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Smart nanocomposites based on thermally reversible networks

R.Araya-Hermosilla[1], A.Pucci[2], F.Picchioni[1*]

[1]ENgineering and TEchnology Institute Groningen (ENTEG), Chemical Product Engineering, University of Groningen, 9747 AG Groningen, The Netherlands
[2] Smart Polymers Group, Department of Chemistry and Industrial Chemistry, University of Pisa, Via Moruzzi 13, I-56124 Pisa (Italy)

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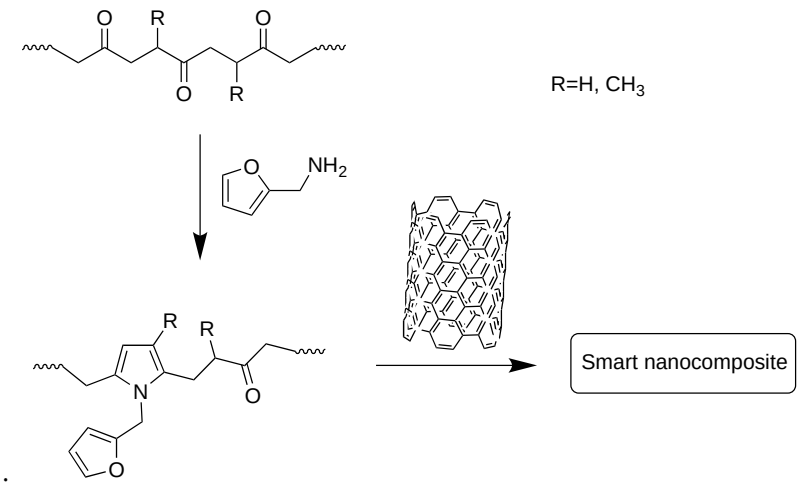

Abstract

This work focused on the synthesis and characterization of different kinds of reversible thermosets and thermoset nanocomposite materials by using alternating aliphatic polyketone (PK) as raw material. We started by studying the basics of PK modification by the Paal-Knorr reaction with a series of primary amines[1]. This modification route proceeds in the bulk with relatively fast kinetics under mild experimental conditions (80°C) and with quantitative conversion of the amine (up to 80% conversion of the carbonyl groups along the backbone). In particular, by using furfuryl-amine as functional reagent in combination with hydrogen bonding moieties, thermally reversible thermoset systems can be easily prepared (upon addition of bis-maleimide as crosslinker via the Diels-Alder reversible reaction). These were investigated to outline the benefits for the synergistic cooperation between reversible covalent and supramolecular interactions[2,3]. Moreover, improvements regarding the mechanical performance, reversibility, recyclability, self-healing and electrical conductivity of the thermosets were investigated by incorporating rubber particles and nanofillers into the thermoset matrices[4]. In particular, we investigated the chemical modification of alternating aliphatic polyketones with aliphatic and aromatic amine compounds using the Paal-Knorr reaction to obtain thermally reversible polymers with relatively high glass transition temperatures. These materials display the desired mechanical properties with the exception of toughness. This could be achieved by preparing a reversible and toughened thermoset system based on the covalent incorporation of furan-functionalized ethylene-propylene rubber into a thermoset furan-functionalized polyketone. In order to confer also electrical properties to these materials, conductive nanocomposites containing well-distributed, exfoliated and undamaged MWCNTs were prepared. These new smart nanocomposites, designed by mixing furan-functionalized polyketone cross-linked with aromatic bis-maleimide and MWCNTs via Diels-Alder (DA) reversible cycloaddition, display electrically-induced self-healing properties.

Keywords: alternating aliphatic polyketones; nano-composites; thermally reversible networks

Acknowledgements
The authors are grateful to the support of the Programa Formación de Capital Humano Avanzado, CONICYT, BECAS CHILE; grant number: 72111428.

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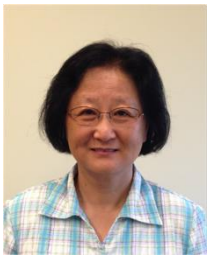
Lightweight, Conductive, and Recoverable Nanocarbon/Polymer Nanocomposite

Alayna B. Huckleby, Jiang Li, and Mei Zhang

High-Performance Materials Institute, Florida State University;
Department of Industrial and Manufacturing Engineering, FAMU-FSU College of Engineering,
2525 Pottsdamer Street, Tallahassee, FL 32310, USA



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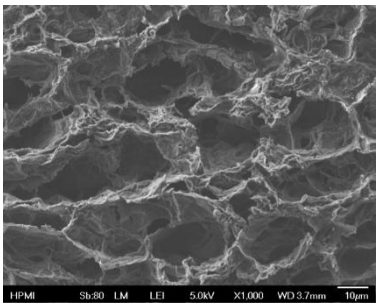
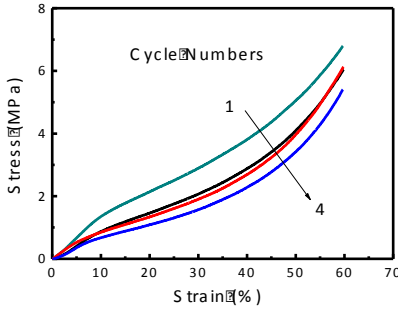


SEM image of the nanocomposite with a density of 229 mg/cm^3.



Green: the 1st compression test
Black: after the 1st recovery
Red: after the 2nd recovery
Blue: after the 3rd recovery

Mechanical behavior of the nanocomposite.

Abstract

The demand for lightweight and strong structures continues to rise especially for weight critical applications such as aerospace and automotive. It is also desired that the materials can recover after being deformed. In this work, we fabricated a special lightweight material, nanocarbon foam, and then reinforced the foam by infiltrating the thermoplastic polymer into the foam to form a nanocomposite. Such nanocomposite is lightweight, strong, and recoverable in both structure and property after deformation.

Nanocarbon foam is a porous carbon material based on carbon nanotubes (CNTs). Different from various methods used to produce CNT foams [1-3], we made nanocarbon foams by using polymer spheres as template and achieved the foams with regular cell shape and controllable pore size. The produced foam is lightweight, conductive, and exceptionally elastic [4]. The nanocomposite was made by infiltrating thermoplastic polymer into the nanocarbon foam. In the fabrication process, the polymer was coated on to the surface of the CNTs in the cell walls. The polymer coatings reinforce the wall of the cells in the foam effectively. The compressive strength is increased tens of times while the electrical property is kept intact [5]. The nanocomposites are not elastic. When compressed, the permanent deformation occurs due to the plastic deformation undergone by the polymer. We found that the permanent deformation can be recovered by simply using heat. Heating the deformed nanocomposite to the temperature around the glass transition temperature (T_g) range of polymer, results in the full strain recovery of the nanocomposite. It is because that the polymer assumes a soft and rubbery behaviour beyond T_g, while the intrinsically elastic CNTs, which are still surrounded by polymer, are able to rebound and exhibit their elasticity by overcoming the force applied by the enclosing polymer upon the reduction in its Young's modulus. This proves that the robust CNT network formed at the beginning is not damaged during the deformation process. At the temperature higher than the polymer's T_g, the nanocomposite is elastic, while it becomes rigid again when its temperature is lower than T_g. It is remarkable that the recovery in both structure and property can be repeated.

Keywords: nanocomposite; porous material; recovery; carbon nanotube.

Acknowledgements
This work was supported by Florida State University Research Foundation GAP program and partially by the National Science Foundation under Grant No. EEC-1005016.

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Innovative synthesis of polymerization and molding for high applicability by thermoplastic epoxy resin

Kiyoshi Uzawa[1], Hirofumii Nishida [1], Katsuhiko Nunotani [1]

[1]Innovative Composite materials research & development Center, Kanazawa Institute of Technology, Hakusann, 924-0838, Japan

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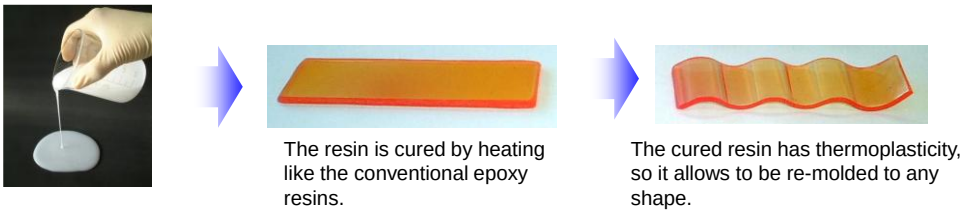
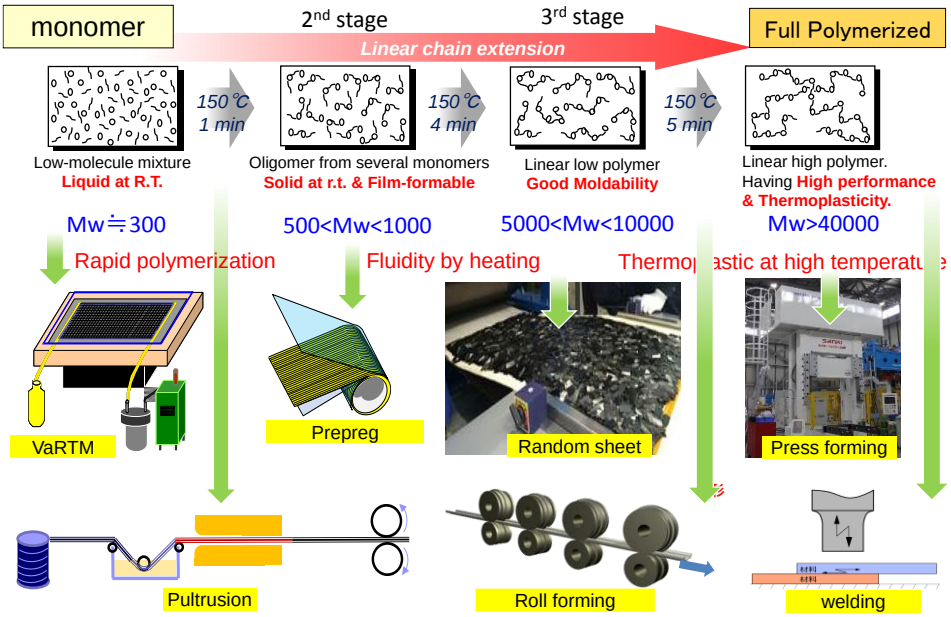
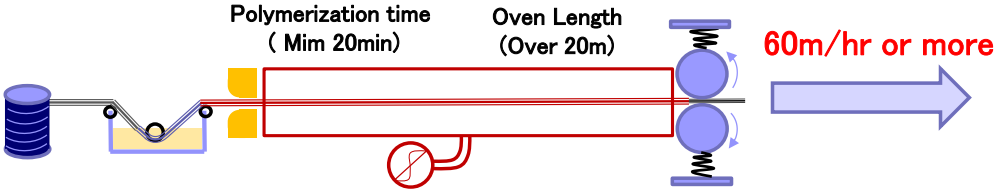
Thermoplastic epoxy resin cure like an epoxy resin and can be re-shape like a plastics.



There are various molding methods with each polymerization stage of thermoplastic epoxy resin.



In-situ polymerizing process to suit the ultrahigh speed manufacturing process.



Examples applied to secondary processing.

Photo of strand rod and seismic reinforcement construction for Ex-headquarter of Komatsu Seiren Co., Ltd.

Abstract

The authors succeeded innovative synthesis by integrating and optimizing between curing/polymerization of resin and molding method using the thermoplastic epoxy resin to various manufacturing processes. To expand the application of composite materials, further cost reduction is required, and for that purpose it is important to optimize as much as possible from material to design and manufacture. The authors have been investigating in situ-polymerizing thermoplastic epoxy resin, a liquid epoxy resin mixture in the initial state that can be allowed to polymerize linearly by heating to produce a thermoplastic polymer.
This thermoplastic epoxy resin is one of formulated two-pack-type liquid epoxy resins, and can start chemical reaction as well as conventional epoxy resins when the mixture of resin and hardener is heated. The reaction of this resin makes its molecular chain successfully extended only linearly, resulting in the formation of a thermoplastic resin while conventional ones are cross-linked to form a network structure during the curing. In each stage, the rheological property of the resin drastically changes and different molding processes including infusion, RTM, stamping, roll forming, etc. can be accordingly applied. It also has easy thermo-forming characteristic and excellent secondary processability such as thermal bending and welding after the curing/polymerization of resin. In this presentation, I will explain the property of thermoplastic epoxy resin and its composites and some innovative high cycle molding and application examples realizing ultra low cost. The authors supported to optimize the in-situ polymerizing thermoplastic epoxy resin to suit the manufacturing method and establish ultrahigh speed (10 times faster than existing pultrusion) manufacturing process of CFRTP Strand Rod at low cost utilizing the characteristic of this resin. In particular, the authors contributed to optimize the reactivity of a special catalyst and improve the viscosity characteristics of the resin, then the impregnation was highly improved and polymerization in the atmospheric air became possible.

Keywords: In situ-polymerizing; Thermoplastic; Epoxy resin; Molding process, Pultrusion.

Acknowledgements
The author appreciates COI program "Construction of next-generation infrastructure using innovative composite materials；Realization of a safe and secure society that can coexist with the Earth for centuries； supported by MEXT and JST.

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Composite Material Selection, Design and Manufacturing for Automotive Structural Parts

Xiangfan Fang, Marco Grote, Tobias Kloska, Institute of Automotive Lightweight Design, University of Siegen, Germany

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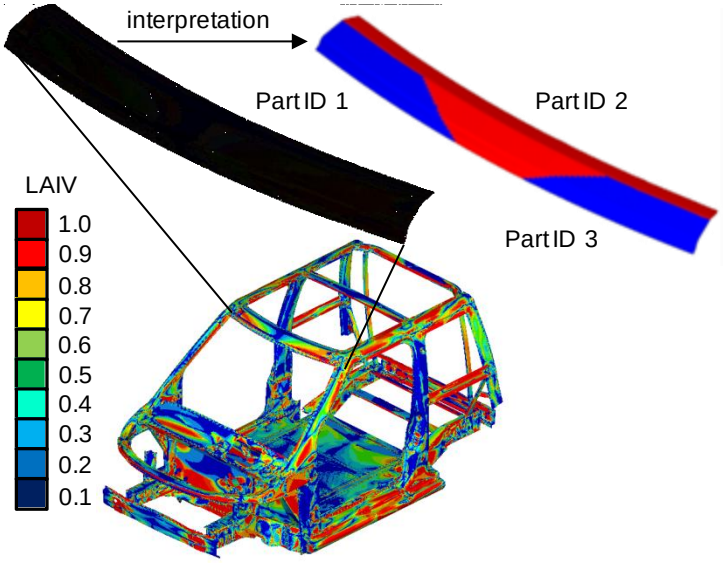

LAIV of the whole vehicle model and the FRP layout for the front roof cross member.

A FRP-steel composite control arm designed and made by hybrid forming

Abstract

Fibre reinforced plastics (FRP) are being increasingly used in automotive structure panels to reduce the vehicle weight due to their superior performance in specific stiffness, strength and energy absorption. On the other hand, the fail safe properties and prediction of failure must be strongly improved to meet all relevant requirements in vehicle structures such as body in white panels and especially for the wheel guiding chassis components.

At first a method for the selection or determination of vehicle components which is suitable for FRPs will be described. The method is based on the determination of the so called load anisotropy value (LAIV). The method was firstly developed by Durst [1] for 2-dimensional static load situations. Later Alberts [2] proposed to extend it to 3-dimensional cases. The basic idea is to use the FEM results, select the relevant stress information of FEM and determine the major direction of loading which results in LAIV. Fang and Grote [3] further developed the methods by adding the thickness effects using force flow instead of stress and combine the clustering method proposed by Klein/Wartzak [4] and Dlugosch etc.. In addition to the static load cases a superposition of different static and crash load cases have been realized. A few examples for the determination of LAIV both for stiffness and crash load cases are given as well as the comparison between them. On one example the design of a car part which is suitable for FRP, i.e. how to layout the composite layers and orientations for max. weight reduction and feasible manufacturing will be shown.

One of the most important conclusions which can be driven from the above mentioned results is that many car parts are not suitable for uni-directional or woven FRPs due to the so called fail safe requirements. Either metal (steel or aluminium) or metal-FRP composites may meet these requirements. A new method has been introduced in this work to determine a so called "bending

value" to differentiate the appropriate parts for material with high energy absorption and load carrying capability in axial or bending direction. Examples in vehicle crash situation and some implications will be given.

In addition a FRP-metal hybrid forming method was invented [5] to simultaneously form both sheet metals and thermoplastic FRPs in a single forming die in the same processing step. This novel method combines the principle of hydro-mechanical forming of metal sheets and the compression moulding of thermoplastic FRPs. The joint between metal sheet and FRPs is also simultaneously created during the one step forming process by using a bonding agent which function is similar to a structure adhesive. Due to the joint between FRPs and metal over the entire surface of the part, a firm connection has been generated. The fail safe requirement can be met and this kind of FRP-metal composite can be used in wheel guiding chassis component. A weight reduction of more than 20% can be realized.

Keywords: Anisotropy of loading; Material selection; lay out of FRPs, hybrid forming of FRPs and metal

Acknowledgements
Part of the research has been supported by the German Department of education and research (BMBF) within the program of "High Performance Production 2013" to which we are indebted.

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What can sea ice tell us about composite materials?

Kenneth M. Golden[1], Elena Cherkaev[1], N. Benjamin Murphy[1], Noa Kraitzman[1], Rebecca Hardenbrook[1], Huy Dinh[1], Kyle Steffen[1], Christian Sampson[2]

[1]Department of Mathematics, University of Utah, Salt Lake City, Utah 84112-0090 USA
[2]Statistical and Applied Mathematical Sciences Institute, Durham, North Carolina 27709 USA

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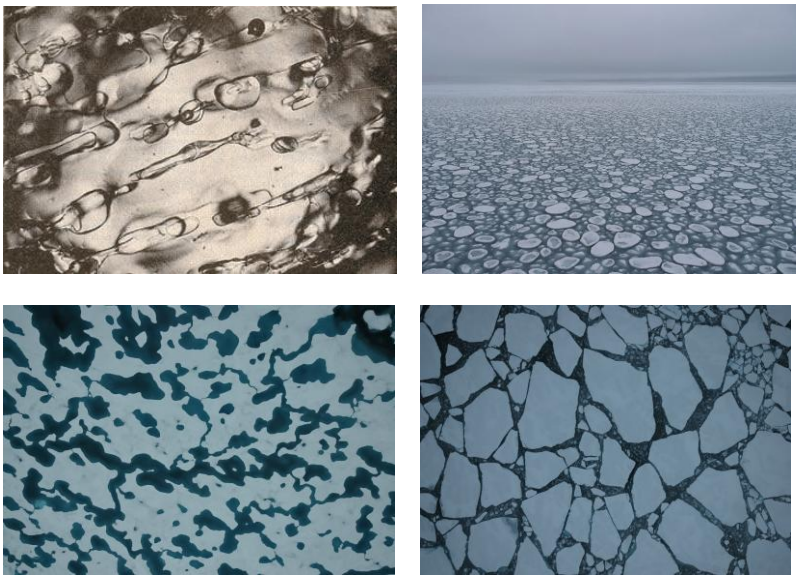

Sea ice – or frozen sea water – is a multiscale composite material, exhibiting complex structure over length scales ranging from millimeters to tens of kilometers. Images above – clockwise from upper left: sub-millimeter scale brine inclusions, meter scale pancake ice forming in a wave field in the Southern Ocean, ice floes many kilometers across, and kilometer scale melt ponds on Arctic sea ice.

Abstract

Polar sea ice is a key component of Earth's climate system. As a material it exhibits complex composite structure on length scales ranging over ten orders of magnitude. A principal challenge in modeling sea ice and its role in climate is in *linking scales*, that is, relating behavior and structure on small scales to effective or homogenized behavior on larger scales, and estimating parameters controlling small scale processes from large scale observations. Similar issues are central to the development of advanced composite materials. I will give an overview of how we are using theories of composite materials and statistical physics to link behavior on various scales in the sea ice system. These mathematical advances, motivated by sea ice, tell us more generally how to analyse and compute the effective properties of a broad range of composite media, and how to address the inverse problem of reconstructing composite microstructure from effective property measurements. In particular, we address fundamental questions in sea ice homogenization, including fluid flow through the porous brine microstructure, remote sensing of polycrystalline materials, ocean wave propagation in the marginal ice zone, advection enhanced diffusion, and the evolution of melt ponds on Arctic sea ice. This work is helping to advance how sea ice is represented in climate models, and to improve projections of climate change and the response of polar ecosystems.

Keywords: Sea ice; multiscale composites; homogenization; polycrystalline media; diffusion processes.

Acknowledgements: We thank the US National Science Foundation and the US Office of Naval Research for funding this research.

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The machinability of composite materials of various internal structure in drilling process

Śliwa Romana Ewa[1], Tyczyński Piotr[2],,Ostrowski Robert[1]

[1]Rzeszow University of Technology, Rzeszow, 35-959, Poland
[2]Mapal Poland , Rzeszow, 35-959, Poland

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a) b)

Results of using: a) standard drill for composite materials, b) the modified drill.

Abstract

Composite materials gives unlimited possibilities of modification of their mechanical, usable and endurance properties depending on internal structure and influencing their machinability., Every modification of the composite brings a significant change of its property, which, in turn, makes it impossible to form standard geometry of drills, which would meet the requirements of such a wide range of materials. Because of a dynamic development of this material group (e.g. CFRP, GFRP, GLARE type composites **)** but also a bigger number of applications of composite materials, the research on modification of geometry of drills and new cutting materials and protective covers (e.g. PCD, CVD) have a key importance for effective machining of these materials. The process of machining the composite materials is a very complicated and may cause many problems such as delamination, elongation down the fibers, scorching of the matrix material, high wear of tools, etc. Selection of proper geometry of tool is difficult and requires a lot of knowledge of the mechanics of the processes [e.g.1,2]. These undesirable phenomena are multiplied, when it is simultaneous machining of these materials for instance in combination of titanium or aluminum alloys, or drilling in complex multi-layers composites. Machining main difficulties are a variety of cutting properties of each material group, hardness and elasticity, different thermal properties (thermal conductivity), a method of forming a chips. Interaction between cutting edge and reinforcement/matrix material ,when cutting edge meets the reinforcement material of different shape and orientation, causes the various mechanisms of cutting a reinforcement material. Additionaly due to the complexity of the shape of parts made of composite materials often it is necessary to drill parts not only perpendicularly but at an angle (askew) as well as parts of inclined surfaces . Modification of drill geometry in order to avoid negative phenomena able to meet the specific requirements of complex processing composite materials [3.4.5]. Presented research work have been carried out in order to identify main results of machining composites of different structures and to choose an appropriate geometry of drill, cutting parameters and machining strategy. This work presents concept of new drill bit geometry adjusted to a given composite type and results of drilling without negative effects such as: delamination, rapid tool wear, matrix burns, pulling out of fibers etc. The experimental work was subjected to different samples of the type of composite materials (GLARE,., CFRP, GFRP). Different machines were used for machining of composite materials, with various cutting parameters (,cutting speed, rotation speed, feed rate) , using Kistler dynamometer for measuring forces, fixing device,-signal registration station and electronic microskope (macro and micro analysis of cutting results on cross sections, imput surface, output surface). Main results of machining composites of different structures and choice of appropriate geometry of drill, cutting parameters and machining strategy, adjusted to various requirements of a given composite material have been presented.

Keywords: drilling, composite, drill geometry, delamination

Acknowledgements

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5. Patent EP 2981385 Twist drill bit for drilling composite materials **2017**

Discovery of New Transition Metal Dichalcogenide Superconductors

Huixia Luo[1*], Robert Cava[2*]

[1] *School of Materials Science and Engineering, Sun Yat-Sen University, No. 135, Xingang Xi Road, Guangzhou, 510275, P. R. China*
[2] *Department of Chemistry, Princeton University, Princeton, New Jersey 08544, USA*

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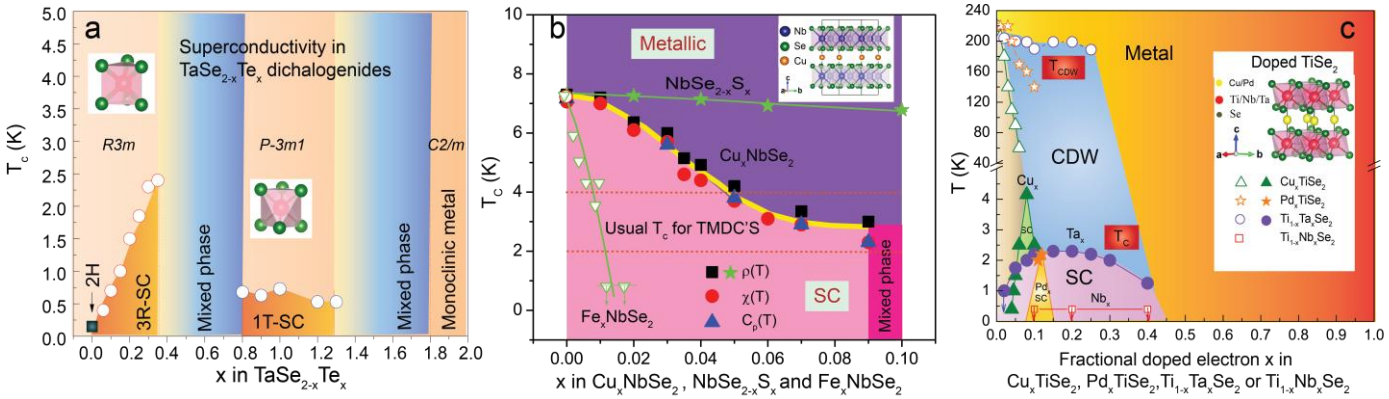

Figure 1 Phase diagrams for (a) $TaSe_2$-xTe_x; (b) 2H-Cu_xNbSe_2; (c) 1T-$Ti_{1-x}Ta_xSe_2$.

