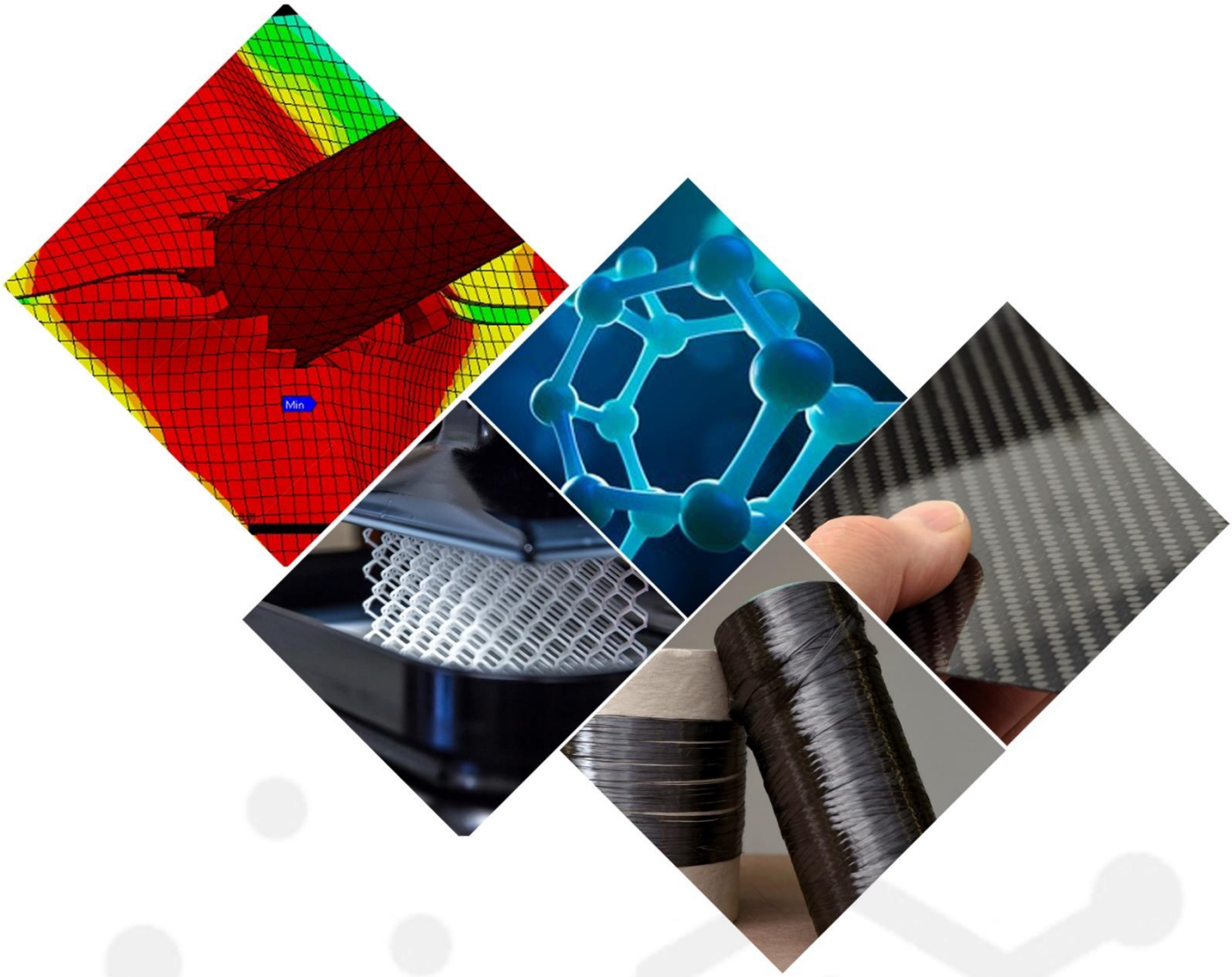

Conference Proceedings

1st International Conference on Polymers & Composites

7-8 December,2021 (ONLINE)

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National Textile University, Pakistan

ICPC

Main Organizer

Department of Materials, National Textile University Faisalabad

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Department of Polymer & Process Engineering
University of Engineering and Technology,
Lahore

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Fax: (+92) 41-9230098

Email: icpc@ntu.edu.pk, khubab@ntu.edu.pk

MESSAGE FROM THE CHAIRMAN OF CONFERENCE

It is my pleasure to welcome all the participants to the first International Conference on Polymers and Composites, organised by the Department of Materials, National Textile University, Faisalabad. I would like to thank the collaborators of this conference, University Teknologi Malaysia, University of Engineering and Technology-Lahore, Pakistan Aerospace Council, COMSATS University (Lahore Campus) and School of Chemical & Materials Engineering (SCME) – NUST.

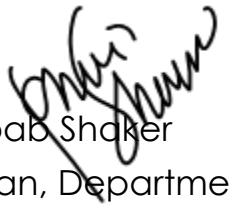
I would like to thank the distinguished speakers and poster presenters who participated in this conference to make the event successful. I hope that this event will surely help the participants to gain more wisdom and knowledge from the speakers.

Dr Yasir Nawab
Dean, School of Engineering and Technology
National Textile University, Faisalabad-Pakistan

FOREWORD FROM THE CONFERENCE SECRETARY

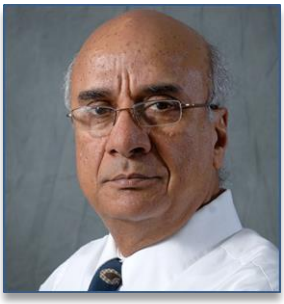
It is a pleasure for me to thank the speakers, organisers and participants of this event. The theme of this conference is "polymers and composites". The "polymers and composites" is a promising field finding application in every walk of life from disposable to the durable, and cheap to high value products. Various national and international speakers explored different domains of polymers and composites including polymer synthesis, 3d printing, hydrogels, aerogels, polymer systems, sandwich composites, advanced composites, nanocomposites, sustainable developments, functional materials, etc.

This conference also the first step towards the international recognition of our department, making it a world-class institute in the areas of polymers and composite materials. I am convinced that this event will serve as a platform for strengthening our relationships not only in knowledge sharing but also for joint research collaborations within the research community. It is my aspiration that this event will be a base for the growth of new ideas towards a better tomorrow.



Dr Khubab Shaker
Chairman, Department of Materials
National Textile University, Faisalabad-Pakistan

KEYNOTE SPEAKERS



Prof. Abdel-Fattah Seyam

North Carolina State University, USA

Prof. Mehmet Karahan

Uludag University, Bursa, Turkey

Prof. Xiaodong Wang

Beijing University of Chemical Technology, China

Prof. Mohd Sapuan Salit

Universiti Putra Malaysia

Dr. Arshad Mehmood

Archroma Pakistan

Prof. Manwar Hussain

Hanyang University, South Korea

Dr. Ahmad Ilyas Rushdan

Universiti Teknologi Malaysia

Dr. Muhammad Ali Nasir

UET, Taxila

KEYNOTE TALKS

Maximizing the performance of 3D printed fiber-reinforced composites

Prof. Abdel-Fattah M. Seyam, NC State University, USA

Experimental Investigation of Low Energy Impact Properties of 3-D Spacer Fabric Sandwich Composites

Prof. Mehmet Karahan, University of Uludag, Turkey

Pressure Sensitive Nanocomposites of MWCNT Coated Poly-methyl methacrylate dispersed Thermoplastic Polyurethane

Prof. Manwar Hussain, Hanyang University, South Korea.

Development and Characterization of Natural Fibre Reinforced Biopolymer Composites for Packaging Applications

Prof. S.M. Sapuan, Universiti Putra Malaysia, Malaysia

Flexible and Foldable Composite Films Based on Polyimide/Phosphorene Hybrid Aerogel and Phase Change Material for Infrared Stealth and Thermal Camouflage

Prof. Xiaodong Wang, Beijing University of Chemical Technology, China

Unsaturated Polyester Resin – Pakistan Market dynamics & growth opportunities

Dr. Arshad Mehmood, Archroma Pakistan Ltd.

Development and characterization of multi-network hydrogels for building cooling applications

Prof. Muhammad Ali Nasir, University of Engineering and Technology, Taxila-Pakistan

Nanocellulose as reinforcement in polymer nanocomposites

Dr. R.A. Ilyas, Universiti Teknologi Malaysia, Malaysia

MAXIMIZING THE PERFORMANCE OF 3D PRINTED FIBER-REINFORCED COMPOSITES

Abdel-Fattah M. Seyam, S M Fijul Kabir, and Kavita Mathur

Wilson College of Textiles, North Carolina State University, Raleigh, NC, USA, 27965

The ability of 3D printing (3DP) technology has recently established itself in the scene of fiber-reinforced composites. As an additive formation technique, its ability to form complex/intricate shapes provides numerous opportunities to manufacture net shape parts, without the need for machining. However, 3DP technology for high-performance applications such as aerospace, automotive, marine, building structures, defense, wind turbine blades, and leisure. However, several research gaps have been identified that need to be addressed to advance 3DP technology to compete with 3D woven fiber-reinforced formation technologies. One of these gaps is that 3DP fiber-reinforced composite structures suffer from low fiber content compared to the traditional composite such as 3D orthogonal woven preforms solidified with Vacuum Assisted Resin Transfer Molding (VARTM) that impedes their high-performance applications. The present research included fabrication of 3DP fiberglass reinforced Nylon composites with maximum possible fiber content dictated by the current 3D printing technology at varying fiber orientations, including 0/0, 0/90, ±45 and 0/45/90/-45 and characterizing their microstructural and performance properties such as tensile and impact resistance (Drop-weight, Izod and Charpy). Results indicated that fiber orientation with maximum fiber content has a tremendous effect on the improvement of the performance of the 3DP composites even though they inherently contain structural defects in terms of voids. Benchmarking the results with VARTM 3D orthogonal woven (3DOW) composites revealed that 3DP composites had slightly lower tensile strength due to poor matrix infusion between adjacent fiber layers/raster and delamination due to lack of through-thickness reinforcement, but excellent impact strength (224% more strong) due to favorable effect of structural voids and having laminated structure developed in layer-by-layer fashion.

Keywords: Fiber volume fraction, 3D printing, fiber-reinforced composites, fiber orientations, tensile properties, impact resistance, failure mechanism

EXPERIMENTAL INVESTIGATION OF LOW ENERGY IMPACT PROPERTIES OF 3-D SPACER FABRIC SANDWICH COMPOSITES

Mehmet Karahan and Nevin Karahan

University of Uludag Vocational School of Technical Sciences, Gorukle Bursa TURKEY

In this paper, the low-velocity impact characteristics and impact damage of sandwich composites, produced at four different core thicknesses from 3D integrated sandwich fabrics, with and without foam filling, have been examined. The 3D sandwich fabrics have been produced using the same yarn and weaving densities. Thus, the impact characteristics are only affected by the core thickness and whether foam filling is used or not. Low-velocity impact tests have been conducted at 32 and 48 J energy levels. The impact behavior has been determined as a function of the peak load, the energy to peak load, the time to peak load and the absorbed energy. The impact damage and the change in the compressive strength after impact have been analyzed. The findings obtained indicate that core-skin delamination on 3D sandwich composites has been fully prevented. Impact tests carried out on integrated 3D sandwich structures have shown that impact damage is limited to the vicinity of the point of impact and does not affect the integrity of the structure. This indicates that such damage can be easily repaired, and the service life of the product can be sustained.

The low-speed impact behavior of 3D integrated woven sandwich composites has been evaluated and following conclusions are drawn:

- By means of foam filling in the core sections of 3D integrated sandwich composites, the pile yarns are supported by the foam in the core section. This results in a significant increase in core resistance and structural integrity improvement. Foam filling also constitutes additional damping properties.
- Since the core resistance of the unfoamed samples is low, impact initially causes shearing in the core and pile buckling damage. As the core thickness increases, the core resistance decreases. This prevents the skin performance to be put into use. As the core thickness increases, the peak load values decrease with decreasing core resistance.
- Since foam filling increases the core resistance, both the top skins and cores have been perforated in foam-filled panels. The peak load is in line with the impact resistance of the top skin.
- The peak load values obtained from foam-filled samples where full perforation has taken place slightly differ from each other. This shows that the top skin resistance changes with the core thickness. Peak load values in foam-filled samples are related to skin rigidity.
- The highest peak load values have been obtained from the sandwich composites of 15 mm core thickness.

- The amount of absorbed energy decreases with increasing core thickness for unfilled samples because the decreasing core resistance increases core shear deformations.
- Foam-filled samples absorb more energy than unfoamed samples.
- In foam-filled samples, the amount of absorbed energy does not decrease with increasing core thickness. This is explained by the fact that the damage occurs as perforation of the top skin which is the same for all samples.
- The compression strength after impact (CAI) of the unfoamed samples drops 10-15% at 32J, and17-27% at 48 J impact energy. For the foam-filled samples, a decrease of 18-25% at 32 J and 26-37% at 48 J impact energy was found.
- The tests conducted on integrated 3D structures have manifested that impact damage is restricted to the point of impact and barely affects the integrity of the structure. This indicates that the products can be easily repaired, and their service life can be sustained.

Key Words: 3D integrated sandwich, low-velocity impact, damage tolerance.

