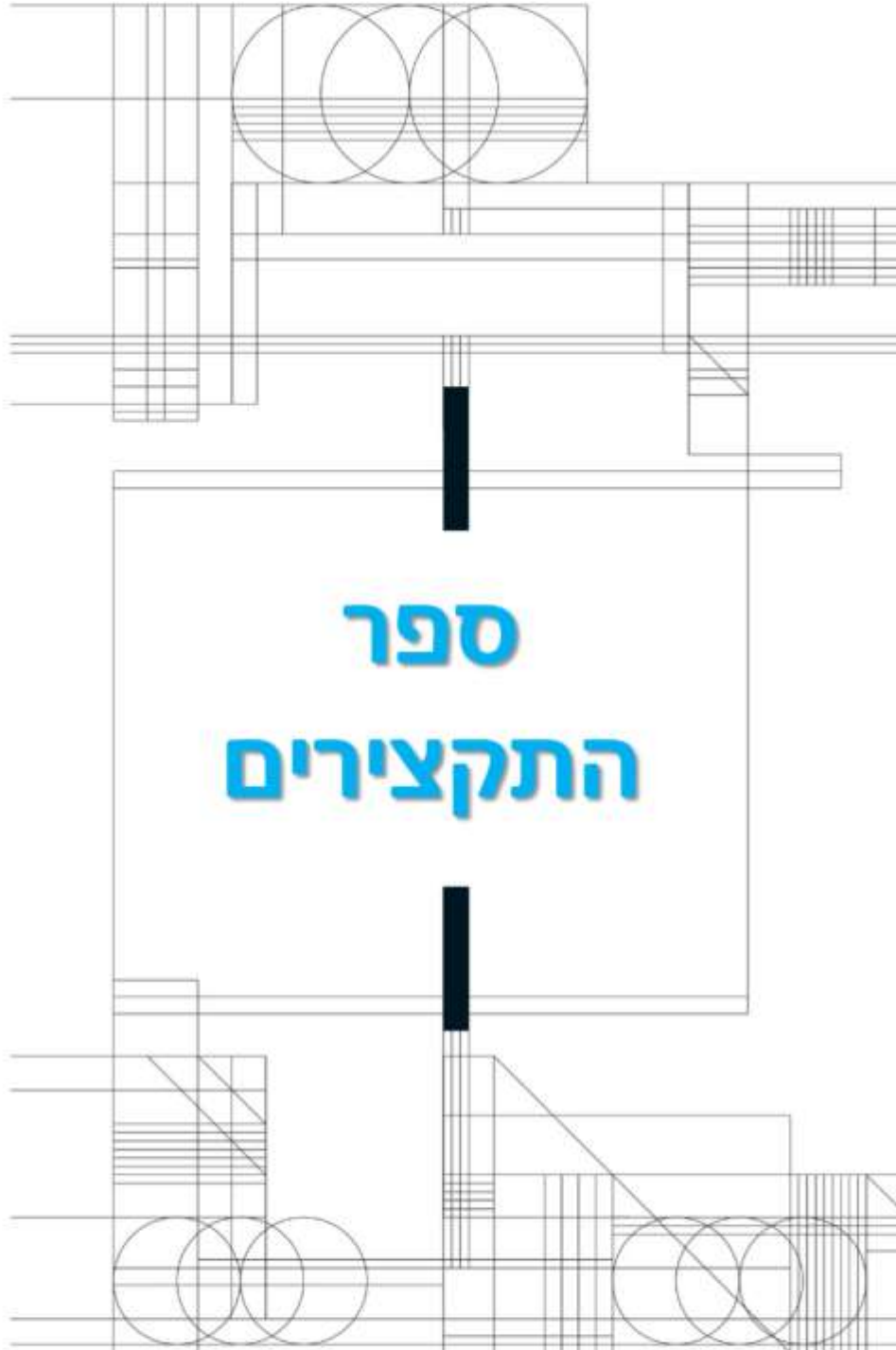


הצגת פרויקטי גמר בתואר ראשון
המחלקה למדע והנדסה של חומרים

יום חמישי, 29.10.2020, 16:00



אלה שמתאהבים בבעיה
הם אלה שממציאים לה פתרון

The Effect of POSS Type and Quantity on the Mechanical Properties of POSS-Epoxy Nanocomposites

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Abstract

In recent years Epoxy - Polyhedral Oligomeric Silsesquioxane (POSS) nanocomposites have gained great interest because of their unique properties; namely, they can obtain vastly different properties and meet a wide range of requirements.

