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B3. Smart Composite Materials and Their Technological Applications

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SB3-O001
DEVELOPMENT OF LAMINATED COMPOSITE BASED ON POLYPROPYLENE FILLED WITH WOOD FLOUR

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This project is focused to approach waste wood flour chipboard, as filler for polypropylene. The idea is to replace commercial polypropylene laminates filled with cellulosic fibers, that is used in automobile industry, with emphasis in flammability reduction. These laminates are elaborated with a content of waste wood flour 30 to 40% in wight, without any additive. The maximum thickness of aminates is 4 mm. The final properties of this type of laminates, depends on filler type, content and its geometrical properties. In this case the filler has an apparent density of 0.40 g/cm^3, which is twice times apparent density of pine wood floor. Granulometric analysis of waste wood flour shown a predominance of particles smaller than 0.177 mm. This wood flour has a good thermal stability. weight loss at 100°c is 2%, which corresponds to volatile or low molecular weight components. Between 200 and 400°C a weight loss of 30% corresponds to cellulosic material loos. Results shown that flammability velocity is reduced to values lower than one-inch per minute (0.9 inch/min). This value represents a reduction of 4 times this property respect to the commercial prototype (3.6inch/min). This is due to the presence of urea formaldehyde used in the manufacture of laminates which sawdust is obtained. As conclusions we can say Although it has been possible to demonstrate the benefit of using sawdust waste, it is convenient to carry out tests with coupling additives. This kind of additive reduce the torque and mix energy and permit obtain more homogenous materials, which is the key forget a better material.

Keywords: COMPOSITE, LAMINATED, FILLED

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SB3-O002
THERMAL CHARACTERIZATION OF COMPOSITES LOADED WITH PARALLELLY ARRANGED GRAPHITE RODS AND THE INFLUENCE OF GEOMETRIES ARRANGEMENTS IN THE THERMAL PROPERTIES.

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In this work we present results of how graphite rods can help to improve the thermal properties of a polymeric resin and whether the the arrangement of the rods within the resin has any influence. The samples contain 30, 40, 50 and 60 of graphite rods and correspond to 5.39, 7.18, 8.98 and 10.78 % v/v of graphite inside the resin matrix. Additionally, the rods inside the matrix were placed in three different geometrical configurations for each graphite concentration, polygonal, rectangular and radial. Those composites were compared with a composite with the same v/v concentration, but the graphite inside the resin was in form of powder and randomly arranged inside the polymer matrix. It is shown, using infrared thermography, that the samples with graphite rods present a significant increase of thermal diffusivity compared with the reference resin. It was found that all distributions with the rods present observable differences between them. Nevertheless, the polygonal distribution is the one that present in all cases the lowest thermal diffusivity. This work could give us an important way to elaborate heterogeneous composites with required specific thermal properties.

Keywords: composites, thermal diffusivity, front flash

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SB3-O004
IMPROVED PROPERTIES AND PROCESSABILITY OF PLASTICIZED PVDF-BASED NANOCOMPOSITES REINFORCED WITH MXENES ($Ti_3C_2T_x$)

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Polyvinylidenefluoride(PVDF) is a polymer with unique properties, including high chemical and thermal resistance, dimensional stability, and excellent mechanical properties like tensile and flexural strength. It also exhibits piezoelectric properties. The presence of the β-phase in PVDF is crucial to enhance its mechanical strength, dimensional stability, and piezoelectric properties. MXenes are a new family of 2D materials that possess high electrical conductivity, mechanical strength, and chemical stability. MXenes with functional groups can be used to improve the interfacial affinity, dispersion, and stability of composite materials, thereby enhancing the mechanical, electrical, and thermal properties of the polymer. Modification of PVDF is necessary to overcome issues during processing such as low solubility, high viscosity, and crystallization tendency. The addition of nanomaterials can significantly enhance the processability of PVDF and promote crystallization in the β-phase, making it suitable for various applications in electronics, energy, and advanced materials. This work presents the results of developing nanocomposites based on a PVDF matrix, which is both plasticized and reinforced with MXenes ($Ti_3C_2T_x$). Results showed that adding a plasticizer (specifically TPPE SCONA1102 PALL) helped to address the challenges encountered in processing PVDF nanocomposites using extrusion. However, it was observed that the addition of plasticizer resulted in the loss of crystallization in the β-phase of the polymer. It was also observed that low concentrations of nanoreinforcement (below 0.1% wt.) favor the crystallization of PVDF in the α-phase, the lower energy conformation. The β-phase of the polymer is significantly promoted at MXene concentrations above 0.1% wt. both for composites with and without plasticizer. Moreover, nanoreinforcement concentrations around 0.2% wt. also promote the polymers processability in interaction with the plasticizer, expanding its potential applications through other complex

processes. In summary, the use of MXenes in PVDF-based nanocomposites offers a promising route to improve their mechanical, electrical and thermal properties, as well as their processability. The optimization of the MXene concentration and the addition of a suitable plasticizer could allow for the fabrication of PVDF-based materials with enhanced properties for various applications.

Keywords: PVDF nanocomposites, MXenes, β-phase

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SB3-O005
STRUCTURAL HEALTH MONITORING USING EMBEDDED, FULLY PRINTED PIEZOELECTRIC SENSORS

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In todays society, datais considered one of the most important resources. By collecting and monitoring large amounts of data, we are able to analyse our environment, predict the behaviour of mechanical structures and prevent failures as early as possible.Sensors are essential tools for collecting data. In the aerospace industry,structural health monitoring is a major concern and our goal is to embed strain/force sensors in composite laminates to detect cracks and delamination in the material. Extensive research has been carried out to integrate various sensors such as strain gauges, Bragg fibres and piezo sensors into composite materials to monitor their behaviour. However, to our knowledge, no study has proposed a way to automate the fabrication and embedding of sensors by 3Dprinting them directly onto the composite during the manufacturing process. In Our work, we use 3D printing, which gives us the freedom to choose the substrate, shape, size, number and position of the sensor, providing greater flexibility and versatility in the design of composites for structural health monitoring. The sensors in this work are based on a piezoelectric polymer,polyvinylidene fluoride (PVDF), which is dissolved in solvents to form an ink.The ink is deposited as a thin film using a pressurised ink dispensing system and a modified fused filament fabrication (FFF) direct ink writing (DIW)printer. After the solvent has evaporated, a high electric field is applied to the film to enhance its piezoelectric behaviour. To create fully functional sensors, layers of conductive ink and insulating ink are printed before and after the sensor printing to create electrodes. Finally, a coating layer is printed to protect the sensor the external environment. The entire stack of layers is printed and then placed directly into the composite fabric. The Piezoelectric behaviour of the sensor is confirmed by Fourier TransformInfrared Spectroscopy (FTIR), X-ray powder diffraction (XRD), DifferentialScanning Calorimetry (DSC) analysis and piezoelectric coefficient determination tests in bending and compression modes. The sensor is successfully embedded directly between two layers of fabric during the manufacturing process without damaging it. Dynamic mechanical tests are also carried out to demonstrate the sensors ability to detect imperfections in the composite fabric. Automated manufacturing of composite materials is becoming increasingly common. As the sensor can be fully 3D printed and added during the manufacturing step of the composite structure, it allows the entire manufacturing process to be optimized, resulting in cost, time and energy savings.

Keywords: Piezoelectricity, Sensor, Composite

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SB3-O006 **Invited Talk**

SMART HIERARCHICAL COMPOSITES WITH SELF-SENSING CAPABILITIES FOR ELECTRICAL MONITORING OF MOTION AND STRUCTURAL HEALTH

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Smart materials can render coupling between anexternal stimulus (mechanical stress/strain, temperature, moisture) and acontrolled response (electrical resistance, current, voltage, actuation). Thecorrect interpretation of this response and the elucidation of the transductionfunction could lead to the development of smart materials which are able to self-sensemotion, sense their own strain, and monitor their structural health. Knowledgegenerated through the electrical response of these materials can be used todevelop condition-based maintenance programs for large composite structures,saving resources and possible even human lives. This invited talk will discuss previousand ongoing research of Dr. Avilés' group at CICY (Mexico) oncarbon-nanostructured hierarchical composites for their application as smartmaterials in two major fields: (i) flexible materials for sensing of humanmotion and tactile sensing, (ii) load-bearing hierarchical composites withself-sensing structural health monitoring capabilities. Specific case studieson polymer composites made of carbon nanotubes and polypropylene, as well asgraphenic sheets and polyurethanes will be discussed for motion and tactilesensing. Materials discussed for structural health monitoring involve fiber-reinforcedthermosetting polymer composites modified with carbon nanostructures.