PRESSURE SENSITIVE NANOCOMPOSITES OF MWCNT COATED POLY-METHYL METHACRYLATE DISPERSED THERMOPLASTIC POLYURETHANE

Manwar Hussain

Hanyang University, Erica campus, Department of Materials science, and Chemical Engineering, South Korea.

We have Synthesized thermoplastic polyurethane (TPU) based pressure sensitive nanocomposites via melt mixing method. Poly-methyl methacrylate (PMMA) micro beads with different sizes were first coated with multi-walled carbon nanotube MWCNT and then introduced in TPU matrix for achieving early percolation threshold. The pressure sensitivity results confirmed a decrease in resistance with the increase in pressure. The nanocomposite with 10 µm PMMA beads had shown linear pressure sensitivity response with the increasing pressure and showed a higher strain gauge factor (3.15) as compared to other nanocomposites which makes it suitable for the pressure sensing applications.

Key Words: nanocomposites, pressure, gauge factor, carbon nanotube.

DEVELOPMENT AND CHARACTERIZATION OF NATURAL FIBRE REINFORCED BIOPOLYMER COMPOSITES FOR PACKAGING APPLICATIONS

S.M. Sapuan[1,2]

[1] Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[2] Laboratory of Bio composite Technology Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

Petroleum-based plastics are among the main materials used in the packaging industry, which have been raising global environmental issues for decades. The rise of environmental-hazardous plastic waste has stimulated the development of natural-based, renewable, and biodegradable materials. Environmental sustainability and no damaging carbon emissions during processing, as well as after destruction, are desirable characteristics of possible materials. Besides, the widespread acceptance of natural fibers and biopolymers as green materials is driven by the rapid depletion of petroleum resources, as well as growing awareness of global environmental problems linked with the usage of conventional plastics. Also, the increase in prices of petrochemicals and environmental effects now push up material development made from natural polymeric materials for various applications in food-packaging materials, which are more consumer-friendly. This study looks deeply into food-packaging materials made from biopolymers. Scientists and industry have been attracted to natural fibers, biopolymers and their composites because of their environmentally friendly and sustainable properties. Moreover, natural fibers demonstrated several other advantages, such as comparable specific tensile properties, fewer health hazards, acceptable insulating properties, low density, and less energy consumption during processing, compared to synthetic fibers. Starch is one of the most widely available biopolymers for packaging applications as well as a potential alternative to non-biodegradable plastics as it is affordable, widely available, biodegradable, and renewable. From the manufacturing, distribution, storage, and consumption phase of any product, packaging materials play vital roles. They are designed to be able to safeguard, contain, and handle products for onward distribution either as raw materials or ready-to-eat food products. However, current food-packaging innovations are moving toward the use of materials with light in order to achieve the reduction of high raw materials, low transportation costs, reduced waste, and wide areas for storage. This study reveals the huge potential of starch and natural fibers for the food packaging industry.

Key Words: packaging industry, environmental issues, biodegradable, sustainability, renewable

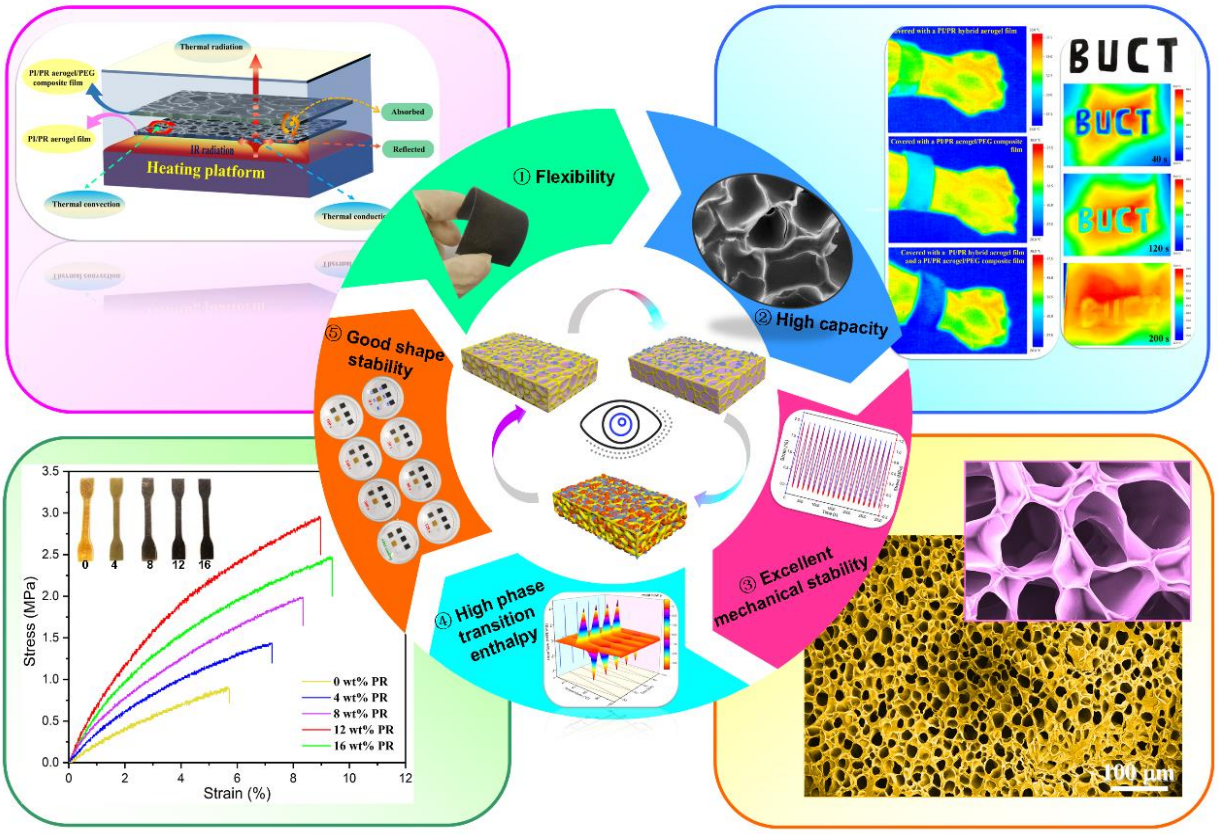
FLEXIBLE AND FOLDABLE COMPOSITE FILMS BASED ON POLYIMIDE/PHOSPHORENE HYBRID AEROGEL AND PHASE CHANGE MATERIAL FOR INFRARED STEALTH AND THERMAL CAMOUFLAGE

Tao Shi, Zhiheng Zheng, Huan Liu, Dezhen Wu, Xiaodong Wang*

State Key Laboratory of Organic-Inorganic Composites, Beijing University of Chemical Technology, Beijing 100029, China

*Presenting Author E-mail: (wangxdfox@aliyun.com)

Infrared stealth technology plays a vital role in the development of the defense industry and new military equipment. The current study focused on a novel type of flexible and foldable composite films based on polyimide (PI)/phosphorene (PR) hybrid aerogel and phase change material (PCM) for infrared stealth and thermal camouflage applications. The composite films were successfully obtained by fabricating a PI/PR hybrid aerogel through pre-polymerization, film casting, freeze-drying, and thermal iridization, followed by vacuum impregnation of polyethylene glycol (PEG) as a PCM into the aerogel framework. The combination of PI and PR nanoflakes endows the hybrid aerogel with an effective enhancement in mechanical properties, near-infrared absorption, and infrared photothermal conservation. The resultant composite films not only present prominent tensile and fatigue-resistant performance but also exhibit a good thermal regulation capability with a high latent-heat capacity of over 150 J/g. More importantly, the composite films demonstrate good infrared stealth and thermal camouflage performance on the high-temperature targets through effective thermal buffer and thermal insulation. With ultra-lightweight, flexible, foldable, shape-tunable, and thermal self-regulatory characteristics, the PI/PR aerogel/PEG composite films developed by this work exhibit great application potential in infrared stealth and thermal camouflage for new military equipment.



Keywords: military equipment, infrared stealth, fabricating, composites

UNSATURATED POLYESTER RESIN – PAKISTAN MARKET DYNAMICS & GROWTH OPPORTUNITIES

Arshad Mehmood

Head of Business Development/Product Stewardship, Archroma Pakistan Ltd.

The market of unsaturated polyester resins (UPR) has expanded rapidly; the dominant applications are still in conjunction with glass-fiber reinforcement to form laminar composites, generically known as fiber-glass-reinforced plastic (FRP) or glass-fiber-reinforced plastic (GRP). Several desirable properties of UPR, make it an ideal matrix material for multifunctional composites. The ever-increasing need for better performance across all modern applications is driving the demand for UPRs. One of the most significant drivers impacting the growth of the UPRs market is the growth of end-use industries. In Pakistan, an overwhelming rise, in both, the demand and supply curves of UPR is being observed. For the same reasons, there is a substantial demand from end-user industries in the country.

Keywords: UP resin, composites, growth opportunities, Pakistan

DEVELOPMENT AND CHARACTERIZATION OF MULTI-NETWORK HYDROGELS FOR BUILDING COOLING APPLICATIONS

MUHAMMAD ALI NASIR

University of Engineering and Technology, Taxila-Pakistan

Perspiring thermal responsive polymeric hydrogels are a flashpoint these days in the passive cooling aspect. Also, they have been widely studied in the past for various applications such as self-healing materials, highly porous and stretchable materials, nanocomposite gels, smart sensors, and drug delivery systems. We have synthesized single network and multi-network hydrogels using acrylamide, acrylic acid, and alginate. Nano reinforcements have also been added which increased the mechanical strength up to 300%. These multinetwork hydrogels demonstrated brilliant cooling performance by providing a temperature difference of 8-12^{o}C above and below the roof of the house for more than 7 hours with a single charge of hydration. Tough hydrogels were also tested under direct sunlight during the summer season of Pakistan where a 10-20^{o}C temperature difference was reported. Two model houses with different materials (brick and cedarwood) were used to make a comparison demonstrating the cooling impact. Thermographs and FTIR spectra showed that the ionic and covalent networks in the multinetwork hydrogel were responsible for the excellent robustness. Due to this, the multinetwork hydrogel gave better strength and cooling effectiveness for a longer period than single network hydrogels. It is certainly conceivable to control the carbon emission and electricity consumption if a building with a roof area of 100m^2 is covered with multinetwork hydrogels. The micrographs and SEM images showed the complex networks formed inside multinetwork hydrogels which were responsible for a higher swelling ratio. The findings collected here indicate that these hydrogels' sweating behavior can be an excellent option for passive cooling of buildings.

Keywords: materials, network, building, nanocomposite, reinforcements

NANOCELLULOSE AS REINFORCEMENT IN POLYMER NANOCOMPOSITES

R.A. Ilyas

[1] School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

[2] Centre for Advanced Composite Materials (CACM), Universiti Teknologi Malaysia, UTM Johor Bahru 81310, UTM Johor, Malaysia

Presenting Author E-mail: (ahmadilyas@utm.my)

Nanocellulose (NC), has been proven to be one of the most prominent green materials of modern times. Nanocellulose exists in a number of forms, including nano-fibrillated cellulose (NFC), nanocrystalline cellulose (NCC) or cellulose nanocrystals (CNCs), and bacterial cellulose (BC). This renewable nanofiber has been used in wide range of applications from flexible packaging to advanced bio-scaffolds for tissue regeneration. It is due to its outstanding properties such as excellent mechanical properties, high thermal resistance, good optical properties, high aspect ratio with anisotropic shape, good biocompatibility, high crystallinity, large specific surface area, abundant surface hydroxyl groups for modification, and tailorable surface chemistry. Currently, nanocellulose is widely used to reinforce biopolymer to improve the mechanical and barrier properties of polymer. In this presentation, Author will explain the outline of current development in this particular field, including the isolation, characterization, behavior, and various applications of nanocellulose reinforced biopolymer nanocomposites. Besides that, we hope to impart the audience with some of the excitement that currently surrounds nanocellulose research, which ascends from the renewable source nature of the particles, their fascinating, morphological, mechanical, chemical and physical properties, and a variety of applications that can be developed from these nanomaterials.

Keywords: nanocellulose, nano-fibrillated cellulose, nanocrystalline cellulose, bacterial cellulose

ORAL PRESENTATIONS

INVESTIGATING THE IMPACT OF OZONE CONCENTRATION AND HUMIDITY LEVEL ON CARBON/EPOXY COMPOSITES AGEING

Fatmagül DEDE[1], Mehmet KARAHAN[2] Emre ORUÇ[1], Mazyar AHRARI[3]

[1] Bursa Uludag University, Graduate School of Natural and Applied Science, Mechanical Engineering Department, Gorukle Campus, 16059, Nilufer/Bursa, Turkey

[2] Bursa Uludag University, Vocational School of Techical Science, Gorukle Campus, 16059, Nilufer/Bursa, Turkey

[3] Bursa Uludag University, Graduate School of Natural and Applied Science, Textile Engineering Department, Gorukle Campus, 16059, Nilufer/Bursa, Turkey

Presenting Author E-mail: (532010007@ogr.uludag.edu.tr)

One of the factors affecting the properties of polymer-based composite materials according to the ambient conditions in which they are applied is ozone. This study was aimed to examine the impact of different ozone concentrations on a carbon-epoxy composite at the various predetermined time and humidity levels. The samples were divided into 2 groups. The 1st group was left intact and considered as a control group. The second group is further divided into 3 distinct subgroups. Ozone-time graphs were obtained by applying ozone to the 2nd group at 1%, 3%, 5%, and 65% humidity at 3 different levels. In the light of the information, we obtained from here, it has been observed in which direction and how fast the aging curve will follow if we increase the ozone concentration at 65% humidity and shorten the time. Keeping ozone and time parameters remain the same, the previous process was applied for 70% and 80% humidity. The data we obtained from here helped about the extent to which the amount of moisture damages the composite material under certain ozone concentrations. Charpy, Drop Weight, acoustic emission, and NDT (non-destructive testing) analyzes of 2 groups of carbon-epoxy composite parts produced by the vacuum infusion method were fulfilled. The damage caused by ozone in composite material at different humidity levels during aging was inspected comparatively.