Abstract

The MX_2 layered transition-metal dichalcogenides (TMDCs, M = Mo, W, V, Nb, Ta, Ti, Zr, Hf, and Re, and X = Se, S or Te), have long been of interest due to the rich electronic properties that emerge due to their low dimensionality. Structurally, these compounds can be regarded as having strongly bonded (2D) X–M–X layers, with M in either trigonal prismatic or octahedral coordination with X, and weak inter-layer X-X bonding of the van der Waals type. Many of these materials manifest charge density waves and the competition between CDWs and superconductivity. A series of new transition metal dichalcogenide superconductors (e.g. 2H-Cu_xNbSe_2, 1T-$Ti_{1-x}Ta_xSe_2$, $TaSe_{2-x}Te_x$) have been discovered by tuning the crystal structures or suppressing the CDWs with a solid state chemistry method. Further, their physical properties such as resistivity, critical fields, magnetic susceptibility and heat capacity et al. were studied in detail. Finally, the superconducting phase diagrams for new transition metal dichalcogenide superconductors (e.g. 2H-Cu_xNbSe_2, 1T-$Ti_{1-x}Ta_xSe_2$, $TaSe_{2-x}Te_x$) were built. High quality single crystals also can be growth, which are promising as carriers for study of the interplay between CDW and superconductivity behaviors.

Keywords: Layered Dichalcogenides; Superconductivity; Charge Density Wave; Polymorphism

Acknowledgements
The research at Princeton University on sample synthesis and structural, resistive, and susceptibility characterization was supported by the US DOE BES through grant DE-FG02-98ER45706. H. X. Luo acknowledges the financial support by start-up funding from the Sun Yat-Sen University and the Natural Science Foundation of China (21701197).

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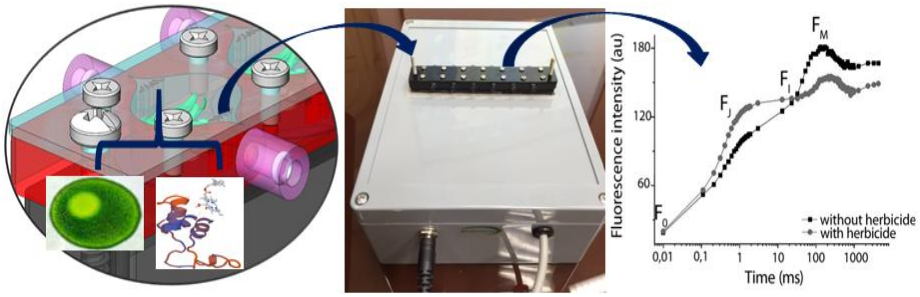
From genetic modifications to biomimetics: innovative microorganisms based biosensors for environmental monitoring

Maria Teresa Giardi[1,2*], Gianni Basile[2], Mehmet Turemis[2]

[1]*Crystallography Institute, CNR Area della Ricerca di Roma, Monterotondo/Rome, 00015, Italy*
[2]*Biosensor srl, Formello/Rome,00060, Italy*



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Abstract

Microalgae are now widely used as relevant biological indicators in the field of environmental impact studies. Owing to their ubiquity, short life cycles, easiness of culture and high sensitivity to a number of pollutants, these organisms are frequently utilized in ecotoxicological screening of contaminated water. Microalgae are especially sensitive in a short time of 10 min to all those pollutants that work as inhibitors at the photosystem II (PSII) level, such as heavy metals and half of the pesticides present in the market. Among the wide range of microalgae species, which have been employed to develop biosensor technology, *Chlamydomonas reinhardtii* possess a number of features that suite perfectly the requirements of an early warning environmental biosensor. It is a grass organism, easily cultivable having 8 hours doubling time and it can grow with or without carbon source, besides, it is easily transformable and all 3 genomes are sequenced. Taking advantage of these features, amperometric/optic biosensors based on microalgal *C. reinhardtii* have been developed in our laboratory, able to detect pesticides in the environment and in food.

Recent efforts have focused on increasing the stability and selectivity of PSII from microalgae for the detection of different subclasses of pollutants. These goals were achieved by using the alga *C. reinhardtii* mutated at the D1 protein herbicide-binding site by site-directed mutagenesis. *C. reinhardtii* was also modified introducing in the chloroplast antioxidant peptides, known in food able to reduce the content of free radicals, thus lessening the photooxidative membrane damage. Measurements of *in-vivo* antioxidant activity showed that mutant strains have improved their survival rate in the presence of singlet oxygen precursors, which highly exceeds the survival rate of control algae, showing increased stability and sensitivity for biosensor applications.

Beyond these scientific achievements, nowadays the market needs highly specific and precise in situ measurement devices able to collect and send the data in real-time for periods of months without maintenance under multi-stressors. These devices demand more robust algal biomediators. Thus, the challenge is the preservation of the algal photosynthetic functionality when integrated with electronic components or operated under fluctuating environmental conditions. To this end *C. reinhardtii* mutants able to quench $_1O^2$ and other ROS, were integrated into a newly developed miniature and portable device, to measure and collect PSII fluorescence induction data in real-time for long periods. Several photosynthetic pollutants were detected within 10 min in concentrations between ng/L-µg/L and the different algae species tested showed diverse pesticide sensitivities.

Always towards to increase the biomediator performance, biomimetic peptides of the photosynthetic D1 binding niche of the microalgae *C. reinhardtii* were developed, both by chemical and biological synthesis. Standing out among the others, the biomimetic mutant peptide, D1pepS268C, bound to specific quantum dots, showed high ability to mimic the microalga in binding pesticides. Replacement of whole microalgae cells or their photosynthetic apparatus by mimetic peptide improved the system in terms of stability.

Keywords: Microalgae, *C. reinhardtii*, biomimic of photosynthetic apparatus, stability, selectivity, biosensor

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5.

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Integrated Point-of-Care Graphene Biosensors for Rapid Biomarker Detection for Brain Dieses

Z. Tehrani*, E.D. Ahmadi, J. Mitchel, R. Bigham, A. Devadoss, M. Ali, H. Abbasi, D. T. Gethin and O.J. Guy

Colleague of Engineering, Swansea University, Swansea, SA2 8PP, UK,

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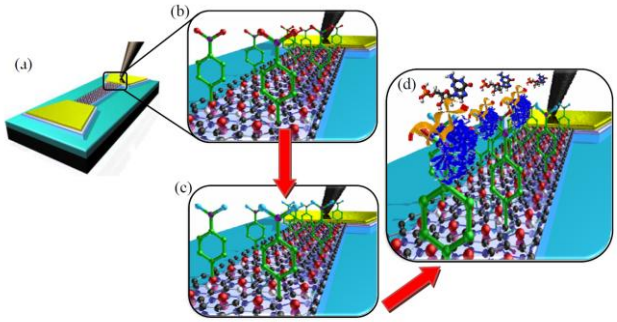

Abstract

With graphene technology, graphene-based biosensor, it is possible to diagnose diseases like cancer [1, 2] and dementia during very early stages compared to the conventional techniques and current biosensors. High performance of graphene biosensor is due to its large surface-to-volume ratio, remarkable optical, electrical, thermal and mechanical properties which provide high detection sensitivity, room temperature operation and open new generation of electrochemical biosensors, based on direct electron transfer between the enzyme and the electrode surface. Graphene biosensors are the new generation of sensing devices proved to be a promising and excellent nanomaterial for broad range of applications from optoelectronic to biomedical applications including sensing, drug delivery, imaging and photo-thermal therapy.

In this study, two different methods of passivation were studied.
First method initially the effect of utilising bi-layer photoresist in comparison to mono-layer photoresist in device fabrication of graphene biosensors was investigated. It is followed by passivation layer characterisation of low/high temperature deposition of silicon nitride (Si_3N_4), high temperature deposition of silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3) in graphene based biosensor. In this work, comparison between low temperature nitride and aluminium oxide deposition with high temperature Si3N4, silicon dioxide (SiO_2) and Al_2O_3 deposition as passivation methods were explored, as the low temperature one is resistant to the widest variety of chemical etchants. Regarding Si_3N_4 passivation layer, effect of deposition temperature (room temperature to 300 ^{O}C), silane (SiH_4) gas flow (36-48 sccm) and low frequency power (30-60 W) on layer thickness and roughness were fully characterised by using ellipsometer and scanning electron microscope (SEM). In addition to Si3N4 and SiO2 passivation layers, Al_2O_3 passivation layer deposited by ALD and sputtering were also investigated. In the second method, the screen print passivation layer was studied.
Finally, after fully characterisation of the results, final optimised chip which passed all our electrochemistry tests required for dementia was fabricated. This technique is scalable, reliable, and capable of providing a rapid, quantitative, label-free assessment of biomarkers at µg/mL concentrations in analyte solutions. This system has been specifically developed for Point-of-Care (POC) use.

Keywords: Graphene, Biosensor, Screen Print, Brain Dieses

Acknowledgements

This work was supported by the Engineering and Physical Science Research Council (grant number EP/I00193X/1), Welsh Government and EDRF.

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Laser performance of 10 *at.*% Yb:YSAG ceramic

Angela Pirri[1*], Guido Toci[2], Jiang Li[3], Yagang Feng[3], Tengfei Xie[3], Zhaoxiang Yang[3], Barbara Patrizi[4], Matteo Vannini[2]

[1]Istituto di Fisica Applicata "Carrara", Consiglio Nazionale delle Ricerche, IFAC-CNR,Via Madonna del Piano 10C, 50019 Sesto Fiorentino (Fi), Italy
[2]Istituto Nazionale di Ottica, Consiglio Nazionale delle Ricerche, INO-CNR,Via Madonna del Piano 10C, 50019 Sesto Fiorentino (Fi), Italy
[3]Key Laboratory of Transparent and Opto-functional Advanced Inorganic Materials, Shanghai Institute of Ceramics, Chinese Academy of Sciences, 1295 Dingxi Road, Shanghai 200050, China
[4]Istituto Nazionale di Ottica, Consiglio Nazionale delle Ricerche, INO-CNR, Largo Fermi 6, 50125 Firenze, Italy

Abstract

In this seminar we present the laser performance obtained with a 10 *at.%* Yb:$Y_3Sc_{1.5}Al_{3.5}O_{12}$ (=YSAG) ceramic sample and its spectroscopic characterization. Longitudinally pumped in *quasi*-Continuous Wave and in CW at 936 nm, the ceramic have been shown good laser performance in terms of laser output power (above 6W), slope efficiency (above 65 %), laser threshold (below 0.5 W). Finally, the tunable laser action has been obtained in the range between 991.5 nm and 1073 nm, *i.e.* 81.5 nm, by using a ZnSe prism.

Keywords: Solid-State Laser; Laser ceramics; Ytterbium.

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Novel formulations to enhance the efficacy of existing drugs and expand their therapeutic spectrum

Jinu George

[1]*Department of Chemistry, Sacred Heart College, Thevara, Kochi, INDIA 682013*

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Abstract

Cancer drug targeting is challenged by problems like low solubility and bioavailability of drug candidates in proper medium. Research in our laboratory is focused in the field of biological chemistry for the past several years. We focus on developing a nanotechnology-based system that will improve the current inadequate therapeutic management of infectious diseases. We envisage that our targeted drug delivery system (DDS) will target infected cells, and enable easier entry; slow release and retention of the antibiotics in the cells for longer, hence reducing the current dose frequency and lessen severity of infection.
We have successfully nano-encapsulated recently, a novel inhibitor of Nonhomologous DNA endjoining (NHEJ), termed SCR7 which acts by targeting DNA binding domain of Ligase IV (Srivastava et al, Cell . 2012; 151 (7): 1474–1487). NHEJ is one of the DNA double-strand break repair pathways predominantly operative in all mammals. Nanoencapsulation has increased its efficiency 5 times (F. John et al, macro mol. Bio sci. 2015) with an encapsulation efficiency varying from 50-65% in particle of 23 nm. We have observed through in vitro release assays performed in phosphate buffer solution (PBS) at various pH ranges, that the drugs were released in a slow manner over a period of several days. Furthermore, we have performed intracellular drug delivery studies in Nalm6 (Leukemia cell line) and MCF7 (breast cancer cell line) cells. Evaluation of its biological properties by using a variety of techniques, including Trypan blue, MTT and Live-dead cell assays, reveal that encapsulated SCR7 can induce cytotoxicity in cancer cell lines, being more effective in breast cancer cell line. Encapsulated SCR7 treatment resulted in accumulation of DNA breaks within the cells, resulting in cell cycle arrest at G1 phase and activation of apoptosis. More importantly, we found ~5 fold increase in cell death, when encapsulated SCR7 was used in comparison with SCR7 alone. A preliminary study of use of natural polymers: carrageenan and alginate, as potential nanocarriers increasing the bioavailability has been investigated. The study showed promise towards the development of a natural polymer-based drug delivery system.

Keywords: SCR7 polymer-based drug delivery system

Acknowledgements
To my funding agency, KSCSTE.

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Metal replacement and oil lubrication suppression: challenges and perspectives.

Carlo Rosso[1], Paolo Baldissera[1], Cristiana Delprete[1], Chenye Jian[1], Mauro Giorcelli[1] Aamer Khan[1], Alberto Tagliaferro[1]

[1]*Politecnico di Torino, Turin, Corso Duca degli Abruzzi, 24, Italy*

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Abstract

The reduction of pollutant gases is the challenge for modern reciprocating machines. Composite materials play an important role in allowing weight reduction. Aside the metal replacement, the composite materials can also help avoiding the usage of oil or grease lubrication, because of the lower friction coefficient and the self-lubricating properties of some fillers. In order to achieve these goals, research has to focus on the improvement of design strategies and on finding new composite combining fillers and matrices.

Metal replacement in engine components
In the present talk, the challenges of metal replacing in main engine components such as connecting rod and piston pin are presented, trying to figure out the potential of some composites. In particular, two different solutions are compared for designing a plastic composite connecting rod: one considering a thermoplastic matrix filled with short carbon fibres, the second using the pre-preg technique with a thermoplastic matrix filled with long carbon fibres. The advantages and the drawbacks of such technologies are presented, highlighting the possibility to save at least the 16% of weight.
The most important result in term of weight saving (66%) is achieved designing the piston pin using traditional carbon fibre epoxy composite and comparing it to the pre-preg technique with a thermoplastic matrix filled with long carbon fibres.

Oil lubrication suppression
Another depicted activity is the possibility to remove lubrication in a connecting rod / crankshaft coupling in a piston compressor. This goal is pursued by means of the comparison on dedicated test benches of different composites. This research proves that it is possible to use some particular composite materials for avoiding the presence of oil and grease lubrication and, as a consequence, the reduction of mass and maintenance of the device.

Improvement of plastic matrix composites
Finally, some perspectives in the usage of carbon nanofiller for changing the mechanical properties of plastic matrix composites are presented. The addition of a few wt% of biochar to the resin led to remarkable improvements in mechanical properties of the composites such as: transition from fragile to ductile behaviour, increase in Young modulus and friction coefficient reduction.

Concluding remarks
The research activities here reported prove that important goals in rethinking components can be achieved by improving the design practises, the composite material features and by finding the right combination of them.

Keywords: Metal replacement, oil lubrication suppression, nanofiller, improved mechanical properties

3.

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Structural performance of severely damaged reinforced concrete beams after SRP repair

Hayder Alghazali[1], Zuhair Al-Jaberi[1], John J. Myers[2*], Zena Aljazaeri[3],

[1] Graduate Research Student, Civil, Arch. and Envir. Engr, Missouri University of Science and Technology, Rolla, MO 65409, USA
[2] Professor of Civil, Arch. and Envir. Engr and Associate Dean, Missouri University of Science and Technology, Rolla, MO 65409, USA
[3] Lecturer, Nahrain University, Bagdad, Iraq

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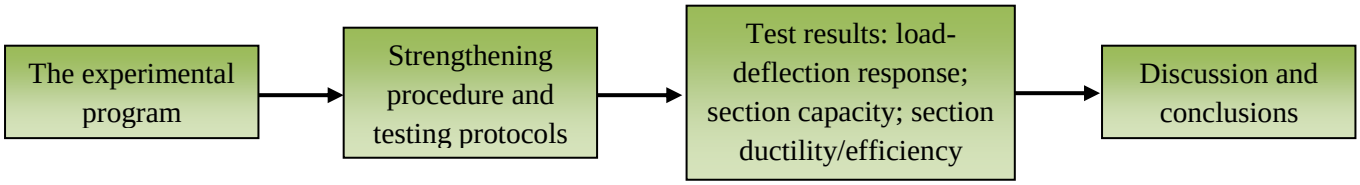

Abstract

Strengthening and repairing of concrete structures are among the major challenges in the civil engineering field. Comprehensive experimental research that has been implemented in the past have shown that the strengthening using advanced composite material has several advantages over the traditional ones, such as high strength, low weight and improved durability and the long-term life expectancy of the structure. The results presented within this paper are part of an on-going research program whose main objective was to upgrade the flexural capacity of RC beams with very short splice length. This research herein focused on using SRP sheet as a strengthening material and using the U-wrap strip as an anchorage system to prevent or delay the premature failure of longitudinal SRP sheet and to act as a confinement to the lap splice zone.

An experimental test program was carried out to investigate the performance of repaired damaged concrete beams with (SRP) repair technique. Six full-scale reinforced concrete (RC) beams were designed and tested using 4-point load test setup to be failed in lap splice in the middle region of the beam. The damaged concrete was repaired, and SRP sheet (longitudinal soffit laminates and transverse U-wrapping strips) was applied to restore the original flexural capacity. All beams were 10 ft (3.0 m) in length, 18 in. (457 mm) in depth, and 12 in. (305 mm) in width. Different repairing configurations were investigated. The studied variables were the number of plies and the amount and distribution of U-wrapping strips. Ultimate load capacity, deflection, and mode of failure were recorded during testing. The test results were compared to beam results with continuous reinforcement. It was concluded that repairing beams with SRP plies and U-wrapping strips can restore the beam to a capacity similar to that of reinforced concrete (RC) beam with continuous reinforcement.

Keywords: Steel reinforced polymer (SRP); severely damaged beams; flexural strength; confinement; lap splice zone.

Acknowledgements
This research was conducted at Missouri University of Science and Technology in the Structural Engineering Research Laboratory (SERL) in Rolla, Missouri. The authors gratefully wish to acknowledge the support of Sika USA Corporation for donating the epoxy agent and Hardwire LLC for providing the steel wire materials used in this study, Center for Infrastructure Engineering Studies (CIES) at Missouri University of Science and Technology, and HCED (The Higher Committee for Education Development in Iraq). The authors also wish to thank the technical support staff at Missouri University S&T for their efforts in this research study.

Thermal performance of composite phase change materials in energy storage units

Krzysztof Naplocha[1], Anna Dmitruk[1] , Jacek Kaczmar[1]
[1] Wroclaw University of Science and Technology, Faculty of Mechanical Engineering, Wyb.Wyspińskiego 27, 50-370 Wroclaw, Poland

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AlSi aluminium alloy foam

Manufacturing of metal foam/PCM composite
-moulding and heat treatment of polyurethane foam,
-investment casting,
-submerging in liquid paraffin.

↓

Examination of heat transfer
-charging and discharging of accumulator with composite PCM,
-monitoring of temperature distribution inside chamber,
-determination of temperature gradient and heating rate.

Abstract

Experimental research on thermal properties of paraffin/metal foam composite materials were discussed. Phase change materials (PCM) due to latent heat can storage high volume of energy in several thermal applications like solar panels or building constructions. To improve thermal conductivity high porosity metal foam was produced and integrated with paraffin. The thermal conductivity of the aluminum foam could be 2-3 orders of magnitude higher than liquid or solid phase change materials like paraffin. Therefore to improve heat transfer and reduce charging time low thermal conductivity PCM materials are supplemented with metal foam, fibers, fins or graphite powders. Developed production technology based on investment casting includes preparing of polyurethane foam, as a replica, molding with ceramic slurry and casting of aluminum alloy under low pressure. For complete mold filling and creating foam with thin wall structure suitable process parameters were established. Metal foams as a replica of PUR foam characterizing of 10 PPI, open porosity, were next submerged in liquid paraffin RT 92 maintained in steel chamber of the heat accumulator. Thermal properties of composite obtained in this way were examined by cyclic heating (melting) and cooling. The temperature distribution inside metal foam with paraffin was monitored at different distance from the heat source during entire process (20-100C). The effect of metal foam on charging performance i.e. heating rate, melting and cooling was studied in comparison with pure paraffin. Metal foam exhibiting skeleton, expanded structure can accelerate heat transfer and hence melting of paraffin. Temperature distribution within accumulator is more uniform and difference along distance from the heat source much smaller than that in pure paraffin. Using composite phase change materials it is possible to reduce charging/discharging time of heat accumulator. Some shortcomings of metal foam application relate to its durability. During phase transformation paraffin undergoes severe shrinkage putting metal structure into tension and compression. Though generated stresses are relatively low, acting dozen of times can deform metal foam due to fatigue weakening and developed microcracks.

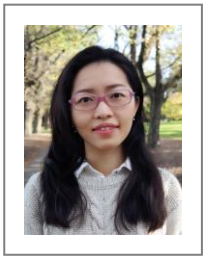
Keywords: metal foam, PCM, heat transfer

Acknowledgements
This work was supported by the project ACCUSOL ‘‘Elaboration of the novel cooling/heating system of buildings with the application of photovoltaic cells, solar collectors and heat accumulators” (ERANET-Lac, Cod. No. ELEC2015/T06-0523).

Numerical modelling of ultra-high performance fibre reinforced concrete panels under intense impact

Xiaoshan Lin*, Lei Yang

School of Engineering, RMIT University, Melbourne, 3000, Australia



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1. Introduction

   In recent years, due to the increasing risk of terrorist attacks and the accidental industrial explosions, the blast and impact resistance has become more and more important in the design of engineering structures. UHPFRC a promising construction material for protective structures due to its superior material characteristics compared to normal concrete.

2. Material model calibration

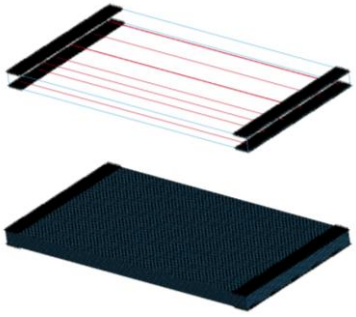
   The Concrete Damage Model (MAT72 R3) in LS-DYNA is employed in this study for modelling of UHPFRC under dynamic loading. The material model is calibrated based on the reported experimental data from three aspects, including the failure surfaces, the damage parameters and the equation of state.

3. Dynamic material properties

   A comprehensive and unified DIF formula with the consideration of various influencing parameters will be discussed, including the effects of matrix strength, fibre shape and fibre volume dosage.

4. Finite element model

   A 3D finite element model is established using LS-DYNA for simulating UHPFRC panel under blast load. The predicted displacement-time history is compared with the experimental results from literature.



Finite element model for UHPFRC panel.

5. Conclusions

A 3D finite element model is developed in this study for simulating the responses of UHPFRC panels subjected to intense impact loads. The developed finite element model and modelling techniques are validated to be effective and accurate.

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Abstract

In recent years, due to the increasing risk of terrorist attacks and the accidental industrial explosions, the blast and impact resistance has become more and more important in the design of engineering structures. Compared to normal concrete, ultra-high performance fibre reinforced concrete (UHPFRC) exhibits superior material characteristics, such as high tensile strength, high

ductility, improved strain capacity, excellent energy absorption ability and good fatigue resistance, which have made UHPFRC a promising construction material for protective structures. However, at present, a reliable design guideline for the application of UHPFRC in the protective structures is still lacking due to the insufficient reference data. As the great variety of UHPFRC, resulting from the use of different fibre type, fibre shape and fibre volume dosage in the mix design, difficulties are usually encountered in the prediction of dynamic material behaviour of UHPFRC by using a unified formula. In addition, in most of the reported numerical studies, the material model for normal concrete has often been used for the simulation of UHPFRC components, which might lead to inaccuracies in the numerical predictions due to the different post-cracking behaviour of UHPFRC compared to normal concrete. In this study, a finite element model is developed for the simulation of structural responses of UHPFRC panels subjected to intense impact loads. In order to capture the special characteristics of UHPFRC, the material model for normal concrete is calibrated for UHPFRC. The failure surfaces, damage parameters and the equation of state are adjusted based on the reported experimental data. In addition, the effect of strain rate on the dynamic material properties is taken into account in the present model by employing appropriate dynamic increase factors (DIFs) to describe the ratios of dynamic to static material properties at different loading rates. The values of DIF are determined using a comprehensive and unified formula recently proposed by the authors with the consideration of the effects of various parameters. The numerical predictions obtained from the current finite element model are compared with the test results from literature, and the proposed numerical model is demonstrated to be accurate in predicting the structural responses of UHPFRC panels under impact and blast.

Keywords: Ultra-high performance fibre reinforced concrete; material model; strain-rate effect; dynamic increase factor.