Keywords: Smart materials, hierarchical composites, cabon

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SB3-O007

DECOUPLING THERMAL AND ELECTRICAL PROPERTIES OF GRAPHENE-MAYENITE COMPOSITES FOR THERMOELECTRIC APPLICATIONS

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Mayenite, $Ca_{12}Al_{14}O_{33}$,is an Earth-abundant oxide, which exhibits low thermal conductivity and electrically-insulating behavior. It forms a cubic unit cell (S.G. I-43d,cell parameter a≈11.98 A) with extra-framework oxide anions contained within subnanometer-sized cages. Its unique crystalline structure allows the substitution of extra-framework oxide ions by electrons, forming a mayenite electride and thus leading to a metallic or semiconducting material. In this communication, we present the synthesis of mayenite by a sol-gel method, while the reduction of the sample to the electride has been done by the preparation of graphene-mayenite composites, sintered by "Spark Plasma Sintering". To prepare the composites, few-layers graphene was first suspended in acetone and sonicated in an ultrasound bath. Then, mayenite powder was added and the mixture was frozen in liquid nitrogen and freeze-dried. Neutron powder diffraction data confirm the formation

of mayenite electride in the composites, achieving a composition of $Ca_{12}Al_{14}O_{32.4}$ for the mayenite + 2.0 wt.% of few layer graphene sample. Furthermore, the presence of graphene alters the predominant charge carriers in the system, switching p-type to n-type semiconducting behavior. Compositing also causes the electrical resistivity at 320 K to decrease by 13 orders of magnitude, while the already low thermal conductivity is not affected. In this way, an effective decoupling of the electrical and thermal transport properties is achieved, which is one of the main challenges in thermoelectric materials research. This strategy may be extendable to other materials, especially high-efficiency thermoelectric compounds.

Keywords: composites, thermoelectrics, Structure-property relationships

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SB3-O008
CHARACTERIZATION OF POLYMERS AND CARBON-NANOSTRUCTURED NANOCOMPOSITES FOR 4D PRINTING

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Additive manufacturing through three-dimensional(3D) printing is the fabrication of pieces adding material layer by layer until the desired shape is formed. For smart materials, sensing or actuating capabilities when subjected to environmental stimuli are added to the 3D-printed structures, a term that has been named “4D printing”. With this technique, it is possible to control the shape-shift, directionality, and specific actuation properties, greatly broadening the applications of smart materials. A combination of smart materials and other functional materials, such as carbon nanostructures, is useful to improve performance properties. For example, 4Dprinted carbon-based materials can yield increased response to stimuli, high deformation capability, faster shape recovery, and/or better shape recovery ratios. The present work aims to modify commercial 3D-printing filaments with carbon nanostructures, to render thermo-electrical actuation. Three 3D-printing filaments are investigated, viz. polylactic acid (PLA), polyhydroxyalkanoates(PHA), and a PLA-PHA blend. Initial research efforts will be presented in this direction regarding the physicochemical and mechanical characterization of such polymeric filaments. Comparison of the mechanical properties will be conducted between filaments, film specimens made by solution casting, and by 3D printing. The filaments will also be dissolved in chloroform, modified with carbon nanostructures, and recast in film form, yielding carbon-nanostructured nanocomposites. The electroconductivity of such nanocomposites will be assessed, targeting electrical percolation. Finally, using the modified electroconductive nanocomposites, proof of thermo-electrical actuation will be provided. Perspectives on the path forward of this research will be discussed towards simultaneous actuation and sensing of 3D printed polymeric nanocomposites, capable of shaping and reshaping by a thermo-electrical stimulus.

Keywords: smart materials, nanocomposites, 4D printing

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SB3-O009
EFFECT OF COMPOSITE OXIDE PARTICLE SIZE ON THE PROPERTIES OF SCREEN-PRINTED NIO-ScSZ AND LSM-YSZ ELECTRODES FOR SOLID OXIDE ELECTROCHEMICAL CELLS

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Composite electrode micro-structural properties play an essential role in the overall performance of solid oxide electrochemical cells. Specifically, for fuel and electrolysis cell energy storage and conversion applications, component oxide distribution, porosities, and particle or grain sizes affect the triple-phase boundaries and the electrochemically active sites. In this study, electrode composite precursors of NiO-ScSZ and LSM-YSZ were prepared with different particle sizes, about 150 nm and 260 nm average particle sizes, via ball-milling and employing different synthesis methods. The resulting screen-printed electrode thin films prepared with different precursor particle sizes were characterized for its structure, morphology, and electrochemical performance. For the sintered NiO-ScSZ films, cubic structures the X-ray diffraction (XRD)patterns have been observed in all prepared samples for NiO (4.18Å) and ScSZ (5.09Å).In addition, a more even morphology with less agglomeration and better dispersion of NiO and ScSZ phases was revealed by the scanning electron microscopy (SEM) micrographs and elemental mapping for the smaller precursor particle size with a more porous morphology and a thinner film. The total conductivity of the prepared thin films,Ea of about 0.48 eV, for NiO-ScSZ/YSZ is 4.63e-3 S/cm with finer particles compared to 8.79e-3 S/cm for coarser particles. On the other hand, the structure, morphology, and conductivity values of the LSM-YSZ electrode thin films were also similarly investigated. The total conductivity of the LSM-YSZ/YSZ half-cell is about 4.63e-3 S/cm. The electrochemical performance of the full cell in both fuel cell and electrolysis cell modes will be reported.

Keywords: composite oxides, fuel cell, electrode materials

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SB3-O010
STUDY OF THERMAL, OPTICAL AND ELECTRICAL PROPERTIES OF COMPOSITES MADE OF SILVER IODOMERCURATE (AG_2HGI_4) IN A POLYMERIC MATRIX

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The use of composite materials with in a polymer matrix has increased over time, since in this way the thermal properties of the polymer can be improved. Additionally, the matrix can be used to stabilize filler materials that tend to degrade easily. In this work, the development of a composite made of silver iodomercurate (Ag_2HgI_4) powder, synthesized by the co-precipitation method, embedded in a polyester resin matrix, is reported. Silver iodomercurate is a thermochromic material that exhibits a discontinuous thermally induced change in their physical properties. At room temperature, silveriodomercurate is in the stable β phase with a tetragonal crystal

lattice structure and the samples exhibit a yellow color; above 323 K the material changes to the disordered α phase with a cubic crystal lattice structure and the samples exhibit an orange color. Ag_2HgI_4 is a superionic conductor because its electrical conductivity is similar to the one of molten salts at the high temperature α phase. The concentration of Ag_2HgI_4 in the composite was varied 1 to 4 wt%. The hysteresis loop of the thermal diffusivity was measured, in a temperature range 20 to 70 °C, using the modified Angstrom method. During the heating and cooling processes, it can be observed how the reversible phase transition occurs gradually. Thermal diffusivity decreases by 50% on average during the phase transition. In order to complement our studies, the electrical conductivity of the samples as a function of temperature, was measured using two points measurement. Additionally, the shift of the band gap, due to the phase transition, was determined by UV-Vis spectroscopy.

Keywords: iodomercurates, thermochromics, thermal properties

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SB3-O011
STUDYOF THE EFFECT OF HNT CONCENTRATION ON THE OPTO-ELECTRONICAL PROPERTIES OF PEDOT:PSS FILMS

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Poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) is regarded as the conductive polymer by excellence dueto its remarkable electrical and physical characteristics. Multiple strategies have been developed to tailor the characteristics of PEDOT:PSS films for specific applications. Among them, the introduction of nanofillers to the polymer matrix has been widely demonstrated to be an effective way to improve opto-electronic and mechanical properties. Commonly, nanofillers consist of conductive or semiconductive materials, like carbon nanotubes or metal oxide nanoparticles. In This work we present a study of the optical and electrical properties observed in PEDOT:PSS composite films by using an alternative type of nanofiller: aluminosilicate nanotubes (halloysite, HNT). A material significantly different to others commonly found in the literature; HNTs areinsulating, more affordable, and less ecologically impactful. Thus, we studied the effect that different loadings of HNT has on the opto-electronic properties of PEDOT:PSS-HNT films by FT-IR and UV-Vis-NIR spectroscopy, as well as impedance spectrometry analysis. The results obtained offer an insight on the interactions pertaining to PEDOT:PSS and HNT that enable different potential applications.

Keywords: PEDOT:PSS composite, Halloysite, Impedance spectroscopy

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SB3-O012
PREPARATION AND STUDY OF POLYESTER/GRAPHENE OXIDE MIXTURES AS RAW MATERIAL FOR

MANUFACTURING THERMAL SPRAY COATINGS ON ALUMINUM-BASED ALLOYS.