Keywords: Ageing, polymer-based composite materials, carbon/epoxy composite, ozone, humidity

INVESTIGATION OF SURFACE PROPERTIES OF CARBON FIBER THERMOPLASTIC COMPOSITES PRODUCED BY HOT PRESSING METHOD

Mehmet KOPAR[1], Mehmet KARAHAN[2], Mazyar AHRARI[3]

[1] Bursa Uludag University, Graduate School of Natural and Applied Science, Automotive Engineering Department, Gorukle Campus, 16059, Nilufer/Bursa, Turkey

[2] Bursa Uludag University, Vocational School of Technical Science, Gorukle Campus, 16059, Nilufer/Bursa, Turkey

[3] Bursa Uludag University, Graduate School of Natural and Applied Science, Textile Engineering Department, Gorukle Campus, 16059, Nilufer/Bursa, Turkey

Presenting Author E-mail: (512025007@ogr.uludag.edu.tr)

Composite materials are generally known as novel materials formed by combining two or more materials. Composite materials are applied in many areas such as the automotive, aviation, and space industries. Many reinforcement elements are used in the preparation of composite materials. Natural (cotton, silk, wicker, sisal) and synthetic fibers (glass fiber fibers, carbon fibers, polyester, polypropylene) could be mentioned as reinforcement elements. In this study, carbon fiber reinforced polypropylene woven fabrics were cut into 13, 40*40 cm pieces and placed on top of each other. Composite plates were produced by the heat pressing method. The first step is 300 sec. under 50 bar pressure, the second step is 300 sec. at 100 bar pressure, and the third step is 120 sec at 120 bar pressure. Immediately after the hot-pressing process, the composite sheet production was completed by cooling the material under 100 bar pressure until it dropped to 20°C. The microstructure and surface morphology of the composite material was investigated by scanning electron microscope (SEM) and stereo microscope. Considering the results of stereo microscopy, ruptures were noticed in some areas. In the case of SEM micrographs, it was observed that the carbon fiber was homogeneously distributed throughout the polypropylene matrix. Cracks were identified between the layers and breaks were noticed in some regions of carbon fiber. The results of SEM and stereo microscopy support one another.

Keywords: Composite material, carbon fiber-reinforced, thermoplastic, hot pressing method, polypropylene, surface morphology

ELECTROTHERMAL JUTE FIBER REINFORCED GREEN COMPOSITES

Azam Ali[1], Mohanapriya Venkataraman[1], Muhammad Murad[2], Tao Yang[3], Blanka Tomkova[1], Jiri Militky[1]

[1] Department of Material Sciences, Technical University of Liberec, Czech Republic

[2] Centre for Agriculture, biochemistry and biotechnology, University of Agriculture, Faisalabad

[3] Institute for Nanomaterials, Advanced Technologies and Innovation, Technical University of Liberec

Presenting Author E-mail: (azam.ali@tul.cz)

The current study is focused on the development of electrically and thermally conductive green composites filled with jute/carbon systems. The carbon particles were refined to the scale of micro/nanoparticles using ball milling and morphological properties were studied by Malvern zeta sizer and SEM. The influence of different concentrations of carbon particles in green epoxy resin for electrical and thermal conductivity was studied. The thermal conductivity was measured by Alambeta measuring device. Moreover, the heat generating response of all the developed samples was also analyzed by the Joule heating behavior. Additionally, the electromagnetic shielding ability of conductive composites were analyzed by using the Waveguide method at high frequency (i.e., at 2.45 GHz). The composites with higher carbon filler concentration showed maximum electrical conductivity (1.4E-02), shielding effectiveness 24 dB and mechanical properties.

Keywords: Electrical conductivity, EMI Shielding, Green composites, Joule heating

ELECTRICALLY CONDUCTIVE SUSTAINABLE GREEN COMPOSITES

Asif Ali[1], Hafiz Taimoor Ahmed Awan[2], Ammad Aslam[3], Azam Ali[4], Sundaramoorthy Palaniamy[4], Dana kmarkova[4]

[1] Department of Electrical Engineering, Information Technology University, Lahore, Pakistan

[2] Faculty of Engineering Sciences, GIK Institute of Engineering Sciences and Technology, KPK, Pakistan

[3] Department of Physics, University of Lahore, Pakistan

[4] Department of Materials Engineering, Technical University of Liberec, Czech Republic

Presenting Author E-mail: (asif.ali@itu.edu.pk)

The present work focusses on the development of sustainable green conductive composites based on recycled materials. The cotton waste and green resin were selected to make the composites, thus addressing environmental issues related to biodegradability and recycling. Additionally, different concentrations of carbon particles were added to impart the conductive properties in composites. At first surface morphology was analyzed by SEM analyses. The prepared samples of composites were then characterized for the electrical conductivity, EMI shielding and mechanical performance. The conductive paste having 12% carbon particles showed better results as compared to the others.

Keywords: Electrical conductivity, EMI Shielding, Green composites, Carbon fillers

THERMO-OXIDATIVE EXFOLIATION OF CARBON BLACK FROM GROUND TIRE RUBBER AS POTENTIAL REINFORCEMENT IN GREEN TIRES

Adeel Ahmad Hassan

Department of Polymer Science and Engineering, Shanghai Key Lab. of Electrical Insulation and Thermal Aging, Shanghai Jiao Tong University, Shanghai 200240, China

Polymer recycling and biodegradable polymeric materials are two major routes towards sustainable development of the polymer industry. However, the three-dimensional crosslinking network of waste tire rubber greatly prevents it from green recycling. At the same time, owing to the finiteness, impact on human health, and environmental impacts of fossil oil, efforts are switched to search and develop renewable, sustainable, and eco-friendly alternatives of commercial plasticizers, such as bio plasticizers. In this regard, an eco-friendlier approach is presented wherein high reclaiming degree (66%-sol content) of ground tire rubber (GTR) was achieved by low-temperature air oxidation under swollen action of soybean oil. Low-temperature oxidation limits energy consumption and volatilization of harmful products. Hereafter, the soybean oil derived polymeric materials from ground tire rubber through free-radical chain reactions, are explored as reactive plasticizers. To select an ideal application of reactive plasticizer, investigated for chemical structure, thermal stability, composition, and morphology. Exfoliated rubber was incorporated within tire rubber composites as a reinforcing material due to the core-shell structured CB, which was observed with increased effects to on the rubber composites.

Keywords: green recycling; tire rubber; reclaiming; soybean oil; reactive plasticizer

PROCESS - PROPERTY RELATIONSHIP OF POLYLACTIC ACID NANOCOMPOSITES: APPLICATION AS ANTIMICROBIAL AGENT

Aliya Fazal

Department of Chemistry Fatima Jinnah Women University Rawalpindi Pakistan.

Presenting Author E-mail: (aliyafazal@fjwu.edu.pk)

This study presents the potential effects of reaction parameters on the synthesis of biopolymer Polylactic acid (PLA) and its nanocomposites. Metal oxide nanoparticles (NPs) of cobalt, zinc, copper and nickel are synthesized by biogenic and co-precipitation method. NPs are used as nanofiller for composites. The effect of polymerization reaction time and quantity of NPs for composites is explored to identify product performance. In addition, photo degradation behavior of pristine polymer and its nanocomposites is also considered. The structure, functional groups and morphologies of PLA and PLA-nanocomposites is investigated by Fourier transform infrared (FTIR), X-ray diffraction (XRD), Scanning Electron Microscopy with Energy Dispersive X-Ray Analysis (SEM-EDX), Ultraviolet–visible absorption (UV-vis), Diffuse reflectance spectroscopy (DRS), and Thermo gravimetric analysis (TGA). Based on SEM analyses, it is found that progressive increase of reflux time facilitate the monomer to polymerize with more refinement within its helical chains at particular temperature. By tuning the reaction time minor improvement in carbon and oxygen content of polymeric matrix is noted from EDX.FTIR peaks suggest polymerization of monomer (lactic acid) and active contribution of carbonyl group in metal oxide attachment. XRD peaks for nanocomposites are noticed at lower 2θ position as compared to the pure PLA. The nanoparticles are found homogeneously dispersed in the PLA-matrix with a low degree of agglomeration, as seen by SEM. Three stages of weight loss are figured out from TGA curves of PLA, ZnO NPs, and PLA-ZnO nanocomposite. Thermal degradation of PLA-ZnO nanocomposite from 100-800°C is found occurring at higher temperatures than pristine PLA. TD50 of PLA is occurring at 248 °C while for PLA-ZnO nanocomposite at 287 °C. Band gapes calculated for PLA samples having 10 h and 20 h reflux time was 5 eV and 1 eV respectively revealing decreasing trend with increasing reaction time. Photocatalytic degradation of PLA nanocomposites was higher than native PLA, almost 80% degradation was noted within 120 minutes. Promising antifungal and anti-bacterial activities of PLA and its nanocomposites suggest them an eco-friendly candidate to be designed as functionalized textiles.

Key words: Biopolymer; nanoparticles; nanocomposites; photocatalytic degradation; antimicrobial agent

SYNTHESIS OF THIENO [3, 2-B] THIOPHENE (TT)-BASED COPOLYMERS FOR ORGANIC FIELD EFFECT TRANSISTERS

Bibi Amna[1,2], Sheida Faraji[2], Recep Isci[2], Mehmet S. Eroglu[3,4], Humaira M. Siddiqi[1], Turan Ozturk[2,4]

[1] Department of Chemistry, Quaid-i-Azam University, Islamabad 45320, Pakistan

[2] Istanbul Technical University, Department of Chemistry, 34469 Maslak, Istanbul, Turkey.

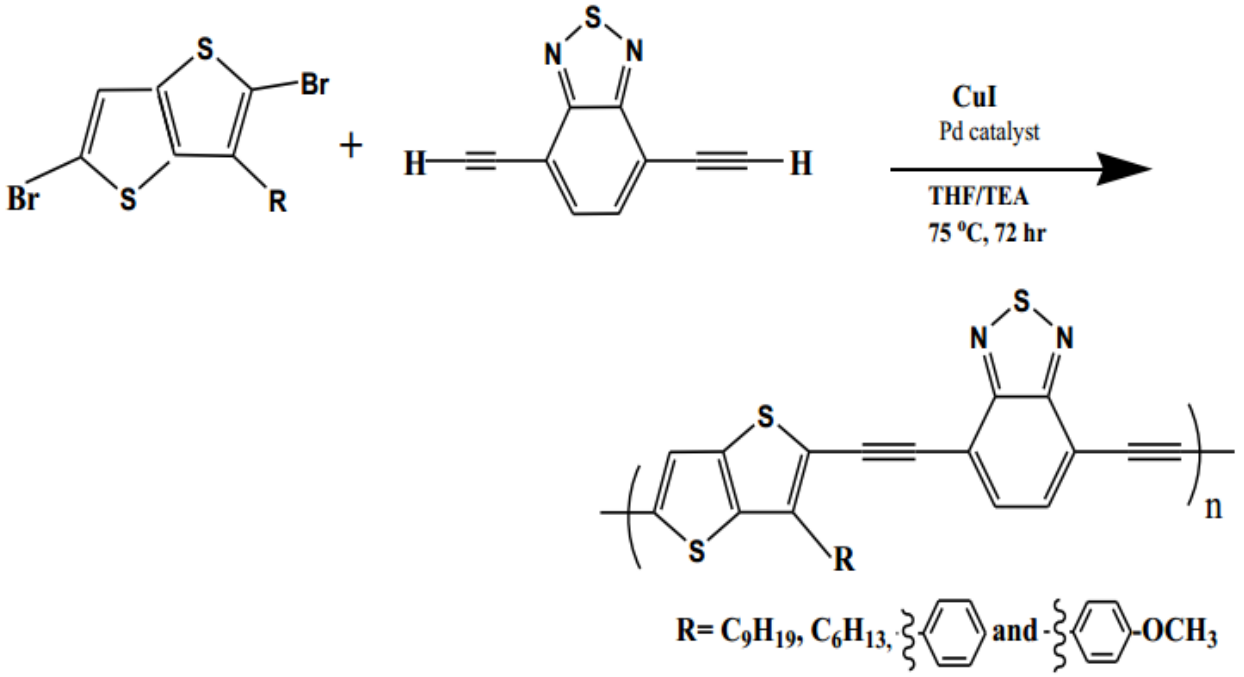
[3] Department of Chemical Engineering, Marmara University, 34722, Kadikoy, Istanbul, Turkey

[4] TUBITAK-UME, Chemistry Group of Laboratories, PO Box 54, Gebze, Kocaeli 41471, Turkey.