Nickel/alumina Metal Matrix Nanocomposites Obtained by High-Energy Ball Milling and Spark Plasma Sintering

Enrique Martínez Franco[1], Chao Ma[2], Ricardo Cuenca Álvarez[3], Jesús González Hernández[1] and Juan Manuel Alvarado Orozco[1]

[1]Center for Engineering and Industrial Development, Queretaro, 76125, MEXICO
[2]Department of Engineering Technology & Industrial Distribution Texas A&M University, College Station, 77843, USA
[3]National Polytechnic Institute-CIITEC, Mexico City, 02250, MEXICO

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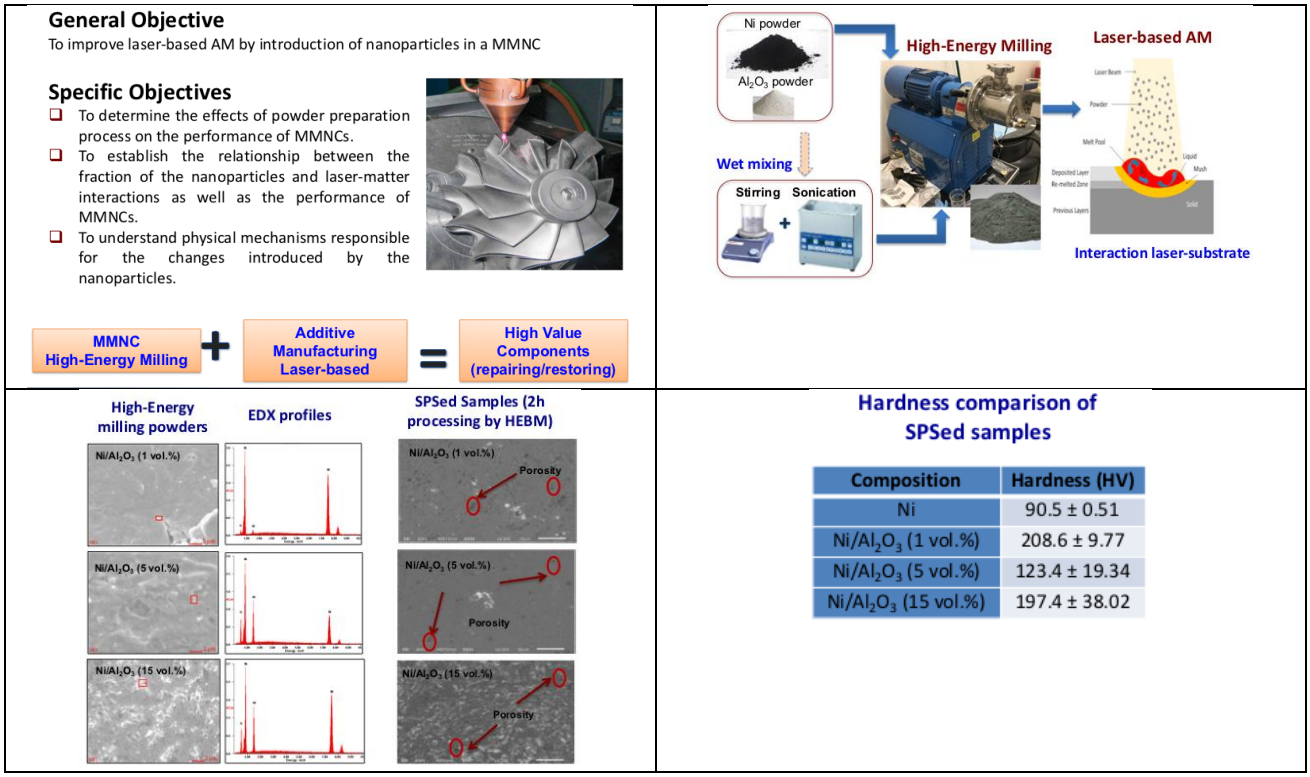

Abstract

Metal matrix nanocomposites (MMNCs) are anticipated to offer significantly better performance than the well-known Metal Matrix Composites (MMC) produced long time ago, and particularly for those existing superalloys. Nickel/alumina nanocomposite materials were fabricated with a powder metallurgy method, combining the High-Energy Ball Milling (HEBM) and Spark Plasma Sintering (SPS). The objective of this research is to determine the effect of alumina nanoparticle fraction and HEBM parameters on the powder preparation and sintering processes, and resultant microstructure and properties. Nickel powders containing various fractions (1, 5 and 15 vol.%) alumina nanoparticles were prepared by HEBM. The initial particle sizes were 44 µm and 50 nm for nickel and alumina, respectively. The milling process was conducted by cycling operation at high and low speeds (1200 rpm for 4 min and 150 rpm for 1 min). Samples at different milling times (30, 60, 90 and 120 min) of each composition were obtained. Scanning electron microscopy (SEM) was used to evaluate the dispersion of nanoparticles in the powders at different milling times. SPS technique was used for consolidation of the HEBM processed powders. SEM images showed that alumina nanoparticles are homogeneously dispersed in the metal matrix in the sample containing 15 vol.% alumina. Hardness measurements in cross sections of SPSed samples showed higher values for Ni/Al2O3 MMNC compared to pure Ni.

Keywords: Metal Matrix Nano-Composites; High-Energy Ball Milling; Spark Plasma Sintering

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Authors acknowledge to CONACYT-TAMU program research for the funding support for this research.

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REVERSIBLE CROSSLINKING IN COMPOSITE BINDERS - IN-SITU REPAIR SOLUTIONS and RECYCLABILIY

T. S. Coope[1], I. P. Bond[1], D. H. Turkenburg[2], S. Giannis[3], K. Kitsianos[4], H. R. Fischer[5]
[1] Advanced Composites Centre for Innovation and Science (ACCIS), Department of Aerospace Engineering, University of Bristol, Bristol, BS8 1TR, UK
[2] Océ, P.O. Box 101, 5900 MA Venlo, The Netherlands
[3] Element Materials Technology, Wilbury Way, Hitchin, SG4 0TW, UK
[4] GMI AERO, 9 rue buffault, 75009 Paris, France
[5]TNO Materials, HTC 25, NL-5656 AE Eindhoven, The Netherlands

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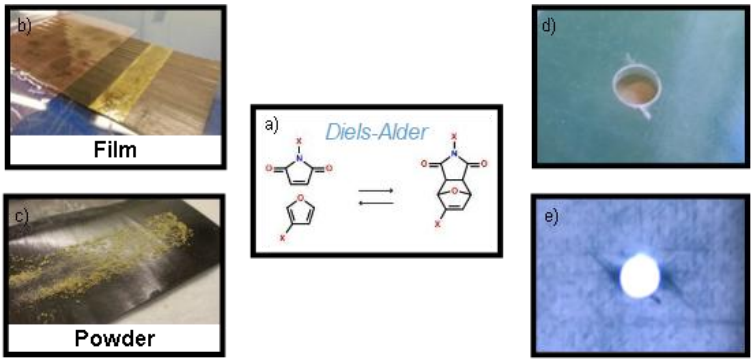

Abstract

Internal microscopic damage is ubiquitous in composites that have been subjected to damage, whether this be during the manufacturing process (i.e. via thermal stresses), from machining (i.e. drilling holes for bolted joints), during component assembly or ultimately from in-service loading. Incorporating an in-situ repair solution that can be activated after each of these individual processes could, in the first instance, have a significant impact on reducing composite component scrappage rates, post-manufacture repairs and increase the time-period for non-destructive testing (NDT) inspection. By utilising specific self-healing chemistries (i.e. via epoxy-amine polymers containing Diels-Alder based thermo-reversible bonds and/or epoxy resin healing agents) that can achieve multiple repair/healing cycles, damage generated throughout a components life cycle can be repaired and service life extended as well as complete recycling of fibres and resins can be possible. Materials of optimized composition form densely crosslinked networks at room temperature while repeatedly regaining the ability to flow at elevated temperature. Mechanical testing of bulk epoxy and reinforced polymer composite films demonstrate that the thermo-reversible effect is strong enough to achieve full self-healing of a severely cracked and delaminated test specimens. The critical load of the developed resin is only 50% lower compared to an epoxy benchmark without any self-healing capability; repetitive healing was found not to affect the mechanics of the resin significantly. The resin has been integrated in prepreg based test specimen and the self-healing efficiency remained around 40% with 5 subsequent healing cycles. Carbon and glass FRP prepreg-based laminates were manufactured and tested in double cantilever beam (DCB), open-hole tension (OHT) and skin-stiffener debond specimens; to represent specific areas or design features of high stress concentration where damage predominately occurs during manufacture and in-service. The embedded self-healing agents are thermally activated post-damage to repair the internal structure, akin to the healing functionality in animals and plants. This approach represents a truly positive benefit to industry to aid in the optimisation of composite manufacture, by reducing post-manufacture inspection time and material wastage costs, and also to maximise the longevity of composite components in service.

Keywords: self-healing composites, retro-Diels Alder reaction, epoxy

Acknowledgements
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Synthesis and application of uniform carbon sphere made from the reduced graphene oxide wall

Takahiro Saida[1, 2*], Kan Sakakibara[2], Takahiro Kogiso[2], Takahiro Maruyama[1, 2]

[1] Department of Applied Chemistry, Meijo University, Nagoya, 468-8502 Japan
[2] Faculty of Science and Technology, Meijo University Nagoya, 468-8502 Japan.

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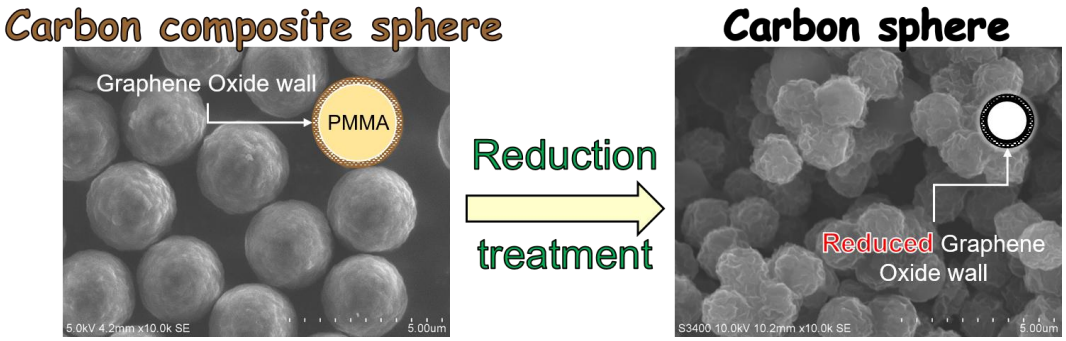

Abstract

The ordered structure carbon (OSC) with uniform pore size and pore structure has attracted attention as the electrode material of secondary batteries and super-capacitor, the catalyst support of fuel cell and heterogeneous catalyst, and biomaterials. OSC, in general, is made by the hard- or soft-template method according to the desired purpose. We had reported the uniform carbon composite sphere which was made from the graphene oxide wall and the polymethyl-methacrylate (PMMA) core[1]. This carbon composite sphere was preparation by one of the hard-template method, but the introducing process of carbon source and the carbonization process are not necessary since the graphene oxide is directly attached to PMMA core surface by Layer by Layer method. However, our carbon composite sphere has a PMMA core as a template, and its structural wall is still the graphene oxide. To achieve high surface area and better electron conductivity, it is necessary to remove a PMMA core and reduce a graphene oxide wall. In this study, removing of PMMA core and reduction of graphene oxide wall in the carbon composite sphere which made by the Layer by Layer method was conducted by the heat treatment in order to enhance its surface area and electron conductivity. The carbon composite sphere was prepared by allowing to a previous literature[1]. The heat treatment was carried under the vacuum conditions. Temperature and heating time of heat treatment was 300-350ºC and 5-12 h, respectively. A Raman peak attributing PMMA was drastically decreased by the heat treatment, but not disappear. From X-ray photoelectron spectroscopy analysis, amount of sp^2 carbon species depended on not only heating temperature and time but also a stacking number of graphene oxide layer. The sphere shape of carbon composite sphere was collapsed at a higher temperature of heat treatment. Although it is expected easy, the sphere shape was retained at a low temperature of heat treatment. But sphere size shrunk and the sp^3 carbon species originating PMMA core trended to remain. At this time, optimum conditions of heat treatment, which is keeping the sphere shape and changing to sp^2 carbon species from sp^3 carbon, were 300ºC and 12 h. In this conditions, the chemical state of carbon species of carbon composite sphere was almost composed of sp^2 carbon species. Thus, we thought that a PMMA core was nearly removed and the graphene oxide wall changed to the reduced graphene oxide. Additionally, the electrochemical capacitance in the acidic electrolyte was increased after heat treatment at the optimum conditions.

Keywords: Graphene oxide; Carbon sphere; Layer by Layer method.

Acknowledgements
This work was supported by KAKENHI, a Grant-in-Aid for Young Scientists (B) (15K17918), from the Japan Society for the Promotion of Science (JSPS). Part of this work was supported by the Nanotechnology Platform Program (Molecule and Material Synthesis) of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

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Composites of AISI 316L Stainless Steel and nanocrystalline Ti-B-C Ceramic Powders

S. M. Kaczmarek[1], T. Bodziony[1], V.H. Tran[2], P. Figiel[3], A. Biedunkiewicz[3], G. Leniec[1]

[1] Institute of Physics, West Pomeranian University of Technology, Al. Piastów 17, 70-310 Szczecin, Poland

[2] Institute of Low Temperatures and Structural Research, 2 Okólna str., 50-422 Wrocław, Poland

[3] Institute of Materials Science and Engineering, West Pomeranian University of Technology, Al. Piastów 17, 70-310 Szczecin, Poland

Series of nanocrystalline TiC, TiB_2, and B_4C powders as dopants embedded in an AISI 316L austenitic steel have been prepared by the selective laser melting technique and investigated by ferromagnetic resonance and magnetic measurements [1]. The homogeneous composites with the dopants up to x = 7 vol. % exhibit superparamagnetic properties, characterized by i) bifurcation between the field-cooled $M_{FC}(T)$ and zero-field cooled $M_{ZFC}(T)$ magnetization below T_{ir} and ii) a maximum at T_{max} in low-field $M_{ZFC}(T)$ curves. We found that the T_{ir} and T_{max} values depend proportionally on the dopant concentrations x. The magnetization measurements in fields above 1000 Oe suggested an induced phase transition from superparamagnetic state to ferromagnetic one but presumably without long-range magnetic correlation. An analysis of magnetic anisotropic energy barrier distributions implied that different sizes and compositional types of dopants may contribute to the superparamagnetic relaxation process. The results demonstrate possibility of obtaining new steel-based materials with desired properties and potential applications as combining magnetic and mechanical advantages.

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Application of biocomposite materials in building wall constructions

Juris Skujans, **Staņislavs Pleiksnis**[#], Edmunds Visockis

[#]Latvia University of Agriculture Faculty of Environment and Civil Engineering

Abstract

In Latvia, stocks of traditional building materials (limestone, dolomite, clay, gravel, gypsum) are limited. It is therefore necessary to think about alternative building materials what are renewable and can provide a sustainable construction process. These issues are also addressed at the national level. Paragraph 5 of Article 4 of the Construction Law of the Republic of Latvia on construction principles states: "Construction complies with the following principles: the principle of sustainable construction, in accordance with which the construction process creates a quality environment for current and future revisions, for this purpose also increasing energy resources and promoting other natural resources Effective use."

The international scientific publication offers a solution for the use of renewable resources what available in Latvia - tree leaves, legumes, cannabis shoots and sapropel can be used in building envelope as thermal insulation material. The aim of the work is to find out the thermal properties of these natural composites and to compare them. By using such building materials, the environment, the energy and money will be saved.

The grader of alternative building materials discussed in this research work meets the requirements of the normative documents of the Republic of Latvia on sustainable construction principles. At the end of its lifetime, the eco-insulation can be re-used as a soil for growing various ecological products and later also recirculated in the environment by improving soil fertility.

Keywords: Maple leaves, legume, hemp shives, sapropel, heat conductivity coefficient.

Vertically aligned composite electrodes using carbon nanotubes and pseudocapacitive materials for supercapacitors

F.Ghamouss[1], B.Pibaleau[1, 2], M. Porcher[1], M. Pinault[2], M. Mayne-L'Hermite[2], F.Tran-van[1]

[1]*Laboratoire PCM2E Université de Tours, France*
[2] *NIMBE, CEA, CNRS, Université Paris-Saclay, CEA Saclay, Gif-sur-Yvette, France*

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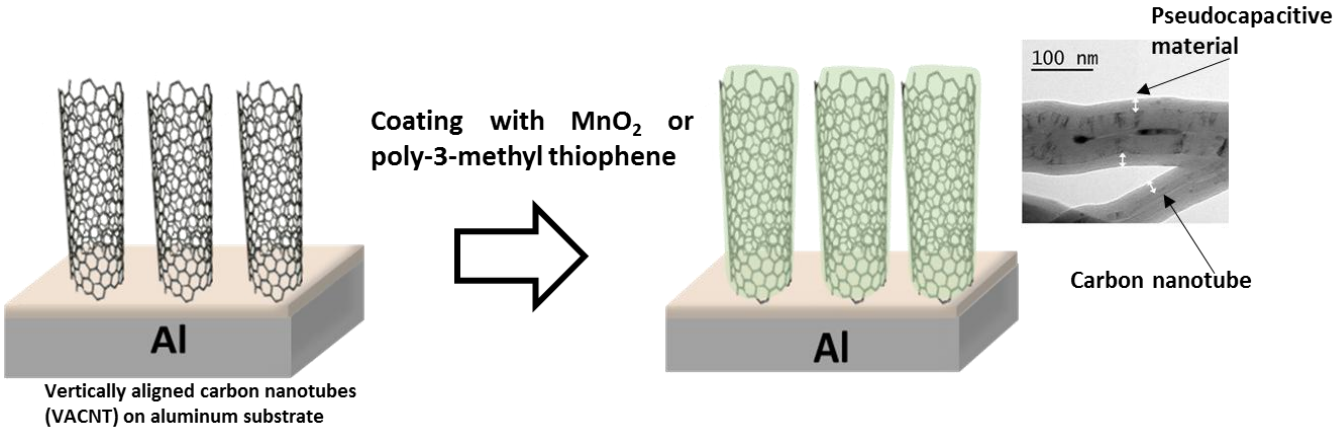

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Abstract

Electrochemical energy storage systems are today well established for portable and miniaturized devices, as well as, for automotive applications. Among these systems supercapacitors, also called electrochemical supercapacitors have attracted increasing interest in the recent years. Supercapacitors largely outperforms secondary batteries in terms of delivered power and cyclability but challenges remain in order to improve their energy. Actually, compared to secondary batteries, supercapacitors are much less energetic (1).

Conventional supercapacitors use two activated carbon-based electrode separated by a liquid electrolyte and electrical storage is simply ensured by electrical charges accumulation of the electrolyte on the polarized electrodes. Then and unlike secondary battery the electrical storage process in conventional supercapacitors does not involve faradic reactions allowing a fast storage kinetics (high power) but with relatively low energy (less electrical charge and capacitance). However, such an issue can be overcome by using pseudo-capacitive materials that combine both battery-like and supercapacitor–like behavior (2,3). Pseudo-capacitive materials such as oxide materials, e.g. MnO2 and RuO2 or electronic conducting polymers, e.g. polypyrrole and polyaniline, show higher capacitance by comparison to carbonaceous materials. Therefore, they have attracted an increasing interest as electrode materials for achieving high-energy supercapacitors. Indeed, when pseudo-capacitive materials are deposed as thin films on conductive substrates they can exhibit an impressive capacitance. Moreover, the capacitance can be further increased by using 3D substrates that allows high electrode surface and faster electrolytes diffusion.

In this work, vertically aligned carbon nanotubes (VACNT) prepared by an aerosol assisted CVD on aluminum substrate and coated with thin films of pseudocapacitive materials (manganese oxide and poly-3-methyl thiophene) are prepared (4). The VACNT coating by the pseudocapacitive materials were performed using anodic electrochemical depositions. The obtained composite materials were examined in terms of their structural and textural properties, as well as, their electrochemical performances. Furthermore, the 3D composite architectures were optimized to deliver high gravimetric capacitance, high-rate capability and cyclability at high mass loading in view of practical applications.

Keywords: Supercapacitors; carbon nanotubes; pseudocapacitance, metal oxides, conducting polymers.

Acknowledgements
The French National Agency Research (ANR) supported this work through the DGA ASTRID program and the H2ECap project.

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Design of cost-efficient high modulus steels as innovative lightweight materials

Christian Baron[1], Hauke Springer[1], Dierk Raabe[1]

[1]*Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf, 40237, Germany*

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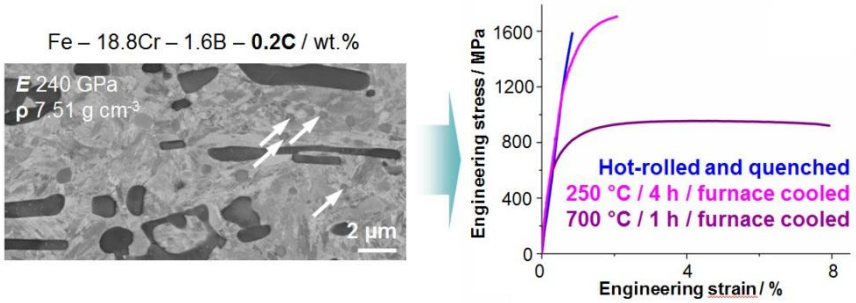

Abstract

Ever growing demand of efficiency and performance of materials utilised in transportation systems pushes frontiers of material design towards the development innovative structural lightweight materials. Typical approaches, especially regarding steels as the most common group of iron (Fe) based alloys, focus on increasing materials' strength, thereby to decrease wall thickness and thus weight. Only recently other key material parameters such as stiffness (expressed by the Young´s modulus; (*E*)) and the mass density (ρ) have come into focus. The desired property profile can be achieved by utilising substantial amounts (about 10 – 25 vol.%) of stiff and low-density particle phases and thus so termed high modulus steels (HMS) designed. From theoretical point of few a plethora of particles seem applicable [**1**], however e.g. their thermodynamic stability, interfacial properties (such as wettability) and formation kinetics have to be taken into account, narrowing down the range of possible candidates. Consequently most HMS concepts typically rely on the Fe – Ti – B model system due to the outstanding properties of the in-situ formed Titanium diboride (TiB_2). However, while tailoring of these particles is possible (e.g. changing size and shape), the modification of the iron matrix microstructures is very limited and the production costs high.

It is therefore of high interest to identify and develop alloy systems consisting of low cost elements, which allow to achieve optimum physical performance in combination with a wide range of mechanical properties achieved by established synthesis and processing procedures. In this context the Fe – Cr – B system was found to be extremely attractive for HMS design [**2**] as it allows straightforward processability and well tuneable mechanical properties via plain heat treatments [**3**].

The base alloy Fe – 18 Cr – 1.6 B (wt.%) contained 14 – 17 vol.% of $(Cr,Fe)_2B$ particles of ellipsoidal morphology in a ferritic matrix and revealed after hot rolling a specific modulus of 32.8 GPa g^{-1} cm^3, exceeding that of conventional Fe-Cr steels by almost 30 %. The addition of 1 wt.% Cu to the base alloy allowed to mildly increase the strength values by ageing treatments, however at the price of a reduction of the specific modulus. More interestingly, C additions of 0.2 wt.% did not affect the $(Cr,Fe)_2B$ particles greatly, but free C dissolved in the matrix allowing us for the first time to utilize the full spectrum of equilibrium and non-equilibrium phase transformations typical of C steels also in high modulus steels. The alloy design concept for was demonstrated for the example case of a martensitic matrix achieved by a quenching and tempering treatment, leading to a drastic strength increase from 800 MPa (soft annealed) and even up to more than 1600 MPa (quenched and tempered at 250 °C).

Keywords: stiffness, density, strength, composite, high modulus steels

Acknowledgements
Financial support of subproject S02 'Validation' of the Collaborative Research Center SFB 1232 "Farbige Zustände" by the German Research Foundation (DFG) is gratefully acknowledged.

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Chances and challenges in the application of fibre metal laminates

Daniel Stefaniak, Robert Prussak

Institute of Composite Structures and Adaptive Systems, German Aerospace Center (DLR), Braunschweig, Germany

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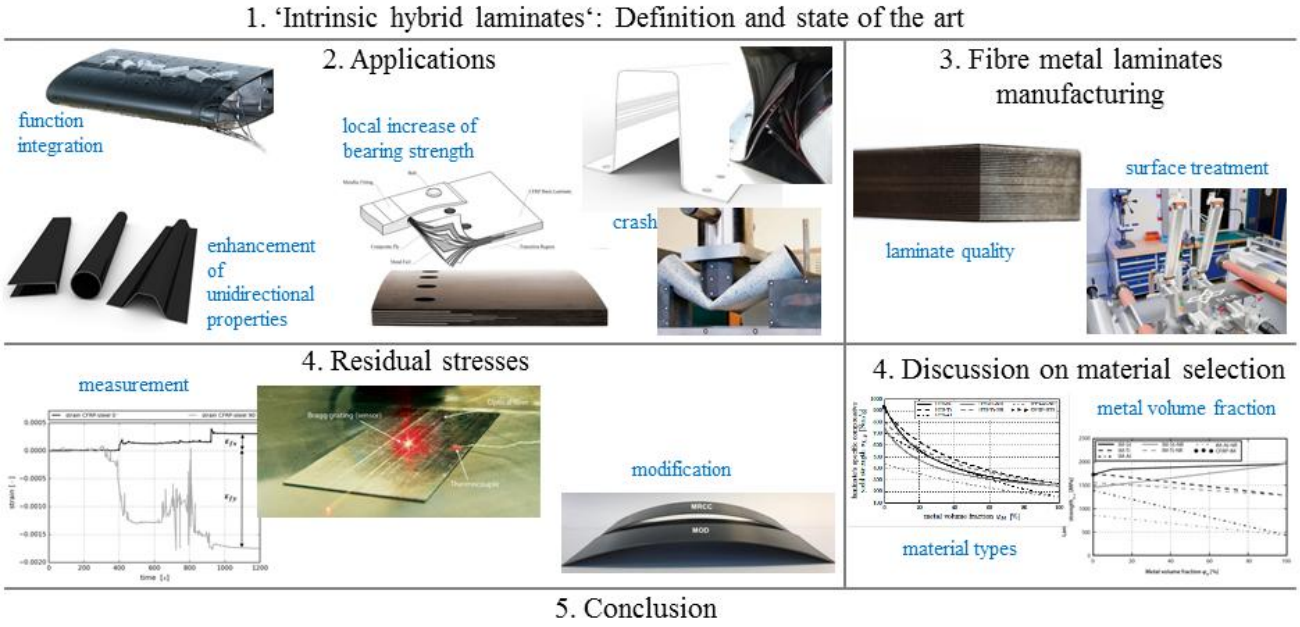

Abstract

Fibre-metal laminates (FML) as a combination of metals and fibre reinforced plastic materials are investigated in a variety of current research projects. The intention of combining these two different materials is the compensation of their inherent weaknesses. However, their application as a multi-layered laminate is also accompanied by a wide range of challenges. 'Intrinsic hybrid laminates', FML where the cohesion between FRP and metal is created by the FRP matrix during its cure without the use of any additional adhesive, are in focus of this work. The most well-known example is glass fibre reinforced aluminium (GLARE) which is used to enhance fatigue properties in aerospace structures [1]. Unfortunately, it can be observed that FML are taken into consideration for former metal parts which are made of FRP without changing their geometry. This approach is strikingly called 'black metal' design as often carbon fibre reinforced plastic (CFRP) is used in the geometry of a metallic part instead of adapting the design to the specific demands of FRP with regard to mechanics and manufacturing. Intrinsic hybrid laminates are than employed to compensate the inappropriate design.
The aim of this work is to derive certain key parameters for the material selection process and to discuss certain material configurations with respect to specific applications and challenges. Therefore, different applications using FML in current research projects at German Aerospace Center are discussed and requirements are deduced. The applications cover UD-CFRP steel laminates [2], local metal hybridization [3] as well as the use for impact [4] and crash prone structures. Then, the manufacturing of FML is discussed as the design of the interface between matrix and metal surface has a large impact on the material´s behaviour. In addition, the metal layers serve as a barrier layer against fluids. Different surface treatments are compared and experimental results with respect to interlaminar shear strength are presented.
Other specific challenges in the use of FML are the process- or manufacturing induced residual stresses. Residual thermal stresses occur as a consequence of the difference in coefficient of thermal expansion (CTE) of the two constituents of an ´intrinsic hybrid´ and the difference between cure temperature of the matrix and operational temperature of the cured laminate and generally depend on the fraction and stiffness of its constituents. Previous findings showed that the stresses additionally depend on the manufacturing process and parameters [5]. Therefore, the term 'stress free temperature' (SFT) is used to represent

the temperature at which the laminate may be regarded as stress free on laminate level and to provide a process parameter irrespective of the constituents used. With the help of the SFT, the residual stresses in a laminate are predictable for any arbitrary temperature when stiffness, CTE and fraction of the constituents are known. The formation of strains during cure is measured in certain laminates with the help of fibre Bragg grating sensors (FBGs). A certain procedure, which is described in detail, allows the calculation of the stresses retroactively. These findings also show that the stress level may be reduced significantly by modifying the curing process. Finally, the suitability of different material combinations at different constituent fractions is discussed under consideration of the findings in residual stress development.

