flexible and Conductive Carbon Sponge/Polydimethylsiloxane Composite

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Wearable devices that monitor the personal health, track the human motions, deliver drugs, and generate medical treatment are highly demanded in personalized healthcare. However, a desirable feature missing in emerging wearable devices is the ability to deliver advanced therapy

at the same time of signal collection. Herein, a multifunctional wearable “wrist band” made of a flexible and conductive carbon sponge/polydimethylsiloxane (CS/PDMS) composite is fabricated, which can work both as a heater for thermotherapy and a sensor for personal health and motion monitoring. Importantly, the key functional material in the “wrist band”, conductive CS, is prepared from waste paper by a freeze-drying and high-temperature pyrolysis process. When the “wrist band” worked as a heater under 10 V, a stable temperature difference of 29 oC between the “wrist band” and the ambient is achieved. In addition, as a wearable strain sensor, the “wrist band” exhibits fast and repeatable response, and excellent durability within the strain range of 0-20% and the working frequency of 0.01-10Hz. Finally, the typical applications of the multifunctional wearable “wrist band”, including as a heater, and a senor for blood pulse, breathe and walk monitoring are demonstrated. Considering that the low cost, high flexibility, moderate conductivity, and excellent strain sensibility, the wearable devices based on CS/PDMS composite are believed to have promising application in personal healthcare and treatment.

G21

Ultralight conducting PEDOT: PSS/ Carbon Nanotubes Aerogels Doped with Silver for Thermoelectric Materials

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Significant enhancement of thermoelectric performance was observed for Poly (3,4-ethylenedioxythiophene):Poly(4-styrenesulfonic) (PEDOT:PSS) and multi-walled carbon nanotubes (MWCNTs) (PC) three-dimensional aerogels which were obtained from PEDOT:PSS/MWCNTs suspensions by adding different concentrations of metallic silver (Ag). We find that the electric conductivity and Seebeck coefficient were increased simultaneously. Moreover, the unique structures of conducting aerogels lead to ultra low thermal conductivity (0.06 W·m-1·k-1) and large Brunauer–Emmett–Teller surface area (228 m2·g-1).The highest ZT in this study was 7.56×10-3 at room temperature upon addition of Ag content of 33.32 wt%, which is nearly one order of magnitude improvement compared with that of PC aerogel. Although the ZT value was too low for TE material, our work may provide new insights into the design and development of TE material for application. Further investigation with PEDOT:PSS aerogel will be continued to get an economical, lightweight and efficient polymer TE material.

G22

Fabrication and Properties of the W-40wt.%Cu Composite Material Prepared through Hot-press Sintering

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The W-Cu composites are widely used as welding electrodes, electronic packaging materials, electric discharge materials and heat sinks because of the excellent properties. In this research, the W-40wt.%Cu composites were prepared through the vacuum hot-press sintering method, and the effect of sintering temperature on the microstructure and properties of the W-40wt.%Cu composites was studied. Microstructure and coposition of the origin W and Cu powders and sintered composites were analyzed by field emission scanning electron microscopy (FE-SEM) and energy dispersion spectrometry (EDS). The relative density, Vickers hardness, bending strength and electrical conductivity of the sintered composites were invested. The results show that the relative density of the W-Cu composite is raised along with the increasing of the sintering temperature, there are less voids in the composites, and the mechanical and electrical properties are better with the increasing of the sintering temperature. And the W-40wt.%Cu composites prepared at 900℃-200MPa-2h has the relativity of 98%, the bending strength of 507.3 MPa, the Vickers hardness of 376.2 HV and the electrical conductivity of 32.5% IACS, respectively.

G23 (Invited)

MnO2 Sheets Based on Carbonized Cotton Textile for Flexible Supercapacitors

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There is an increasing demand of low cost, flexible, stable, and environmentally benign power sources for emerging wearable electronic equipment. Herein, we develop high performance psudo-supercapacitor electrodes based on nano MnO_2 deposited on a carbon textile, which was made from cotton cloth by carbonization in Ar gas, served as 3D flexible scaffolds as shown in Fig. 1. The MnO_2 nanostructures were realized via a simple in situ redox replacement reaction between potassium permanganate and the carbonized cloth. The morphology of nanostructures was tuned and optimized through the process parameters into curled sheet-like, which provided large surface area

and fast ion transport without local stress residue (Fig. 2). Electrochemical measurements showed that the curled sheet-like MnO_2 had a specific capacitance of 465 F g-1 at 0.1 A g-1, and exhibited an excellent cycling stability with a specific capacitance retention ratio of 98% after 2500 cycles (Fig. 3). Due to this curled shape as well as the flexible nature of the carbonized cotton textile, the hybrid electrodes were able to bend freely, and the capacitance and cyclability almost remained unchanged even at a bending angle of 150°. Such flexible and stable electrodes from low cost and environmentally benign biomass offer new potentials for energy storage and wearable electronic applications.