Presenting Author E-mail: (bibiamnahussain@gmail.com)

Corresponding Author E-mail: (humairas@qau.edu.pk; ozturktur@itu.edu.tr)

A series of New co-polymers containing thieno [3, 2-b] thiophenes (TTs) as donor units and 2,1,3-Benzothiadiazole (BTD) as acceptor units were synthesized using palladium-catalyzed Sonogashira coupling polymerization. The optical and electrochemical properties of these conjugated polymers were investigated using UV-Visible, fluorescence, and cyclic voltammetry. The thermal properties of these polymers were examined via thermogravimetric analysis and differential scanning calorimetry. These polymers were used as organic semiconductors in bottom-gate, top-contact (BGTC) organic field effect transistors. The transistor characterization was performed under ambient conditions. Four OFETs were constructed with polymers bearing TT units with different substitutions. All devices showed p-channel current-voltage behavior and successfully operated below -3 V with the highest charge carrier mobility of 0.1 cm^2/VS obtained on OFETs using thienothiophene-based OSC with C_9H_{19} side chain.



Keywords: Thieno [3, 2-b] thiophenes, Conjugated polymers, Sonogashira coupling, Hole mobility, Solution processing, Field effect transistor.

REINFORCEMENT OF POLYANILINE COATED GRAPHENE PARTICLES IN POLYMER-BASED NANOCOMPOSITES FOR EMI SHIELDING

Khadija Zubair, HM Fayzan Shakir

Department of Materials, School of Engineering and Technology, National Textile University, Faisalabad, Pakistan.

Presenting Author E-mail: (Khadijazubair65@gmail.com)

Thermally reduced graphene oxide (TRGO) was coated with polyaniline (PANI) and used as a reinforcement in PVC matrix. TRGO was first prepared buy modified hummer's method and then PANI is coated on it by in-situ polymerization of aniline in the presences of TRGO. XRD is used for the confirmation of successful formation both TRGO and TRGO-PANI nanoparticles. Techniques such as XRD, DC conductivity, SEM and impedance analyses were used to evaluated microstructure, DC conductivity and the formation of interconnected network structure of TRGO-PANI nanoparticles inside polymer matrix. Three ranges of electromagnetic spectrum i.e. Microwave region (0.1 GHz to 20GHz), Near InfraRed (NIR), and Ultraviolet region (UV) were targeted to observe EMI properties of the prepared composite. PANI act as a compatibilizer for graphene to be dispersed in polymer matrix homogeneously. At 40 wt% filler, EMI shielding was found to be 104 dB because of the filler forms an interconnected structure in matrix that enhance the DC conductivity and in turns enhanced EMI shielding effectiveness. UV and NIR transmittance were found to be less than 0.5% in the whole UV (200nm-400nm) and NIR (700nm-2500nm) region as well.

KEYWORDS: Polyaniline, Graphene, EMI shielding, Nanocomposites, Polymer Composites.

INDIGENOUS DEVELOPMENT OF LIGHT WEIGHT FRP COMPOSITE LEAF SPRINGS FOR AUTOMOBILE SUSPENSION SYSTEMS

Ahsan Mahboob[1], Khazar Hayat[1]

[1] Mechanical Engineering Department, The University of Lahore, 1-KM Defense Road, Lahore, Pakistan

Presenting Author E-mail: (ahsanmahboob15@gmail.com)

Fiber-reinforced plastic (FRP) composite leaf springs can offer a significant weight reduction while providing functionality at par with their metallic counterparts in the suspensions of wheeled vehicles. The leaf springs of glass fiber reinforced plastics (GFRPs) and carbon fiber reinforced plastics (CFRPs) composites are designed by analysis using ABAQUS finite element solver. The optimal design subject to various loading conditions is reached while meeting the stiffness and strength design requirements. The prototype leaf springs are manufactured using the open molding process, followed by experimental testing to characterize their mechanical behavior. The measured results are also compared with the numerical results of the finite element analysis, and a good agreement is found. The use of composite materials for the leaf springs resulted in a weight reduction in a range of approximately 50-60% using GFRP and CFRP while demonstrating the mechanical performance of that the metallic ones. Further, various manufacturing techniques are investigated to evaluate their low-cost mass production potential.

Keywords: Composite leaf spring; Automobile suspension; Finite element analysis.

POLY(VINYL) CHLORIDE BIOPLASTICS: THE GREEN REPLACEMENT OF CONVENTIONAL PLASTICS

Nadia Akram, Amina Shafi

Department of Chemistry, Government College University Faisalabad, Faisalabad 38000, Pakistan

Presenting Author E-mail: (nadiaakram@gcuf.edu.pk)

The diverse and ubiquitous consumption of polymers urges the necessity to make these materials easily available. However, the excessively used petrochemical-based polymers such as poly(vinyl) chloride (PVC) are nonbiodegradable, which is a motivation to modify them with "green" alternatives. In the present study, PVC (Mw = 48 000 g mol−1) has been incorporated with corn starch (CS) to synthesize a series of 25 samples of bioplastics in addition to blank polymer samples. The films of five various thicknesses (0.1, 0.2, 0.3, 0.5, and 1.0 mm) have been synthesized using in situ polymerization. Each sample of pure PVC film and bioplastic has been induced with different concentrations of CS in the range of 1–5 wt %. The synthesized samples were subjected to structural characterization by using Fourier transform infrared. Thermogravimetric analysis has demonstrated the three-step degradation with the improved stability of 250 ^{0}C. The 3% concentration of CS has shown the optimum storage modulus (E') of 1 660 MPa from dynamic mechanical analysis and Tan δ as 0.50. The swelling test performed using water has shown induction of hydrophilicity in PVC up to 4%. CS-induced bioplastics can be a potential eco-friendly alternative to conventional polymers.

Keywords: Biomaterials, films, mechanical properties, poly(vinyl) chloride, thermogravimetric analysis

SODIUM ALGINATE-BASED NANOCOMPOSITE MEMBRANES FOR OIL-WATER SEPARATION FROM WASTEWATER

[1]Mehwish Ehsan, [1]Humaira Razzaq and [2]Shumaila Razzaque

[1] Department of Chemistry, University of Wah, Wah Cantt, Pakistan

[2] School of Chemistry and Chemical Engineering, Huazhong University of science and technology, Wuhan, China

Presenting Author E-mail; ([1]humaira.razzaq@uow.edu.pk)

Other Authors E-mail;(mehwish1170@gmail.com, shumailarazaq@hust.edu.cn)

In the current situation, wastes from industries, notably the petroleum sector, at any stage from drilling through transportation, are important environmental issues. In this study, hydrophilic graphene oxide (GO) and Zinc oxide nanoparticles (ZnO NPs) were synthesized and employed as a filler in the production of efficient and robust Sodium Alginate (SA) nanocomposite membranes for oil-water separation using a pressure-driven filtration approach. These membranes prepared by solution casting and crosslinking method were found to be extremely hydrophilic, with increased porosity, pure water flux (PWF), and mechanical strength. The antifouling test of the nanocomposite membranes revealed significant improvements over the pristine SA membranes without the need for alkaline or acidic cleaning. The composite membranes' morphology, structure, mechanical strength, and wettability were studied using Scanning electron microscopy (SEM), Fourier transforms infrared spectroscopy (FTIR), X-ray diffractometry (XRD), and tensile testing and water contact angle measurement, respectively. Separation efficiency, pure water flux, and flux recovery ratio (%FRR) were all investigated. The findings reveal that incorporation of 1.5 weight percent GO and 0.1 weight percent ZnO NPs to the SA matrix resulted in increased oil removal efficiency along with prominent advantages of cost-effectiveness and environmental friendliness.

Keywords: Sodium alginate; Graphene oxide; Zinc oxide NPs; Nanocomposite membranes; Mechanical strength; Oil-water separation.

DEVELOPMENT OF DURABLE VISIBLE-LIGHT-INDUCED SELF-CLEANING TEXTILE BY APPLICATION OF ZNO-DOPED-FE_2O_3 NANOPARTICLES

Shagufta Riaz, Munir Ashraf

Department of Textile Engineering, National Textile University, Faisalabad-Pakistan

Presenting Author E-mail: (shaguftariaz84@gmail.com)

The use of nanotechnology for chemical and physical modification of materials has been established as a breakthrough for the development of value-added multifunctional textiles with the success of substituting traditional textiles. Nanoparticles (NPs) could impart properties like antibacterial, antiviral, conductive, hydrophilicity, hydrophobicity, and organic decay. Semiconductor materials like ZnO, TiO_2, and Fe_2O_3, etc. are mostly UV photocatalysts. Among these Fe_2O_3 is an important material emerging as a potential photocatalyst for organic degradation due to its adequate bandgap. NPs of Fe_2O_3 is UV active with an issue of less or no binding with the textile substrate. In the following study, the Fe_2O_3 NPs were doped with ZnO to make them visible light active. Further, to increase their immobilization onto textile, organically modified silanes were grafted at the surface of ZnO doped Fe_2O_3 NPs (ZOFN). The ZOFN was applied to the cotton fabric by the pad-dry-cure method. At neutral pH, under visible light, these ZOFN showed good dye degradation. Their antibacterial properties were also improved with the increased concentration of the silane coupling agent and the dopant. Under D65 artificial sunlight, a significant difference was observed between the dye degradation percentage of undoped and doped functional NPs. Nearly the same results were observed after 25 industrial laundering cycles, confirming the durability of functional textiles. The treated textiles also gave good UV protection making them potential applicants for various applications.

Keywords: nanotechnology, physical modification, photocatalysts, degradation, visible light.

INVESTIGATION OF RAW MATERIAL CHARACTERISTICS OF POLYVINYL ALCOHOL FILAMENT FOR SUTURE APPLICATIONS

Ali Afzal, Salman Saeed, Naqash Ahmad, Amna Siddique

Department of Textile Engineering, National Textile University, Faisalabad-Pakistan

Presenting author: Ali Afzal (aliafzalch89@gmail.com)

Although surgical sutures are needed to have different properties depending on the site of use, high tensile strength and knot strength are especially required when used in large abdominal walls, bone marrow, tendon, heart, ligamentum, large blood vessels and fascia operations, as well as in artificial organ transplantation. Polyester and polypropylene fibers are among the surgical sutures widely used today, these are two products that can maintain high resistance in vivo for a prolonged period of time. They have a tensile strength of just about 5 g/d, However, their break elongation is as high as about 20%, so they are not ideal for use in bone fixation, etc. PVA fiber has a good strength and initial modulus for general purpose. Further they also have low elongation at break and also biocompatible. In this work spinning parameters of PVA filament are investigated for surgical sutures which will be helpful in medical textile for sutures. It is concluded that tensile strength and knot strength increases with the increase in degree of polymerization while elongation at break decreases.

Keywords: Polyvinyl alcohol, suture, medical, filament

MECHANICAL CHARACTERIZATION OF WOOD BASED BIODEGRADABLE GREEN COMPOSITES

Adeel Mehmood[1], Muhammad Ali Nasir[2], Khubab shaker[3]

[1] Department of Metallurgy and Materials Engineering, UET Taxila, Pakistan

[2]Department of Mechanical Engineering, UET Taxila, Pakistan

[3]Department of Materials, NTU Faisalabad, Pakistan

Presenting Author E-mail: (engr.adeel89@gmail.com)

In recent years the importance of composites made up of renewable resources has been increased significantly due to the global demand for fibrous materials. Work is being actively pursued into the production of composites prepared using various biodegradable materials. There are many problems associated with the use of wood in composite materials due to their susceptibility to moisture and decay due to fungal activity, but on the other hand, there are many benefits in the use of wood in composites, they are lightweight with high strength, low friction coefficient, and most importantly renewability. Furthermore, they are economical, renewable, abundant, and biodegradable. Several different types of composites have been prepared in the last few years and one of them is wood-based biodegradable composites. In the field of wood-plastic composites, a lot of research has been done. The hypothesis is that the presence of wood in the composite will enhance the mechanical properties of composites. In this research, we study the mechanical properties of wood plastic composite made up of Cedarwood (local name diyar) as filler in low-density polypropylene (LDPP) as a matrix while as a coupling agent maleic anhydride polypropylene (MAPP) will be used. Various composition of sawdust of cedarwood (10, 15, 25, 40% wt.) was added into a polymer and tested for mechanical and morphological properties. Tensile, fatigue, and impact tests were conducted for analysis of the mechanical properties.

Keywords: green composite, biodegradable, wood composite, polypropylene, morphological

INCREASING THE REPRODUCIBILITY OF CHITOSAN NANOFIBER FOR MEDICAL TEXTILES

Sharjeel Abid[1], Tanveer Hussain[1,] and Ahsan Nazir[1]

[1]Electrospun Materials & Polymeric Membranes Research Group, NTU

Presenting Author: Sharjeel Abid (m.sharjeel.abid@gmail.com)

Medical textiles are among the most rapidly growing technical textiles worldwide due to their importance in health care and hygiene. Chitosan is well known for its biocompatibility and antibacterial activity. Though the formation of chitosan nanofibers has been well explained in the literature, the reproducibility of the chitosan nanofiber production, using water-based solvents is challenging due to its structure, and other intrinsic properties. Thus, the addition of co-polymers is necessary, which aids its nanofiber formation ability but achieving a low standard deviation of diameter of the chitosan nanofibers is a challenge with the same morphology within a sample. Therefore, in this study, we have tried to optimize the nanofibers formation of chitosan and minimize its standard deviation to increase the reproducibility and have validated the results using statistical analysis. Nanofibers having an average diameter of less than 200 nm with a standard deviation of less than 30 nm were achieved. It was interesting to see that every selected parameter influenced the output diameter to a large extent. The antibacterial activity of these mats was measured to be coated on some gauze or other textile materials for potential application in wound management, where the primary concern is microbial infection.