Keywords: fibre metal laminate; fibre reinforced plastic; residual stress; fibre Bragg grating sensors

Acknowledgements

The presented findings were essentially gained during the project no. 8 of the 'Schwerpunktprogramm SPP1712´ funded by the 'Deutsche Forschungsgemeinschaft´. The authors like to thank for funding and support. Another word of thanks is addressed to Salzgitter Mannesmann Forschung for providing material.

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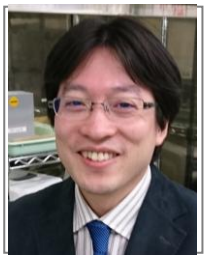
Innovative Lithium Recycling Technology from Used Li-ion Batteries using a Lithium Ionic Superconductor

Tsuyoshi Hoshino[1]

[1] *Breeding Functional Materials Development Group, Department of Blanket Systems Research, Rokkasho Fusion Institute, Fusion Energy Research and Development Directorate, National Institutes for Quantum and Radiological Science and Technology (QST), 2-166, Obuch, Omotedate, Rokkasho-mura, Kamikita-gun, Aomori, 039-3212, Japan*



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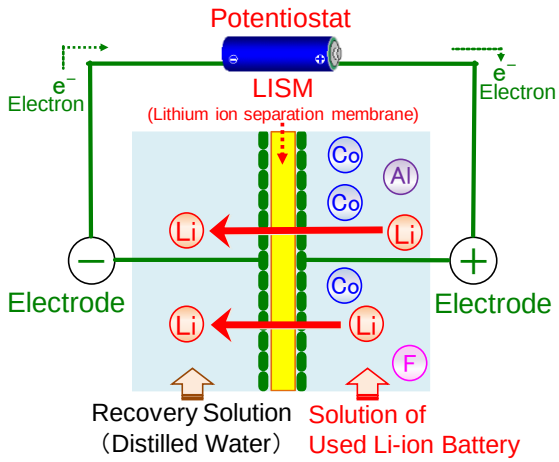

Fig.1 Li recovery from used Li-ion battery solution using the proposed electrodialysis method with LISM.

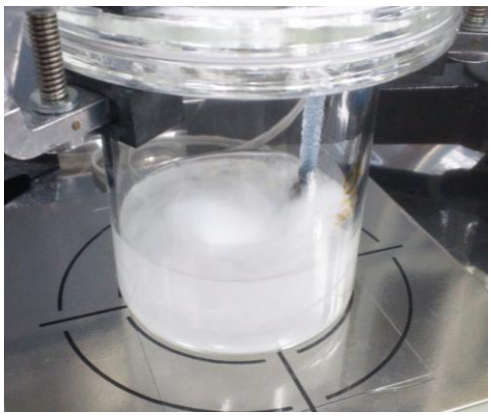

Fig.2 Li_2CO_3 fabrication as a raw material for Li-ion batteries by the chemical reaction of CO_2 gas.

Abstract

In recent years, the industrial importance of lithium (Li) has increased due to its use in Li-ion batteries. I have developed a method for the recovery of Li from seawater using a Li ionic superconductor functioning as a Li-ion separation membrane (LISM) [1]. Only Li ions were successfully recovered from seawater through the LISM. Therefore, I have developed an innovative new method for recycling Li from used Li-ion batteries using the LISM.

Figure 1 shows the proposed Li recovery method. This innovative method involves the use of an LISM whereby only Li ions in a solution of used Li-ion batteries permeate from the positive electrode side to the negative electrode side during electrodialysis; the other ions, including Co, Al, and F, do not permeate the membrane. $Li_{0.29}La_{0.57}TiO_3$ was selected as the LISM. The positive side of the dialysis cell was filled with used Li-ion battery solution. Then the negative side was filled with distilled water. The applied dialysis voltage was 5 V, and electrode area was 16 cm^2. The Li recovery ratio increased with electrodialysis time. Then, Co, Al, and F were not permeated.

After electrodialysis, CO_2 gas was bubbled in the Li recovery water to produce lithium carbonate (Li_2CO_3) as a raw material for Li-ion batteries. The Li_2CO_3 deposition was easily generated by the reaction of CO_2 gas and the Li recovery solution as a lithium hydroxide (LiOH) solution (Fig. 2).

This new method for recycling Li-ion batteries shows good energy efficiency and is easily scalable. Thus, this electrodialysis method is suitable for the recovery of Li from used Li-ion batteries.

Keywords: Lithium; Recycling; Used Li-ion Batteries; Lithium Ionic Superconductor; Electrodialysis

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Possibilities of filling polymeric anchors with secondary raw materials with effect on price and final parameters

Rostislav Drochytka[1], Jakub Hodul[1], Tomáš Žlebek[1]

[1]Brno University of Technology, Faculty of Civil Engineering, AdMaS Centre, Brno, Czech Republic

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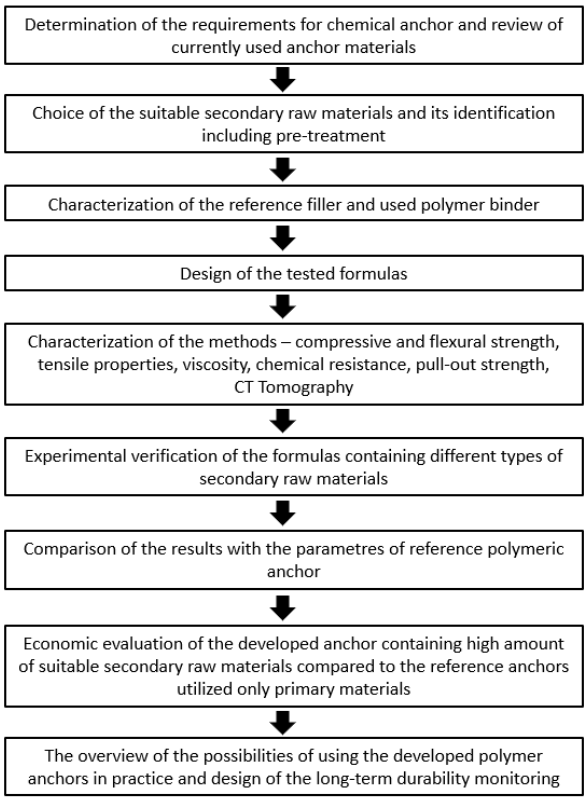

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Abstract

Within this work different types and amounts of the suitable secondary raw materials as filler to polymer anchor were tested as possible substation of the currently used primary fillers. Physical and mechanical properties of the fast curing anchoring material based on epoxy resin were determined. The aim of this research was to achieve the anchor containing high amount of the secondary raw materials with the same or better final properties than reference anchors. As the suitable secondary raw materials, waste packaging glass (PG), high temperature filter fly ash(CF) and circulating fluidized bed combustion (CFBC) filter fly ash contaminated by the selective non-catalytic reduction (SNCR) denitrification technology were chosen. To use as much as possible suitable secondary raw materials to limit its landfilling and save the price for the expensive epoxy resin was verified. It was found out that the developed polymer anchors containing up to 45% contaminated filter fly ash shows better physical and mechanical properties than reference anchors utilizing only primary materials. This ascertainment should make the production of polymer anchor both environmentally and financially less demanding. Furthermore, the microstructure of the developed anchors was investigated by the CT tomography, and it was found out that even after the pull-out force of 120 kN there was no deterioration of the polymer anchor and a filler in the form of fly ash was evenly distributed in the polymer mass.

Keywords: Polymer anchor, secondary raw materials, filler, strength, economical aspect, green material

Acknowledgements

This work was financially supported by the project No. FAST-J-18-5343 "Development of highly resistant repair composite for the reconstruction of cast basalt objects using secondary raw materials."

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Fracture toughness of MIM (metal injection molding) materials.

Vratislav Mares[1], Radek Tomasek[1], Lukas Horsak[1], Katerina Dedkova[1]

[1]Center of Advanced Innovation Technologies - VŠB-Technical University of Ostrava, 17. listopadu 15, 708 00 Ostrava-Poruba, Czech Republic

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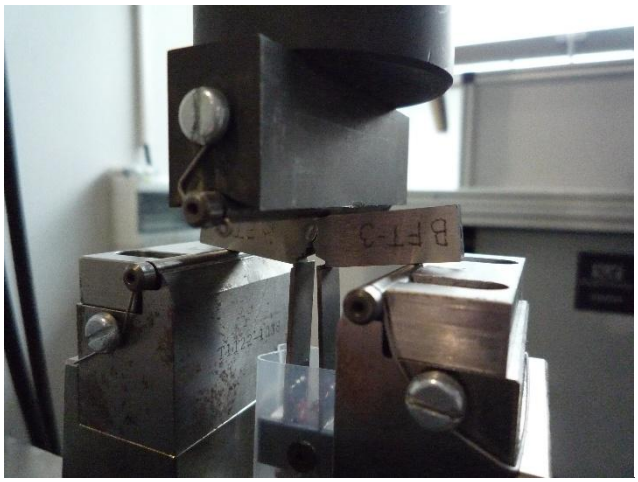

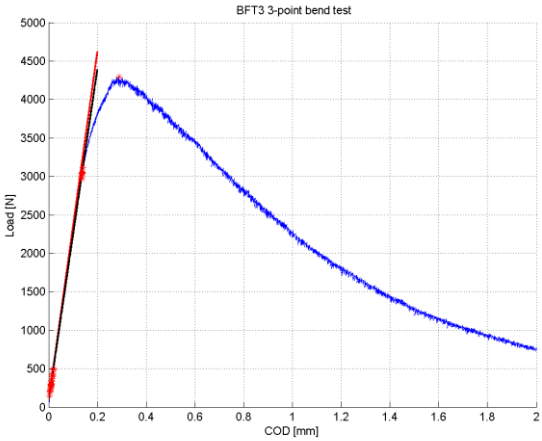

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Abstract

Metal injection molding (MIM) is a metalworking process in which finely-powdered metal is mixed with binder material to create a "feedstock" that is then shaped and solidified using injection molding. The molding process allows high volume, complex parts to be shaped in a single step. The materials produced in this way can have better their usable and mechanical properties then materials produced by standard metallurgical process. From material properties was aimed to determine fracture toughness. Fracture toughness means the resistance of the material to the origin and subsequent crack growth. It originates from the mechanics of the quarry and is essentially a material characteristic, using which can calculate the load-carrying capacity of the crack component. From a practical point of view, toughness is possible to characterize as the ability of the material to absorb energy before or before the violation reaching a certain limit state. The intention of a fracture toughness test is to measure the resistance of a material to the presence of a flaw in terms of the load required to cause brittle or ductile crack extension (or to reach a maximum load condition) in a standard specimen containing a fatigue precrack. The result is expressed in terms of toughness parameters such as K_{Ic}, critical J-integral or critical crack opening displacement. The fracture toughness of 4 types of steel made by MIM (metal injection molding) was discussed. Due to the use of MIM materials, the mechanical properties are quite high, especially the ultimate strength. Because of the high strength, the materials are relatively brittle and the K_{ic} value itself may not have large differences. The J-integral value, which takes into account the plastic behaviour of materials, is also discussed in the research. The testing itself was focused on instrumental impact toughness and fracture toughness with J-integral calculation. Knowledge of fracture properties will enable the component to be well dimensioned and thus improve its lifetime. The fracture properties also allow calculations of the residual life of structures containing a subcritical defect. Above-mentioned materials are widely used in the industry as special constructions parts. These properties must be examined in connection with the technology.

Keywords: Fracture toughness; Metal injection molding; Mechanical properties. Steel

Acknowledgements
This study was supported by project LTI17023 (INTER EXCELENCE, INTER INFORM*)*

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Elastomeric composite materials with giant permittivity

A. Serghei[1], W. Xu[1], L. David[1], B. Cantaloube[2], P. Heuillet[2]

[1]University of Lyon, Ingénierie des Matériaux Polymères, 69622 Villeurbanne, France
[2]Laboratoire de Recherches et de Contrôle du Caoutchouc et des Plastiques, 94400 Vitry-sur-Seine, France

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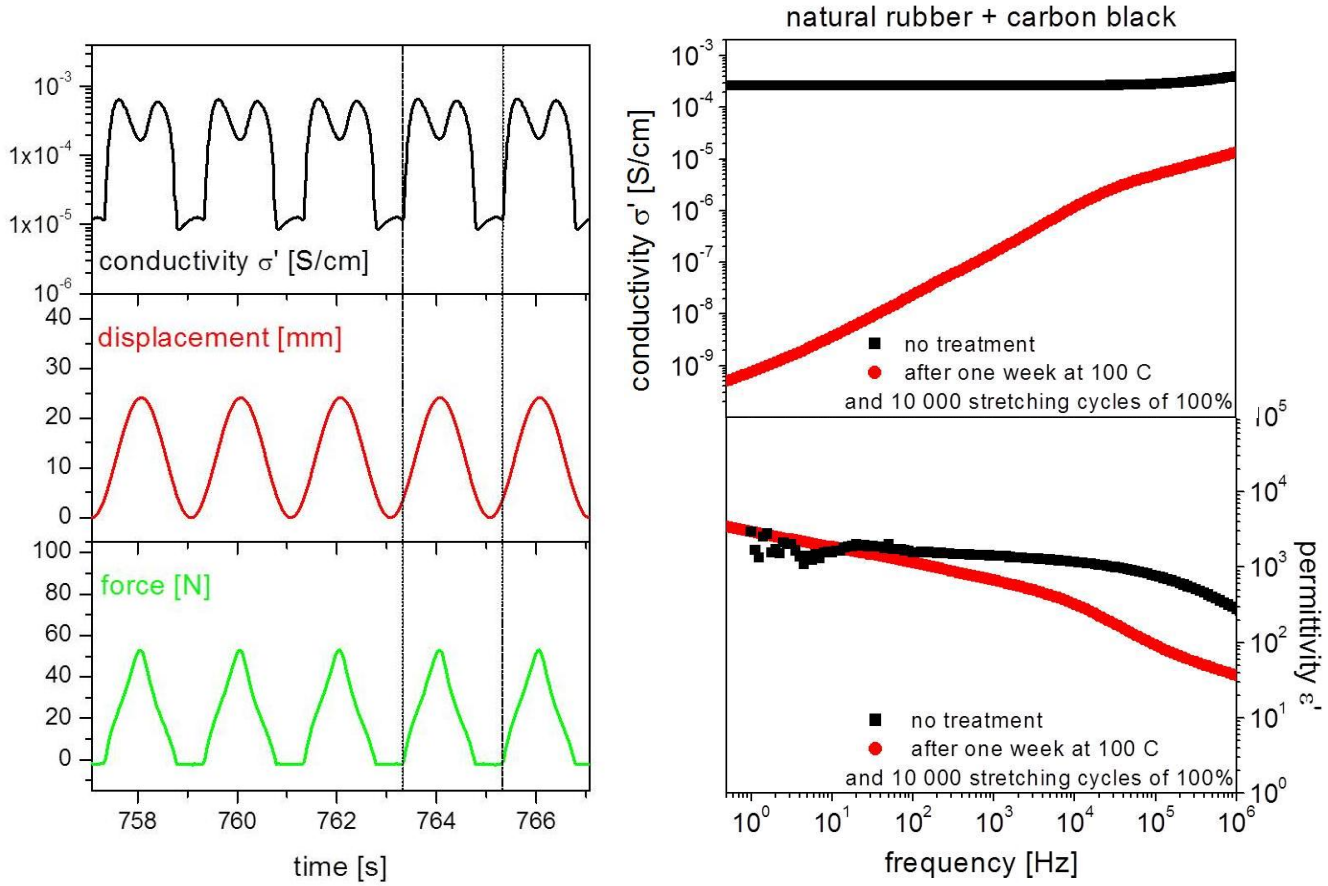


Abstract

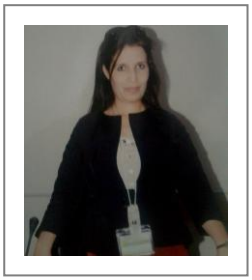
A recently developed experimental approach is applied to carry-out coupled electrical-mechanical investigations on elastomeric composite materials upon mechanical deformation. The goal of the study is to develop a platform that allows one to detect, by means of in-situ electrical measurements, the impact of thermal and mechanical fatigue on the functionality of elastomeric composite materials (natural rubber, nitrile-butadiene rubber and EPDM rubber filled with carbon black). Two orthogonal directions are accessible for the electrical measurements, carried-out by means of Broadband Dielectric Spectroscopy: parallel and perpendicular to the direction of the mechanical stretching. For the perpendicular direction, a non-conventional approach to measure the conductivity value without employing a direct contact between the electrodes and the samples under investigation has been developed and implemented. Large variations in conductivity, for both the parallel and the perpendicular directions, were detected (Figure 1), proving the sensitivity of this approach in assessing the effects of the thermal and mechanical fatigue on the properties of the elastomeric materials. Our study brings, for the first time, a direct experimental evidence for a strong anisotropy in the evolution of conductivity upon mechanical stretching. Furthermore, it is found that after a thermal treatment combined with a mechanical treatment, the natural rubber filled with carbon black, initially conductive, shows negligible conductivity values (in the order of 1E-12 S/m) while preserving high values for the electrical permittivity (~1000). This finding brings evidence for an alternative approach to develop polymer materials with enhanced permittivity values.

Keywords: coupled mechanical/electrical measurements, functional composite materials, in-situ fatigue monitoring

Synthesis, Processing, and Fabrication of Antiseptic Composite (Apatite/Collagen)

Soumia BELOUAFA

Laboratory of Biomolecules and Organic Synthesis. Faculty of Sciences Ben M'Sik. University Hassan II of Casablanca. Avenue Driss El Harti B.P 7955, Sidi Othmane Casablanca, Morocco.



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Abstract

Because of their physicochemical characteristics, ceramics are synthetic, biocompatible and bioactive materials. Following a phenomenon of dissolution / precipitation / resorption / bone substitution, they provide at their expense bone formation by osteoconduction.
However, the bone and dental defects induced by certain pathologies require in addition to the stabilization of the lesion, to erase the destructive effects of the disease which the general treatment is difficult. Hence, it is necessary to be able to treat them by local and prolonged release of the active subtances, using support matrixes based on calcium phosphate/collagen.
Phosphocalcic apatite vector of antiseptics are characterized by the presence of oxygen species within their structure, responsible for antiseptic property, which has earned them the name of “oxygenated apatites”.
The objective assigned to these research works is to develop a novel process for the synthesis of phosphocalcic apatite/collagen vector antiseptics with dissolution rate adaptable to that of bone neoformation and a progressive diffusion of antiseptic agents " oxygen species ".
In order to reduce the cost of this process while enhancing our natural resources, we were interested in the development of these biocomposites using, as a precursor of phosphorus, phosphoric acid main derivative of the first Moroccan wealth; natural phosphate.
These biocomposites can be indicated in several clinical cases of filling, as examples:

- Filling after extraction,
- Filling of peri-implant defects,
- Filling cavities after apical surgery,
- Filling infra-osseous bags in periodontics.

After implantation, molecular oxygen and peroxide ions are released into the living medium either by progressive dissolution of the material, or by chemical exchange with the medium while maintaining the apatitic structure and the related properties of biocompatibility.
This allows to limit the development of bacteria, fungi, ... that are present before the intervention (caries, periodontal diseases ...) or that are the consequence (imperfect asepsies including mouth, inflammation ...).

Keywords: Antiseptic activity; apatites; collagen; biocomposite.

Acknowledgements
The author wish to Laboratory of Process and Environment Engineering, Faculty of Sciences and Technologies Mohammedia, Morocco for supporting this research.

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Injectable hydrogel composites for biotechnological applications

Laura Chronopoulou[1*], Antonio Di Nitto[1], Adriana Amalfitano[2], Giuseppina Nocca[2], Alessandro Arcovito[2], Ilaria Cacciotti[3], Robertino Zanoni[1], Cleofe Palocci[1]

[1]*Department of Chemistry-University La Sapienza, Rome, 00185, Italy*
[2]*Biochemistry and Clinical Biochemistry Institute-Catholic University Sacro Cuore, Rome, 00168, Italy*
[3] *Engineering Department- Niccolò Cusano University, Rome, 00166, Italy*

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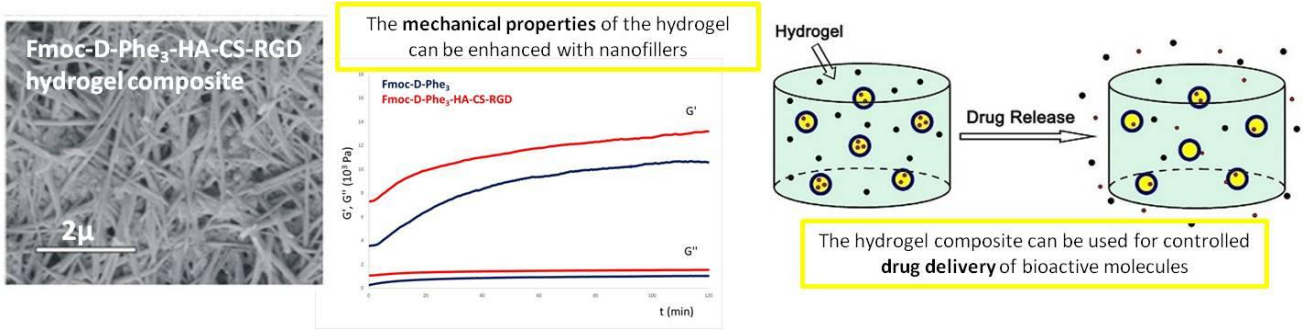

Abstract

Hydrogel materials, thanks to their biocompatibility and biodegradability, are very promising for the development of new biocompatible scaffolds for controlled drug release, tissue regeneration and tissue engineering. Low molecular weight peptide-based hydrogels (LMWPGs) are an interesting class of soft materials for the preparation of versatile systems that can be easily modified, both chemically and biologically. Recently, we developed an enzymatic approach for the preparation of injectable, self-assembling materials based on Fmoc-oligopeptides[1]. The reaction products (Fmoc peptides) spontaneously self-assemble in water to originate fibrils, that become entangled to form a three-dimensional structure of fibers with a diameter of approximately 7 nm, as evidenced by atomic force microscopy (AFM) measurements. Macroscopically, a stable, self-supporting hydrogel material is produced. These materials can be used as controlled drug delivery systems for a wide spectrum of bioactive molecules[2,3] and may enhance cell production of growth factors[4]. For biomedical applications, hydrogel biomaterials require adequate structural stability, sufficient mechanical properties and biocompatibility. To this aim, hydrogel materials can incorporate nanofillers, such as polymeric or inorganic nanoparticles and nanocarbon based structures. We have employed Fmoc-oligopeptide hydrogels for the preparation of composite materials specifically designed for bone tissue regeneration. These tailor-made hydrogel systems contain biopolymeric spheres delivering bioactive molecules, as well as pure and substituted calcium phosphate (CaP) nanoparticles to provide bioactivity, osteoconductivity and improved mechanical properties. The morphological and viscoelastic properties of the synthesized hydrogels were investigated by SEM and rheological measurements. The biocompatibility of the composite materials with different mammalian cells was also assessed. The injectability of the prepared materials makes them suitable for *in vivo* applications. Ongoing work is aimed at investigating the biological properties of the composite hydrogel systems, in terms of adhesion, growth and differentiation of human mesenchymal stem cells. Moreover, we are developing new hydrogel composites through the incorporation of graphene based nanofillers, that offer the potential to tailor the mechanical strength of the native material, adding binding sites for further bio-functionalization with biological molecules, and supplying additional properties such as conductivity for regulating cell behaviors such as cell proliferation, differentiation or protein synthesis.

Keywords: Hydrogels; biopolymeric nanoparticles; biocompatibility; self-assembly.