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In the aeronautical industry, it is common to use metals of the aluminum family to manufacture various aircraft parts. These aluminum alloys are used due to their high mechanical strength, fatigue resistance, and machinability. However, in most of the alloys used, there is a great tendency for corrosion problems. For this reason, it is necessary to find a coating that delays these processes and improves the service life of aluminum. This work prepared graphene oxide-reinforced polyester powders in different percentages through high-energy milling to obtain raw material which can be used in thermal spray techniques to fabricate coatings for alloy protection. During the pre-experimentation, the degree of oxidation, the reinforcement materials working range (in wt.%), and two-stage milling were settled, a low speed and a second high speed, to ensure that graphene oxide was homogeneously dispersed. Time was varied during the milling stages. Then, their effect in the mixtures was established through FTIR and Raman spectroscopy, SEM, and DLS, respectively, evaluating structural and morphological properties. Polyester particles were also observed to retain most of their morphology and particle size with the established milling parameters and were coated with graphene oxide particles. Finally, the final mixtures were prepared using the graphene oxide in an acid oxidation stage, ranging 0.25 to 1 wt.%. These mixtures were also characterized by FTIR, RAMAN, SEM, and XPS, where structural and morphological properties permitted to discard of undesired changes due to the process. Moreover, thermal behavior through DSC and TGA was obtained, and thermodynamic variables of the mixture were established. The evaluated characteristics allowed us to predict that the mixtures obtained in the experimental phase can be used as feedstock in thermal spray technologies (such as HVOF), considering that the enveloping effect of the graphene oxide on the polyester particles was achieved, which can act as a protective layer for the polymer.

Keywords: graphene oxide reinforcement, high-energy milling, Polyester

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SB3-O013 Invited Talk
DAMAGE EVOLUTION MONITORING OF GLASS FIBER / EPOXY COMPOSITES WITH AND WITHOUT SEAWATER AGING USING SELF-SENSING CAPABILITY AND ACOUSTIC EMISSION

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The damage initiation and evolution of seawater(SW) aged glass fiber reinforced polymers (GFRPs) subjected to flexural loading was evaluated using the self-sensing capability and acoustic emission (AE)techniques. The self-sensing capability of GFRPs was provided by the integration of carbon nanotube (CNT) networks for a

better damage evolution monitoring. The specimens were manufactured with different stacking sequences($[0_6]$,$[0_4]$,[0/90]s, and [90/0]s) using the vacuum assisted resin infusion process where the CNT were incorporated onto the glass fiber surface by the spray coating technique. The electromechanical response, through the measurement of electrical resistance change, and some AE parameters such as the cumulative energy and/or strength cumulative, obtained simultaneously throughout the bending test, were able to capture the occurrence of specific failure events during the composite damage evolution, confirming their capability for structural health monitoring applications. An important reduction of mechanical properties of composite laminates produced by SW aging, as a consequence of plasticization and swelling effects of the polymer matrix, was revealed. Despitethis physical degradation, the piezoresistive effect of the CNT networks was preserved and damage monitoring of SW aged composite samples by them self-sensing capability was possible. A comparison of damage mechanisms of specimens with and without SW aging using these non-destructive techniques was performed. Damage evaluation of failed specimens via scanning electron microscopy was performed, and it exhibited a less damage severity on specimens with CNT due to the reinforcement effect in accordance with our previous studies. Another important fact is that the self- sensing capability of GFRPswith CNT was exhibited even after the seawater aging, making this technique suitable for structural health monitoring of marine components and structures. Thus,this work demonstrates the complementarity and synergy of both non-destructive inspection techniques for monitoring damage progression in composite structures.

Keywords: seawater aging, self sensing, acoustic emission

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SB3-O014
3D PRINTING WITH NATURAL AND BIODEGRADABLE POLYMER AND THEIR POLYMER COMPOSITES:POTENTIAL USES WITH A SUSTAINABLE APPROACH

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The research focused on natural polymers has increased notably due to the severe pollution caused by fossil-based plastics. Also, the uses of natural fibers considering as by-products and cellulose fiber have taken a second wind in research due to their biodegradable characteristics and the possibility to diversify their sizes and properties. Besides the beforementioned, 3D printing has emerged as an important processing technique to develop natural composites with biodegradable matrix and natural materials as reinforcements. Thus, this talk shows the new materials development in our group, taking advantage of their features of biodegradable polymers and different reinforcement processed by green methods. Polylactic acid (PLA)processing by FDM reinforced with different types of keratin material obtained from by-products and their mechanical thermal and biodegradable properties are shown. Different designs of scaffolds are also analyzed and the effect of geometry and structure of keratin materials in biocompatibility and thermomechanical properties are evaluated. The surface modification of keratin materials by green methods is also analyzed in 3D-printed composites. In addition, complex structures of PLA-keratin composites are studied as sound absorption materials with the influence of design structures and reinforcements. Following the sustainable approach; PLA printing by FDM is also analyzed in other designs and composites development by biomimetics and for biocompatibility. Finally, the advances in another natural polymer (polycaprolactone-anthocyanin) as a smart

3D-printed material for sensing pH changes are also shown and discussed.

Keywords: 3D PRINTING, NATURAL POLYMERS, SUSTAINABILITY

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SB3-O015
3D AND 4D PRINTING POLYMER AND COMPOSITES, DIVERSIFYING THE ENGINEERING POTENTIAL USES WITH SIMPLE AND COMPLEX STRUCTURES.

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Polymer composites have increased and diversified their applications in this century; considering the typical applications of these materials developed in the last century and the growth of processing methods of nanomaterials the potential developments and applications of polymer composites, nanocomposites and hybrid composites have increased notably. In addition, all mentioned, additive manufacturing of polymers in the last years has increased the possibilities to create diverse forms complicated with other techniques. Thus, 3D and 4D printing of polymer and polymer composites can be used to develop nanocomposites reinforced with one or two nanomaterials to analyze their mechanical and thermal properties, but also, the method is useful to diversify the structures toward complex forms. This talk is focused to show the advances reached in our research group. The 3D printed materials include nanocomposites processing by Fused Deposition Modelling (FDM) reinforced with carbon nanomaterials in 1D and 2D dimensions, graphene nanoplatelets obtained by green methods, dichalcogenides, and mxenes, and the analysis of their mechanical and thermomechanical properties. 3D printing is also extended to diversify the potential applications with complex structures by FDM and stereolithography (SLA), in the development of filters from nanocomposites designed to photocatalysts comparing the performance in airflow evaluation; cores of sandwich composites with hexagonal and auxetic structures with potential applications of the aeronautic field, and the study of other complex designs printed by FDM focused to femoral stem prosthesis. Finally, some studies of recovery form using 4D printing of Polylactic acid-Polyhydroxyalkanoate (PLA-PHA) and their nanocomposites with some complex structures are also presented. Thus, diverse potential applications in different fields of engineering and materials science are presented as a result of the synergic effect from additive manufacturing, polymer, and nanomaterials reflected in the novel designs combined with composite properties.

Keywords: 3D PRINTING, POLYMER NANOCOMPOSITES, COMPLEX STRUCTURES

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SB3-O016
MULTI-MATERIAL 4D PRINTING OF SMART COMPOSITE STRUCTURES

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Adaptive structures sought after in aerospace and automobile industry need to satisfy three main criteria, they must be – lightweight, reconfigurable, and load bearing at the same time, which has been a continuing engineering challenge for decades. The bulkiness of current mechanical actuation systems that rely on heavy hydraulics or pneumatics outshines the advantages coming their use. It is thus imperative to apply lighter, smart material-based actuation systems to achieve shape morphing in aircraft. Smart materials like shape memory alloys (SMA), magneto-rheological fluids, electroactive polymers, piezoelectrics are being heavily researched and applied towards shape morphing. However, new challenges emerge – firstly, in terms of integration of smart materials in composites; secondly, given the manufacturing restrictions only basic standard shape changes are possible; and thirdly, in terms of compatibility between the smart materials and the composite/host matrix. Most smart material integrations so far have come at the cost of reduced fatigue life and increased susceptibility to crack propagation. This talk presents novel multi-material additive manufacturing techniques to develop load-bearing and lightweight reconfigurable structures using different modes of actuation.

Keywords: Additive manufacturing, smart materials, actuation

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SB3-O017
SMART MATERIALS FOR FOOD PACKAGING BY 4D PRINTING OF POLYCAPROLACTONE MODIFIED WITH AGRO-INDUSTRIAL EXTRACTS: BLACKBERRY AND RASPBERRY

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There is a great demand for food packaging with superior but environmentally friendly characteristics, seeking to take advantage of agro-industrial waste to minimize costs and reduce the carbon footprint. Therefore, processing smart materials with acceptable properties to be used as food packaging material is an actual aim. Thus, this research involves the development of smart materials using agro-industrial wastes (raspberry, blackberry, chitosan, and cactus mucilage) using as a matrix a biodegradable polymer (Polycaprolactone). Thermal and structural chemistry characterization was achieved by Differential Scanning Calorimetry (DSC) and Fourier Transform Infrared Spectroscopy (FTIR) to verify the effect of the thermal process in functional compounds. Color change in the function of pH and humidity were also analyzed by studies of color variation and sorption isotherms by Guggenheim Anderson de Boer model (GAB model); mechanical and permeability properties were also evaluated. As results were obtained materials with mechanical and barrier properties were suitable for use as packaging materials, enough to be used in liquid food, also with the modeling of GAB by sorption isotherms it was determined that the moisture contained within the packaging can have a second impulse and generate a color change that can be correlated as well as with the pH change in a metabolic process that should not be present in the food, i.e. potential microbial contamination that showed the change in the color change of the processed material. Finally, the FTIR and thermal study by means of DSC showed that the functional materials within the matrix are not affected by shearing when the filaments are processed

by thermal extrusion or printing. The best results were obtained in the materials with blackberry extracts since the raspberry generates changes that are not as perceptible to the consumer as the anthocyanins in the blackberry. The perspectives of this work now are to apply it as a finished package and evaluate its effectiveness through a shelf-life study.