Keywords: Chitosan, Electrospinning, Medical Textiles, Nanofibers, Reproducibility

PREPARATION AND CHARACTERIZATION OF GUARAN BASED MEMBRANES FOR WASTE-WATER TREATMENT

Nayab Siddique, Erum Akbar Hussain*

Department of Chemistry, Lahore College for Women University, Jail Road, Lahore

Presenting Author Email: (nayabsiddique999@gmail.com)

Other Authors Email: (erum.hussain@gmail.com)

A surplus amount of water is used in the textile, leather and paper industries of Pakistan. Soluble dyes effluents eluted out into the natural water bodies and are very difficult to remove. This contaminated water reduces the water quality, is hazardous to aquatic animals and causes serious human health problems like diarrhea, leukemia and stomach problems. Natural polymer-based materials have played an imperative role in this connection due to their biocompatible, biodegradable nature. The physiochemical properties of polymers can be enhanced by making their binary or ternary blends. Thus, polymeric membrane provides an effective network for the entrapment of dye effluents. In this research work, guaran-based membranes have been prepared by blending guaran, alginate and polyvinyl alcohol. Dye loading capacities of membranes were investigated by swelling test and UV visible spectroscopy. The extent of cross-linking in polymeric membranes was analyzed through Fourier Transform Infrared spectroscopy (FTIR). Prepared membranes served as efficient adsorbents for the removal of a wide range of waste effluents.

Keywords: *Adsorption, Guaran, Polymer membranes, Waste-water treatment.*

AN ANALYSIS OF THE CARBON PREFORMS FOR ELECTROMAGNETIC SHIELDING

Sundaramoorthy Palaniamy[1], Azam Ali[1], Martina Ryvalova[2], Veronika Tunakova[1], Jiri Militky[1]

[1]Deaprtment of Material Engineering, Faculty of Textile, Technical University of Liberec, Liberec, Czech Republic

[2]Institute for nanomaterial, Advanced technology and innovations, Technical University of Liberec, Czech Republic

Presenting Author E-mail: (asundaramoorthy.palanisamy@tul.cz)

Electromagnetic shielding is mandatory for most electronic devices to protect against electromagnetic interference or disturbance. An interference of electromagnetic radiation from an external source can disrupt or malfunction electronic devices. In this work, the four different carbon fabric preforms were purchased from HP-textiles and analyzed for electrical conductivity and electromagnetic interference shielding as per the ASTM method. The carbon roving's laid in the quadri-axial fabric is showing the shielding effectiveness of 58 dB at 1.5 GHz frequency and its electrical resistivity is 2 ohm/ square.

Keywords: Electrical conductivity, EMI Shielding, Green composites, Carbon fillers

EXTRACTION AND COATING APPLICATION OF A BIO-COLORANT ON TEXTILES

Amna Siddique[1] Faizan Shafiq[2]

[1] School of Textile Engineering and Technology, National Textile University, Faisalabad, Pakistan.

[2] College of Chemistry, Chemical Engineering and Biotechnology, Donghua University, Shanghai, China.

Presenting Author Email: (amnasiddique104@hotmail.com)

Despite the application as a food colorant, the leaves of wormwood plants; native to China, Korea, and Russia, are rarely considered for the coloration of textiles such as dyeing, printing, or coating. We have optimized the extraction procedure of the bio-colorant from leaves of wormwood. Two different solvent systems, namely tri-ethylamine/water (TEA/water) and hydrochloric acid/water (HCl/water) were applied through a simple aqueous extraction method. Maximum phytochemicals yield was obtained using a TEA/water system. Optimized dye extracts were then applied to 100 % cotton fabric through the blade coating technique. Coated fabrics showed medium to high colorfastness against washing, rubbing, and light. TEA/Water extracted dye coating provided smooth touch while HCL/water extracted dye coating provided a rough effect. The coated fabric was characterized by using XRD, FTIR, and SEM techniques. Stiffness, rubbing, bending, tearing and tensile strength were measured to analyze the effect of coating on the physical properties of the fabric. There was no significant effect on the tearing and rubbing of the fabric. The present study adds value in the plant industry as well as provides the textile industry with a new promising natural colorant source for coating.

Keywords: wormwood, coloration, solvent, cotton fabric

IN-SITU POLYMERIZATION OF ANILINE/DODECYL BENZENE SULFONIC ACID & ELASTOMERIC BLEND

Iqra Abdul Rashid

Department of Materials, School of Engineering and Technology, National Textile University, Faisalabad, Pakistan

Presenting Author E-mail: (iqrarashid0@gmail.com)

A strain sensor defines and describes the human body pressure and heart-beat by its sensing capability. There are a lot of conductive polymers and here we used polyaniline to make the strain sensor. In this research work blends of Pani and SBR with different ratios were prepared through in-situ polymerization. Four blends with different ratios of 20/80, 30/70, 40/60, and 50/50 were prepared. The prepared sheets were characterized for spectroscopic analysis by using Fourier transforms infrared spectroscopy, thermal properties by using differential scanning calorimetry, mechanical properties by using the universal testing machine, and electrical properties by using four probes. The blend with the ratio of 40/60 (Pani/SBR) shows excellent conductivity and mechanical properties as compared to other ratios. The prepared blends were used for strain sensor and EMI shielding applications.

Keywords: Polyaniline, Styrene-butadiene rubber, in-situ polymerization, strain sensor

MODELING AND SIMULATION OF LOW-DENSITY POLYETHYLENE PRODUCTION IN TUBULAR REACTOR

Ashraf Azmi[1], Iylia Idris[1], Nur Liyana Bekri[1], Fakhrony Sholahudin Rohman[2], Dinie Muhammad[2], Ahmad Ilyas Rushdan[3], Sudibyo[4]

[1] School of Chemical Engineering, College of Engineering, Universiti Teknologi MARA Shah Alam,40450 Shah Alam, Selangor, Malaysia

[2] School of Chemical Engineering, Engineering Campus, Universiti Sains Malaysia, 14700 Nibong Tebal Penang, Malaysia 40450 Shah Alam, Selangor, Malaysia

[3] School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor 81310, Malaysia

[4] Research Unit for Minerals Technology, Indonesian Institute of Sciences, Lampung, Indonesia

Presenting Author E-mail: (ashraf.azmi@uitm.edu.my)

Low-density polyethylene (LDPE) is one of the most widely used polymers in the world. It is produced in high-capacity tubular. The significance of LDPE polymerization process has created numerous works of modeling and simulation of LDPE tubular reactors. A thoroughly mathematical model for LDPE should be capable to present the profiles of initiator conversion, monomer conversion, reaction mass temperature, and pressure, the moments of free-radical and polymer chain length distribution, and the number of unsaturated bonds in polymer chains. It has been proven that mathematical models help to evaluate and develop the control, performance, and outline of chemical processes. The sensitivity study is an observation of the relationship between information flowing in and out of the model. The main point of the sensitivity study is to determine the relative importance of model parameters and inputs in deciding output. In this work, the sensitivity study of input parameters in an industrial low-density polyethylene tubular reactor is discussed by manipulating several input parameters. Coefficient of determination (R^2) equivalent to 0.991 and 0.989 is obtained for the reactor temperature and the monomer conversion profiles, respectively. The comparison of the product properties at the reactor end also shows a satisfactory agreement where a low percentage of error in the range of 0 to 0.39% is observed in the validation stage, indicating the high accuracy of the developed model. Based on the sensitivity studies, monomer flow rate, initiator flow rate, and solvent flow rate are identified to give significant effect to the performance of LDPE process in a tubular reactor.

Keywords: Low-density polyethylene; polymerization; tubular reactor; modeling; simulation

ELECTROSPINNING: AN EFFECTIVE NANO-FIBERS PRODUCTION METHOD FOR ADVANCED APPLICATIONS

Zubair Khaliq, Muhammad Bilal Qadir*, Sumra Zulfiqar, Anum Javaid

Presenting author: Zubair Khaliq (zubair.khaliq@ntu.edu.pk)

Electrospinning is an efficient, inexpensive, and reliable process for fabricating fibers with diameters ranging from 10^{-6} to 10^{-9} meters. In this method, polymer melt, or solution is added into the solution carrier. The carrier ejects the polymer melt or solution towards the collector plate via applied voltage. The polymer nanofibers are collected on the collector plate, and the solvent evaporates before reaching the collector plate. These nanofibers have high porosity, dimensional stability, mechanical strength, aspect ratio, surface to volume ratio, and ultrathin. Nanofibers are used as nanofibrous webs which have applications in biomedical, electronic, cosmetic, defense, agriculture, construction, and food packaging industries. Functionality can be imparted in nanofibers via incorporating specific compounds exhibiting functional properties into the polymer melt or solution. However, there are some limitations of nanofibers: only electrolyte polymers are electro-spinnable, toxic solvents may be used in this process, and a three-dimension structure is impossible to obtain. There are many types of electrospinning: needle, needleless electrospinning, multi-jet, multi-needles, and coaxial electrospinning. These types are used depending upon the application. Needleless, multi-needle, and multi-jet electrospinning are used to get high production. However, repulsive forces are generated in multi-needle and multi-jet electrospinning. The nanofibers can be used in advanced applications as fire-retardant, breathable facemask, wound dressing, food packaging, enzyme carriers, sound barriers, protective clothing, flexible electronic device, and transparent conductive material.

EFFECTS OF MEMBRANE SELECTIVITY AND CONFIGURATION ON PURITY AND RECOVERY OF CARBON DIOXIDE FROM A COAL FIRED POWER PLANT

Iylia Idris[1], Ashraf Azmi[1], Mohd. Roslee Othman[2] , Rashid Kapara[2], Ahmad Ilyas Rushdan[3], Sudibyo[4]

[1] School of Chemical Engineering, College of Engineering, Universiti Teknologi MARA Shah Alam,

40450 Shah Alam, Selangor, Malaysia

[2] School of Chemical Engineering, Engineering Campus, Universiti Sains Malaysia, 14700 Nibong Tebal Penang, Malaysia 40450 Shah Alam, Selangor, Malaysia

[3] School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor 81310, Malaysia

Presenting Author E-mail: (iyliaidris@uitm.edu.my)

Carbon dioxide (CO_2) level in the atmosphere has been a serious global concern for the climate for it reportedly causes climate change. Several kinds of research have been and are still being conducted to figure out the best way to capture this gas before it reaches the atmosphere. In this thesis, a study of membrane performance on the purity and recovery of the gas is investigated where two areas given focus are the selectivity of the membrane and the configuration of the separation modules. The simulations of membrane separation were performed for the separation of CO_2 from flue gas at coal-powered power plants. In the work, Mathcad software of version 15 is used for purity-recovery computation. To optimize the capture efficiency, the exploited system is optimized using RSM--Response surface methodology. The parameters involved are feed pressure, selectivity, and stage cut. The main focus is to establish the optimal performance of the system with maximum purity and recovery. Simulated data are then fitted to a quadratic model and then regressed under ANOVA to justify its suitability. The dimensional response surface plots derived from the mathematical models are utilized to investigate the effect between each parameter on the purity and recovery of the permeated CO_2 and N_2. Results for configuration-1 showed that the optimum conditions are feed pressure of 37.03 atm, selectivity of 26.09, and stage cut of 0.9. This process achieves 38.40% purity and 11.88% recovery, whereas it improved in configuration-2 to CO_2 purity of 92.88% and 86.34% recovery under conditions of 3.82 atm-Feed pressure, 10.0 selectivity, and stage cut of 0.9. In the high selectivity(s)-membrane, results for configuration-2 were even better with 96.43% purity and 91.79% recovery for CO_2. The research concludes therefore that, configuration 2 is the more suitable arrangement towards these separations with membranes that are highly selective than the current commercial one in the market. Also, a single-stage membrane separator in

configuration 1 with smaller values of selectivity(s) proved that it cannot yield high CO_2 purity and recovery in a go, thus a need for multi staging

Keywords: Carbon dioxide recovery; membrane; purity; gas separation

PREPARATION OF CHITOSAN/ALGINATE/FE_3O_4 VIA CROSSLINKING FOR ASPIRIN REMOVAL FROM WASTEWATER

Abu Hassan Nordin[1], Norzita Ngadi[1]*, R.A. Ilyas[1,2]

[1] School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

[2] Centre for Advanced Composite Materials (CACM), Universiti Teknologi Malaysia, UTM Johor Bahru 81310, Johor, Malaysia

Presenting Author E-mail: (abuhassannordin@gmail.com)

Corresponding Author E-mail: (norzita@cheme.utm.my)

The environmental issue arises when the disposal of aspirin into water bodies becomes unavoidable as it may cause adverse effects on the environment. This study presents a preparation of non-conventional adsorbent derived from natural polymers of chitosan and alginate modified with magnetic nanoparticles via crosslinking method for aspirin removal from aqueous solution. The combination of chitosan with alginate and magnetic nanoparticles was to obtain the good characteristics of these materials such as the vast number of active sites for adsorption and easy recovery of the used adsorbent from the water phase. The effect of crosslinking time and crosslinker (glutaraldehyde) volume on the efficiency of aspirin removal was investigated. The result showed that there was no significant change in the efficiency of aspirin removal by the adsorbent as the crosslinking time varied from 1 min to 30 min. Meanwhile, the finding found that the best glutaraldehyde volume used for crosslinking was 1 ml, as the percentage of aspirin removal was excellent (77.9 %). The separation efficiency of the used adsorbent from the solution was investigated using an external magnetic field. It was noted that the unique combination of chitosan and alginate polymers with magnetic nanoparticles is not only good for adsorption of aspirin but also recovery of the used adsorbent from wastewater.