The Epoxy-POSS adhesive contains Epoxy resin (EPON 826), hardner (Jeffamine D230), and various amounts of POSS. In previous studies, the effect of the amount of POSS on various physical properties was studied. In this project, two types of POSS were examined, Epoxy-based (EP-POSS) and amine-based (AM-POSS), and the effect of both the POSS type and quantity on the mechanical properties of the nanocomposites was tested.

Both types of POSS were examined in different concentrations (batches) and at two testing temperatures: 30°C and 130°C, the latter above the material's glass transition temperature (T_g).

First, the mixture of monomers was outgassed in vacuum at 70°C, poured into a mold and placed in an oven for 5 hours. Afterwards, the dimensions of each specimen were measured. Deviations larger than 1% in its thickness disqualified it. Finally, the specimens went through a three-point bending test to the point of failure. The fractured surfaces were characterized in a scanning electron microscope (SEM).

The results show that both types of POSS produced more brittle, and in some cases stronger, materials compared to pristine epoxy.

The effect of the EP-POSS concentration on the material's mechanical properties was of opposite trends at both temperatures. At 30°C, higher concentration caused a decrease in the material's strength. In contrast, at 130°C, high EP-POSS concentration produced a material with substantially higher stress at break values. The addition of AM-POSS, on the other hand, resulted in stronger material compared to pristine epoxy at both temperatures.

Fractography showed that the addition of both types of POSS resulted in a more brittle fracture.

It is thus concluded that both the quantity and POSS type have a significant effect on the mechanical properties of the nanocomposite.

Body Work and Chassis for Formula Racecar for Formula Students Competition

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Abstract

This project is carried out as part of a racing vehicle project for the Formula Students Competition of the Faculty of Engineering at Tel Aviv University. The project is divided into two parts: bodywork and a chassis. In the first part the goal is to design and manufacture bodywork for the race car, the outer part of the vehicle that attaches to the chassis. It is composed of two side parts, nosecone, upper and lower parts. The main demands are best strength-weight ratio and affordable costs. Alternatives for materials were examined such as various composites and aluminum 6061, as well as alternatives for production methods, considering key criteria such as weight, strength, cost, and production ability. Fiberglass and aluminum were dismissed due to excessive weight. The material chosen is carbon fiber in 5052 epoxy matrix. The manually soaked fabrics oriented in a $[0\pm45]_2S$ layout are placed in a vacuum bag for curing. The production includes preparation of molds for each part, aluminum molds for nosecone and side parts, and wood molds for the upper and lower parts. In the second part of this project, a new framework was designed, during which alternatives for its general design were examined, as well as materials for steel pipes and welding processes. Steels like chrome-molybdenum alloy and 0.45% Carbon alloy were reviewed considering material properties, cost, and manufacturing abilities. The design of space frame was chosen, made of high strength double phase steel Docol R8, welded by MIG with a mixture of CO₂ (80%) and Argon (20%) shielding gas.

This year, the project has encountered unexpected delays and cancellations, after the 2020 competition was postponed to 2021. Nonetheless, we continued planning, designing, and working on everything we could. Therefore, in the project I will describe the requirements, considerations, alternatives, and stages of work theoretically.

Aortic Valve Design from Natural Bio-composite Material for Replacement Procedures

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Abstract

Cardiac valve replacement surgeries have been performed since the 1960s. There are two main types of valves in the industry: mechanical valves, and bioprosthetic valves. Although they save the lives of thousands of people around the world every year, they have drawbacks: mechanical valve replacement causes a constant need for blood-thinning medications that may lead to bleeding complications, and bioprosthetic valve undergoes degeneration and fails after few years. The main goal of this project is to construct a new aortic valve made from natural bio-composite material: collagen fibers and alginate matrix, emphasizing the mechanical superiority properties.

During the project, we conducted depth research on the human aortic valve, its structural and mechanical properties. Samples with different orientations of fibers were produced and mechanically tested, in order to find the orientation that has similar mechanical properties to the native valve. Special frames that held the samples during the tests, without sliding, was designed.

The results show that the fiber fraction, the wetting, the continuity of the fibers, and the thickness of the samples are some of the factors that affect the mechanical properties, the UTS value, and the stress-strain curve obtained. It was found that the stress-strain curve of the 30 degrees orientation is the most similar to the curve obtained in the radial direction of native tissue.