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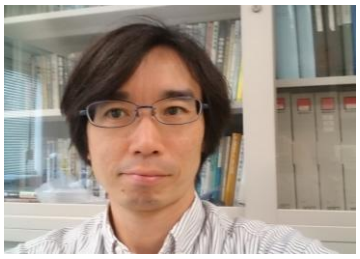
Fabrication of ceramic composites of zirconium phosphates and nearly zero thermal expansion properties

Ikuo Yanase[1], Hidehiko Kobayashi[1]

[1]Saitama University, Saitama, 338-0825, Japan



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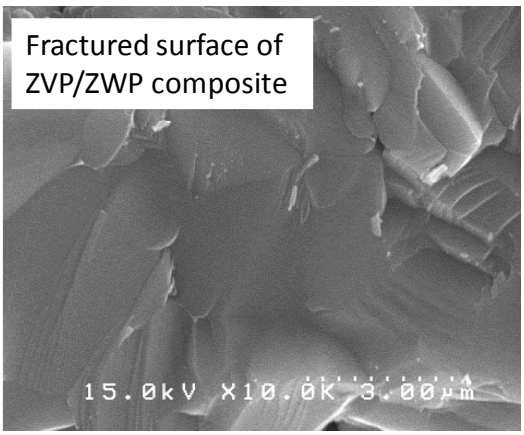

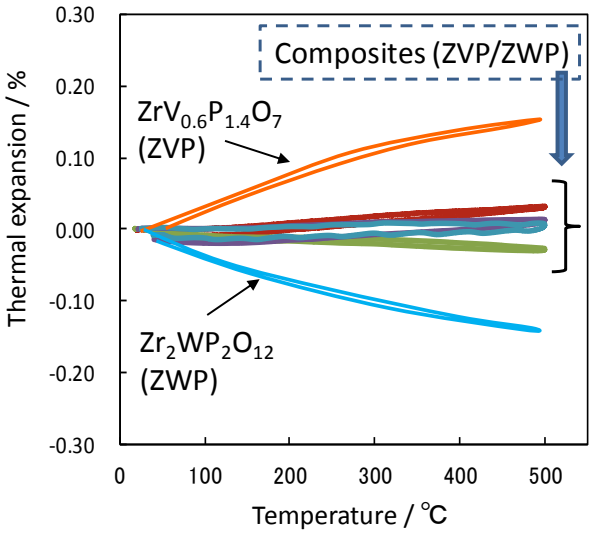

Abstract

$Zr_2WP_2O_{12}$ (ZWP) and $ZrV_{0.6}P_{1.4}O_7$ (ZVP) were synthesized by heating their precursors at 900 and 400 ℃ in air, respectively. The synthesized ZWP and ZVP powders were pressed to fabricate ZWP and ZVP compacts. Then, these compacts were sintered at 1000 ℃ for 20 h in air. Thermomechanical analysis (TMA) indicated that the fabricated sintered bodies of ZWP and ZVP had -2.9 × 10^{-6} ℃$^{-1}$ and 3.3 × 10^{-6} ℃$^{-1}$ of linear thermal expansion coefficients (TECs) in the range 25-500 ℃, respectively. To obtain sintered composites with a zero-thermal-expansion property, ZWP/ZVP compacts with ZVP/ZWP volume ratios of 0.5/0.5, 0.53/0.47, 0.55/0.45, and 0.6/0.4 were sintered. Scanning electron microscopy (SEM) revealed that the sintered ZVP/ZWP composites were densified in comparison with the sintered ZWP. The sintered ZVP/ZWP composite with a ZVP/ZWP volume ratio of 0.53/0.47 exhibited a nearly zero-thermal expansion. X-ray diffractometry and energy dispersive X-ray analysis spectroscopy analysis clarified that the sintered ZVP/ZWP composite mainly consisted of ZWP and ZVP grains. TMA revealed that the sintered ZVP/ZWP composite had a very low thermal expansion property with a TEC of -0.29 × 10^{-7} ℃$^{-1}$ in the range 25-500 ℃.

Keywords:

Reference .

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Development of smart composite materials and their novel application field aiming at disaster mitigation

Hiroshi Asanuma

Chiba University, Chiba, 263-8522, Japan

Smart composites such as optical fiber sensor or metal-core piezoelectric ceramic fiber embedded metal matrix composites and active composites/laminates to be used in harsh environment have been developed and a new field named as "Disaster Mitigation and Sustainable Engineering" as examples shown in Figure 1 to use them efficiently is proposed and demonstrated.

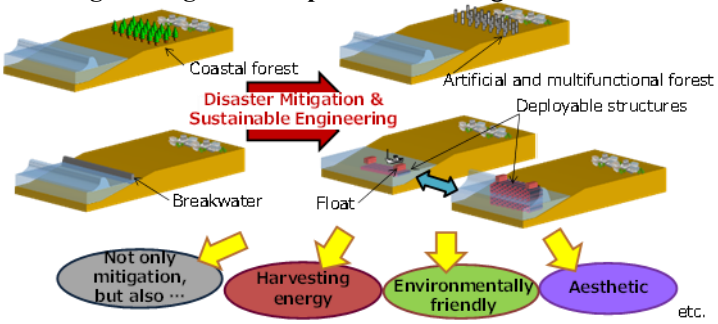

Figure 1: Typical examples to show the concept of "Disaster Mitigation and Sustainable Engineering."

Abstract

In this presentation, various developments of smart and robust composites are shown, and then, their newly proposed novel application field aiming at disaster mitigation is also introduced. The following composites developed by the author are firstly introduced: embedding optical fiber sensors in aluminum and SiC fiber-reinforced aluminum composites to use as sensors; fabricating a sensor to detect temperature and strain of aluminum and its composite by embedding an oxidized nickel fiber; embedding metal-core piezoelectric ceramic fiber in aluminum matrices to make robust and highly multifunctional metal matrix composites. These metal-based composites are all robust and having high mechanical properties to be used in harsh environments such as disasters. Then, recent developments in active/smart laminates and composites originally proposed by the author are introduced. They usually use a couple of competitive structural materials without using sophisticated functional materials to generate functions, which can be explained that composites of competitive structural materials may have not only high mechanical properties, but also functional properties generated by their inconsistent secondary properties. As examples of this type, CFRP/Al active laminates, active FRMs and Ti fiber/Al multifunctional composites are successfully developed. The active laminates have been especially modified to acquire higher performances and/or new functions, such as higher actuation capabilities, healing function, internal thermal management function using IPMCs, and so on. Finally, the author has proposed to use novel materials/technologies such as shown above for revolutionary prevention/mitigation of disasters. A typical example is deployable breakwater which can be used daily for energy harvesting, small enough not to be an obstacle, as well as a smart breakwater autonomously deployable by the force/energy and material of tsunami or high wave. The author et al. discussed on new reliable approaches to cope with disasters, which intend to enable sustainability as well as disaster mitigation, and they named it as "Disaster Mitigation and Sustainable Engineering." To explain the proposed concept, two examples, that is, artificial forest and novel deployable structure based on honeycomb to be used against flooding etc. are proposed and demonstrated. The researches listed below are also undergoing by the author and/or his collaborators. 1) Applications of piezoelectric polymers in electrical power generation using ocean waves (Su). 2) Dynamic deployment of smart inflatable tsunami airbags (TABs) for tsunami disaster mitigation (Shahinpoor). 3) A novel underwater inflatable structures for smart costal disaster mitigation (Adachi). 4) Structural health monitoring of pipelines for environment pollution mitigation (Felli et al.). 5) The contribution of LARES to global climate change studies with geodetic satellites (Sindoni et al.). 6) Smart disaster mitigation in Italy (Felli et al). 7) Smart disaster mitigation in Thailand (Aimmanee et al.). Disaster Mitigation and Sustainable Engineering has to be brushed up to become a basis for the above introduced emerging field with more variety of disasters to be smartly overcome or rather utilized.

Keywords: Smart composites; active composites; harsh environment; disaster mitigation; sustainability.

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New N-doped ZnO nanoDots/Graphene layers matrix nanostructure platform for biosensing

Yang Zhang

[1]*Department of Electronics Science and Technology, Hangzhou Dianzi University, Hangzhou, 310018, China*
[2]*Firmorb Technologies, Gainesville, FL32606, USA*

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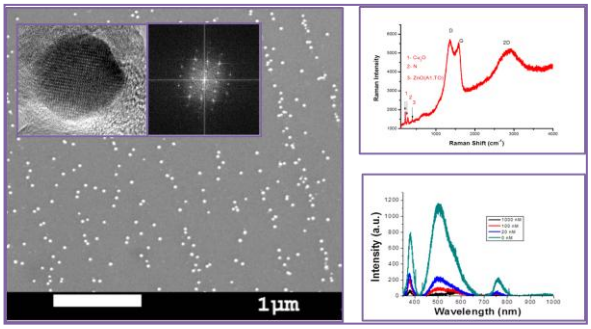

- ✧ Synthesis of N:ZnO/Graphene layers nanocomposite via plasma heating process
- ✧ Structure characterization and photoluminescence measurement
- ✧ Visible photoluminescence tuning and enhanced effects of the nanostructures used as platform for biosensing

Abstract

We report a new structural biosensing platform consisting of N-doped ZnO nanoparticles and graphene layers matrix. This new kind of nanocomposite was prepared by a plasma heating process using a natural protein and Zinc acetate as precursors. Which can be coated on different substrates including conductive substrates (GC, Cu, Ni etc.) and insulate substrates (quartz etc.) as application requested. Structure characterizations were carried out by several microscopic techniques including field emission electron microscopy (FE SEM), high resolution transmission electron microscopy (HRTEM), x-ray photoelectron spectroscopy (XPS), and micro-Raman analyses. Uv-visible absorption characteristics and photoluminescence properties of the samples were studied. It evident that tuning absorption and photoluminescence in the nanocomposites based on bandgap engineering strategy (doping and DLEs tailor) is an effective rout to manipulate photophysical properties of the ZnO dots. The as-synthesized nanocomposites show strong photoluminescence in the visible-NIR. The doping effects and enhanced mechanism for the DLE were further investigated through photoluminescence with micro-Raman technique. Study results indicate the N-doped ZnO nanoDots/graphene layers nanostructure is a competitive candidate in the biosensing field. This report opens up avenues for the non-destructive, label-free detection of biomolecules with high sensitivity.

Keywords: N:ZnO; N doped Graphene layers; Photoluminescence; biosensing platform.

Acknowledgements
Please acknowledge the funding authorities and other research supports.

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Disulfide-cleavage-triggered nanomicelles for effectively specific detection of glutathione and application of 3D µPAD based fluorescent device

Chiraporn Chaicham[1], Thawatchai Tuntulani[1], Boosayarat Tomapatanaget[1]*

[1]Supramolecular Chemistry Research Unit, Department of ,Chemistry, Faculty of Science, Chulalongkorn University, Phayathai Road, Patumwan, Bangkok 10330, Thailand.

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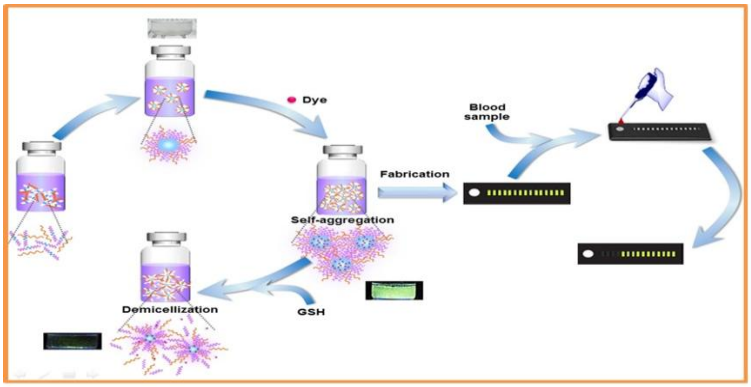
Turn on/off dye-doped nanomicelles related to aggregation and disaggregation with a proportional to amount of glutathione (GSH) and further applied to 3D µPAD device for a simple detection of GSH in blood sample.



Abstract

Glutathione (GSH) is an important antioxidant of the organism. The microemulsion shows several benefits for entrapment of dye regarding to a high fluorescent intensity, easy preparation and a long-shelf life. We have designed a micellar system that Triton-X 100 and a co-surfactant of bis(6-hydroxylhexyl) disulfide, S2, mediated the aggregated nanomicelles with a particle size of approximately 200 nm, to encapsulate the fluorescent dyes of curcumine-BF_2 (Cur-BF_2) and dansyl boronic acid (DA), namely, **TSC** and **TSD**. The well-constructed nanomicelles demonstrated a strong emission band at 587 nm and 525 nm, respectively, for both systems in aqueous solution. Based on the excellently optimized amount of surfactant and cosurfactant to form nanomicelles, the presence of GSH induced the cleavage of a disulfide bond of S2 encapsulated in nanomicelles leading to reduce the tight of aggregated nanomicelles. Consequently, the fluorescence intensity of dye encapsulated in nanomicelles was remarkably decreased corresponding to the concentration of GSH. For analytical analysis, the limit of detection (LOD) of **TSD** and **TSC** toward GSH in PBS buffer pH 7.4 was 7.3 µM and 9.2 µM, respectively. Interestingly, the behavior of sensory materials enables to be applied for 3D paper based microfluidic device for detection of GSH under the visualized fluorescence response with length-based assays for quantitative analysis. Moreover, **TSD** nanomicelles doped in 3D paper based device demonstrated the quantitative analysis of GSH in blood sample with the % recovery in range of 100-102. The 3D-µPAD containing aggregated nanomicelles as a sensing platform offers advantages in disposability, low cost, simple operation and visual quantitative readout. It is an ideal platform for point of care testing in region where limited resources are realized.

Keywords: Glutathione detection, 3D microfluidic paper base, Fluorescence probe, Aggregation Micelle, Biothiol compounds

Acknowledgements

Authors would like to acknowledge the Thailand Research Fund (RSA6080012 and RTA6080005**)** and the 90th Anniversary of Chulalongkorn Fund **(**Ratchadapisek Sompoch Endowment Fund**)** for research grant**.** CC is the Ph**.**D student supported by the Human Resource Development in Science ProProject **(**Science Achievement Scholarship of Thailand, SAST**).**

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Characterization of the thermo-mechanical behaviour of smart composites

X. Chen[1,2], Y. Meyer[1,3], R. Lachat[4], M. Ouisse[2]

[1]Univ. Bourgogne Franche-Comté, UTBM, Belfort, FRANCE
[2]Univ. Bourgogne Franche-Comté, FEMTO-ST Institute, CNRS/UFC/ENSMM/UTBM, Besançon, FRANCE
[3]Sorbonne Universités, université de technologie de Compiègne, CNRS, UMR 7337 Roberval, centre de recherche Royallieu, CS 60 319, 60203 Compiègne cedex, FRANCE
[4]ICB UMR 6303, CNRS Univ. Bourgogne Franche-Comté, UTBM, Belfort, FRANCE

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Abstract

Smart composites, embedding piezoelectric implants, are more and more popular in the modern industry field. The smart composite structures are able to modify their mechanical properties with respect to their environment (e.g. active vibration control), to interact with other structures (e.g. mechatronic) or with human beings (e.g. Human-Machine Interaction). Inevitably, the influence of temperature on the function of smart composite becomes a hot topic. However, literature on the topic of thermomechanical behaviour of smart composite is unfortunately poor.
The aim of this paper is to characterize the thermomechanical behaviour of some smart composites over a temperature range between 20 ° C and 200 ° C. In this work, a series of smart composite plates with piezoelectric ceramics embedded inside are manufactured. Different type of composite materials are investigated: glass fibre/polyester, carbon fibre/epoxy, bio fibre/epoxy. The fibre directions in the matrix are also studied with a unidirectional fabric, woven and a multi-axial fabric with +45° and -45° layers obtained with the 'Weave & Stitch' method. The embedded piezoelectric ceramics are used as actuators and sensors. They are separated at the side of the plate, one is used as an actuator, the other five are used as sensor, the directions of each path are 0°, 30°, 45°, 60°, 90°, as shown in Figure 1, piezo 1 is the actuator.

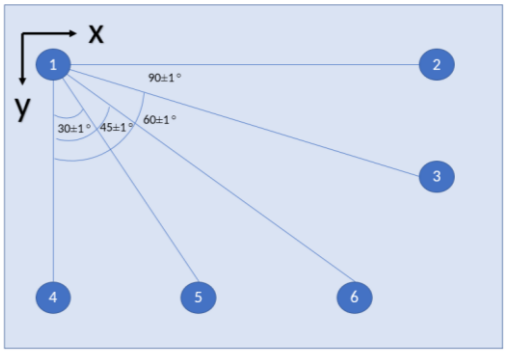

Figure 1. Graphics for the path directions

An identification method based on Time-of-Flight method, which is developed by our team [1], is used to measure some relevant parameters (like Time-of-Flight, Young ‘s modulus and Poisson’ s ratio) in different direction of the plates. Then, the parameters of smart composites under are measured at 10 ° C intervals over the range between 20 ° C and 200 ° C. At the end, the results are compared and discussed, to make the characterization of thermomechanical behaviour for the different types of smart composites investigated.

Keywords: composite material; smart composite; piezoelectric implant; T-o-F method; thermos-mechanical behaviour.

Acknowledgements

This project has been performed in cooperation with the Labex ACTION program (contract ANR-11-LABX-0001-01). This work was partly supported by a financial support from the UTBM, France. The authors are grateful to Mr Romain Viala from the FEMTO-ST Institute for his help and his fruitful assistance on modal analysis. The first author thanks the China Scholarship Council for financial support gratefully (contract N. 201504490012).

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Development of anti- bio deteriorate sustainable geopolymer by SiO_2 NPs decorated ZnO NRs

Manas Sarkar[1], Shilang Xu[2], Md. Akbar Malik[3]

[1]Post-doctoral Researcher,
[2]Professor and director,
[3] Research scholar
Institute of Advanced Engineering Structures and Materials, College of Civil Engineering and Architecture, Zhejiang University, 310058, China

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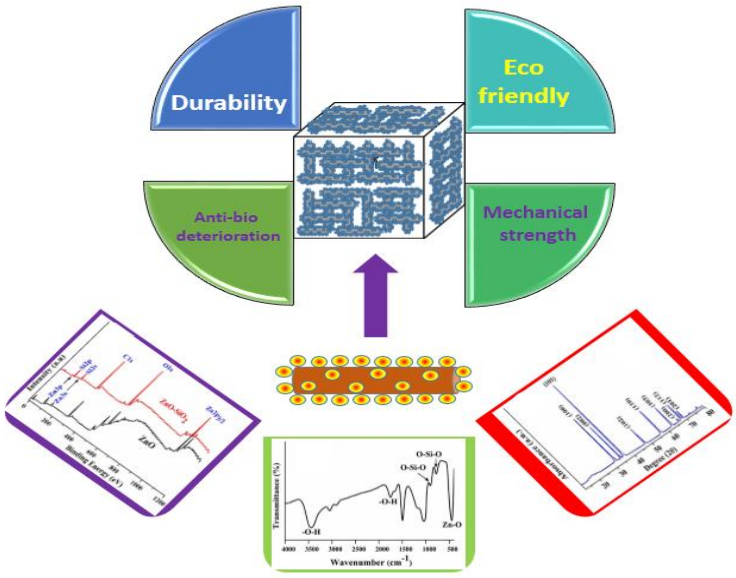

Abstract

Geopolymer, an alternative building material of ordinary cement, fashioned by industrial by-product; fly ash with alkaline activator which owns similar/greater mechanical strength and durability. Although chemical degradation is regarded as the most important reason of concrete corrosion along with another significant deterioration bio-deterioration. Sewer systems, bridge piers, numerous pipelines and offshore platforms have been suffering due to different types of biogenic corrosions. The present exertion has effort to develop a sustainable geopolymer ($GM_{ZnO–Si}$) which is modified by zinc oxide–silica nanohybrid for the development of anti-microbial building composite along with significant mechanical strength and durability. Initially, zinc oxide Nano-rods (ZnO NRs) has been prepared and spherical nano silica was decorated on the surface of ZnO NRs. The ZnO-SiO_2 nanocomposite was characterized by FTIR, XRD, FESEM, EDS, TEM, and XPS techniques. The mechanical strengths and durability properties of the synthesized geopolymer have been studied by different techniques. Applicability of ambient cured $GM_{ZnO–Si}$ mortar were investigated in terms antimicrobial (*E. coli*, *S. aureus*, *A. niger*) activities. The mechanical properties of the $GM_{ZnO–Si}$ are found significantly higher corresponding to conventional control samples. Different experimental (MIC, MBC, MFC) results exhibit that $GM_{ZnO–Si}$ has the ability to enhance the antimicrobial activity which can resist the biogenic deterioration. The antimicrobial pathway has been studied by Inner permeability assay, Reactive Oxygen Species generation and microscopically images of the cell wall rupture and DNA damage experiments. The experimental findings propose that incorporation of ZnO-SiO_2 nanohybrid in geopolymer will pave the way for biodeterioration-resistant structure with significant mechanical properties and the mechanistic pathway for anti-bio deterioration.

Keywords: ZnO-SiO_2 nanohybrid, Geopolymer, Anti-microbial activity, Durability, Mechanical properties.

Metal OxideV_2O_5 incorporated fly ash based geopolymer for better sustainable engineering composites

Muhammad Akbar Malik[1], Shilang Xu[1#], Manas Sarkar[1$]

[1]Research Scholar,
[1#]Professor and director,
[1$]Post-Doctotal Researcher,
Institute of Advanced Engineering Structures and Materials, College of Civil Engineering and Architecture, Zhejiang University, Hangzhou, 310058, China

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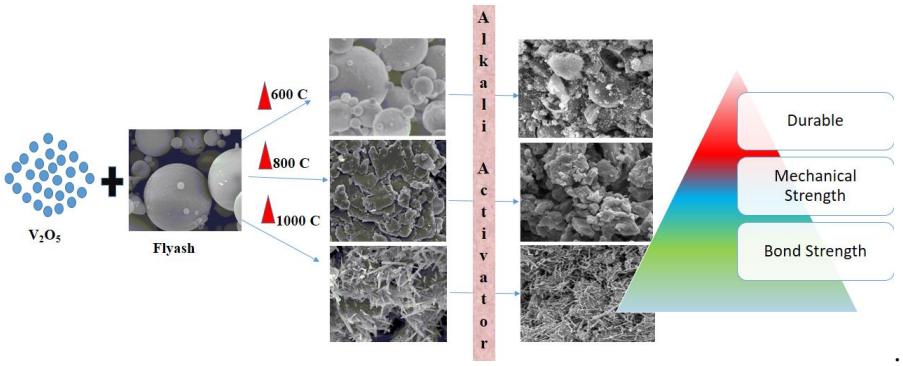

Abstract

In the coal burning process Fly ash produced as a by-product and disposal of this vast waste material is becoming challenge in the recent scenario. The waste material fly ash with alkaline activators has been used as cementitious materials in the development of new concrete technology. Usually, effectiveness of fly ash needs higher temperature above 1400^0C. In the present work metal oxide V_2O_5 with 5% weight of fly ash was utilized to lower the mullitization temperature below to 1000 ^{0}C. The building composite were made by using sintered fly ash and alkaline activators at room temperature. The micro structural analysis (FTIR, EDS, FESEM, XRD) of the composites reveals the formation of needle like nano sized mullite at 1000 ^{0} C. The durability and mechanical strengths tests including, compressive strength, chloride ion permeability, water absorption, ultrasonic pulse velocity, and sulphate resistant were conducted on the composites specimens. The tests showed the better strength and enhanced durability properties of the building composites. Thermal behaviour of the metal oxide (V_2O_5) facilitated fly ash described the exothermic reaction. The study suggested a new methodology to utilize the waste material fly ash with metal oxide V_2O_5 at lower temperature condition for advanced durable cementitious-based building composites.

Keywords: Fly Ash; V_2O_5; Mullite; Building composite

3D-Printable Composite of [HA/PMMA/Sericin] with VEGF Coating for Smart Bonegraft

Alva E. Tontowi[1*], Agus Purnomo[2], Dian S. Putra[3], R.D. Almy[1], K.A. Sekarjati[1]

[1]*Department of Mechanical and Industrial Engineering UGM, Yogyakarta, 55281, Indonesia*
[2]*Faculty of Veterinary UGM, Yogyakarta, 55281, Indonesia*
[2]*BATAN, Jakarta, 12440, Indonesia*

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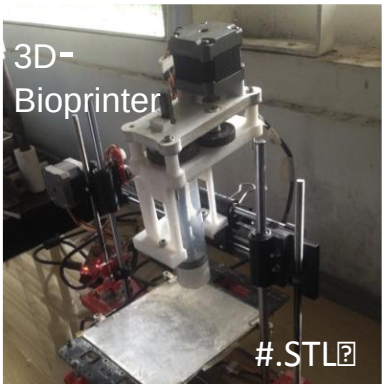
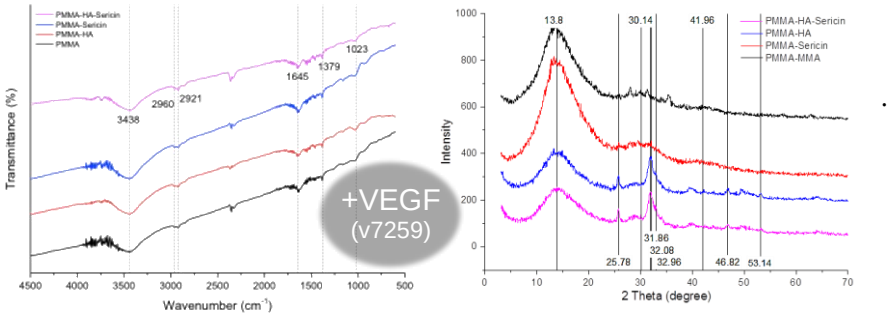
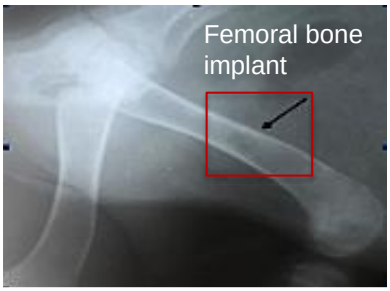
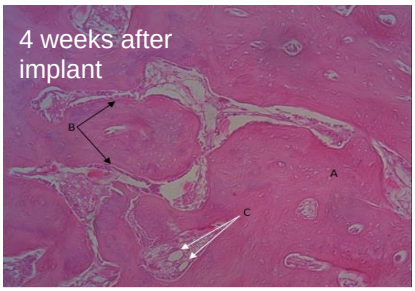




3D-Printable Composite Material of [HA/PMMA/Sericin]+VEGF coating





Abstract

Composite of [HA/PMMA/Sericin] has been experimentally developed as a 3-dimensional printable composite material. Each material in the composite has contributed a benefit to improve its bioactivity due to present of HA and to accelerate bone cell proliferation as Sericin existence. In the recent study, the printable composite material of [HA/PMMA/Sericin] has been further developed to be a smart bonegraft enabling to grow a new blood vascular. The composite material was composed by HA (synthesized from Baramundi scale/Lates calcarifer bloch), PMMA (commercial) and Sericin (derived from Bombyx mori silk). The ratio of HA/PMMA was 50 %w/w, P/L ratio of PMMA was 1/1 w/v and ratio of Sericin/HA was 0.32%w/w. A deep coating of the composite by vascular endothelial growth factor (VEGF) was carried out prior to implant for animal test. A series test was performed including Physical (FTIR, XRD), mechanical (SEM, tensile stress, flexural stress) and in vivo test of animal. Observation of the vascular growth was carried out in 2 and 4 weeks after implant and data was analyzed by ANOVA. Results show that the 3D-printable biomaterial of [HA/PMMA/Sericin]-VEGF coated, mechanically and biologically have satisfied to be used as a smart bonegraft. The new vascular has grown after 2 weeks implant and further growing as indicated by histology observation.