Keywords: Adsorption, polymers, chitosan, alginate, magnetic nanoparticles, wastewater treatment

PRODUCT DEVELOPMENT OF NATURAL FIBRE COMPOSITES: A REVIEW OF DESIGN OF SUSTAINABILITY

M. R. M. Asyraf[1], Agusril Syamsir[1], M. R. Ishak [2,3,4], S. M. Sapuan [5], R. A. Ilyas [6]

[1] Institute of Energy Infrastructure, Universiti Tenaga Nasional, Jalan IKRAM-UNITEN, Kajang 43000, Selangor, Malaysia.

[2] Department of Aerospace Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

[3] Aerospace Malaysia Research Centre, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

[4] Laboratory of Biocomposite Technology, Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.

[5] Advanced Engineering Materials and Composites Research Centre (AEMC), Department of Mechanical and

Manufacturing Engineering, Universiti Putra Malaysia, Serdang 43400, Selangor, Malaysia

[6] Centre for Advanced Composite Materials (CACM), Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia

Presenting Author E-mail: (asyrafriz96@gmail.com)

Corresponding Author E-mail: (asyrafriz96@gmail.com, Agusril@uniten.edu.my)

New product development review article aims to consolidate the principles and current research works on "Design for" or DfX literatures to seek the future direction of the field. In this point of view, the DfX methods can be established under the idea of sustainability in dimensions of ecology, economy and social pillars. A DfS or design for sustainability concept is implemented in concurrent engineering which includes of concept, embodiment and detail design processes. The integration of the sustainability in engineering designs crucial to produce greener products, system innovation and services align with current market demand. Currently, many concurrent engineering studies related to natural fibre reinforced polymer composites associated with sustainability to enhance the application of DfX techniques by professional designers and to enable DfX strategy research. The current literatures is scarce in bridging the DfS concept with concurrent engineering during design development stage, and these areas should be further developed. Several other future research directions, such as the need for aligning with principles and applications, along with exploring the relationships between the DfS techniques and views of sustainability, are presented in this review paper.

Keywords: Biocomposites; Conceptual Design, Product Development; Design for Sustainability; Sustainability Development.

SUGAR PALM FIBRE REINFORCED UNSATURATED POLYESTR COMPOSITES: EFFECT OF FIBRE LOADING AND FIBRE ORIENTATION ON TENSILE AND FLEXURAL PROEPRTIES

Mohd Nurazzi Norizan[1,2], Khalina Abdan[2,*], S.M. Sapuan[2], R.A. Ilyas[3,4]

[1] Centre for Defence Foundation Studies, Universiti Pertahanan Nasional Malaysia (UPNM), Kem Perdana Sungai Besi, Kuala Lumpur 57000, Malaysia

[2] Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia (UPM), Seri Kembangan 43400, Malaysia

[3] School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia (UTM), Skudai 81310, Malaysia

[4] Centre for Advanced Composite Materials (CACM), Universiti Teknologi Malaysia, UTM Johor Bahru, Skudai 81310, Malaysia

Presenting Author E-mail: (mohd.nurazzi@gmail.com)

Corresponding Author E-mail: (khalina@upm.edu.my)

The effect of Sugar palm [Arenga pinnata (Wurmb.) Merr] fibre reinforced unsaturated polyester composites with 0°, 45°, and 90° fiber different orientations, and fibre loading of 10 to 50 wt.% was investigated. The composites were characterized for tensile and flexural properties according to ASTM D3039 and ASTM D790 standards, respectively. The highest mechanical performance of composites was achieved at 0° of fiber orientation composites followed by 45° and 90° fiber orientations. The fiber loading was insignificant for the 90° fiber orientation as the tensile and flexural properties were inconsistent. The theoretical value of modulus from the tensile test was calculated using rules of the mixture (ROM) and compared with the experimental values for all composites specimens. This research showed that the optimum properties occurred at 30 wt.% fibre loading as reflected by the superior tensile and flexural strengths. Composites with 0° fibre orientations exhibited the maximum strength and modulus under tensile and flexural stress associated with the continuity of fiber length to sustain the different forces applied and the minimum fiber end effects compared to the 45° and 90° fiber orientations. This study presented results that significantly provided a bottom-up approach to determine the effect of fibre orientation and fibre loading on fabricated composites to further expand this material for structural applications, especially in automotive, marine, aerospace and sporting goods.

Keywords: Different fibre orientation; Fibre loading; Sugar palm fibre; Mechanical properties; Unsaturated polyester

IMPACT OF HOLLOW GLASS MICROSPHERES ON THE DAMAGE RESISTANCE OF NATURAL FIBRE (HEMP) REINFORCED COMPOSITES

Habib Awais

Department of Textile Engineering, School of Engineering and Technology, National Textile University, 37610 Faisalabad, Pakistan.

Presenting author: Habib Awais (habib.awais07@gmail.com)

One of the key design concerns of the structures developed by composite laminates is their susceptibility to damage from concentrated out-of-plane impact forces. Familiarity with the impact properties of laminated composites is essential for product development and material selection. This research work studied the effect of different concentrations (0 %, 1.5 % and 3 %) of hollow glass microspheres (HGMs) on the impact strength of hemp fibre reinforced composite. Drop weight and Charpy impact tests were performed on the specimens of composites made of unsaturated polyester resin by vacuum infusion technique. The analysis indicated that the addition of 1.5 % HGMs enhanced the impact properties compared to without HGMs specimens, while the addition of 3 % HGMs reduced the properties owing to the agglomeration of HGMs. This study also indicated that adding filler particles up to an optimum level in fibre reinforced composites improved the impact properties. After that, the properties deteriorated due to agglomeration and poor adhesion.

Keywords: Glass microspheres, fibre reinforced composites, vacuum infusion, impact resistance.

EFFECT OF HYBRIDIZATION OF POLYUREA AND POLYURETHANE COATING ON MECHANICAL PROPERTIES

Madeha Jabbar, Yasir Nawab
Department of Textile Engineering, School of Engineering and Technology, National Textile University, 37610 Faisalabad, Pakistan.

Presenting author: Madeha Jabbar (madihajabbar@gmail.com)

Polyurea and Polyurethane are used as a protective coating in vast applications including sports construction, aerospace, furniture, and automotive industry. Polyurea is usually applied using a spray gun due to very short gelation time. This poses a limitation on extensive use of polyurea due to cost and availability of spray guns. On the other hand, brushing technique provides good coating strength and can be used for vast applications. This study aims to determine the effect of hybridization of high strength polyurea and polyurethane coatings by using brushing technique. Investigations were performed by varying number of coatings of polyurea and polyurethane on glass-epoxy composites. Three different samples were prepared using glass and epoxy and four coats were applied on the composite plate. Design of experiment is provided in Table-1

Table-1 Samples developed for hybridization of polyurea and polyurethane coatings

Sr#	Sample ID	Polyurethane Coating + Polyurea Coating
1	H4-1PU-3PUR	1PU+3PUR
2	H4-2PU-2PUR	2PPU+2PUR
3	H4-3PU-1PUR	3PU+1PUR

Mechanical testing of the samples was performed including Flexural testing (ASTTM D 790), Chapry Impact strength (ASTM D 6110-18), Izod impact strength (ISO-9854) and Hardness test (ASTM-E18) of the composites and results were evaluated.
Flexural properties and hardness of sample-1 with 3 Polyurea layers was better. Charpy impact strength was greater for samples with highest coatings for polyurethane. All samples indicated approximately equal amount of absorbed energy for Izod test. It is concluded that hybridization of coatings results in improved hardness and flexural properties for composites comprising of a greater number of polyurea coats with compromised flexural properties.

NANOCELLULOSE AS A NOVEL FILTRATION MATERIAL OF ORGANOPHOSPHORUS COMPOUNDS

Mohd Nor Faiz Norrrahim[1], Noor Azilah Mohd Kasim[1,2], Victor Feizal Knight[1], Norhana Abdul Halim[3], Noor Aisyah Ahmad Shah[2], Siti Aminah Mohd Noor[2], Siti Hasnawati Jamal[2], Keat Khim Ong[1,2], Wan Md Zin Wan Yunus[4]

[1] Research Centre for Chemical Defence, Universiti Pertahanan Nasional Malaysia, Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia.

[2] Department of Chemistry and Biology, Centre for Defence Foundation Studies, Universiti Pertahanan Nasional Malaysia, Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia.

[3] Department of Physics, Centre for Defence Foundation Studies, Universiti Pertahanan Nasional Malaysia, Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia.

[4] Centre for Tropicalisation, Universiti Pertahanan Nasional Malaysia, Kem Perdana Sungai Besi, 57000 Kuala Lumpur, Malaysia.

Presenting author E-mail: (norrrahim@gmail.com)

Corresponding author email: (azilah@upnm.edu.my)

Organophosphorus (OP) compounds are highly toxic and dangerous chemicals that have long been used as pesticides and have been developed into warfare nerve agents. Malathion is one of the commonly used OP compounds as a pesticide. The development of protection material towards these compounds is gained interest among researchers. Nanocellulose is a renewable material that combines a high adsorption capacity, large surface area, lightweight, high strength, chemical inertness, and versatile surface chemistry make it a suitable material for the high-performance filtration material. It can be an alternative to the currently available filtration material (activated carbon). From the current result obtained, nanocellulose has a higher adsorption capacity (51.2 ml/g) towards OP than activated carbon (9.76 ml/g).

Keywords: nanocellulose, organophosphorus, organophosphorus adsorption, filtration material

DEVELOPMENT OF THERMOPLASTIC ARROWROOT STARCH-BASED FILMS AND ITS FOOD PACKAGING APPLICATION: A REVIEW

J. Tarique[1], S.M. Sapuan[1,2], A. Khalina[2,3], R.A. Ilyas[4], E.S. Zainudin[1,2]

[1] Advanced Engineering Materials and composites Research Centre (AEMC), Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[2] Laboratory of Biocomposite Technology, Institute of Tropical Forest and Forest Products (INTROP), Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[3] Department of Biological and Agricultural Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

[4] School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, 81400, Skudai, Johor, Malaysia

Presenting Author E-mail: (tarique5496@gmail.com)

Corresponding Author Email: (sapuan@upm.edu.my)

The widespread use of non-biodegradable plastics, mainly in the area of food packaging, has caused serious consequences for the environment and human beings, including waste disposal contamination, natural resource depletion, and expensive recycling costs. As a result, to mitigate this negative impact, "greener" and environmentally friendly food packaging materials are necessary. One of the best alternatives is starch-based film; it is a low-cost material that has been studied as an excellent raw material for the production of biodegradable films. Recently, there has been an increased interest in using arrowroot starch (*Maranta arundinacea*) as a biomaterial derived from arrowroot tubers for developing biodegradable food packaging, due to its excellent film-forming properties and abundance in nature. However, native starches are brittle and do not possess any thermoplastic properties. As a result, incorporating plasticizers into film materials improves the functional properties of films by increasing extensibility, dispensability, flexibility, elasticity, and rigidity. In general, the plasticization effect of plasticizers strengthens the film structure, increasing tensile strength and elongation while decreasing water barrier properties. This study reveals the huge potential of thermoplastic starch-based films for the food packaging industry.

Keywords: Thermoplastic arrowroot starch; starch film; plasticizers; bio-packaging

DEVELOPMENT AND CHARACTERIZATION OF 3D WOVEN STRUCTURES FOR ADOPTIVE GEOMETRY COMPOSITES

Zakariya Zubair, Ibrahim Goda, Gildas L'hostis, Muhammad Zubair

National Textile University, 38000 Faisalabad, Pakistan

Université de Haute Alsace, LPMT EA 4365, F-68100 Mulhouse, France

Shape memory polymer (SMPC) is famously known to be an incredibly smart material. The attractiveness of SMPCs lies in their remarkable attributes and versatile functionality. For instance, SMPCs provide a hybrid of shape memory attributes and other commonly known mechanical and functional characteristics of composites. Particularly, 3D reinforced preforms are significant potential resources for developing functional composites. This may usually be achieved via combining tremendous attributes of 3D woven fabric preform design with those of polymer shape memory behavior within a composite. Considering this scope, the present research intends to explore the shape memory behavior and shape recovery properties of a specific type of 3D multilayer woven SMPC in response to external stimuli. To reach this aim, firstly, nine multi-layered stitched fabrics are made having versatile weaving patterns. At the second step, an evaluation is made regarding the mechanical and physical attributes of these nine produced fabrics. Thirdly, SMPC samples are achieved with the help of layered fabric design having high mechanical performance. The shape recovery capacity of these samples is further explored. Later on, for the evaluation of shape memory attributes of prepared samples, the fold deploys test and some other memory cycle testing is conducted. Moreover, to get the quantitative evaluation of shape fixity and shape recovery behavior, an optical 3D scanner having fringe projections is proposed. This scanner helps to accurately determine the geometry data and to conduct deformation analysis.