This study shows that it is possible to produce aortic valve leaflets from the natural composite material made of collagen fibers and alginate. This material has many advantages in this use, due to its bio-compatibility and its hyperelastic mechanical behavior.

Development of Applicable Photopolymer Resin for 3D Printing of Stimuli Responsive Hydrogels

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Abstract

The following work presents the formation of multi stimuli responsive hydrogels using a 3D printer, using digital light processing printing method. An interesting and remarkable use of stimuli responsive hydrogels can be found in various biomedical applications such as drug release, gene delivery and tissue engineering. The advantage of using 3D printing for drug eluting devices is the ability to establish micrometric complex structures with high surface to volume ratio, leading to controlled drug release. During this research, few hydrogels were prepared based on the following polymers: poly(N-isopropylacrylamide), poly(acrylic acid) and poly(2-hydroxyethyl acrylate). It was attempted to receive good mechanical properties and good resolution by changing crosslinking density, adding additives, and changing the printing parameters. During the research it was found that in order to achieve good resolution for the printed object, it was necessary to add a UV absorbent material in order to absorb some of the UV light produced by the printer, enabling only the necessary pixels to be polymerized. After the improvement in the resolution, pH and temperature responsive hydrogels were formed with a complex structure and high surface to volume ratio. Different combinations of stimuli responsive polymers were printed in order to achieve multi responsive hydrogels that undergo physical or chemical changes in response to environmental stimuli such as temperature, pH, electric field and etc.

Thermally treated nanowire-structured stainless-steel as an attractive cathode material for lithium-ion batteries

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Abstract

This work will discuss and present a novel and promising 3D composite cathode architecture, based on $MnCr_2O_4$ spinel nanowires (NWs) suited for Lithium-Ion batteries. The synthesis of said cathodes is extremely simple and consists primarily of a single-step process, without any external reagents needed for the substrate – a weaved mesh of stainless steel (316L). The spinel NWs were grown on the substrate in a mixture of hydrogen and nitrogen gases containing oxygen traces, at various pressures under high temperature (1100°C). This method results in a three dimensional and highly crystalline spinel-based complex structure directly from the stainless-steel mesh, which can be used as a cathode without further processing, unlike commercial cathodes. Moreover, the product allows for NWs density control via pressure and time management. The resulting material exhibit high capacity ($> 230mAh/g$), for prolonged periods ($> 370cycles$) while maintaining high coulombic efficiency and high rate performance ($> 99\%$ and $> 2C$ respectively). This work also lists several major advantages over the commercially used two dimensional cathodes, especially in terms cost-effectiveness and the simplicity of the synthesis process.

Synthesis and Characterization of Light and Complex Single to Multi-layer Graphene Foam

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Abstract

Graphene has extraordinary properties and a unique structure that increased the interest in it and its possible applications. With a high theoretical surface area and high electrical conductivity, it can be very useful in energy-storage systems specifically supercapacitors as a current collector. To improve the graphene's performers, a thin film graphene foam (GF) with a high-density porous structure is needed. Our projects goal was to grow a monolayered up too few layered high-density GF by chemical vapor deposition (CVD). A Ni foam compressed with Cu powder was used as the metallic substrate with methane as the carbon feedstock. The substrate was first annealed and sintered at high temperatures, low vacuum, and hydrogen environment and afterwards the methane was introduced to the system to initiate the graphene growth process. After cooling, the samples were coated with polymethyl methacrylate (PMMA), etched by iron (III) chloride and wet transferred onto a silicon substrate. A PMMA coated high-density graphene foam was produced. The structure of the few-layered GF is gentle following the metal etching and volume loss which requires a strengthening coating such as the PMMA for it to preserve the structure. The Raman spectra of both the pre-etched and post-etched sample indicated on a few layered, non-uniform, high quality with low defects density graphene growth. In scanning electron microscopy images, the continuous high-density porous structure was observed with a range of pore sizes that are smaller than the original Ni foam pore size. Additional energy dispersive X-ray spectroscopy and sample mapping analysis confirmed the continuous graphene growth. A high-density with a limited number of layers GF is possible to produce in a CVD process by using a metal substrate with a combination of a low carbon solubility metal and a metal foam frame with large C solubility at the growth conditions.

Growing MoS₂ Layers Using Various Metal Seeds as Nucleation Sites

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Abstract

Being just one or few atoms thick, two dimensional (2D) materials are an ideal candidate for engineering a new class of electronic devices. 2D Transition metal dichalcogenides (TMDs) have attracted attention because of their diverse properties and natural abundance. One of the most researched TMD is the semiconductor Molybdenum disulfide (MoS₂). 2D MoS₂ has unique electrical and optical properties that can be applied in various devices such as transistors, photodetectors and sensors.