Keywords: 3D-printable; composite; bonegraft; vascular; growth

Acknowledgements
This research has been funded by Ministry of Research, Technology and Higher Education Republic of Indonesia with the contract No. 7333/UN1.P.III/DIT-LIT/LT/2017.

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Fabrication of CFRTP parts from nonwoven fabric mixed with carbon fibers and PA6 fibers

Hirohito Hira[1], Shutaro Machiya[1], Hiroyuki Shibaki[2], Makoto Harada[3]

[1]*Daido university, Nagoya, 457-0819, Japan*
[2]*Gifu university, Gifu, 501-1193, Japan*
[3]*Mikawa Textile Research Center Gamagori, 443-0013, Japan*

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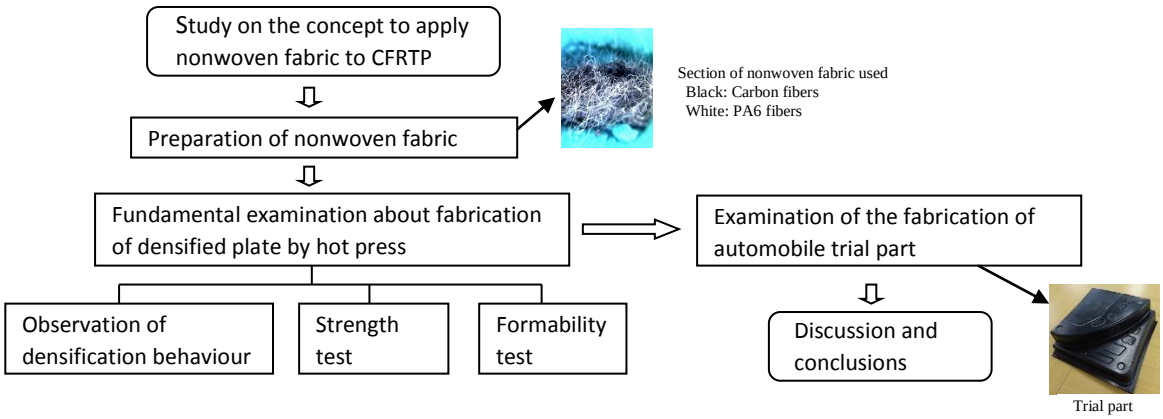

Abstract

Development to extract carbon fibers from CFRP is being promoted now, and nonwoven fabric made by extracted carbon fibers is expected as the promising application target.
Nonwoven fabrics in which reused carbon fibers and PA6 fibers were mixed at various ratios were prepared. Length of carbon fibers and PA6 fibers was about 60mm, and fabrication method of nonwoven fabric was needle punch. Then those were densified by hot press process to CFRTP plates by various process parameters. PA6 fibers were melted to matrix resin.
In order to examine densification behaviors, panels were fabricated by various hot press parameters, these were holding temperature, holding load, holding time to maintain holding temperature and then removal temperature. Effect of volume fraction of carbon fibers (V_f) was also examined. Then tensile and 3 point flexural test of densified plate were conducted, these results were compared with the results of CFRTP made of woven fabric. Formability test and fabrication test of trial automobile parts were also conducted.
Main results were as follows;
1) In order to densify nonwoven fabric to CFRTP, holding temperature of hot press was required to be over melting point of PA6, and it was necessary to hold pressure until 473K in the cooling process in order to prevent spring back of thickness.
2) Required pressure to complete densification was increased with increase of V_f. When V_f of carbon fiber was under 40%, completely densified CFRTP was obtained by suitable hot press condition. However it was difficult when V_f was 50%.
3) Strength of densified plate was isotropic. Strength increased with increase of densification. The strength per cross-sectional area was the largest when completely densified plate was obtained. However, with regard to the rigidity per weight, Good values could be obtained even if they are not sufficiently densified.
4) Strength and modulus of CFRTP made of nonwoven fabric (V_f = 40%) was almost equal or better than that from quasi-isotopically laminated woven fabric (V_f = 45%).
5) Formability of densified plate was almost isotropic. Formability decreased with increase of V_f and densification.
6) Trial automobile part was successfully formed.

Keywords: Reused carbon fibers, Nonwoven fabric, CFRTP, Densification

Acknowledgements
This work was supported by "Knowledge Hub Aichi Priority Research Project".

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Impact detection and localization of composite structures using silicon carbide fiber sensor

Chun-Gon Kim[1], Hyunseok Kwon[2], Yurim Park[2]

[1]KAIST, Daejeon, 34141, Korea
[2]KAIST, Daejeon, 34141, Korea

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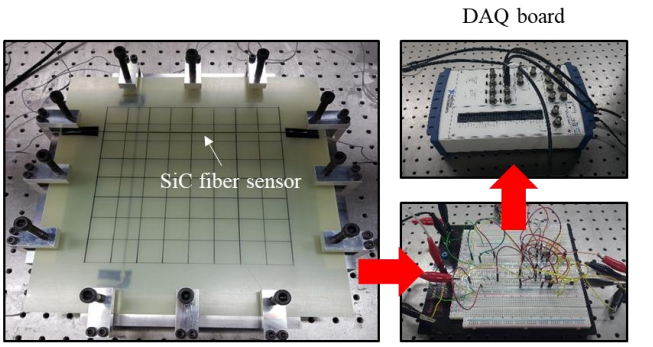

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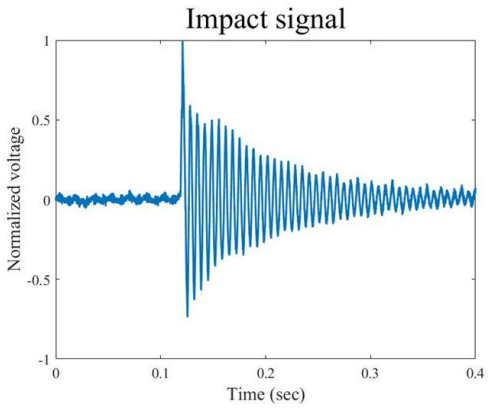

< Acquired impact signal >

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Abstract

Impact detection and localization in composite structures using the silicon carbide (SiC) fiber sensor was proposed. The SiC fibers, which are semiconductor fibers, have the excellent piezoresistive properties, so relatively large resistance change occurs when deformation due to an external impact occurs. In this study, the SiC fibers were used as fiber type sensor by obtaining the resistance changes of SiC fibers and converting them into the voltage changes through a Wheatstone bridge circuit. The SiC fiber sensor was attached to the composite panel. Low-velocity impacts using an impact hammer were applied to the composite panel, and the impact signals were acquired using the surface attached SiC fiber sensor In order to analyze the characteristics of the acquired signals, the similarity and distinguishability between the impact signals were investigated by calculating the correlation coefficient between the acquired signals. Based on the signal characteristics of impact signals from the SiC fiber sensor, reference database impact localization was performed, by acquiring reference signal at each grid point in the test area. A total of 20 random impacts were applied, and the random impacts were successfully estimated.

Keywords: 1; Impact localization 2; Composites 3. SiC fiber sensor

Acknowledgements
This research was supported by Technology Innovation Program (10074278) funded by MoTIE, Korea .

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Consolidation of Cu-based nanostructured pseudo alloys by a combination of high energy ball milling and spark plasma sintering techniques

N.F. Shkodich[1], G.V. Trusov[2], I.D. Kovalev[1], A.A. Nepapushev[2], K.V. Kuskov[2]

[1]Merzhanov institute of Structural Macrokinetics and Materials Science, RAS, Chernogolovka, 142432, Russia
[2]National University of Science and Technology MISiS, Moscow, 119991, Russia

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Abstract

Cu-based matrix composites (also called pseudo alloys) from immiscible metals have been of current interest due to excellent combination of high mechanical strength, temperature resistant, high electrical and thermal conductivities. They find a variety of applications including heat-sink elements in microelectronic devices, contacts in high-voltage circuit breakers, as well as plasmatron nozzles for rocket engines.
Difficulties in production of high quality pseudo-alloys are related to low mutual solubility of metals, high difference between their melting points and densities, and high wetting angle. And it cannot be overcome completely through the conventional melting and casting methods. In the present study a combination of high-energy ball milling (HEBM) and spark plasma sintering (SPS) methods has been shown to be suitable for the production of highly dense Cu-Cr and Cu-Cr-W nanostructured bulk materials. The HEBM processing times varied from 5 to 150 minutes. After milling nanostructured Cu-Cr and Cu-Cr-W powders were sintered into bulks by short-term (5-10 min) SPS on a Labox 650 (Sinter Land, Japanise) System in a vacuum chamber at different temperatures (600ºC –1000ºC) under pressure (50 MPa) to obtain essentially pore-free pseudo-alloys.
The structure of the initial Cu-Cr, Cu-Cr-W powder mixtures undergo a substantial evolution during high HEBM. The set of randomly distributed particles transforms into a layered structure and the layered thickness decreases with increasing milling time. HEBM leads to deformation and multiple flattening of Cu particles, while the Cr and W particles are crushed into smaller ones. The initial components intermixed and formed agglomerates. It has been shown that after 60 min of HEBM the grain size of Cr and W was in the nanometer range. SPS is a newly developed process which makes it possible for sintering at low temperature, inhibiting of grain growth and preservation of microstructure.
Microstructure, crystal structure, and local atomic structure were characterized by XRD, high-resolution SEM, and high-resolution TEM.
Based on experimental results we have come to conclusion that SPS allow us to consolidate nanostructured Cu-Cr and CuCr-W bulk materials (preserving a mechanocomposite nanostructure) with a relative density of 97-99%, microhardness up to 7 GPa, conductivity higher than 25% IACS, which make them promising candidates for electrical contact materials.

Keywords: Pseudo alloy; high energy ball milling; spark plasma sintering; nanocomposite.

Acknowledgements

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Innovative Applications of Advanced Composites in Infrastructure

Hamid Saadatmanesh, Ph.D., P.E.
Global Director, DowAksa Infrastructure Division
And Professor of Structural Engineering
University of Arizona
Tucson, Arizona USA

Abstract

During the past two decades significant attention has been paid to demonstrate the benefits of advanced fiber composite materials for strengthening of structures against seismic forces as well as against environmental degradation and aging. These materials have superb mechanical properties as compared to conventional materials. Their tensile strength generally is several folds that of steel with modulus of elasticity varying anywhere from 20,000 to 90,000 ksi. In addition, these materials are very durable and do not corrode in aggressive environments like steel does. These characteristics of fiber composites have attracted many structural engineers worldwide to use them in numerous structural strengthening projects.

In particular, due to their extremely light weight, high strength, and versatility for application in difficult to access areas, these materials are uniquely suitable for applications in complex construction projects. They are very easy to transport and require minimal equipment for installation. In this seminar, the results of almost thirty years of research and applications performed by Dr. Saadatmanesh on various upgrading of structures with epoxy bonded composites will be briefly discussed. More specifically, the utilization of these materials for strengthening of concrete beams and columns, wood beams, steel and concrete pipes as well as application to masonry structures will be discussed.

Dynamic fracture of fiber reinforced concrete

prof. Ing. Jaroslav Buchar, DrSc.[1], Ing. Miloslav Popovič[1]

[1]SVS FEM s.r.o., Škrochova 3886/42, Brno, 615 00, Czech Republic

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Abstract

In the given paper the dynamic fracture of composites in form of fiber reinforced concrete has been studied by using the dynamic Brazilian test. Combined with a high-speed photographic system, a split Hopkinson pressure bar was used to conduct dynamic Brazilian tests on concrete specimens with carbon, aramide, glass, polyprophylen and wollastonite fibers. Based on the images recorded by a high-speed camera, the displacement and strain fields were obtained by the digital image correlation method. The dynamic deformation and failure of the brittle materials were analyzed with respect to the loading rate. The preliminary numerical simulation of the experiments was also performed.

Keywords: Brazilian Hopkinson test; DIC analysis; reinforced concrete.

Acknowledgements
This work was supported by the Ministry of Interior of the Czech Republic
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Strong and Automatic Self-healing Oxidized-CNT/Polymer Composite Hydrogel

Yujie Chen[1], Mikael S. Hedenqvist[2], Hua Li, Hafeez Ur Rehman, Hezhou Liu[*]

[1]State Key Lab of Metal Matrix Composites, School of Materials Science and Engineering, Shanghai Jiao Tong University, Shanghai, 200240, P. R. China
[2]Department of Fiber and Polymer Technology, School of Chemical Science and Engineering, Stockholm, SE-100 44, Sweden

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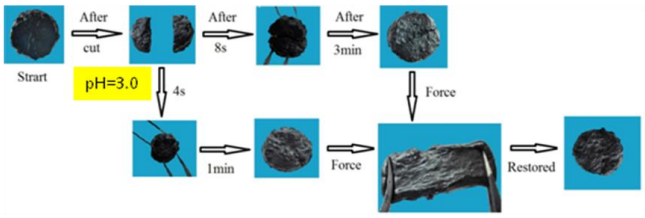
The strength of PAACA/CNTs composite hydrogel is up to 512.4 kPa at a break elongation of 1146.15%. Two contacted halves autonomous self-healed within 3 min and the self-healing time of composite hydrogel can be shortened to 1 min with the pH=3 aqueous solution, which not only enhance self-healing but also increase tensile stress value from 400 kPa to 600 kPa for different contents of CNTs.



Abstract

As self-healing ability is antagonist to mechanical strength of hydrogel, self-healing hydrogels so far suffer from mechanical weakness, which limits their application for any load-bearing devices such as actuators, tissue engineering scaffold and artificial cartilages. For most designs, external energy is required to achieve healing, especially for polymer materials with high mechanical strength. We fabricated a novel composite hydrogel having well defined network structure amongst poly (acryloyl-6-amino caproic acid) (PAACA) and oxidized CNTs. Since carbon nanotubes generate a great potential in the synthesis of polymer composite due to its axial strength and has attracted great interest in electro-active and thermos responsive polymer composite. Whilst AACA hydrogel precursor have efficient, accurate and robust polymer bonding network decorated with dangling groups (carboxyl and amino groups) that mediate hydrogen bonding. We observed the self-healing and mechanical properties. Meanwhile, oscillatory rheological experiments proved the special strength and reversible behavior of composite. Structure features and internal cross linking density of the composite were observed by allowing swelling and deswelling of composite in different pH solutions. The composite prepared by reversible hydrogen-bonding network generated amongst PAACA chains and oxides CNTs have high mechanical strength and best self-healing performance. This strengthens the composite up to 512.4 kPa at a break elongation of 1146.15% than that of pure PAACA hydrogel with a fracture stress of 64.54 kPa and elongation of 812.29%. Simultaneously, two contacted halves autonomous self-healed within 3 min which is less than PAACA whose minimum self-healing timing is 5 min. With the pH=3 aqueous solution, the self-healing time of composite hydrogel can be shortened to 1 min, which not only enhance self-healing but also increase tensile stress value from 400 kPa to 600 kPa for different contents of CNTs. However for pure PAACA the self-healing timing decreases from 5 min to 3 min. This study has introduced a new bulky hydrogel composite material to biological scaffolding, artificial cartilages and engineering. Further the high storage stability of composite categorizes it for advance soft materials holding applications in biomedical science and engineering.

Keywords: Self-healing; CNTs; Polymer; Composite

Acknowledgements
The work was supported by the Funds for Natural Science Foundation of China (NSFC), 51373096 and 11704244 , Shanghai Sailing Plan Project, 16YF1406100, and Shanghai Natural Science Funding, 17ZR1441000.

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Towards nano-modified carbon fiber composites

G. Singer, G. Sinn, H. Rennhofer, P. Siedlaczek, H. C. Lichtenegger*

[1]University of Natural Resources and Life Sciences Vienna, Institute of Physics and Material Sciences, Peter-Jordan-Straße 82, 1190 Vienna, Austria

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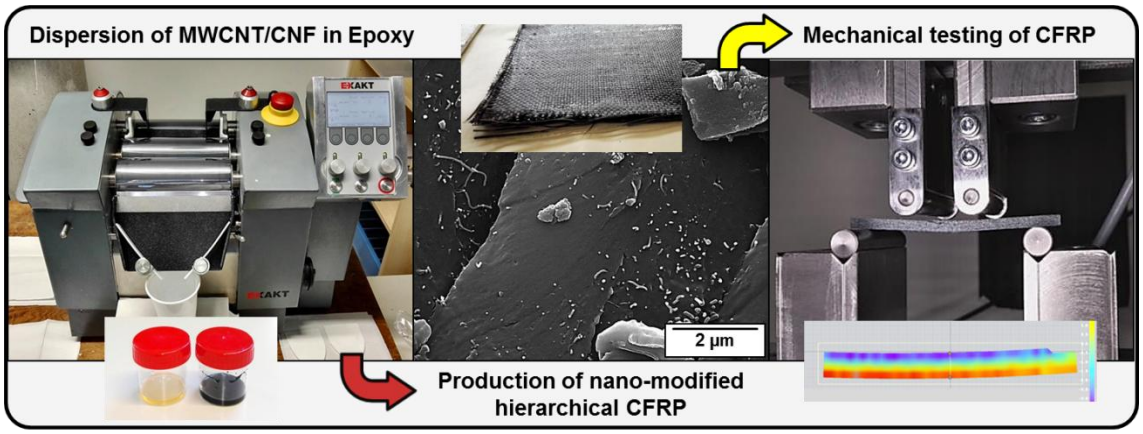

Abstract

Modern lightweight construction materials gain increasing interest in transportation industry as they combine high performance material properties and low specific weight. In many cases conventional materials like metals are replaced by reinforced polymer matrix composites (PMC) or combined to hybrid composite materials to reduce weight and thus contribute to saving energy and fuel. Carbon fiber reinforced polymers (CFRP) are one of the key engineering materials for load bearing primary structure applications in aerospace and automotive sector, since carbon fibers offer high specific stiffness and tensile strength, as well as good resistance to temperature and chemicals. Depending on the laminate layup and fiber orientation, CFRPs can be designed for specific requirements in order to fully exploit their potential. However, weak interlaminar properties, resulting from the anisotropic laminate structure, are sometimes limiting their performance. In this study, Multi-walled carbon nanotubes (MWCNT) and Carbon nanofibers (CNF) were dispersed in epoxy matrix on a Three-roll mill (TRM) for the production of nano-modified hierarchical CFRP [1]. These 1-dimensional nanoparticles exhibit not only extremely high mechanical properties, but also high specific surface area and aspect ratio, enabling an efficient transfer of mechanical load from the matrix. The dispersion quality was studied on the microscopic scale (optical light microscope) and on the nanoscale using scanning/transmission electron microscopy (SEM/TEM). An environmentally friendly and acid-free oxidation method was developed to improve dispersibility and the compatibility between CNTs and matrix. The degree of oxidation was analysed by X-ray photoelectron spectroscopy (XPS) and compared to a conventional oxidation method using nitric acid. Mechanical tests show that modulus and strength of the nano-modified hierarchical CFRP were significantly improved. Also the interlaminar properties were increased, resulting in reduced tendency to delaminate. The principle shown in this study exhibits the potential to create advanced CFRPs and to expand their field of application.

Keywords: Carbon fiber reinforced polymers (CFRP); carbon nanotubes (CNT); high performance polymers; dispersion; hierarchical nanocomposite

Acknowledgements
The authors acknowledge the financial support of the Austrian Research Promotion Agency (FFG). In addition we would like to thank Karl Heinz Semlitsch, Werner Stöger and Peter Peyrer from Secar Technologie GmbH producing the composite samples.

Reference

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Nondestructive Characterization of Material Properties in Fiber-Reinforced Composites Using a Hybrid Laser Ultrasound Technique

Seng-Po Tseng, Leslie Bustamante and Che-Hua Yang[1*]

[1]*Graduate Institute of Manufacture Technology, National Taipei University of Technology, Taipei, Taiwan*

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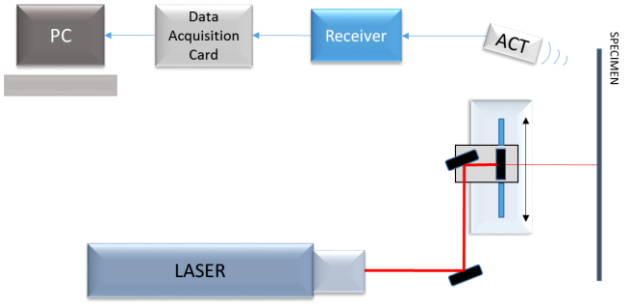

Fig. 1 Hybrid laser ultrasound system for FRC characterization

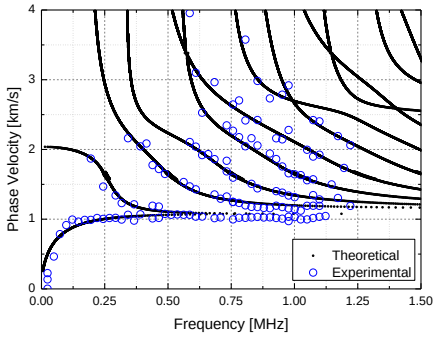

Fig. 2 Measured and theoretical dispersions for FRC plate

Abstract

Material properties such as elastic moduli for fibre reinforced composites (FRC) are important, however, can vary substantially due to manufacture process. Therefore, characterization of the material properties, preferred in a non-destructive way, becomes an important task during or after the manufacture of FRC. Nondestructive material characterization methods based on leaky Lamb waves have been proposed [1], however requires an immersion testing condition. Characterisations with non-contact air-coupled transducers (ACT) has been proposed for testing composites [2]. Together with the use of a laser with ACT), a hybrid system have been proposed for non-destructive testing of structures [3]. Not only for defect detection, laser-based ultrasnonic inspection technique been proposed for quantitative characterization of mechanical properties [4]. In this research a hybrid technique as shown in Fig. 1 employing laser-generation and ACT-detection is investigated for non-destructive evaluation of material properties of composites. The system is based on the generation of guided waves in a plate by laser, and the detection of leaky Lamb waves in the air using an ACT. Dispersion relations for the A0 and S0 Lamb modes were measured with the hybrid method as shown in Fig. 2. By using a nonlinear optimization computation algorism known as particle swarm optimization (PSO) [4], material properties such as elastic moduli are obtained from the measured dispersion curves. The proposed non-contact hybrid system offers an attractive alternative for non-contact testing and characterization of mechanical properties in a wide variety of composites during or after their manufacture process.

Keywords: Fiber reinforced composite; material properties, non-destructive testing; laser ultrasound technique.

Acknowledgements
This work was supported by Ministry of Science and Technology Taiwan under the grand number MOST-105-2221-E-027-012-MY3.

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Size effect in crashworthiness simulation of woven fabric thermoplastics

Bilal Ahmad[1], X.F. Fang[1]

[1]*University of Siegen, Siegen, 57076, Germany*

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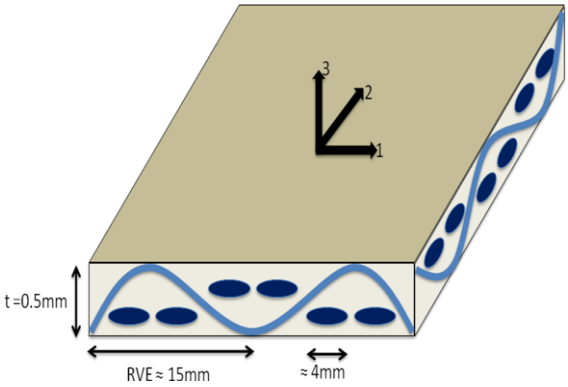

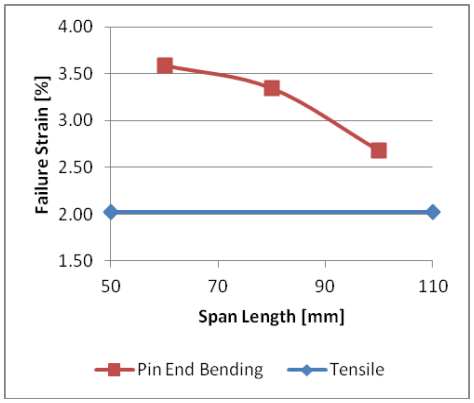

Abstract

The thermoplastic composites have the huge potential to revolutionize the automotive sector due to their high specific strength and energy absorbing capabilities. In order to fully utilize the potential of woven fabric thermoplastics, more precise prediction of crash results is required in finite element simulations. The state of the art material models for woven fabric composites assumes these materials to be homogeneous and they wrongly predict the flexural strength of these elastic brittle materials equal to their tensile strength. Therefore crash simulation results are not satisfactory [1]. In the present study, the experimental investigations showed that the flexural strength of woven fabric thermoplastic composites is higher than their tensile strength. The flexural strength also increases by reducing the size of flexural specimen. It has also been shown that measured surface failure strain in flexural specimens is also higher than tensile failure strain which means that increase in flexural strength is not due to stress gradient effect rather size effect. Similarly compressive failure strain in bending is also higher than compressive failure strain measured in simple compression test. The reason behind this size effect is that the probability of containing strength critical defects such as cracks and voids in a bigger volume of material is higher and hence the strength will be lesser. Through the simulation of different sized flexural specimens, it is shown that the material strength should be selected based upon the size of the specimen. The comparison of simulation results shows a good agreement with experimental results. Based on the size effect analysis, it is proposed that size effect must be incorporated in material models by considering the volume of material under constant stress. In simulations this volume can be calculated by the number of integration points with same stress value, adjacent to each other. And the strength of the material can be scaled according to Weibull's statistical theory [2].