Keywords: 4D printed, Smart materials, Blackberry and raspberry

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SB3-O018
HYBRID CARBON NANOSTRUCTURES AS REINFORCEMENT OF 3D PRINTED PLA AND PLA-PHA COMPOSITES: MECHANICAL AND THERMOMECHANICAL PROPERTIES.

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Interest in alternatives to oil-derived polymers increased in the last decade. However, the properties of polymers such as Polylactic acid and Poly lactic acid-polyhydroxyalkanoate need to improve regarding mechanical performance. One alternative to this issue is reinforcement by hybrid nanostructures [1]. Hybrid nanostructures are 3D nanomaterials that can build structures with different geometries, for example, tubes and plates [2]. In this work, we investigated the effect of adding hybrid carbon reinforcement on printed composites thermomechanical and mechanical performance. This study considered graphene oxide and oxidized carbon nanotubes blended with varying weight percent to build a 3D hybrid nanostructure. Polylactic acid and Poly lactic acid-polyhydroxyalkanoate were used as matrix composites. Electron transmission microscopy evidence the formation of the 3D nanostructures. The infrared measurements showed the influence of nanostructure functional groups over the polymer matrix structure. The tensile mechanical test points to a maximum improvement in the tensile modulus of about 29 % for hybrid reinforcement at less material added. Microstructural and fracture surfaces were examined by scanning electron microscopy. Also, the Dynamic Mechanical Analysis evidenced a reduction in the storage modulus related to cooperatively rearranging regions in the matrix. The improved mechanical properties of thermoplastic printed composites were attributed to the homogeneous dispersion of hybrid nanostructures and better transfer of stress matrix to reinforced.
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[2] M. Ali, M. Bonab, and H. Akbulut, Artic.J. Appl. Polym. Sci. 2022, 5, e53269

Keywords: Multidimension nanocomposites, Hybrid 3D reinforcement, Printed composites

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SB3-O019
3D PRINTING PLA-BIOCOMPOSITES: EFFECT OF ENVIRONMENTALLY FRIENDLY METHODS IN KERATIN FIBERS AS REINFORCEMENTS

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With the increasingly severe pollution caused by synthetic fibers of polymeric origin, it has once again been used to look for alternatives for the use of natural fibers. To diversify its properties and possible uses of these, its size reduction has been sought by different procedures. In this research, the steam explosion method was used as a green treatment to obtain keratin fibers. The sources of this biopolymer are chicken feathers (gallus gallus) and angora fiber (Oryctolagus Cuniculus domesticus). This methodology aims to be an ecological alternative for the reuse of these fibers rich in keratin without using any chemical reagent in the process. Steam explosion has been used in lignocellulosic biomass and has had exploration in other natural sources to reduce particle size or modify properties of these materials. The fibers obtained in two different steam explosion equipment were compared: asemi-industrial equipment that includes sudden depressurization and the otherat a laboratory level by liquid hot water (LHW), this with the objective of evaluate and relate the effect of the conditions used in the dimensions of fibers used. The exploited fibers were exfoliated using an ultrasonic probe to separate them and compare their morphology. The exploited fibers and the exploited and cleaved fibers were characterized by Scanning Electron Microscopy (SEM), Thermogravimetric Analysis(TGA) and Fourier Transform Infrared Spectroscopy (FTIR). These fibers were incorporated into a polylactic acid (PLA) matrix to evaluate its function as reinforcement. A mechanical dispersion of the ground PLA was carried out with the fibers treated at different concentrations, to later carry out the extrusion to obtain the filament and it was used in a 3D printer to print the samples that were taken to the laboratory to proceed to their characterization.The printed parts were subjected to different tests, such as a tensile test, to quantify the contribution and influence of the reinforcement within the PLAmatrix and SEM to analyze the fracture zone with the different reinforcements in PLA. Also, samples were characterized by Sorption Isotherms using Guggenheim-Anderson-deBoer (GAB) three-parameter sorption equation to know the different affinity with water by wet media controlled.

Keywords: Biocomposites, keratin, chemical-free treatment

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SB3-O021
CUSTOM-MADE STARCHES FOR SMART PACKAGING USING PULSED ELECTRIC FIELDS

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Starch is a natural material capable of creating bioplastics with high potential for use in food packaging. However, plastic films made only starch usually have poor quality, making them noncompetitive versus non-

biodegradable alternatives in the market. Therefore, modified starches plus a composite matrix are a viable solution that improves the properties of starch films. Recent studies have demonstrated the effectiveness of modifying starches using pulsed electric fields (PEF). This non-thermal technology has the advantages of being fast and not requiring chemicals to be carried out. Therefore, this research aims to prepare custom-modified starches using the PEF technique, to be used later as a matrix in the elaboration of films with natural extracts that will be useful to measure pH changes in contact with food. The research was developed in 4 parts: the modification of the starches (rice, corn, potato, and tapioca) using PEF to different electric field values (1, 3, 5, 9, and 11.5 kv/cm) to the best starch and treatment to manage in better manner a plastic film with similar characteristics to commercial plastics used in the manufacture of food packaging. This was followed by the evaluation of natural extracts (blue corn, turmeric, and hibiscus flower) to achieve the color change when exposed to different pH. The advantages of the reinforcement of films with chitosan were also studied. The exploration as smart starch bioplastics in food the basic food basket is also considered. Characterization techniques used include light microscopy, scanning electron microscopy, differential scanning calorimetry, infrared spectroscopy, wide angle X-ray scattering, as well as mechanical testing and color analysis.

Keywords: Starch films, Pulsed electric fields (PEF), Smart packaging

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SB3-O022
INFLUENCE OF CARBON NANOPLATELETS INTO STARCH FILMS OBTAINED FROM DIFFERENT SOURCES.

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The plasticity behavior that occurs in starch when it is heated in the presence of water has received attention in applications for non-food purposes. Specifically, the development of starch films with carbon nanoplatelets using the pour-on-plate technique allows us to obtain a plastic material with thermal and electrically conductive properties. This research is intended to explore starch as a matrix for the formation of composites with carbon nanoplatelets, while deepening the understanding of the structural changes in starch during the process. The ability to create inclusion complexes is highlighted, due to their hydrophobic cavity and hydrophilic exterior. For the preparation of the film, starches with different types of crystallinities were used (corn, potato and tapioca), as well as different percentages of carbon nanoplatelets (since 1% w/w up to 5%w/w) . The effect of chitosan as a reinforcing agent on the starch matrix was also studied. For both cases with and without chitosan, a plasticizer of vegetable origin (glycerol) was used. The films obtained were characterized by differential scanning calorimetry (DSC), wide angle X-ray scattering (WAXs), scanning electron microscopy (SEM) and infrared spectroscopy (FTIR), and the corresponding mechanical testing were performed. The resulting films are a step forward in research into creating new functional materials using natural materials such as starch.

Keywords: Starch films, carbon nanoplatelets, composites

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SB3-P001
PARTICLE SHAPE-DEPENDENT, PHOTOTHERMAL PROPERTIES OF GOLD NANOSTRUCTURED COLLOIDS IN A PHYSIOLOGICAL FLUID.

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The optical properties of gold nanoparticles have made possible the development of biomedical therapies such as hyperthermia. Photothermal properties depend on the size and shape of the nanoparticles. Likewise, the coatings and biological environment define the efficiency of light-to-heat conversion. In this work, we studied the influence of shape (spheres, rods and stars), coating (polyethylene-glycol and fluorescein) and the biological environment (pH=7.4-blood plasma; pH=7.2-breast cancer) on photothermal properties. The light-to-heat conversion efficiency of star-shaped gold nanoparticles exceeds that of rods and spheres. Behavioral efficiency is inversely proportional to the heat rate, so the energy transferred to the fluid is lower due reduced contact areas, which result in a lower energy transfer, resulting in a lower final temperature. Rod-shaped gold colloid transfers more energy to physiological fluid, resulting in a higher temperature. Polymeric and fluorescein coating contributes to energy concentration. The energy generated by the plasmonic excitation of spheres and star-shaped gold nanostructures is diminished by the physiological environment. Gold nanostructure photodegradation in physiological fluids decreases thermal capacity due to the agglomeration and precipitation of nanoparticles, resulting forces of attraction and repulsion, caused by the physiological medium.