The findings of this research are very promising. It demonstrated that these multi-layered SMP structures can be properly recovered having required design constraints, and this also without any prominent damage to the overall structure.

Keywords: Shape memory composite, Multilayered fabric, Polyimide filament, 3D scanner

STUDY OF FLEXURAL BEHAVIOR OF CARBON FIBRE REINFORCED POLYMER (CFRP)/ AL-HONEYCOMB AND AL-FOAM SANDWICH COMPOSITES FOR AUTOMOTIVE AND AEROSPACE APPLICATIONS.

Muhammad Kashif Bangash[1], Shah Rukh Shahbaz[2], Omer Berk Berkalp[2], Graziano Ubertalli[3], Monica Ferraris[3]

[1] National Textile University, Faisalabad, Pakistan

[2] Istanbul Technical University, Istanbul, Turkey

[3] Politecnico di Torino, 10129, Torino, Italy

Presenting Authors Email: (kashifbangash@ntu.edu.pk)

Material manufacturers and engineering structure designers are currently focused on developing new ways to exploit the benefits of lightweight and cost-effective hybrid materials with improved properties for automotive, aerospace, and industrial applications. In this experiment, CFRP-Aluminum honeycomb and CFRP-Aluminum foam sandwich composites are produced with and without multi-walled carbon nanotubes in the facing skins. The flexural behavior of the sandwich panels is analyzed using a three-point bending test in long and short span configurations. Microscopic examination is carried out to analyze the failure mechanism. A significant improvement in the flexural behavior is observed when MWCNTs were added to the facing skins. CFRP-Al Foam sandwich composites showed superior flexural properties as compared to the CFRP Al-HC sandwich composites. It was also evidenced that the flexural behavior and the collapse mode of the composite panels with fixed composition are significantly influenced by the support span length. Such low-cost performance enhancements can significantly provide alternatives to the designers to experiment with complex design architectures using low-density materials without compromising strength features.

Keywords: cost-effective, applications, honeycomb, sandwich.

EFFECT OF DIFFERENT REINFORCEMENT MATERIALS AND MATRIX ON DELAMINATION CHARACTERISTIC OF METAL-COMPOSITE BOND

Muzzamal Hussain[1], Yasir Nawab[1], Abdellatif Imad[2], Abdelghani Saouab[3], Muhammad Umair[1]

[1] School of Engineering & Technology, National Textile University, Faisalabad, 37610, Pakistan.

[2] Univ. Lille, ULR 7512 - Unité de Mécanique de Lille Joseph Boussinesq (UML), F-59000 Lille, France.

[3] Laboratoire Ondes et Milieux Complexes, UMR 6294 CNRS, Université du Havre, Le Havre, 76058, France.

Presenting Author: Muzzamal Hussain (muzzamal313@gamil.com)

In the current study, the adhesion properties of bonded aluminum-composites bonds are evaluated using the floating roller peel test. The bonds were made using aluminum of 7075-T6 grade and were phosphoric acid anodized before bonding. Both synthetic and natural fiber reinforcement was used along with three types of thermoset and thermoplastic matrices. The samples were prepared using a compression hot press as per the temperature requirement of different matrices. The DIN EN 2243-2 was used to determine the peel performance of metal-composite adhesive bonds. The aluminum was used as a flexible adherend while composite was used as a rigid adherend. The test was performed on Zwick/Roell UTM Z100. The result showed that the thermoplastic-based bonds have the highest delamination force due to better adhesion characteristics as compared to the thermoset matrix. The results also showed that the delamination characteristics depend on the nature of reinforcing materials. Cohesive, adhesive, mixed-mode and Intra-laminar was observed in different kind of bonds. Overall the thermoset-matrix-based bonds have the lowest delamination force and fracture toughness due to their brittle nature, while thermoplastic-based bonds showed better fracture toughness characteristics due to their plastic nature.

Keywords: composites, natural fibers, adhesion properties, characteristics

ENHANCED MECHANICAL PERFORMANCE OF JUTE/PP COMPOSITES USING JUTE SINGEING AND YARN COMMINGLING TECHNIQUES

Muhammad Ayub Asghar[1], Abdellatif Imad[2], Yasir Nawab[1], Muzzamal Hussain[1], Abdelghani Saouab[3]

[1] School of Engineering & Technology, National Textile University, Faisalabad, 37610, Pakistan.

[2] Univ. Lille, ULR 7512 - Unité de Mécanique de Lille Joseph Boussinesq (UML), F-59000 Lille, France.

[3] Laboratoire Ondes et Milieux Complexes, UMR 6294 CNRS, Université du Havre, Le Havre, 76058, France.

Presenting author: Muhammad Ayub Asghar (ayubasghar1969@yahoo.com)

Natural fiber composites are gaining importance due to their lightweight, low cost, eco-friendly and renewability. Using a thermoplastic matrix gives additional benefits of recycling and reshaping into other products. But there are certain issues involved with the fabrication of the thermoplastic composites including high melt viscosity, poor fiber impregnation, etc. in the case of natural fibers, hairiness is another factor that hinders the proper fiber impregnation. This study explores the effect of two techniques i.e. singeing and commingling on the properties of jute/polypropylene composites. The singeing technique involves passing the jute yarn through the flame to burn out the protruding fibers. A commingled yarn was prepared by wrapping the polypropylene yarn on a jute yarn core. The fabric was woven using this commingled jute/PP yarn. The composites were fabricated by conventional thermoforming techniques as well as commingled fabrics. Mechanical performance in terms of tensile, flexural, and impact properties, was investigated. It was observed that the jute yarn singeing has improved the yarn performance during weaving. Furthermore, yarn commingling has simplified/shortened the composite fabrication process. The mechanical performance of commingled composites was also found to be significantly better in comparison to the conventional thermoforming technique.

Keywords: natural fiber, eco-friendly, renewability, thermoplastic, recycling

TUNABLE MOLECULAR-SELECTIVE BORON NITRIDE NANOSHEET COMPOSITE LAMELLAR MEMBRANE FOR DYE SEPARATION

Asif Hafeez
Department of Materials, National Textile University, Faisalabad-Pakistan

Presenting author: Asif Hafeez (ahafeez@ntu.edu.pk)

Two-dimensional (2D) hexagonal boron nitride (h-BN) nanosheets being an isostructural to graphene, has received considerable interest in many emerging applications including water treatment due to its robust properties. However, experimental works on this novel material have not been extensively reported yet. Therefore, in this research, a fundamental investigation on molecular transport through BN nanosheet-based lamellar membrane is conducted. However, h-BN exhibits lower dispersibility in polar solvents consequently limits its utilization for membrane application. A facile two-step processes of (1) liquid-phase sonication assisted exfoliation of h-BN with urea as reduction-stabilizing agent, which is followed by grafting different molecular weight of polyethylene glycol using 3-Aminopropyl triethoxysilane structure-directing agent to synthesize tuneable polyethylene glycol grafted boron nitride PEG$_X$-g-(f-BN) and (2) lamellar membrane fabrication through vacuum filtration of PEG$_X$-g-(f-BN) nanosheet dispersion. In the first step, the liquid-phase sonication assisted exfoliation process yields 6-14 layered 75±2 nm functionalized boron nitride f-BN nanosheets. In the second step, the deposited thickness was tuned through varying the concentration of the PEG$_X$-g-(f-BN) nanosheet colloidal solution.

The final polyethylene glycol grafting intends two-fold outcomes. Firstly, enhancing surface wettability through the transformation of superhydrophobic h-BN to superhydrophilic PEG$_X$-g-(f-BN). Secondly, varying molecular weight of polyethylene glycol aim to alter the interplanar spacing of the nanosheet, implicating the nanosheet tunability in terms of permeability and solute exclusion. Improved wettability (small contact angle of ~36˚) depicts high trans-lamellar membrane permeance of ~1253 L m^{-2} h^{-1} bar^{-1}. With the increasing deposition thickness of PEG$_X$-g-(f-BN) nanosheet layer from ~3 µm to ~12 µm the permeance decreases from ~1253 L m^{-2} h^{-1} bar^{-1} to ~840 L m^{-2} h^{-1} bar^{-1} and the MB exclusion improved to ~98% because of higher hydrodynamic resistance in trans-lamellar membrane. Moreover, with increasing interplanar spacing from ~0.336 nm to ~0.348 nm of the nanosheets the permeability tends to increase from ~849 L m^{-2} h^{-1} bar^{-1} to a maximum of ~1253 L m^{-2} h^{-1} bar^{-1} and then starts to decline to ~250 L m^{-2} h^{-1} bar^{-1}, which is attributed to long polyethylene glycol chain folding. The fabricated membranes inherit stable and interconnected nanopores with nanochannels having an average pore diameter ranging from ~1.4 nm to ~3.0 nm. The high retention of ~99% for methylene blue from aqueous solution through the PEG$_X$-g-(f-BN) decorated membrane was

achieved. This superior performance is attributed to the small nanosheet size and hydrophilic surface functionality.

Keywords: dye separation, lamellar membranes, nanosheet

A COMPARATIVE STUDY ON MODIFICATION OF TIO_2 NANOPARTICLES WITH CATIONIC AND FIBER REACTIVE SILANE COUPLING AGENTS AND THEIR APPLICATION ON COTTON FABRIC

Munir Ashraf and Shagufta Riaz

Functional Textiles Research Group, National Textile University, Faisalabad

Presenting Author: Munir Ashraf (munir.ashraf01@gmail.com)

Different properties such as antibiotic, super hydrophobicity, superhydrophilicity, UV resistance, antistatic, conductivity, chemical self-cleaning and wrinkle resistance have been imparted in textile using nanotechnology. Though, the nanoparticles (NPs) have so many benefits, but their immobilization at textile surface is a big issue. Therefore, a study was conducted to improve their adhesion without affecting the comfort properties of textile and functionality of nanoparticles. NPs were functionalized with fiber reactive silane coupling agent (3-Glycidoxypropyl) trimethoxysilane (GPTS) and cationic silane coupling agent, trimethyl[3-trimethoxysilyl)propyl]ammonium chloride (TPAC). The durability of NPs was attained upto 20 industrial washing cycles. When comparison was made for morphological and functional attributes of treated fabrics by GPTS and TPAC. It was concluded that Morphology UPF and antibacterial properties of fabric treated with TPAC functionalized TiO_2 NPs (A) were better than fabric treated with GPTS functionalized TiO_2 NPs (B). Though the GPTS modified TiO_2 NPs were also homogenously distributed at the fibrous surface but the coverage of TPAC modified NPs was more. This could be possibly due to more affinity shown by TiO_2 NPs because of strong electrostatic force o attraction between TiO_2 NPs and fabric surface. As the higher number of TiO_2 NPs was attached in case of fabrics treated with TPAC functionalized NPs therefore, reflectance and absorbance were higher giving higher value of UPF before and after washing. Similarly, the antibacterial efficacy of fabrics treated with TPAC functionalized TiO_2 NPs was more due to more attached NPs. More number of ROS could be generated by TiO_2 NPs and also cationic agent was responsible for antibacterial activity. Thus, the TPAC could be considered better than GPTS to functionalize TiO_2 NPs.

Keywords: TiO2 nanoparticles, coupling agent, cotton

SMART COMPOSITE STRUCTURES BY 3D PRINTING TECHNOLOGY

Ali Raza[1], Rūta Rimašauskienė[1]

[1]Kaunas University of Technology, Lithuania

Presenting Author Email: (ali.raza@ktu.edu)

3-Dimensional (3D) printing, also referred to as digital fabrication technology or additive manufacturing (AM) that creates physical 3D objects from a geometrical representation by successive addition of materials. 3D printing is one of the fastest emerging technology that is being used in various industries i.e., healthcare, automobiles, construction and aviation with different printing techniques and materials. The advancements in material understanding have led to the development of more sophisticated 3D printing machines. The global 3D printing market expanded to $9.9 billion in 2018 and is predicted to reach $34.8 billion in 2024 as a result of the rapid development of 3D printers. Fused Deposition Modeling (FDM) or Fused Filament Fabrication (FFF), is one of the well-known and commonly used additive manufacturing techniques due to inexpensive FDM process, the affordable initial cost of 3D printers and suitable for a wide range of polymers and can incorporate carbon fibers and other composite materials. In this regard, this research work emphasizes the development of smart composite structures by using the FDM technique. To transfer the composite structure into the smart one, piezoelectric actuators would be integrated into it and the developed smart composite would be used for the active vibrations control.