Keywords: Size effect, strength scaling, crash simulation, woven fabric composites

Acknowledgements

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Temperature and stress analysis for single-bead direct metal laser deposition process through experiment and finite element analysis

Kyeongsik Ha[1,2],Taehwan Kim[1,2],Eunsol An[1],Geonwoo Park[1],Tae-hoon Nam[1,2],
Jong Bae Jeon[2],Do-sik Shim[3],Young Hoon Moon[2],Wookjin Lee[1*]

[1] *Korea Institute of Industrial Technology, Busan, 46948, Republic of Korea*
[2] *Pusan National University, Busan, 46241, Republic of Korea*
[3] *Korea Maritime and Ocean University, Busan, 49010, Republic of Korea*

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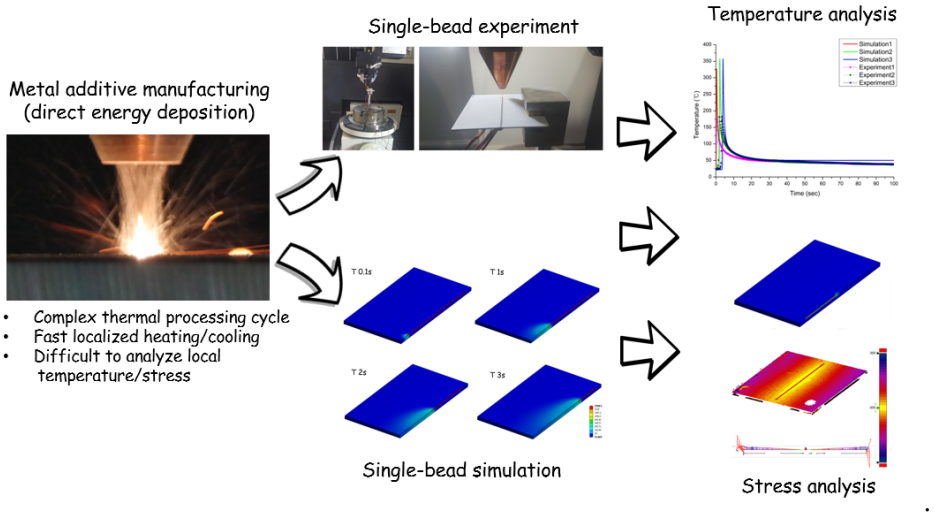

Abstract

DED (Directed Energy Deposition) process is one of the metal Additive Manufacturing (AM) technologies that can produce metal and metal-based composite structures through repeated depositions of metal layers using a moving high energy heat source and metal powder or wire as a feeder. In the process, the shape of each metallic layer is tailored by a computer numerical control system, so that the final form of the product has a desired three-dimensional structure. Since the DED process enables a production of structure with complex shape with relatively good productivity compared to the other metal AM processes, it is regarded as one of the best production system for the so-called "Mass Customization" of metallic materials.
In the DED process, there is a large temperature gradient due to high local heat input from the heat source and rapid cooling effect from the cold substrate/previously deposited layers. Local temperature variation during the process is critical in determining the stress state and, consequently, stress-induced defects such as the thermal distortion and cracking behavior. However, due to the complex thermal processing cycle and fast local heating/cooling, it is very difficult to measure the detailed temperature by experiments.
This study aims at investigating the local temperature and stress evolution during the metal DED process, by combining a numerical finite element model and an experiment. A single-bead DED of high speed tool steel on a low carbon steel plate was considered both in the numerical model and the experiment. In the finite element model, changes of the model geometry by the deposition of the tool steel was modelled by the so-called "Element Birth & Death" technique. On the other hand, in-process temperature variations of the substrate steel plate was measured by welded thermocouples on the bottom. The local temperature variations and the stress evolutions during the DED process were analysed by comparing the numerical results with the experiment.

Keywords: Additive Manufacturing; Direct Energy Deposition; Finite Element Method.

Acknowledgements
This research was supported by the Korea Institute of Industrial Technology as "Development of metal powder larde-area DED process including pre- and post-processes based on simulations (kitech EO-17-0041)".

Evaluation of microstructure of M4 tool steel deposited by direct energy deposition method

Tae-Hoon Nam[1,3], Eun Young Choi[1], Jong-Youn Son[1], Sunmi Shin[1], Kyeong-Sik Ha, Wook-Jin Lee[1], Do-Sik Shim[2], Nam-Hyun Kang[3], Jong Bae Jeon[1*]

[1]Korea Institute of Industrial Technology, Busan, 46948, Republic of Korea
[2]Korea Maritime and Ocean University, Busan, 49010, Republic of Korea
[3]Pusan National University, Busan, 46241, Republic of Korea

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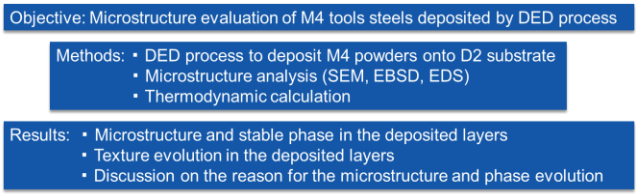

Abstract

DED (Direct Energy Deposition) method belongs to one of the 3D metal printing technique, which realizes 3D metal structure by directly spraying molten metal powder onto a substrate. This additive manufacturing method is advantageous for directly producing medium to large-sized parts and partially repairing broken dies, because of its comparatively fast processing speed and deposition ability onto random surface shape of the substrate. So far some studies have been carried out on DED process, but there is a lack of systematic understanding of the microstructural analysis and phase transformation behavior of high carbon tool steels [1]. In this study, we thus investigated the microstructural analysis and phase transformation behavior of 3-dimensionally deposited layers (AISI M4 high-speed tool steel) onto a substrate material (AISI D2 tool steel). Single-line and multilayer deposition were analyzed by using optical microscope, FE-SEM, EBSD to investigate microstructure, phase stability and texture evolution during DED process. This work also emphasized the evolution of stable phases in the deposited layers by comparing with thermodynamic prediction results. Deposited layers (M4) consisted of γ, α' and W-, V-, and Cr-carbides. EBSD analysis confirmed that α' phase was formed during the rapid solidification stage, which is also supported by thermodynamic calculations and dilatometry analysis. The volume fraction of γ was far higher than bulk counterpart, and this unusual behavior is possibly originated from a decrease of M_s temperature possibly caused by partitioning of austenite-forming elements such as C, Cr etc. Due to the extremely rapid cooling temperature, carbide formation could be hindered and thus the austenite-forming elements could be heavily partitioned in the matrix phases. Carbides were precipitated in inter-dendritic region and showed a transition in shape from columnar to equiaxed (CET), where thermal gradient decreased and growth rate increased. The evolution of microstructure and stable phases during DED was largely different from that of bulk process and thus the present work suggest that new approach for powder alloy design and metallurgical interpretation should be taken into account for DED process.

Keywords: Additive manufacturing; Direct energy deposition; Tool steels; Microstructure

Acknowledgements
This study has been conducted with the support of the Korea Institute of Industrial Technology as "Development of metal powder large-area DED process including pre- and post- processes based on simulations (KITECH EO-17-0041)"

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Hydrazine-functionalized fluorescence micellar sensor for detection of long-chain aldehydes

Piyanan Pranee,[1,2] **Boosayarat Tomapatanaget**[1,2] *

[1]*Department of Chemistry, Faculty of Science, Chulalongkorn University, Bangkok, 10330, Thailand*
[2]*Center of Excellence on Petrochemical and Materials Technology, Chulalongkorn University, Bangkok, 10330, Thailand*

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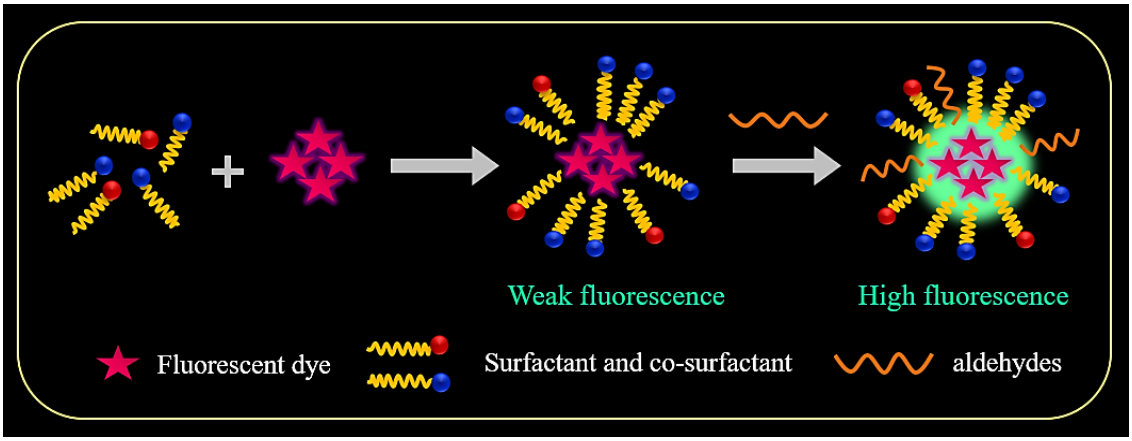

Abstract

Long-chain aldehyde compounds such as hexanal and heptanal are regarded as potential biomarkers of many diseases for biomedical applications. In addition, hexanal is greatly important quality indicators of fat and oil products during manufacturing processes. Apart from hydrophobic tails of long-chain hydrocarbon and hydrophilic heads of aldehyde functional group, we expected that aldehydes should perform as surfactants to form the self-assembling organized nanomicelle. In this research, the nanomicellar probes towards aldehyde have been achieved in the concept that the incomplete micelle, which was prepared by cetyltrimethylammonium bromide (CTAB) and co-surfactant (S2) upon the challenge optimizing task, could form the complete micelle by long-chain aldehyde as a target analyte by self-assembling organized nanomicelle. The fluorescence intensity of hydrazine-functionalized fluorescent dye incorporated in incomplete micelle was enhanced upon the addition of long-chain aldehyde which possibly induce the complete micelle. This can be explained that the hydrophobic chain of aldehyde preferred to thread to react with hydrazine fluorescent dye doped in micelle via a condensation reaction to form the complete micelle of CTAB/S2/Dye resulting in increase of fluorescence spectrum of dye at 542 nm. This aspect served as a high selectivity of this self-assembling micelle toward long-chain aldehyde such as heptanal. The fluorescence change of dye-doped micelle is proportional to the amount of long-chain aldehyde added. The reaction time of probes was completed within 20 min in PBS buffer pH 7.4 with the limit of detection (LOD) of 80.38 µM in the linear concentration range of 0.03 to 0.33 mM. In this approach, this nanomicelle system offers the promising determination of the specific heptanal detection and a benefit for easy checking in food and cancer diagnosis.

Keywords: Long-chain aldehydes; micelle; fluorescence

Acknowledgements
Authors would like to acknowledge Science Achievement Scholarship pf Thailand (SAST). This work was supported by the Thailand Research Fund (TRF), the Commission on Higher Education (CHE) (RSA6080015) and Center of Excellence on Petrochemical and Materials Technology, Thailand.

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The effects of reinforcements on Texture of Al-Sn Alloy Matrix Composite

Jongbae Jeon[1], Jihyeon Bak[2], Pilhwan Yun[2], Jinyoung Park[2], Sunmi Shin[2*]

[1]Functional components and Materials R&D Group, Korea Institute of Industrial Technology, Yangsan, 50635, Republic of Korea
[2] Advanced Forming Process R&D Group, Korea Institute of Industrial Technology, Ulsan, 44413, Republic of Korea

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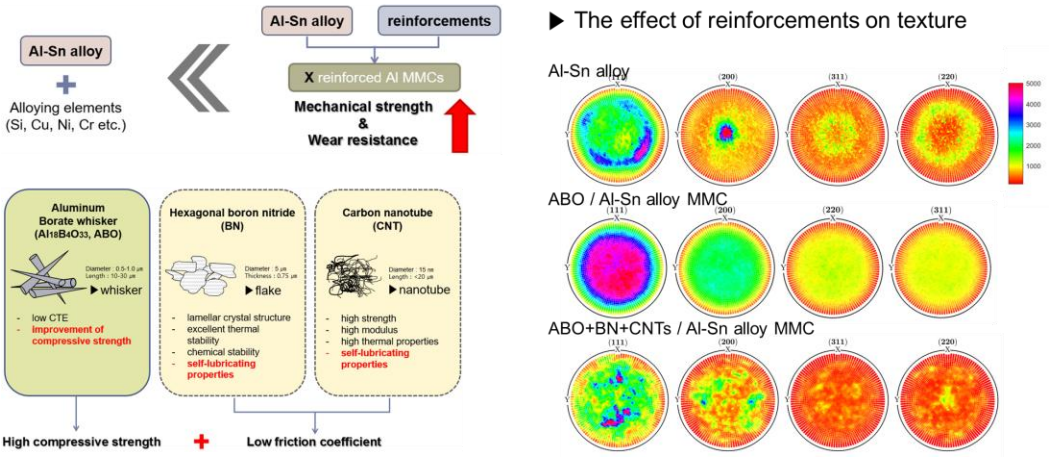

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Abstract

Al-Sn alloys are widely used as bearing materials in the automotive industry owning to their good friction and wear properties. A conventional Al-Sn based bearing system was produced by casting process, however, Al metal matrix composites (MMC) have been recently designed to improve their mechanical strength and wear resistance to withstand high speed and heavy loads in the operating conditions of recent engine bearings. The factors affecting the mechanical properties of metals, including MMCs, comprise the alloying elements, particles, phase, grain size and texture. Most Al MMC research has been focused on the alloying elements and particles, and investigated the effects of alloying elements and reinforcement particles on the strength and wear properties of the MMC. In the present research, we studied the effect of reinforcements on crystal orientation and texture of Al-Sn alloy and Al-Sn alloy MMC. Aluminium borate whisker ($Al_{18}B_4O_{33}$, ABO), hexagonal boron nitride (BN), and carbon nanotubes (CNTs) were used for the reinforcements in Al-Sn alloy MMCs, and the hybrid ABO+BN+CNTs/Al-Sn alloy MMCs were fabricated by squeeze infiltration. The texture of the hybrid MMCs were evaluated using the pole figure measurements by X-ray diffraction (XRD). The effect of reinforcements of ABO, BN, and CNTs on the texture of the Al-Sn alloys was investigated. The crystal orientations of each reinforcement in Al-Sn alloy matrix and their orientation relationships were discussed in detail.

Keywords: Al alloy matrix composite ; Hexagonal boron nitride ; Carbon nanotubes ; Texture ; Crystal orientation ;

Behavior of EB FRP masonry bond under service temperature

Zuhair Al-Jaberi[1], John J. Myers[2*], Chandrashekhara, K.

[1] Graduate Research Student, Civil, Arch. and Envir. Engr, Missouri University of Science and Technology, Rolla, MO 65409, USA
*[2] Professor of Civil, Arch. and Envir. Engr and Associate Dean, Missouri University of Science and Technology, Rolla, MO 65409, USA (*Corresponding and Presenting Author)*
[3] Professor of Mechanical Engineering, Missouri University of Science and Technology, Rolla, MO 65409, USA

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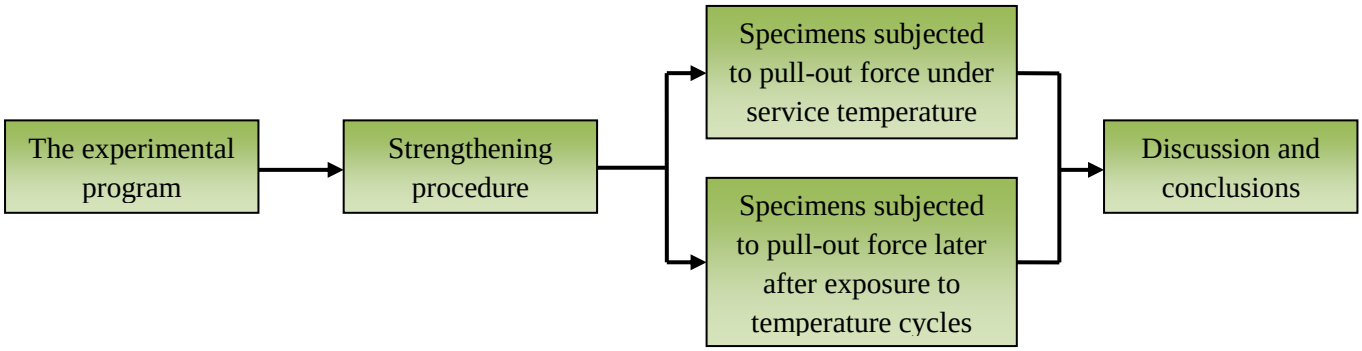

Abstract

The interest in advanced composites in repairing and strengthening infrastructure systems has considerably increased, especially when the application of fiber reinforced polymer (FRP) as externally bonded (EB) has become more established. Previous research on bond behavior has focused on durability by considering exposure to harsh environmental conditions and testing the specimens after exposure, which enables the adhesive material to reset before performing the bond test. On the other side the influence of directly applying temperature on bond behavior represents an open topic that needs to be considered in more detail. This study is one of the first studies to investigate the bond behavior when the composite is subjected to tension force simultaneously with applying temperature. The temperatures considered in this study were freeze, ambient, and high temperature, which is more representative of structural elements in the field. A total of 16 specimens were strengthened and tested under single-lap direct shear. The key parameters investigated include (a) the type of fiber (laminate carbon vs. wet layup glass) (b) the level of temperature applied on specimen, including ambient condition 21^{o}C (70 ^{o}F), freeze condition -18 ^{o}C (0 ^{o}F) and hot weather 49 ^{o}C (120 ^{o}F), and (c) the exposure regime (direct exposure during loading process vs. loading after exposure). Most of specimens were subjected to tension force simultaneously with applying temperature, and the other specimens were later tested after exposure to the heating and cooling cycles. These cycles are proposed to simulate 20 years of the typical in-situ weather conditions of the Central US. The results showed that overall the EB strengthening systems exhibited a good performance when subjected to cycles of heating and cooling prior to testing. High reduction of FRP-epoxy bond properties was up to 59% when exposed to high service temperatures. Different modes of failure were observed such as debonding at fiber- matrix interface and debonding due to shearing in laminate.

Keywords: Masonry; bond; FRP, temperature.

Acknowledgements
This research was conducted at Missouri University of Science and Technology in the Structural Engineering Research Laboratory (SERL) in Rolla, Missouri. The authors gratefully wish to acknowledge the support of Midwest Block & Brick in Jefferson City, Missouri, Center for Infrastructure Engineering Studies (CIES) at Missouri University of Science and Technology, and HCED (The Higher Committee for Education Development in Iraq). The authors also wish to thank the technical support staff at Missouri University S&T for their efforts in this research study.

Biodegradable Composites based on PHA and natural Fibres for applications in different environments

Norma Mallegni[1], Patrizia Cinelli[1], Maurizia Seggiani[1], Cristina Righetti[2],Andrea Lazzeri[1]

[1]*Department of Civil and Industrial Engineering, University of Pisa, Via Diotisalvi 2, 56126 Pisa, Italy*
[2] *National Research Council, Pisa, Via Giuseppe Moruzzi, 1, 56124 Pisa, Italy*
[3]*Department of Biology, University of Pisa, Via Derna 1, 56126 Pisa, Italy*

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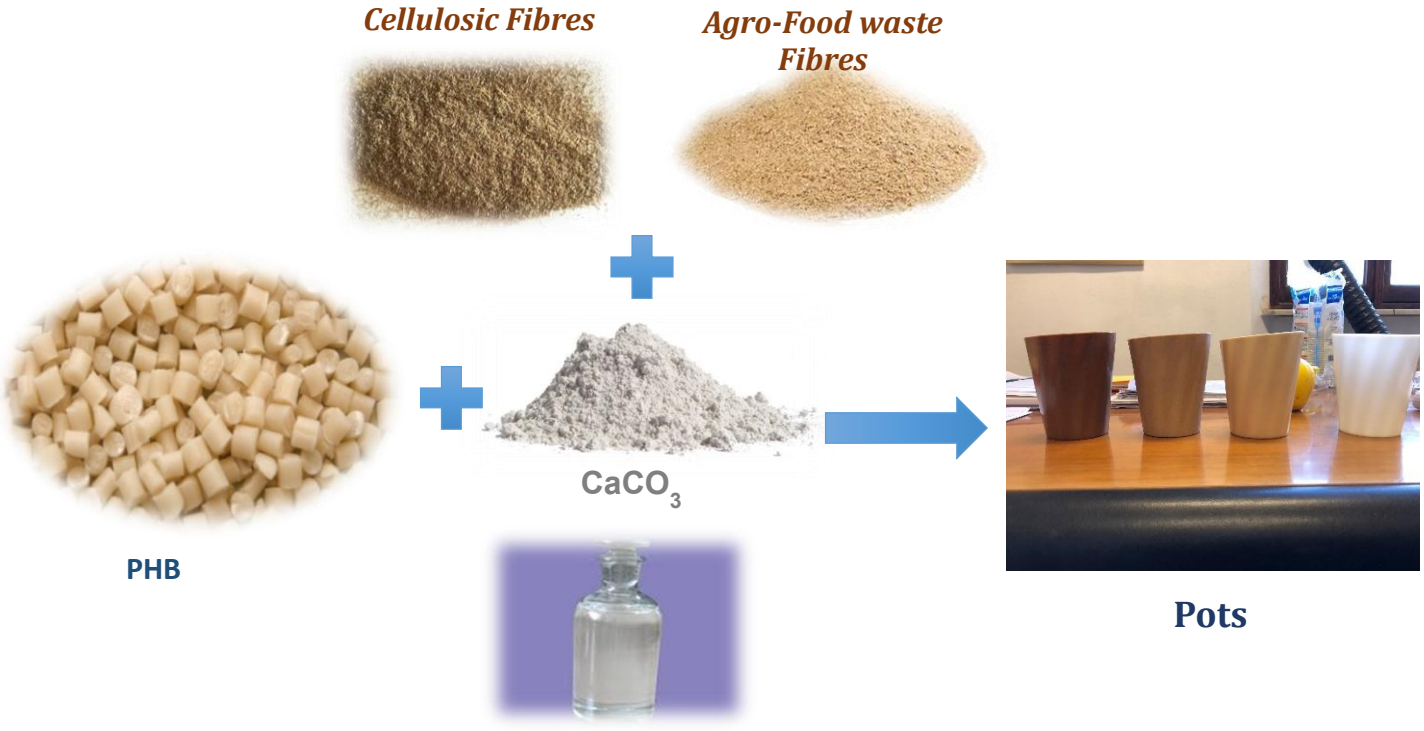

Abstract

Concern for plastic wastes accumulation in environment is raising and is generating the interest for new materials with high sustainability, biodegradability and relevant performances. In this contest bio-composites produced with biodegradable, bio-based polymeric matrices and fibres of natural origin derived from by-products or over production are one of the most important categories of material that is being proposed on the market. In the present abstract we report our contribute to knowledge and advancement in research on biobased composites in particular produced with highly biodegradable and biobased polyhydroxyalkanoates polymers with natural fibres from agro-food industrial waste (potatoes, beet, bran, legume fibers) or cellulosic fibres (Poseidonia oceanica fiber or sawdust).

Composites based on polyhydroxyalkanoate (PHA) and natural fibres were produced by extrusion in presence of appropriate amounts of plasticizer and inorganic fillers. Thermal, rheological, mechanical and morphological characterizations of the developed composites were conducted. Biodegradability of the bio-composites was investigated in different environments (compost, soil and marine water) Under simulated composting conditions in laboratory-scale, as well as in soil and marine water. The presence of the fibres facilitated the disintegration of the PHA matrix and, consequently, accelerated its biodegradation, this is a very important achievement for the development of sustainable plastic products. The developed composites resulted biodegradable in marine environment in a relatively short time and compostable in soil.

In order to deepen the study on bio composites properties different predictive models (Cox, Curtis) have been applied to evaluate how Young's modulus varies with the fibres load content. Then the Pukanszky's model was applied in order to predict the mechanical characteristics of composites in which the dispersed phase consists of short fibers. Considering that PHAs based materials present secondary crystallization and a consequent frequent change in properties with time, an ageing study of the material was carried out to evaluate how the mechanical properties of the final could change over the time.

Keywords: composites, biodegradability, natural fibres

Acknowledgements

The authors thank the European Commission for funding this research developed in the framework of Agrimax and Agrocycle project

Natural fibers waviness: effects on the interfacial shear strength and fiber distribution lengths.

Laura Aliotta[1], Vito Gigante[1], Vu Thanh Phuong[2], Patrizia Cinelli[1], Maria Beatrice Coltelli[1], Andrea Lazzeri[1]

[1]University of Pisa Department of Civil and Industrial Engineering, Pisa, Via Diotisalvi 2 56122, Italy
[2]Can Tho University Department of chemical Engineering, Can Tho City, 3/2 Street, Viet Nam

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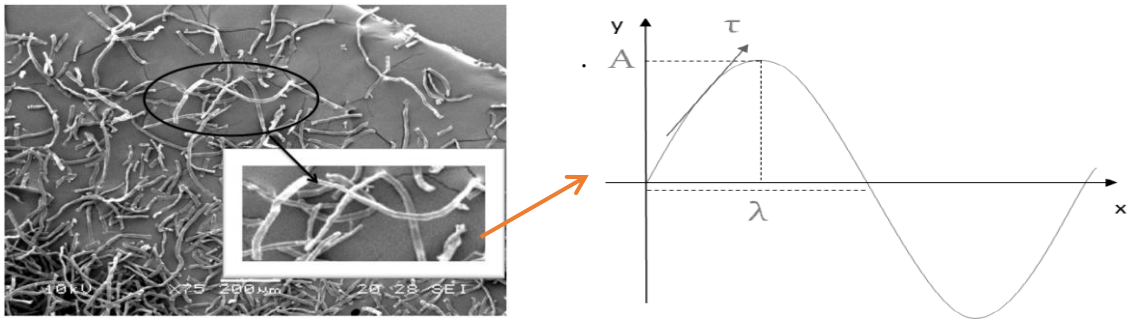

Abstract

Natural fibers are not rigid like glass or carbon fibers so, during extrusion and injection molding processes, they tend to twist in the polymeric matrix. Because of this fiber waviness, the interfacial shear strength (IFSS) and in general the composite mechanical properties decreases. The most widely used analytical models present in literature do not take into account this phenomenon.
In this work, the fibers undulation is approximated as a sinusoidal arch and a corrective factor, used for the IFSS calculation, has been introduced. This corrective factor considers the fiber waviness and affects the effective reinforcement fiber lengths and the fiber length distributions.
In order to verify this new method, blends of PLA / PC (with and without a catalytic system that improves PLA/PC compatibility) with addition of various percentages of cellulosic fibers (5wt%, 10wt% and 15wt%) were prepared and tested.