Keywords: Gold nanoparticles, Photothermal properties, Physiological fluids

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SB3-P002
DETECTION OF UREA/ GLUCOSE BASED IN PA/ PQ/ PVAas A SEMICONDUCTOR MEMBRANE NO ENZIMATIC

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Research has taken an interest based on the improvement of alternative devices to silicium where the flexible superficial area will keep its function, we present the development of a functional and flexible membrane ideal for the detection of urea based on the components of PVA, PA, PQ, starting the SOL-GEL process. This process was carried out at room temperature, deposited by solution casting to membrane highlighting its ideal characteristics such as thin membrane, transparency, flexibility and semiconductor. The results presented are FTIR, UV-Vis before and after analyte, measurement 4 tips in solution and solid, conductometry where the chemical changes occurred to an electrical response give us an adequate response for the proposed

application. We found a trend for UV-Vis turning out to be excellent for these semiconductor materials and their composition in optoelectronics.

Keywords: Membrane, Sol-gel, Urea/glucose interaction

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SB3-P003
DEVELOPMENT OF A TRANSDERMAL SYSTEM FOR THE CONTROLLED RELEASE OF VITAMIN D3

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In the following work, the single injector electrospinning technique was used to obtain polymeric films of polycaprolactone (PCL Mn =14 000 Da and Mn=80 000Da) loaded with vitamin D3(VD3) in two presentations: oil and powder. The concentration of the polymer solution, the type and proportion of solvent, the needle diameter and the applied flow rate were varied to study their influence on the electrospinning process. No fibers were obtained when using PCL Mn=14 000 Da due to its low molecular weight. Well-defined PCLfibers without the presence of defects were obtained when using solutions 5, 7 and 8 with diameters of 1,537 µm, 2,530 µm and 3,950 µm, respectively. This behavior was maintained for the powdered PCL and VD3 fibers. While the morphology of the fibers changed when loaded with VD3 in oil, obtaining fibers fused together. The fibrous films were characterized by Fourier Transform Infrared Spectroscopy showing that there was no chemical interaction between the fiber components. The morphology was analyzed by Scanning Electron Microscopy and the thermal behavior of the fibrous films was studied by Thermogravimetric Analysis (TGA).

Keywords: electrospinning, fibers, vitamin

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SB3-P004
DESIGN AND DEVELOPMENT OF POLYVINYL ALCOHOL (PVA)/ALOE VERA/COLLAGEN/MANUKA HONEY DRESSINGS WITH REGENERATIVE AND ANTIMICROBIAL PROPERTIES FOR THE TREATMENT OF BURNS AND CHRONIC WOUNDS

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This work used the electrospinning technique to obtain polymeric fiber mats of polyvinyl alcohol (PVA= 89,000-98,000 Mw) with encapsulated collagen, aloe vera, and Manuka honey. We varied the electrospinning

parameters such as voltage, distance, concentration, and flow parameters to obtain the ideal fiber diameter for the gradual release of the active ingredients. Once the ideal morphology was established, the compounds were individually integrated into the PVA fibers, using different concentrations to determine their effects on the fiber. The fiber morphology was analyzed by Scanning electron microscopy (SEM). Through Fourier transform infrared spectroscopy (FTIR), we confirmed the presence of the active ingredients in the fibers, and assessed any potential chemical interaction between PVA and the components. To finalize the films characterization, X-ray diffraction was utilized to observe if the structure of the compounds had changed after the electrospinning process. UV-VIS method was employed to asses the release profile of the active ingredients. To verify the antimicrobial properties, the film was exposed to E. coli and S. aureus bacteria to determine the bacterial activity on the surface of the patch.

Keywords: Electrospinning, Chronic wounds, Polymers

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SB3-P005
UNDERSTANDING ROLE OF GO/FLG HETEROSTRUCTURES IN MEMBRANES FOR WATER SEPARATION APPLICATIONS

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The use of membranes based on nanomaterials to treat water is a potential alternative that promises to be low-costand easily scalable. In particular, desalination of water using these membranes is projected as an economical alternative source of clean water. Likewise, the removal of dyes from water constitutes an environmental remediation for common industrial processes. In this direction, the structure and composition of the membranes are always a subject of study to improve the separation capabilities of the membrane. In this project, membranes based on heterostructures of graphene oxide (GO) and few layer graphene (FLG) are formed over a PTFE support. Afterward, the membranes are tested for desalination and dyes separation from water. To produce GO/FLG heterostructures it is important to focus on obtaining the best isolated bidimensional materials. GO is produced using the Hummer's method and FLG is obtained from liquid-phase ultrasonic exfoliation. In both cases, the precursor is a purified graphite, which does not contains metallic elements. Each obtained material is dispersed in N,N-Dimethylformamide and mixtures of both solutions are prepared varying the percentage of GO and FLG in each final mix. The mixtures of the dispersed materials are characterized using UV-Vis spectroscopy to follow up a mass percentage replacement of GO by FLG in the heterostructures. Afterward, the mixtures dispersions are filtrated over a PFTE support for the fabrication of membranes of GO/FLG heterostructures. Raman spectroscopy, static contact angle, and average roughness are used to characterize the obtained membranes. Lastly, the water permeation, rejection percentage of NaCl ions, besides of rejection of dye are evaluated for each membrane obtained with different GO/FLG composition. The presence of heterostructures in the conformation of membranes provide critical information for the tunability of the membrane's properties for its application in water separations.

Keywords: GO/FLG heterostructures, Membranes, Water purification

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SB3-P008
WOOD: DIMENSIONAL STABILITY MODIFICATION USING FURFURYL ALCOHOL

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Wood is a composite, renewable material that presents anisotropy. It consists mainly of cellulose, hemicellulose, and lignin. Cellulose is a linear homopolymer made up of glucose units, hemicellulose is a branched heteropolymer made up mainly of glucose, xylose, arabinose, galactose, and mannose, both are hygroscopic; On the other hand, lignin is a branched amorphous polymer mainly formed, by three monomers and that presents hydrophobicity. On the wood cell wall, the content and arrangement of the main components are different. Naturally, organoleptic, physical, chemical, and mechanical properties of wood depend on factors such as species, age, and orientation of the cut, among others. Wood is used widely as a structural element. To improve its performance, chemical modification treatments have been developed that reduce hygroscopicity by increasing dimensional stability, which is very useful, especially in juvenile wood. Chemical modification treatments seek to use modification agents that improve properties and that work under the principles of green chemistry. In this work, the behavior of dimensional stability of juvenile Pinus montezumae wood was studied by chemically modifying it using in situ polymerization of furfuryl alcohol first in the absence of a catalyst and later catalyzing the reaction with maleic anhydride. The wood came a commercial forest plantation located in the State of Michoacán México, concentration of furfuryl alcohol used was 5 % and 10 % maleic anhydride. Dimensional stability was evaluated according to the ISO 4469 standard – Determination of radial and tangential shrinkage, in wood unmodified and compared with modified wood. Results show a decrease in the hygroscopicity of the wood, which is reflected in an improvement in dimensional stability, contributing to the use of wood as a structural material.

Keywords: wood, dimensional stability, furfuryl alcohol

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SB3-P009
MANUFACTURE OF A FILTER BASED ON A COMPOSITE MATERIAL (TEZONTLE/BAGASSE/CUO-NPS) FOR GRAY WATER TREATMENT.

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In Mexico, the wastewater generated is discharged without receiving prior treatment, for which it seeks to implement economic and environmentally friendly processes for the treatment of the vital liquid. Gray water (GW)constituted 80% of wastewater, and usually, is treated by a filtration process,which allows the separation of solid particles in a fluid. GW passes through a filter medium, in which the solid residues are deposited. For the filtration process, inexpensive materials can be used, which would generate a decrease in cost. However, the problems reported in the literature for the filtration process are that they only treat small volumes of WG, the process is carried out through gravity, and the long residence times required (5 to 15 days). The design of this filter contributes to generating alternatives for sustainable development and environmental remediation, which are objectives of The Socio-Ecological Systems and Sustainability of the National Strategic Programs(PRONACES). In that sense, this work aims to design and manufacture an ascending flow anaerobic filter using green materials for the treatment of domestic GW. The first layer of the filter will be built using tezontle, which carries out the sorption process (absorption or adsorption). The second layer would be a composite formed by a corn bagasse and copper oxide nanoparticles (CuO-NPs).The desire result is that the domestic GW in contact with CuO-NPs present a bacterial reduction. Also the treated water will exhibit low anionic contaminants.