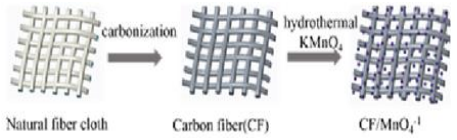

Fig. 1 Illustration of fabrication process

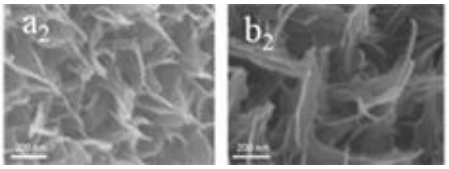

Fig. 2 SEM photos of MnO_2 on textile

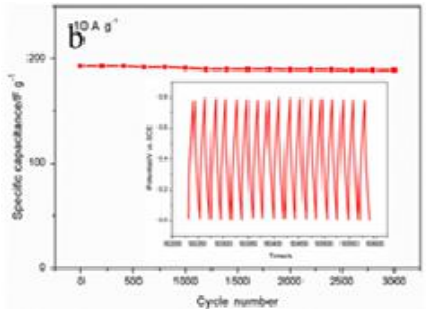

Fig. 3 Cyclic testing of electrode

G24

A Generic and Effective Strategy for Highly Effective "Intrinsic" Molecular Luminescence in Condensed State

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Organic light-emitting (OLE) materials have been extensively studied due to their easy modification, However, the easy crystallization to result in instable spectral performance and quenching effect of luminescence, poor processability and low thermal stability have limited their applications. Polyhedral oligomeric silsesquoixanes (POSS) are a class of inorganic compounds

with nanoscale dimensional (0.5-3 nm) cubeoctameric structures contained a silica-like core (Si_8O_{12}) surrounded by eight organic corner groups (functional or inert), which makes POSS molecules excellent platforms and blocks for nanotechnology applications and for assembly of novel organic/inorganic hybrid nanocomposites. In this work, we explored a generic and efficient approach to realize a highly effective single molecular luminescence in condensed state. In the work, a generic and efficient strategy to realize a high effective “intrinsic” single molecular luminescence in condensed state was proposed by theoretical simulation at macrostructure level at first, and then was confirmed by molecular design and preparation of a dumbbell-typed (H2) and tadpole-typed (H1) polyhedral oligomeric silsesquoixanes (POSS) based hybrid. The enhancement mechanism of optical properties was investigated in theory and experiments. It is found that the incorporation of “huge” inorganic POSS nanometer core into organic light-emitting molecules to form three-dimensional (3D) organic-inorganic hybrids effectively imrpove the optical properties in thrie condensed matter by decreasing the intermolecular dipole-dipole and π-π stack interactions owing to the hindrance of the intermolecular charge-transfer between adjacent organic molecules. The dumbbell-typed hybrid (**H2**) showed the better enhancement effect of optical properties than resultant tadpole-typed hybrid (**H1**) owing to the crisscross-type arrangement of its dimer induced by the incorporation of POSS. Simultaneously, the two hybrids exhibit high thermal stability and good filmforming ability.

G25
Design of The Desirable Interface to Improve the High Energy Density in Fine-Scale Composites –Combined with the Modified Hybrid Processing

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Due to the miniaturization of modern devices require components with light weight, high integration and the ability to store energy in as small volume as possible. As a result, energy storage density becomes an important figure of merit for energy storage devices. In this paper, firstly, we discussed the energy density in fine-grained lead zirconate titanate glass-ceramics composite with the help of the characteristics of dielectric constant and impedance spectrum (IS); than, we proposed the design the interface obtain the homogenous dielectric constant in composites combined with the modified hybrid processing, in which we can get the

high breakdown strength to improve the energy storage ability; and last, we review briefly the comparison between the conventional melt/liquid processing and the modified hybrid processing, including the advantages of the new modified hybrid processing presented in here.

G26

The Synthesis and Characterization of Dodecylbenzenesulfonic Ion Intercalated Layered Double Hydroxides (Ldhs)

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Layered double hydroxides (LDHs) are a class of layered inorganic materials that consist of structurally positively charged layers and exchangeable anions in the interlayer gallery for charge balance. The delamination of LDHs is decided by synthesis method to some extent. In this work, LDHs are synthesized via three different routes and their delamination properties are characterized.

Co-precipitation method, ion-exchange method and hydrolysis method are adopted to synthesize dodecylbenzenesulfonic ion intercalated LDHs. The structure and composition of the as-prepared LDHs are studied by X-ray diffraction and X-ray fluorescence spectrum. The micro-morphology is characterized by transmission electron microscope and the thermal stabilities are characterized by thermogravimetric analysis.

The results show that dodecylbenzenesulfonic ion intercalated LDHs have been synthesized via these three methods. LDHs prepared by hydrolysis method have lower Mg/Al mole ratios which will lead to higher layer charge density. The grain size is different for LDHs prepared via the three methods: about 1um for LDHs prepared by hydrolysis method; 200~500nm for LDHs prepared by Co-precipitation method; about 100nm for LDHs prepared by ion-exchange method.