Keywords: Natural fibers; Mechanical properties; Fiber/matrix bond; Analytical modelling.

Acknowledgements

The authors thank the European Commission for funding this research developed in the framework of Agrimax, Evolution project

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A study on the acid site characteristics of ZSM-5 synthesized with various conditions

Min-Chang Shin, Jung-Hoon Park* (Include all of those who have made substantial contributions to this present work, even if the abstract was written by presenting author)

Dongguk University, Seoul, 04620, Korea

*Corresponding author. Tel: (+82) 0222608598; Fax: (+82) 0222608729; E-mail: pjhoon@dongguk.edu

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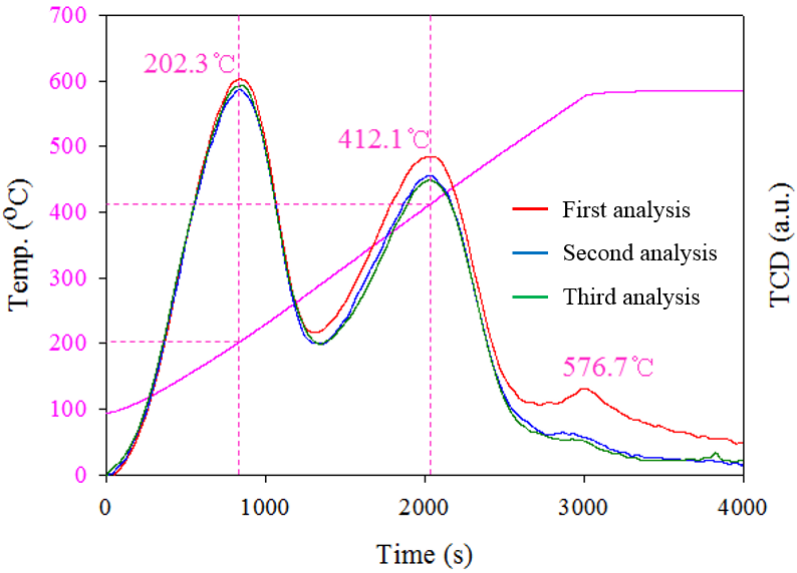

NH_4-TPD analysis graph of ZSM-5.

Abstract

The high speed of an aircraft increases friction with air. Air friction affects the surface temperature of high-speed aircraft. The liquid fuel causing the endothermic reaction is used to cool the surface of a high-speed aircraft heated to high temperatures. There are two main ways of cooling the aircraft through the endothermic reaction. The first is physical heat absorption. When the temperature rises, there is a sensible heat that accompanies it. The second is the heat of reaction corresponding to the chemical heat absorption, which absorbs heat during the fuel decomposes. Generally, since the decomposition reaction of the fuel proceeds at a high temperature, it does not achieve a great efficiency in cooling the high-speed flight body. However, when the catalyst is used, decomposition proceeds at a low temperature thereby increasing the cooling efficiency. However, high-temperature and high-pressure environments in which the fuel of high-speed airplane is operated are restricted in use of common catalysts. Zeolite catalysts are structurally stable and are used in various catalyst fields due to their stability at high temperature and high pressure. In particular, ZSM-5 is used for the endothermic reaction of liquid fuel because of its excellent ability to decompose hydrocarbons. However, when the liquid fuel is decomposed by ZSM-5, a strongly acid site forms a coke, thereby gradually losing the properties of the catalyst. In this study, NH_4-TPD analysis was conducted to investigate the relationship between various synthesis conditions affecting zeolite synthesis and the distribution of acid sites, which are the main causes of coke formation. The crystal structure of ZSM-5 was investigated by SEM and XRD analysis.
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Keywords: Zeolite catalyst; Endothermic reaction; ZSM-5; Acid site.

Acknowledgements
This study was conducted as part of the Basic Research Project (Pure-17-20) of Defense Acquisition Program Administration.

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New Objectives of the Research into Deck Bridges with Encased Filler-Beams of Modified Sections

Viktoria Kozlejova[1], Vincent Kvocak[1]

[1]Civil Engineering Faculty, Technical University of Kosice, Vysokoskolska 4, Kosice, 042 00, Slovakia

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Abstract

Deck bridges with encased steel beams present a structural system that is commonly applied in small and middle-span constructions. Initially, in first designs, rails were employed as rigid reinforcement. Later, welded or rolled steel sections came into use. The currently valid and applied Eurocode 4 standard contains structural requirements and design procedures for such bridges; however, it also prescribes the application of I-sections only. At the same time, it allows for the plastic design, while the position of the plastic neutral axis is to be situated in the steel beam web. The upper flange of a beam thus appears to be near the neutral axis, and its contribution to the bending resistance of the beam is minimal. The fulfilment of this condition is required to ensure composite action as the structural system of this kind does not make use of any sheer connectors. Research into deck bridges with encased steel filler-beams has been carried out at the Civil Engineering Faculty of the Technical University in Košice for several years. Our goal is to make the design of such bridges more efficient by lowering the consumption of steel while maintaining the same load-carrying capacity and stiffness of the structure. T-sections were suggested for deck bridges, and steel savings in the upper flange of the section were achieved as a result. For the components to act together, several types of strip connectors were designed, and their design further refined and verified during the research at the Faculty in the past. Another variant of composite action was designed, making use of the strip connectors experimentally verified at the Czech Technical University in Prague, and two more variants of the specimens used were with straight-edge beams, supplemented with binder bars. The dimensions of the sections remained identical for all beams. Static, dynamic, long-term, and push-out tests proved the assumptions arising from the calculations to be true. The specimens with the T-sections confirmed the same results as the beams with the I-sections. Deck bridges are most suitably applied in rail bridges. The efficiency of their application in road bridges is comparatively lower. Therefore, the further orientation of the research at the Faculty is towards the design and verification of lightened structures. The theoretically calculated bending resistance of such a beam is comparable to that of a full slab. Its bending stiffness and dynamic attenuation are decreased; nevertheless, these parameters are still sufficient for road bridges. Moreover, the consumption of concrete is reduced and so is the own weight of the beam, which eventually further reduces the consumption of steel. Lightening of the section (making it less heavy) is achieved by using arch-shaped formwork between the lower flanges of the steel sections. The concrete is wholly excluded from the part of the section in tension. The section is 670 mm wide and 270 mm high, while two steel beams made of rolled HEA200 sections, flame-cut longitudinally, are used. The section also contains secondary reinforcement (binders) and stirrups as can be seen from Figures 1 and 2.

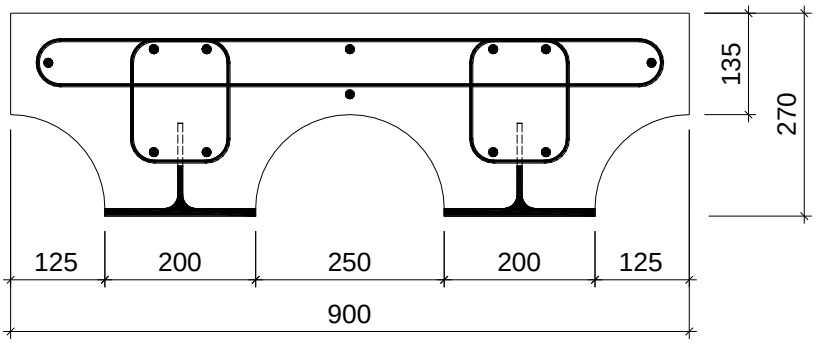

Fig. 1: Cross-section of a lightened section

Fig. 2: Ready-made lightened specimen

Keywords: deck bridges, encased beams, section optimisation

Acknowledgements
This work was supported by the Slovak Research and Development Agency under the contract No. APVV-15-0486 and by the Ministry of Education, Science, Research and Sport of the Slovak Republic under the contract VEGA 1/0108/16.

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Increasing of winding effectivity of fiber prepregs aimed to improvement of mechanical properties of final composite parts

Michal Petrů, Martina Ryvolová, Josef Vosáhlo

Institute for Nanomaterials, Advanced Technology and Innovation, Bendlova 1407/7, Liberec, 460 01, Czech Republic

Abstract

The development of composite materials for weight reducing is a trend in transport and other industrial areas. The composition of the composite material generates a synergistic effect that provides their advantages. The composite consists of a dispersive and continuous phase. For composites different fibres (carbon, glass, basalt, textile, natural fibres) and plastic matrices with specific properties can be applied. The type, quantity and arrangement of fibres in the composite are designed for strength characteristics depending on the maximum applied load. Composites reinforced with filament layers (unidirectional fibres, woven, multiaxial knitted fabric, etc.) are often used for very good mechanical properties.

Samples of the composite material were made by fibre winding technology on nonbearing core with required geometry. An image analysis of the structure and morphology was performed by scanning electron microscopy (SEM). The study of matrix penetration among fibres has shown that the directional fibre winding production technology in the case of uncontrolled winding significantly affects the resulting ratio between fibre and matrix area. This was reflected in the standard tensile, bending and impact tests by a reducing of mechanical properties of the resulting composite. Insufficiently saturated areas create the source of defects and crack propagation in the composite. Cracks can cause a delamination – a separation of layers.

Model simulations for optimal fibre winding were made for increasing of mechanical properties without increasing the weight of the composite. Mechanical properties were determined from numerical models. The nature of strain and stress distribution in individual layers have been identified. Composite samples were made of glass fibres and an epoxy resin. The results of the mechanical tests were compared with the numerical model. A comparison of experimental results and numerical models shows that fully controlled winding allows to increase mechanical characteristics of the resulting composite. The cause can be found in the optimal distribution of the fibres in the composite.

The 2D model was created in software SolidWorks where and then imported to ANSYS software. The filling area value was determined on selected cross-sections of composite using the model. The model was compared with the filling area values that was obtained from the image analysis. The composites were loaded by a different type of loading. The model describes the response of glass fibres in the individual layer and whole composite as well. The model results show the stress and deformation in critical areas for a prediction of cracks and defects.

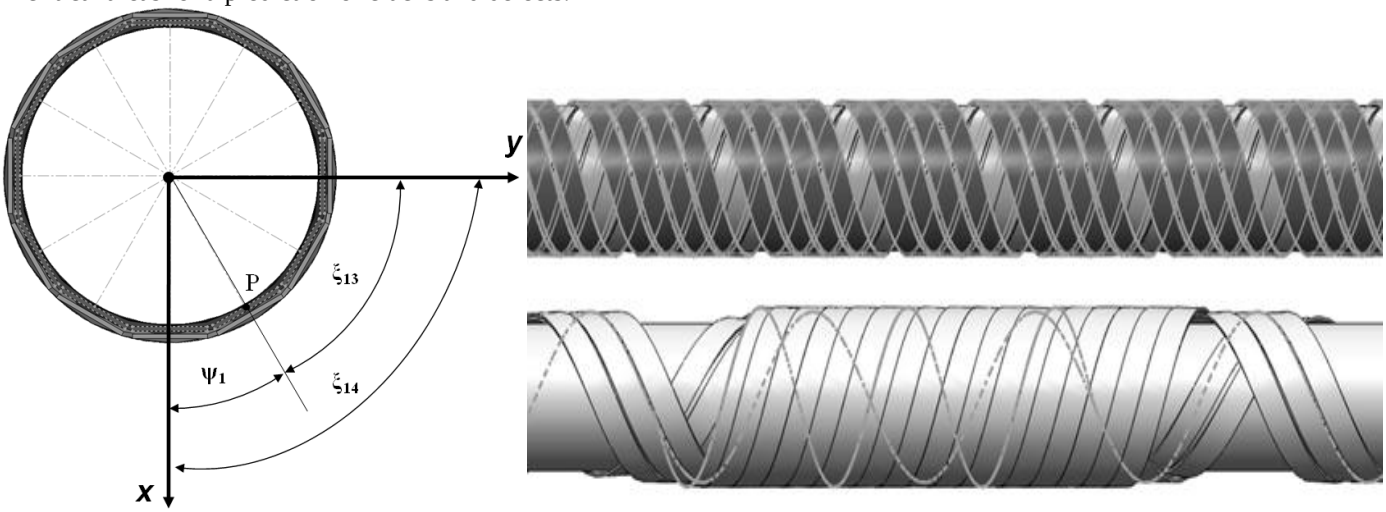

Fig.1: 3D model of optimization winding fibres

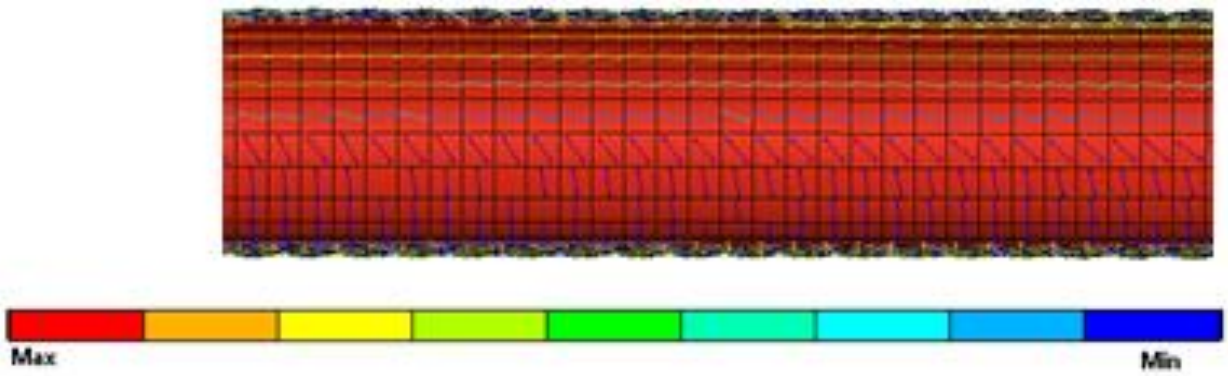

Fig.2: FEM model: distribution of stress tensors

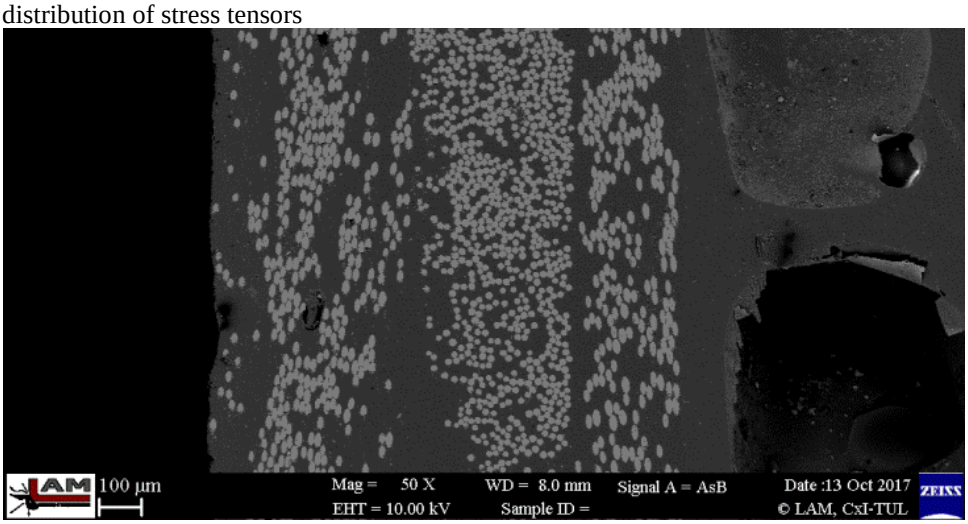

Fig.3: GFRP – unarranged distribution of fibres in composite skin

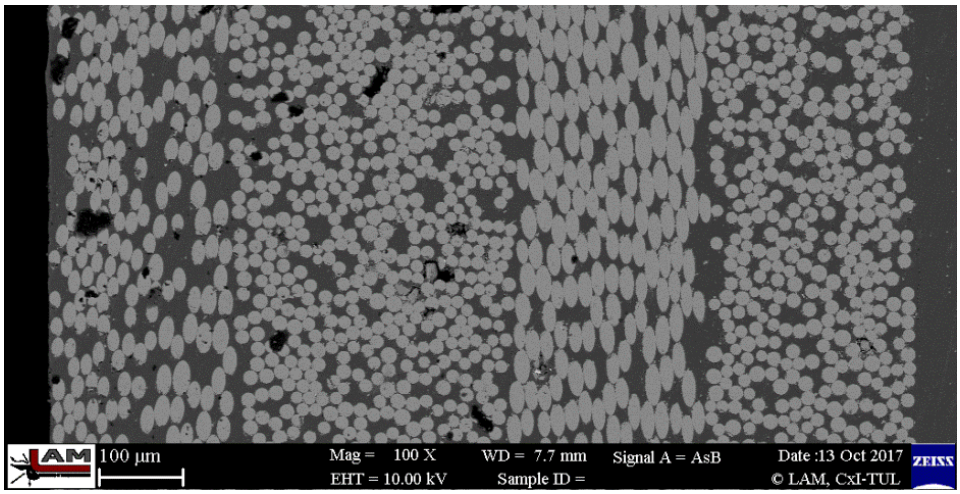

Fig.4: GFRP – arranged distribution of fibres in composite skin

Keywords: glass fibre reinforced plastic; delamination; 2D model, mesh, FEM solution

Acknowledgements
The results of this project LO1201 were obtained with co-funding from the Ministry of Education, Youth and Sports as part of targeted support from the "Národní program udržitelnosti I" program.

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Crystallization and dynamic thermal degradation behaviors of the PCL/graphene oxide composites

Erh-Chiang Chen, Tzong-Ming Wu

Department of Materials Science and Engineering, National Chung Hsing University, 250 Kuo Kuang Road, Taichung, Taiwan 402

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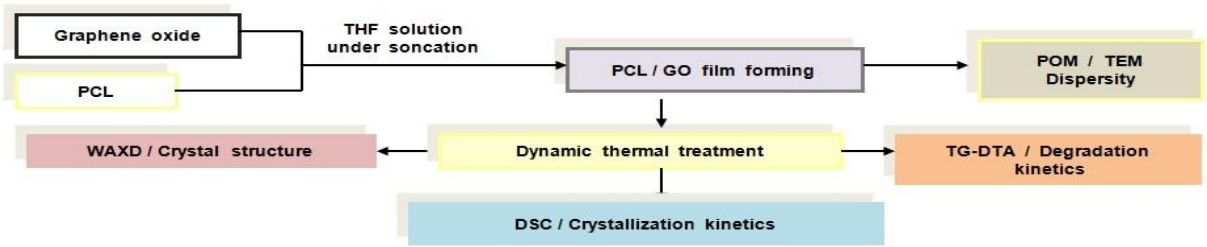

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Abstract

This study describes the preparation of polycaprolactone (PCL)/graphene oxide (GO) composites by ultrasonically mixing the PCL and as-prepared GO in a tetrahydrofuran solution. The transmission-mode OM images show the GO plate-like particles are well separated (intercalated/exfoliated) and uniformly distributed in the PCL matrix. Polarized optical microscopy (POM), Wide angle X-ray diffraction (WAXD), differential scanning calorimeter (DSC) and thermogravimetric/differential thermal analyzer (TGA/DTA) were used to investigate the crystalline morphology and structure, nonisothermal crystallization kinetics, and thermal degradation behaviors of the PCL and PCL/GO composites. We use the WAXD technique to study the PCL and PCL/GO composites after the same crystallization process. WAXD results indicate that PCL contains three strong reflections at $2\theta = 21.4^{o}$, 22.0^{o} and 23.7^{o}, corresponding to the (110) (111) and (200) planes of the orthorhombic crystal form. The strong reflection peaks observed for PCL were also present for PCL/GO composites. These results suggest that the addition of GO to PCL does not charge the crystal structure of PCL. Besides, the WAXD patterns of 3 wt% and 5 wt% PCL/GO composites have shown noticeable peaks around 9.1^{o}. Compared with the diffraction pattern of the as-prepared GO before the addition of PCL, the diffraction peak was shifted to a lower angle can be suggest that the increase in d_{002} value was caused by the intercalation of PCL polymer chains to the interlayer of GO. DSC nonisothermal results revealed that the activation energy of PCL/GO composites slightly decreases with increasing GO contents, suggesting that the additional loading of GO content into PCL further increases the number of heterogeneous nucleation during the crystallization process. From TGA/DTG results, the additions of small amount as-prepared GO into PCL matrix did not greatly enhance the thermal stability of PCL matrix as the T_d closed to that of the pristine PCL at the same heating rates. Nonisothermal degradation data reveal that the activation energy E_d of composites is similar to that of PCL.TGA dynamic degradation data illustrate that the activation energy E_d of the composites is similar to that of PCL. This phenomenon can be attributed to the addition of GO to PCL matrix does not change the dynamic degradation mechanism of PCL under a nitrogen atmosphere.

Keywords: Polycaprolactone; Graphene oxide; nonisothermal crystallization kinetics; dynamic thermal degradation.

Acknowledgements

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Iterative improvement of filament winding angles toward the principal stress directions

Seongjun Kim[1] and **Yoongho Jung**[1*]

[1] *School of Mechanical Eng. Pusan National Univ., Busan, 46241, Rep. of Korea*

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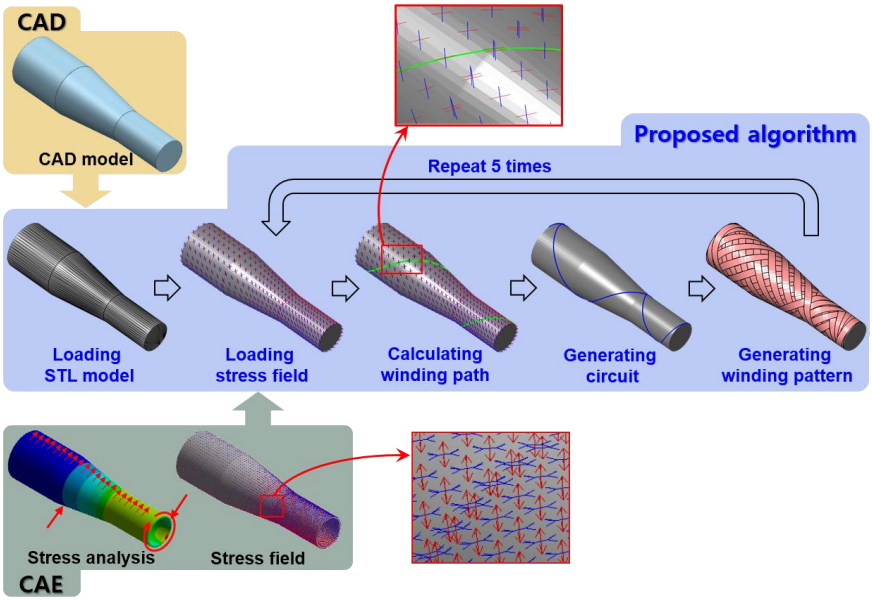

Figure 1. Generating filament winding path base on the pricipal stress direction

Abstract

Filament winding is a process in which glass or carbon fibers are wound around a mandrel to form fiber-reinforced structures of a desired shape. The strength of fiber-reinforced composite material structures is most affected by the direction of the fibers, and the highest strength can be achieved when the fiber direction matches that of the major principal stress exerted on the structure. Previous studies addressed methods to calculate the winding paths of maximum strength by adjusting the mandrel shapes. However, those methods are not appropriate for predetermined shapes that are fixed to satisfy certain special requirements. Therefore another study proposed a method [1] to generate filament-winding paths using the principal stress fields of the part to be manufactured. By the method, variable winding directions as close as possible to the major principal stress directions of the product are calculated to generate filament-winding paths that can support the maximum load without slippage. However, since the winding direction cannot be determined yet before the winding path is calculated, the authors initially assumed the structure as isotropic to get the information about principle stress directions by the finite element analysis. Therefore, a better method would be possible to obtain the winding path approaching the major principal stress directions of anisotropy by adding an iteration process as following: 1) With the initial winding path generated using the principal stress fields of the isotropic part, anisotropic analysis is implemented for calculating more exact principal stress. 2) According to the calculated anisotropic principle stress, a revised winding path can be obtained. The final winding path can be determined by repeating the step 1) and 2) until the winding directions consistent with the major principal stress directions of anisotropic analysis. This research will show a more accurate result for filament winding angles by adding the iterative process to the initial isotropic assumption.

Keywords: Anisotropic; Winding angle; Filament.

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Alginate/κ-Carrageenan and alginate/gelatin composite hydrogel beads for controlled drug release of curcumin

Jinu George

Biotechnology Laboratory, Sacred Heart College, Thevara, Kochi, INDIA 682013

Abstract

Hydrogel beads based on natural polymers like alginate, κ-Carrageenan and gelatin represent an efficient scaffold for controlled hydrophobic drug delivery. We report herein the development and characterization different formulations of hydrogel systems based on the above mentioned polymers having adequate properties as drug delivery matrices. Different combinations of alginate/κ-Carrageenan and alginate/gelatin hydrogel beads were developed and drug release properties were compared using curcumin as a model drug. Alginate/κ-Carrageenan hydrogel beads with 50:50 weight ratio exhibited higher swelling and better drug release percentage than compared to other beads. Antibacterial activity of curcumin released from hydrogel beads against B. cereus was established by disc assay. Encapsulation efficiency and drug release behaviour of different formulations of alginate/κ-Carrageenan and alginate/gelatin, indicates that the polymer blends synthesized possess considerable potential in pharmaceutical and medicinal applications.

Keywords: Hydrogel, drug delivery, new generation drug candidates

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