Keywords: composite, gray water, filter

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SB3-P012
DEVELOPMENT OF A BISMUTH SULFIDE/ BIOGLASS 45S5 HETEROSTRUCTURE. NiS Nps, FOR ITS APPLICATION IN A FLEXIBLE GLUCOSE BIOSENSOR

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In this work, is reported the deposition of bismuth sulfide (BI_2S_3)/ bioglass 45S5.NiS NpS thin films on a flexible polyethylene naphthalate (PEN) substrate and the relevant characterizations before and after exposing the materials to different glucose concentrations. The thin films of BI_2S_3 were obtained by chemical bath deposition at 80 °C, and over these the bioglass 45S5.NiS Nps was deposited by spin coating technique, varying the speed of deposition and number of layers. The materials were characterized by ultraviolet visible spectroscopy (UV.Vis) where it was observed that as the number of layers of the 45S5.NiS bioceramic increases, the absorbance increases, but decreases as the deposition speed increases, the characteristic absorption edge for the Bi_2S_3 at 480nm was observed. Using the Tauc method, the band gap energy was estimated in the order of 1.3 – 1.7 eV. Homogeneous thin films and distribution was presented and a porous structure when depositing the bioglass 45S5.NiS on the chalcogenide, observing structures similar to sea urchins. The films showed characteristic peaks of Bi_2S_3, obtaining an orthorhombic structure and a cubic structure for NiS , thus demonstrating the conformation of the heterostructure and the bioceramic presents an amorphous structure. Using the 4-point method, an increase in electrical resistivity was recorded with respect to the deposition speed and number of layers, obtaining an average of 36.75 GΩ/u2. As the materials were

exposed to a glucose test at different concentrations, it was possible to appreciate an increase in resistivity through 4-points as the glucose concentration increased, as well as an increase in absorption shown by ultraviolet-visible spectroscopy calculated. An increase in the band gap energy with respect to the heterostructure was determined before the tests with glucose. Obtained results allow us to continue exploring the heterostructure formed by the materials proposed here for their application in a glucose biosensor.

Keywords: Bismuth sulfide, Flexible substrates, Polyethylene phthalate

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SB3-P013

THERMAL, MECHANICAL, AND CYTOTOXICITY EVALUATION OF CARBON NANOTUBE REINFORCED PLA/CFRC LAMINATE COMPOSITE USING THREE LOADING METHODS: MIXING BY FUSION, DISPERSION, AND INTERLAMINAR COATING BY SPRAYING AS AN ALTERNATIVE MATERIAL FOR A PROSTHESIS.

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Currently, fiber-reinforced composite materials have been developed to provide a material with mechanical properties consistent with bone structure and high cytocompatibility as an alternative to conventional materials for orthopedic implants. This research evaluates the influence of carbon nanotubes on the recently developed composite of 3D-printed polylactic acid layers and carbon fiber laminates (PLA/CFRC) for prosthetic applications. The following methods carry out the incorporation of the MWCNT: mixing by fusion between the PLA and the MWCNT (PLA-MWCNT/CFRC), dispersion of MWCNT in epoxy resin by ultrasound (PLA/CFRC-MWCNT), and interlaminar coating by the spraying of MWCNT (PLA/MWCNT/CFRC) with potential application in prosthetic implants. The results obtained through thermogravimetric analysis and differential scanning calorimetry (TGA/DSC) indicate that the incorporation of MWCNT significantly impacts the thermal behavior of the polymeric matrix, observed in the degradation, glass transition, and melting temperatures. The results of the cytotoxicity assay indicate that the PLA-MWCNT/CFRC composite has a cellviability of 89%, slightly lower than the other samples. However, it is within the acceptable range according to ISO 10933-5. The tensile tests show that the PLA/CFRC-MWCNT composite has the best mechanical behavior with an elastic modulus of 24.57 ± 0.62 GPa. and a tensile strength of 283.21 ± 19.79 MPa., with mechanical properties similar to bone. The results in this study demonstrate that the PLA/CFRC composite with carbon nanotube loads can be used as a candidate material for fabricating a prosthetic femoral stem.

Keywords: Composite, MWCNT, PLA/CFRC

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SB3-P015

CHARACTERIZATION AND EVALUATION OF POLYCAPROLACTONE/HYDROXYAPATITE COMPOSITE SCAFFOLDS FOR THEIR POTENTIAL USE IN BONE TISSUE REGENERATION

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Polycaprolactone (PLC) is a semicrystalline aliphatic polyester, biocompatible and biodegradable in physiological media. It has disadvantages such as slow degradation and reabsorption kinetics, as a result of its high hydrophobicity and semicrystallinity. This problem is solved by incorporating another material with biocompatible characteristics. such as hydroxyapatite (HAp), a non-toxic, bioactive ceramic biomaterial that generates bone tissue. In this work, composites caffolds were made using the gel-casting technique, of polycaprolactone (PLC)/ 25%, 30%, 35%, 40% and 45% hydroxyapatite (HAp). Using Scanning Electron Microscopy (SEM) it was shown that the percentage condition with the highest homogeneous distribution of the HAp was 35% within the polymeric matrix. Subsequently, PLC / 35% HAp / 3%, 6%, 12%, 24% and 30%Sodium Citrate (Cit. Na) composite scaffolds were prepared to evaluate the effect on the porosity of the scaffolds and their structural stability by meansof a swelling test with PBS solution for 9 days. The porous scaffolds are characterized by: Fourier Transform Infrared Spectroscopy, demonstrating the characteristic bands of PLC and HAp without the presence of new absorption bands in any of the scaffolds made, by X-ray diffraction, a behavior was observed where the polymer completely covers the surface of the hydroxyapatite, makingit evident that a hydroxyapatite signal peak cannot be detected when the scaffold is made, by Scanning Electron Microscopy it was observed that the apparent porosity began to be visible using 12%, 24% and 30% of porogenic agent, being the ratio PLC / 35% HAp / 30% Cit. Na, the one that presented the greatest porosity. The swelling test showed that by day nine, the scaffolds with porosity of 12%, 24% and 30% began to show degradation by hydrolysis. It is concluded that increasing the percentage of porosity increases the rate of degradation by hydrolysis, improving the rate of decomposition of the scaffolds in contact with a simulated physiological fluid.

Keywords: Scaffold, polycaprolactone, hydroxyapatite

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SB3-P016
DETECTION OF UREA/ GLUCOSE BASED IN PC/ PQ/ PVA AS A SEMICONDUCTOR MEMBRANE NO ENZIMATIC

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Research area has focused interest in alternative semiconductors to silicium taking advantage of the two main properties of organic materials such as luminescence and electroluminescence in the active layers by

volumeheteroin biosensing prototype, they have shown optimization with respect to thin film technology. In this paper we present for flexible electronics the detection of urea / glucose based on the components of PVA, PC, PQ by SOL-GEL and as a final product a flexible membrane by the technique of solution casting. The molecular assembly is established by hydrogen bridging to evaluate the optoelectronic characteristics of the composition. The results presented are FTIR, UV-Vis before and after analytes, measurement 4 tips insolution and solid, conductimetry where chemical changes offered an adequate electrical response for the application.

Keywords: Membrane, Optoelectronics, Sol-gel

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SB3-P018
SYNTHESIS AND OPTICAL PROPERTIES OF EU, DY, CU LITHIUM BORATE GLASSES FOR BRIGHT WHITE LIGHT

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This work reports the synthesis and spectroscopic characterization of Eu, Dy, and Cu-tridoped lithium borate glasses for white light emission. The glasses were obtained by the melt quench technique at 1000 °C the precursors lithium carbonate, boric acid, copper nitrate, dysprosium oxide, and europium oxide. An orthogonal Taguchi L9 experimental design was conducted to identify the optimal Eu, Dy, and Cu concentrations for white light emission. The glasses were excited at 340, 360, and 380 nm, showing the typical emission transition Cu (about 450 nm), Dy (about 480 and 575 nm), and Eu (about 611 nm). The light emission intensity and the CIE coordinates were a function of the wavelength excitation. The CIE coordinates of the glasses, when excited at 340 nm, were on the blue region, while at 380 nm wavelength excitation, the color was centered on the red region. Interestingly, the light emission intensity ratio the dopants at 360 nm excitation allows CIE coordinates at (x= 0.31, y= 0.29). The dopant concentration for Dy, Eu, and Cu was 1.5, 1.0, and 0.1 at.%, respectively.