A large, uniform and highly crystalline MoS₂ monolayer is desirable for basic research and application purposes. The most prevalent method to synthesize 2D MoS₂ is chemical vapor deposition (CVD). During the CVD process sulfur and MoO₃ precursors are heated to their gaseous form and react to form MoS₂ on top of a substrate. In order to control the nucleation of MoS₂ the substrate is covered by seeding promoters. However, the CVD process is very sensitive to various experimental parameters, thus the control over the monolayer quality remains a challenge.

The goal of this study was to understand how different CVD process parameters and seeding promoters affect the growth of MoS₂ monolayer and to identify the optimal growth conditions and seeding promoter material. Here, the growth of MoS₂ monolayers was studied as a function of the seeding material, growth temperature, and time and the amount of the precursor (MoO₃). The grown material was characterized by various methods in order to analyze the coverage, number of layers, domain size and quality of the layers as a function of growth conditions. The results showed that the optimal growth parameters are 720°C, 7 minutes and 10mg of MoO₃.

In conclusion, this study represents an additional step towards optimizing the controlled growth of high quality MoS₂ monolayer and its use in practical applications.

Voids Control and Characterization in 3D Printed Chopped Fibers/ Thermoplastic Composite

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Abstract

Fused deposition modeling (FDM), one of the most popular additive manufacturing techniques (commonly known as 3D printing) of composite materials has been of great interest in recent years. Despite the benefits of this method, the quality of the resulted printed parts is limited due to internal defects, such as voids.

In this project, PLA/chopped carbon-fiber composite parts were manufactured by FDM. Two printing parameters, layer thickness and printing temperature, were modified and their effect on voids content was characterized by using advanced Non destructive testing (NDT) methods. X-ray computed tomography (CT) has been used to examine the voids volume fraction, the morphology, and distribution in 3D views. Density testing method based on Archimedes principles were also performed to study the influence of the parameters on the density, showing a correlation with the X-ray CT results. The elastic moduli of the composites were measured by using the Ultrasonic (dynamic) method to examine the sample mechanical performances as a function of the density and voids volume fraction. TGA and DSC tests were performed to inspect the changes in the sample fibers content and crystallization temperature due to changes in parameters.

The results showed that voids content increases with increasing the layer thickness, as well as with reducing the printing temperature. The density and elastic moduli decrease with increasing voids content, indicating the low quality of the part.

In conclusion, printing parameters such as layer thickness and printing temperature have a great influence on the printed part voids volume fraction. There is a strong inverse correlation between the number of voids in the sample and its mechanical performances. Therefore, choosing ideal printing parameters is critical. In the case of PLA/chopped carbon fibers, printing at the highest printing temperature possible and minimizing layer thickness are recommended.

Mechanical and Physical Properties of Novel Injectable Composite Hydrogel for Bone Regeneration

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Abstract

The purpose of bone regeneration is to repair and replace defects within bone tissue. Today, the gold standard for bone regeneration is autograft implantation. Alternative solutions, consisting of particulate bone graft (allograft, alloplastic materials, xenografts etc.) as fillers for the bone defects, are being developed. These alternatives face several challenges. Combination of bone graft with injectable hydrogel scaffold may overcome some obstacles. Still, the main challenge for load-bearing hydrogels is achieving high strength together with high biocompatibility. The general goal of this study was to develop and study a novel injectable composite hydrogel loaded with particulate bone graft, for the purpose of bone regeneration. The composite hydrogel Combines the benefits of bone particles with novel injectable bioadhesive polymer to create a scaffold with improved mechanical properties and biocompatibility compared to existing methods.

Methods: All the composites matrices are based on a Gelatin-Alginate bioadhesive hydrogel, crosslinked with a carbodiimide. Deproteinized bovine bone material (DBBM) particles, in two different size, served as fillers for the matrix. Mechanical and physical tests were conducted in order to characterize the novel composites.

Results: An increase in DBBM concentration significantly improved the compression and tensile strengths and moduli of the hydrogel structures. Increasing the particle size had only little positive effect on those mechanical properties. The conflicting effects controlling the trends are stress concentration (increased with decreased size) and composite homogeneity. The effect of the DBBM concentration on the physical properties (gelation time and swelling degree) is minor.