Keywords: lithium borate glasses, white light emission, europium

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SB3-P019
DESIGN AND 3D PRINTING OF PLA COMPOSITES REINFORCED WITH NANOHIDROXYAPATITE AND ITS STUDY ON BONE COMPATIBILITY

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With the emerging industry 4.0, additive manufacturing has positioned itself in the most important places, which has different techniques applied to polymeric materials, of which the FDM technique [1] can be highlighted due to its easy implementation, having an offer of low cost compared to others on the market, in addition to its versatility in forming,since it allows obtaining a large number of complex geometries and developing innovative and precise prototypes. Thus, the use of FDM has come to complement the processing of new materials, allowing a wide diversity of applications in important fields, such as the health area. A challenge that 3D printing has faced for the development of polymeric biomaterials lies in developing appropriate models that imitate the different tissues with which they are intended to interact [2]. In the case of biomaterials for bone applications,the aim is to generate light materials, which allow the migration, support and proliferation of cells such as osteoblasts, which are cells that initiate bone formation, which allow the integration of the polymeric biomaterial as a prosthesis or implant in the organisms [3]. Thus, in this work different models based on bone mimetic geometry are presented, whose specimens were printed on scaffolds made of PLA (polylactic acid) and nHAp (nano hydroxyapatite particles)at 0.5% and 0.005%, contemplating lattice variables, porosity percentage, size and inter connectivity of the pores. and a decreasing gradient the outside to the center. Models were developed using Solid Works™ and Flash Printing™software. After printing, tension tests, DMA (Mechanical-Dynamic Analysis) and biocompatibility are carried out to monitor the benefits of using a biocompatible polymeric material in conjunction with a reinforcement, to be integrated as a composite material that generates application structures as potential bone substitutes.

Keywords: Fused deposition modeling, biomaterials design, latticework

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SB3-P020
DEVELOPMENT OF SANDWICH COMPOSITE CORES BY 3D PRINTING BASED ON FILAMENTS WITH CARBON MATERIAL REINFORCEMENTS.

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The need for diversifying the materials available for sandwich-type composite cores is increasing due to the search for greater efficiency and adaptability to various situations and needs. Zhu et al [1]. and his team determined that as honeycomb core density increased, flexural strength, stiffness, and fracture toughness increased,although several factors still need to be studied to determine a generalized method for optimizing core design and the variability of the material [2,3].Thus, in this investigation, three commercial filaments based on PLA were selected, two of them with carbon reinforcements, which contain carbon fiber and carbon nanotubes, and the third only PLA as a reference. The research consisted in the study of the printing parameters considering two core designs with complex geometric structures (honeycomb and auxetic hexagon) and later,the characterization of the base material by DSC (Differential Scanning Calorimeter), FTIR (Fourier Transform Infrared), and mechanical evaluation of cores through bending and traction tests. The material and the design of the structure show a positive combined effect on the load capacity of the structure.

Good agreements have been found in terms of the deformation pattern,fracture resistance and flexural stiffness in sandwich structures, showing equilibria that increase the energy absorption capacity. With these data, new insights into the development of structures fabricated by the 3D printing method and its wide range of mechanical applications in the field of composite materials will be conceived.

Keywords: Fused Deposition Modeling, Honeycomb, Core

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SB3-P021
GENERATION OF SMART BIOINSPIRED SCAFFOLDS PLA BY4D PRINTING

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The creation of components/structures or the functions of natural creatures has long been referred to as “bionics” or “biomimetics” Anew word “Bioinspiration” is proposed, meaning the science of creating new materials/devices with properties/functions not necessarily present in inspiring natural creatures. From the words bio means life and mimesis which is mimicry, nature, its systems, examples, processes, elements that imitate nature or inspire to solve problems of human solution [1]. Research is science, the term biomimicry refers to manufacturing processes and materials by mimicking the final state and properties of natural living materials [2] [3]. PLA (Polylactic Acid) has great strength as a biodegradable biopolymer; it generally has a short shelf life and is primarily a natural product. Materials in the field of regenerative medicine are mainly based on natural polymers (gelatin, collagen, chitosan, fibrin, hyaluronic acid, etc., often isolated animal and human tissues). [4]. This research evaluates two different structures based on tree frogs and geckos developed using the software called Solid Works, different mechanical tests were performed such as compression tests, bending tests, DMA tests (Dynamic Mechanical Analysis), SEM tests (Microscopy scanning electronics),biocompatibility tests and smart response to observe the behavior of printed material and verify the benefits of using it in tissue engineering.

Keywords: Fused deposition modeling, Biomaterials, Cell growth

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SB3-P023
MANUFACTURE OF ORGANIC RESISTIVE MEMORIES BASED ON NANOCOMPOSITES POLYMER-CNT.

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In the present work, we studied the interaction effect between functionalized multi-walled carbon nanotubes (f-CNTs) and a polymer matrix on their electrical behavior as resistive memories. The f-CNTs were synthesized by the spray pyrolysis method using a xylene-ethanol mixture (1:0.8 v/v) as a precursor solution, which allowed functionalization (anchoring of -OH, -COOH, C–H, and C–OH groups) in situ on their surfaces and, with this, improve their solubility in polar solvents and their dispersion in a polymeric matrix. For the manufacture of organic resistive memories, polyvinyl alcohol (PVA) is used as a polymeric matrix with two different degrees of hydrolysis; PVA with a high degree of hydrolysis (HD) (Mw 89,000-98,000, 99 + % hydrolyzate) and PVA with low degree of hydrolysis (LD) grade (Mw 9000-10,000, 80% hydrolyzate). The PVA+f-CNT compounds showed significant differences in morphology, thickness, and electrical behavior depending on the degree of hydrolysis of the PVA matrix. The results showed that the Current-Voltage (I-V) measurements were markedly different those reported in the literature. Compounds of PVA-LD+f-CNT at 1.0, 3.0, and 5.0% by weight of f-CNT exhibited rewritable memory behavior, while the PVA-HD+f-CNT compounds demonstrated the type of behavior, rewritable memory, only with 5% by weight of f-CNT. We conclude that the polymeric matrix may be essential in resistive memory behavior.

Keywords: PVA, CNT, organic

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SB3-P029
COMPOSITE MEMBRANES OBTAINED BY ELECTROSPINNING AS DERMAL SCAFFOLDS

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In the present research work, composite materials consisting of a biopolymer membrane and Hydroxyapatite are developed to improve their biocompatibility properties; the mixtures were manually machined for subsequent processing by electro-spinner. The materials proposed in this work comprise functionalized biopolymers for use as coadjuvant cell scaffolds in dermal regeneration; they are composed of Polyvinyl alcohol (PVA), Sodium Alginate (AS), pure Hydroxyapatite and compound Hydroxyapatite with Dysprosium Oxide. (Dy_2O_3), Manganese Chloride ($MnCl_2$), Iron Chloride ($FeCl_3$). The membranes of these composite materials are designed so that their morphology resembles the dermal matrix. The electrospinning machine allows obtaining a morphology to function as a synthetic extracellular matrix. The scaffolds were subjected to cell tests to verify their biocompatibility through cytotoxicity and cell viability

Keywords: Hydroxyapatite, Scaffold, Composite

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SB3-P030
CALCULATION OF EFFECTIVE PROPERTIES FOR FIBER-REINFORCED PIEZOELECTRIC COMPOSITES

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The theoretical and/or experimental investigation of the global properties of composite materials occupies a determining place in obtaining new materials with better specific characteristics, for a given application. The efficiency of the experimental route necessarily depends on a theoretical guide or mathematical model. During the last four decades much research has been directed to the development of homogenization methods capable of theoretically predicting such effective properties. Composite materials with a periodic structure appear in important technological applications in various areas of civil and mechanical engineering, in the sports industry, in electronics, among others. The determination of its effective properties when the physical and geometric properties of its components are known represents a useful tool for an adequate design and optimization. The method of asymptotic homogenization (AHM), which is based on a double-scale asymptotic expansion, is a rigorous mathematical technique for calculating the effective coefficients of such heterogeneous means. From a mathematical point of view, this method guarantees that the solution of the original problem with a periodic microstructure converges to the solution of the homogenized problem when the period of the microstructure tends towards zero. In this way, the study of the initial problem on a heterogeneous medium is transferred to that of an equivalent problem, on a homogeneous medium, which requires the solution of the so-called local problems on the periodic cell. The present investigation is about the effectiveness of the use of the finite element method to calculate the effective properties in piezoelectric materials. Two cases were analyzed in the first one was considered in a cubic cell (epoxy) embedded with a fiber of piezoelectric material (PZT-5), in the second case a hexagonal cell with the same fiber,, for both cases the results obtained were analyzed and discussed.

Keywords: The method of asymptotic homogenization, piezoelectric, effective properties

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SB3-P031
DESIGN,CHARACTERIZATION, AND COMPARISON OF THE TPU INSOLE PRINTED BY FDM VERSUS THERES IN-CARBON FIBER INSOLE PRINTED BY SLA: FOR APPLICATIONS IN THE TREATMENT OF PLANTAR FASCIITIS.