Conclusions: Our new composite hydrogel is based on degradable and biocompatible materials that encourage bone growth and has good adhesion to soft and hard tissue. Our results indicate high potential for improved bone regenerative. The understanding of the effects of DBBM concentration and particle size on the microstructure and the resulting mechanical properties is of high scientific significance.

A Method for Evaluation of Fracture Energy of Glasses

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Abstract

This study expands on H. Cohen's thesis work on the *development of a method for stable crack propagation in brittle crystals*, and presents the development of a new method to propagate a crack in non-crystalline (amorphous) materials, specifically glass, under pure Mode I. It aims to provide a low-cost and accessible approach to evaluate fracture energy, using relatively small specimens. The principal behind it is the thermal expansion mismatch between glass and aluminium. A rectangular piece of soda-lime glass served as the model material. A circular hole was drilled with a conical bit at the end of the specimen and a straight pre-crack was created via thermal shock. The pre-crack serves as a guideline to assure the crack propagates straight ahead. Thus, the energy release rate (ERR) is equal to the J-integral. An aluminium pin was slotted into the circular hole and slowly heated to cause it to expand and induce strains in the glass, initiating and propagating the crack. Observations hinted that it propagated in an unstable fashion, but further experimentation might prove or otherwise disprove this statement. The experiment was recorded in a high-resolution camera, to measure the crack length, as well as the pin's temperature using a thermocouple. The ERR was calculated by inputting the measurements to a finite element analysis model, assuming displacement control conditions, and is later compared to a theoretical value to validate the method. The obtained results are very promising; however, further refinements are needed to improve the method's validity.

Formation of Functional Coatings on Zn92Al8 Powder by Cementation and Electroless Plating

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Provisional patent: N. Eliaz, D. Svetlizky and H. Kazimierczak, Method for forming functional coatings, US provisional patent application 63/093,535, filed October 19, 2020.

Abstract

To date, only little has been reported on electroless deposition on zinc and its alloys. Due to the high electrochemical reactivity of zinc in aqueous solutions, it is challenging to obtain high-quality electroless coatings on zinc, particularly in the powder form. The latter has never been reported before. This study presents an innovative coating procedure on ZA-8 powder (Zn92Al8, wt.%) using cementation followed by electroless deposition. The study discusses the effect of the cementation and electroless bath process parameters on the coating quality. Several coatings with different chemistries were studied and optimized: nickel coating, cobalt coating, nickel coating on cobalt coating, and copper coating on cobalt coating. The coated powder, with a core-shell structure, was characterized by scanning electron microscopy coupled with energy dispersive X-ray spectroscopy as well as X-ray diffraction. The latter was done to identify the phases in the coated ZA-8 powder and compare them to those in the untreated ZA-8 powder, with the aid of TOPAS software. The oxide layer on either coated or untreated ZA-8 powder was identified as $\text{Al}(\text{OH})_3$ and Al_2O_3 , respectively. The average coating thickness was determined using image analysis on randomly selected SEM cross-section images. The success in obtaining high-quality cobalt (and other) coatings on metal powder for additive manufacturing (AM) may pave the way to AM of novel metal matrix composites and other exciting applications.

A Method to Semi Quantify Adhesion between Hydrogels and Silicone Rubber by Uniaxial Stretch

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Abstract

Studies of mechanical behaviors and properties of biological hydrogels are important in various developing fields, such as tissue engineering and biomechanics, due to their structural similarities to the extra-cellular matrix (ECM) and biological tissues. Stretching biological hydrogels in-vitro is a difficult task due to their soft and liquid-like consistency, making them incompatible for use in most conventional tensile systems. In this project, three different hydrogels, which include agarose, fibrin, and collagen were synthesized and uniaxially stretched using a method and device that was created in the lab. The method exploits the natural adhesive interactions that are formed between hydrogels and silicone rubber during the gelation process. The adhesion is then semi-quantified and qualitatively evaluated by conducting static and dynamic uniaxial tensile experiments, recording strain measurements of the stretched gels, and determining sustained adhesion. The fibrin and collagen had shown promising results, reaching maximal strain amplitudes of 71% and 83% respectively. The agarose, on the other hand, was ultimately found to be incompatible to stretch using this technique. The method described in this paper can be further enhanced and used in future research for a variety of purposes, such as observation of embedded cell response to mechanical loads, uniaxial stretching of soft polymers, introduction of complex strain gradients within the gel, and more.