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Currently, additive manufacturing(AM) as a 3D manufacturing method is widely used due to the advantages it provides such as: complexity of designs, customization, and rapid prototyping, among others. Thus,this research uses AM for the design and manufacture of Thermoplastic Polyurethane (TPU) insoles using Fused Deposition Modeling (FDM) and Photopolymeric Resin Composite insoles reinforced with Carbon Fibers using Stereo lithography (SLA) for applications in the treatment of plantar fasciitis, which is characterized by localized pain in the antero-internal area of the calcaneus that can radiate to the inner edge of the foot. Similarly, the insole as the main component of footwear helps to reduce vertical and shear pressure on area sof the foot that are subjected to excessive load or effort. Using the Solid Works and Ntopology programs,

three types of structures were designed for printing the templates, namely: Octect Truss (OT), Iso Truss(IT) and Re Entrant (RE). Subsequently, these structures are printed using Creality Slicer for FDM and PreForm for SLA. The TPU was characterized by infrared spectroscopy, observing the characteristic vibrational modes of Polyurethane, such as the amino, aliphatic, and C-H groups located at 3314,2933, and 2852 cm^{-1}, respectively. Density was determined by Archimedes principle using an Explorer Ohaus balance, obtaining a value of 1.23± 0.01 g/cm^3 which agrees with the reported in the literature of 1.22 g/cm^3 [5]. In addition, a structural analysis of the printed TPU insoles was carried out using ANSYS 2019 R3 applying a force of approximately 750 N on the insole's surface. Also, the insoles were printed in Photopolymeric Resin reinforced with Carbon Fiber for their analysis and structural characterization.

Keywords: 3D printing, plantar fasciitis, insole

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SB3-P033
HOMOGENIZATION BASED COMPOSITE MATERIALS PROPERTIES ESTIMATION: AN APPROACH FOR DESIGN AND OPTIMIZATION

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Homogenization techniques have been receiving wide attention for decades in the academic community. Mathematically, an equivalent homogeneous medium is sought to describe the behavior of heterogeneous materials. For most of the cases, composite materials are described as homogeneous at the macroscopic level and heterogeneous at the microscopic level. Then, homogenization techniques offer a unique tool to connect microheterogeneities with macrohomogeneity to better understand the structure-properties relationship and make more efficient optimization and designs. Hence, the connection between homogenization and composite materials overall properties is analyzed. In the present work, we apply the asymptotic homogenization method (AHM) to estimate the effective properties of composite materials. A proposal to maximize the magnetoelectric coupling is reported. The effect of fiber spatial distribution on the final properties is also presented. A hybrid between AHM and Finite Element Method known as SAFEM is also presented to analyze polycrystalline materials that can be studied as composites ones.

Keywords: Homogenization, Effective properties, composite materials

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SB3-P034
EFFECTS OF THE TEMPERATURE, PRESSURE, AND TIME OF CURING OVER THE DEGREE OF CURING,

DENSITY, POROSITY, AND DIMENSIONAL STABILITY ON A [EL-322 RESIN SYSTEM/CARBON FIBRE/SIC PARTICLES] COMPOSITE MATERIAL.

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A good carbon-carbon composite material used for manufacturing rocket nozzles is hard to achieve since during the pyrolysisprocess the part tend to have either bending or crack defects which are directly related with the curing parameters (time, temperature, and pressure)of the pre-pyrolyzed material. The following project reports the results of a design of experiments in which different combinations of pressures, times, and temperatures impact over the degree of curing, the density, the porosity, and the dimensional stability of a composite material composed of resin systemEL-322, carbon fibre and SiC particles used for the manufacturing of carbon-carbon composites. Density and porosity characteristics of testspecimens were measured with the recommendations stated by standards ASTM D792,ASTM D2734 and ASTM D2584. Degree of curing has been measured using FTIR method with a “PerkinElmer frontier” machine, processing all the data in software“Spectrum” and “Spectragryph”. Dimensions of test specimens were measured usinga 3D scanner and software “Geomagic Control X”, measuring specially the straightnessof the specimens. Results show what the main impacts of each parameter the design of experiments: The increase of pressure duringcuring gives the composite materiathese characteristicss dimensional stability once is cured as well as a decrement on the porosity and the density; In terms of time, a longer curing process tend to give the test specimens a higherdimensional stability, but more important, an increment in the degree of curing; The temperature parameter has a considerable impact over the degree of curing and the density, making this characteristics to rise when the temperature does. The knowledge about how this composite material behaves when different curing parameters are applied, is essential to understand how to obtain a carbon-carbon composite material with minimum bending defects or fissures, non-desirable characteristics on a high stressed part like the rocket nozzle. This research will also decrease the time and resources spent during the manufacturing of a real scale part.

Keywords: Carbon-carbon composite material, Degree of curing, Curing parameters time, pressure, temperature

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SB3-P035
MICROMECHANICAL CHARACTERIZATION OF QUASI-PERIODIC MULTI-LAMINATED COSSERAT ELASTIC COMPOSITES

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Micromechanical models based on Solid Mechanics have been efficient tools for the theoretical study of multiphase composite materials. Their results contribute to materials characterization mechanisms, to define

structure-property relationships in new heterogeneous materials with specific geometric properties and conditions, and to the design and optimization of material manufacturing processes. On the other hand, restrictions to periodic geometric microstructures in composite materials imply strong limitations and are not frequent in engineering applications or in nature. A wide range of composite materials with practical applications has non-periodic, quasi-periodic, or even random structures. In this work, the effective moduli of elastic micropolar composites with quasi-periodic structures are found by the two-scale asymptotic homogenization method (AHM). Constituents are assumed centro-symmetric and isotropic materials and perfect contact conditions are considered at the interface. From AHM, the local problems over the representative cell Y and the corresponding non-null effective stiffness and torque properties are presented. Multi-laminated elastic Cosserat structures are studied considering periodic and quasi-periodic distributions of layers. The quasi-periodic arrangements follow the Fibonacci sequence. Numerical results are illustrated and discussed. The effect of the quasi-periodic laminated structure is noteworthy on the overall effective behavior of the micropolar elastic composite.

Keywords: Asymptotic homogenization method, Centro-symmetric Cosserat elastic composite, Quasi-periodic multi-laminated structures

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SB3-P036
TRIBOLOGICAL BEHAVIOR AND ACOUSTIC INSULATION OF GEOMATERIAL COMPOSITES BASED ON VOLCANIC, WOOD, AND SUGAR CANE ASH WITH EXPANDED POLYSTYRENE

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Geomaterials composites can be formed by the polycondensation of an amorphous solid aluminosilicate in an alkali medium through a geopolymerization process. Raw materials such as metakaolin, volcanic ash, alongside with alkali solutions are used in the synthesis of geopolymers. Besides, wood ash (WA) releases semi-volatile organic compounds that can be captured by living beings, in addition, they represent a source of pollution in air, water and earth. Sugarcane bagasse ash (SCBA) is a waste material generated sugar production industry as a result of incineration to feed the boilers. The pozzolanic nature of these waste materials (calcium, silicon and aluminum contents) allows the development of composites with low manufacturing cost. This work studies the feasibility to combine WA and SCBA with volcanic ash (VA), metakaolin (MK) and expanded polystyrene (PS) in the production of composites. The composites were obtained in different percentage ratios of waste materials with the addition of NaOH as an alkali activator. Tribological behavior (coefficient of friction and wear rate) and acoustic insulation were evaluated. Regarding the tribological results showed an increase in the coefficient of friction observed for all composites with PS added, due to PS may form interlocking pores in the matrix and the surface of the composites after dry process. The lower wear rate values were in the composites with VA contents compared to those containing MK. These results are consistent with the density of the materials. It is known that the wear rate of low-density material is lower compared to high-density materials. The acoustic insulation was higher in those compounds containing PS as well as those formed with amorphous materials (MK and CV crystallinity values 31.30% and 66.9% respectively (XRD).

Keywords: Composites, Volcanic Ash, Metakaolin

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SB3-P037
INDUCTION OF THE β-PHASE IN ISOTACTIC POLYPROPYLENE WITH PIMELIC ACID-MODIFIED GRAPHENE NANOPLATELETS

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In this study, graphene oxide nanoplatelets (GnPs) were oxidized to functionalize them with pimelic acid (PA) molecules. The presence of two characteristic bands assigned to C-H bonds of the aliphatic chains of pimelic acid (2939cm^{-1}and 2860cm^{-1}) confirmed this fact; additionally, the IR spectra show two vibration bands around 1575-1570 cm^{-1} and 1413-1410cm^{-1},which could be attributed to ionic bridging linkage between the oxygenated sites of the oGnPs and the organic molecules. The chemical modification was followed by XRD and RAMAN, where an increase in the D/G ratio would indicate alarge disorder in the structure due to the attachment of oxygen and pimelicacid in the first instance during functionalization. To demonstrate the nucleating ability of our nanofiller, we used percentages of 0.05, 0.5, and 1 wt% in an iPP matrix. DSC and WAXD were used to determine the relative percentages of the crystal in all samples, 72% and 75% for the oGnP0.05%-PA, respectively. DMA measurements were used to determine the effect of reinforcements on the visco-elastic characteristics of the iPP matrix. The results showed a 161.2% increase instorage modulus at -40°C and a 54.2% improvement in loss module for the composite with 1% w/w modified oGnPs.

Keywords: Polymer-matrix composite, Mechanical properties, Graphene nanoplatelets

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Zizumbo López, Arturo SB3-P013