Keywords: 3D printing, Additive manufacturing, fused deposition modeling, Smart composite structures, Active vibrations

DEVELOPMENT OF DURABLE MULTIFUNCTIONAL TEXTILES THROUGH AG DECORATED TIO_2 NANOPARTICLES

Amjed Javid, Kainat Majeed, Munir Ashraf

Department of Textile Engineering, National Textile University, Faisalabad-37610 Pakistan

Presenting author email: (amjad1238@gmail.com)

The consciousness of people about cross-infection of bacteria and viruses has raised further owing to the Covid-19 pandemic. A lot of research work is being carried out to eliminate pathogens from surfaces and the environment. Here, the modification of TiO_2 nanoparticles was carried out using Ag and Cu through the electroless technique. The modified nanoparticles were applied on cotton fabrics using (3-Glycidyloxypropyl) trimethoxy silane coupling agent. The treated fabric was characterized for functionality and durability using various techniques. It has been observed that the treated fabrics exhibited excellent hydrophobicity and UV resistance. The washing durability of fabrics for UV resistance was increased with the increase in the concentration of coupling agent. The fabrics had shown promising photocatalytic and antibacterial activity. The modified $Ag@TiO_2$ and NPs $Cu@TiO_2$ NPs degraded Methylene Blue dye 93.6% and 92.3%, respectively. The textiles treated with modified TiO_2 nanoparticles can be an excellent solution for enhanced functionality with promising durability.

Keywords: antibacterial activity, modified nanoparticles, photocatalytic activity, UV protection, textile.

3D WOVEN HYBRID COMPOSITE BASED PANELS WITH IMPROVED MECHANICAL PERFORMANCE FOR BULLET PROTECTION IN VEHICLES

Muhammad Umair, Tehseen Ullah, Yasir Nawab, Khubab Shaker

National Center for Composite Materials, School of Engineering and Technology, National Textile University, 37610, Faisalabad-Pakistan

Presenting author Email: (umair.ntu@gmail.com)

Historically, a number of materials have been used in armoured vehicles for protection against ballistic impact. These materials have certain disadvantages like higher in weight, joining problems, lower fracture toughness, higher cost, increased weight, reducing mobility and range, etc. One of the possible solutions is to replace the steel and other metallic ballistic panels with composites structures, which are lighter in weight, have excellent specific strength, stiffness, and energy absorption for the same protection level. Currently, 3D woven composites are preferred in ballistic applications which have 10-15% improved damage tolerance, through-thickness properties and delamination resistance as compared to the 2D woven composites. Because in 3D structures offer better mechanical properties due to the presence of z-yarns. This research focuses on the development and characterization of novel 3D woven jute/green epoxy composites having hybrid interlocking patterns. Four conventional derivatives of 3D woven reinforcements i.e., orthogonal layer to layer (OLL), orthogonal through-thickness (OTT), angle interlock layer to layer (ALL), angle interlock through-thickness (ATT) and three novel 3D woven reinforcements i.e., H1 (combination of OTT and ATT), H2 (combination of OTT and ALL), H3 (combination of OLL warp and weft interlocks) were developed using different binding patterns on the dobby loom. OTT composite structure showed the highest values of tensile strength, modulus, and maximum force both in warp and weft directions as compared to the other 3D interlock structures, due to the least interlacement/crimp of binder yarn. While ATT composite exhibited the highest value of flexural strength and modulus both in warp and weft directions due to through-thickness angle binder yarns. H3 composite showed the highest values of force and short beam shear strength in the warp direction. These hybridized 3D woven composites with improved mechanical performance can be used in bullet protection panels for vehicles.

Keywords: Reinforcement hybridization, 3D woven structures, 3D woven composites, green epoxy, mechanical performance, bullet protection, vehicle

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POLYETHERSULFONE COATED AG-SIO2 NANOPARTICLES: A MULTIFUNCTIONAL AND ULTRAFILTRATION MEMBRANE WITH IMPROVED PERFORMANCE

Zulfiqar Ahmad Rehan

Department of Materials, National Textile University, Faisalabad-Pakistan

Presenting author: Zulfiqar Ahmad Rehan (zarehan@ntu.edu.pk)

Silver-silica (Ag-SiO2) embedded in polyethersulfone (PES) composite membranes were prepared by adding different ratios of Ag-SiO2 in PES and designated as PES-Ag-SiO2 -01 ~ PES-Ag-SiO2 -05. The synthesized hybrid membranes were investigated to check the influence of Ag-SiO2 on the morphology, hydrophilicity, porosity, mechanical properties, water permeability, bovine serum albumin (BSA) separation, nitrophenol adsorption and antibacterial characteristics of the hybrid membranes. The inclusion of Ag-SiO2 enhanced the porosity of PES hybrid membranes (79% ~ 84.7%) and as result, the hybrid membranes exhibited lower mechanical properties comparative to PES membranes. However, the hydrophilicity of the PES hybrid membranes was enhanced by adding Ag-SiO2 nanoparticles causing a gradual decrease in contact angle (73.4° to 58.8°). The hybrid membranes displayed higher water permeability and nitrophenol adsorption as compared to pure PES and furthermore these properties were enhanced by increasing Ag-SiO2 content in the PES hybrid membrane. The hybrid membrane with higher contents of Ag-SiO2 showed a water flux of 127.7 L/hm2 which is much greater than pure PES membrane (73.30 L/hm2). In addition, the PES hybrid membrane exhibited a strong BSA rejection and PES-Ag-SiO2 -04 showed a maximum BSA rejection (91%). The incorporation of Ag-SiO2 nanoparticles improved the antimicrobial activity of the membranes which strongly depend on the contents of nanoparticles.

MICROPLASTICS: IDENTIFICATION, CHARACTERIZATION AND EXTRACTION FROM DRINKING WATER

Salma Shahid

Govt college women University Faisalabad

Presenting author: Salma Shahid (dr.salmashahid@gcwuf.edu.pk)

Microplastics is becoming promising concern globally. They are formed mainly by the decomposition of plastic components exist in water/ecosystem. Microplastics are reported in marine sediments, rural and urban regions, textile effluents, freshwaters, and seawaters. It leads high contact of these microparticles with living things. They are produced by the degradation of bigger plastic polymers such as low- and high-density polyethylene, polypropylene (PP), polyethylene terephthalate (PET), polystyrene, polyvinyl chloride (PVC), acrylic, nylon, polylactic acid, polyurethanes, and polycarbonate into micro-fragments. Recently, the effects of MPs on human health and ecosystem have been studied and this topic has been successful in gaining world's attention. Microplastics present in textile effluents and drinking water become direct contact to the living organisms. In this context, industrial wastewater effluent and drinking water were sampled and analyzed using extraction, purification techniques. The particles were analyzed using FTIR and zeta analyzer techniques. Their number and length were quantified by stereomicroscope. An average of 351 MPFs L^{-1} was identified in the mill effluent. Length of more than 85 % fibers were shorter than 1000 µm. Additionally, the sampling strategy was used to identify the optimal volume necessary to adequately subsample the effluent. Very less amount of microplastics fibers were found in drinking water.

DEVELOPMENT OF REINFORCEMENT NON-WOVEN FABRIC INTENDED TO BE USED IN COMPOSITE USING WASTE MATERIAL

Zuhaib Ahmad[1], Ahsan Ali[1], Syed Muhammad Salman[1], Faheem Ahmad[1], Muhammad Salman Naeem[2]

[1] School of Engineering and Technology, National Textile University, Sheikhupura Road, Faisalabad 37610, Pakistan

[2] School of Arts and Design, National Textile University, Sheikhupura Road, Faisalabad 37610, Pakistan

Presenting author: Zuhaib Ahmad (zuhaibahmad.ntu@gmail.com)

According to environmental and health, recycling technology is important to save resources and reduce environmental pollution. The recycling of textile fibers reduces the carbon footprint of textiles and is beneficial for the environment. Fibers are widely used in various applications and one of the important applications is thermal insulation. Waste fibers nonwovens are presently in high demand in industry due to benefits such as low price, biodegradability, good mechanical, and physical properties, etc. This study contributed to the body of knowledge about the thermal insulation capabilities of nonwovens made from waste fibers which contains recycled polyester, recycled Jute, and coir. The coir, recycled polyester, and recycled jute fiber needle punched nonwoven were prepared and the air permeability, thermal resistance, tensile strength, and water vapor permeability test were conducted. The results show that, the coir fiber shows good thermal resistance than the recycled jute due to the pores in coir fabric is lower than jute, pores decrease thermal resistance increase. It may be concluded that, manufactured nonwovens are good to be used as low cost and environment friendly insulation materials not only in composites but also in buildings, and clothing industries.

Keywords: waste, non-woven, needle punching, composite material

DESIGN & FABRICATION OF GLASS FIBER REINFORCED FLAME RETARDANT COMPOSITE FOR REPLACEMENT OF PLYWOOD

Ayesha Afzal

Department of Materials, School of Engineering and Technology, National Textile University, Faisalabad, Pakistan

Presenting author: Ayesha Afzal (ayeshaafzal91@yahoo.com)

This work aims to develop glass-fiber reinforced unsaturated polyester resin composites with significantly improved flame retardancy using aluminum phosphate (AP) and ammonium dihydrogen phosphate (ADP). The focus was to prepare flame retardant resin incorporated to 7 layered glass fiber reinforced polymer composite (GFRP). Flame retardants (FR) (AP+ ADP) were added in 5 wt%, 10wt% and 15wt% and then samples were tested. The UL-94 Tests were conducted, and it was observed that as we increase the concentration of FR in composite the flame retardancy increases and we obtained V-0 at 15 wt% in $E_{75\%}FR_{15wt\%}$. Thermo gravimetric analysis (TGA) showed maximum mass residue of 50% after complete combustion of $E_{75\%}FR_{15wt\%}$. Tensile modulus achieved was 5% lower than that of the pure resin. While bending properties were improved by 2% and Charpy test showed improvement to 4%. When GFRP composite was prepared it was observed that the declined mechanical properties were overcame and shown improved modulus up to 6% in $E_{75\%}FR_{15wt\%}$. Moreover, the bending test, Charpy test showed increase of 5.5 and 6 % respectively.

POSTER PRESENTATIONS

DEVELOPMENT AND CHARACTERIZATION OF FAST-DRYING AND SUSTAINABLE WATER-BORNE ROAD MARKING PAINT

Ahmed Usman, Zubair Khaliq, Zulfiqar Ahmad Rehan

Department of Materials, National Textile University, Faisalabad 37610, Pakistan

Presenting Author: Ahmad Usman (ahmadusman084@gmail.com)

Recently, waterborne road marking paints have gained significant importance in the market due to strict environmental pollution regulations. Conventional road marking paints are harmful to the environment due to VOCs emission into the environment. Waterborne road marking paints are suitable for asphalt, concrete, and cement. Bituminous and tar surfaces. But these paints are sensitive in terms of drying time under humid conditions and other barrier properties. In this study, high PVC fast-drying waterborne road marking paint was prepared by using a high Tg value pure acrylic binder in combination with calcium carbonate, titanium dioxide and other color pigments. Different samples of white and golden yellow paint were prepared in the lab by using a low shear mixer under very controlled conditions and studied the results of dry paint films by using different characterization techniques. Then we investigated the drying time of the wet paint films and also calculated the PVC values, %volume solids, and density value of the paint samples by using conventional formulas. We also studied the thermal stability of the paint film by using TGA and noted the Tg value of paint films by using DSC. Viscosity, flow behaviour and stability of the waterborne road marking paints were investigated by using a Rheometer.

Keywords: Paints, environmental pollution, VOCs emissions, waterborne.

FABRICATION OF LOW EMISSIVITY PAINT FOR THERMAL/NIR RADIATION INSULATION FOR DOMESTIC APPLICATIONS.

Aiman Ali[1], Ahmed Usman[1], HM Fayzan Shakir[1], Usman Zubair[1], Zulfiqar Ahmad Rehan[1]

[1] Department of Polymer Engineering, National Textile University, Faisalabad 37610, Pakistan

Presenting Author: Aiman Ali (999aliaiman@gmail.com)

Recently, low emissivity paint has gained significant importance than commercial paints. Low emissivity (Low-E) Paint is also termed as a coating for radiation control. The emissivity of radiations of longer waves is reduced dramatically (i.e., the emissivity of commercially available paint is 0.9) by imparting low emissivity particles in the base paint but not suitable to reduce near-infrared radiation. The low emissivity property of paint makes it particularly suitable for reducing the radiative heat exchange in many domestic applications, i.e., home electronics, building construction components, roof surfaces, heat storage tanks, pipes, etc. In this work, different samples of white paint were prepared in the lab by using a low shear mixer (mechanical stirrer) under very controlled conditions and studied the results of dry paint films to reduce the thermal emissivity then commercially available paint. Then we investigate the drying time of the wet paint films and also analyze thermal heat into visible light through thermal imaging camera, Crosshatch and IR transmission. We also studied the emissivity through ET-100 and aging stability through weather-o-meter instrument through which investigate that emissivity value achieved in the range of 0.4-0.6 than commercial paints. The results showed that paint exhibits an acceptable aesthetic emissivity valueof ~0.60.

Keywords: emissivity, paints, commercial, visible light, domestic.

FABRICATION AND CHARACTERIZATION OF CARBOXYLATED GRAPHENE OXIDE (C-GO) EMBEDDED POLYSULFONE NANO COMPOSITE MEMBRANE FOR TEXTILE APPLICATIONS

Sidra kanwal[1], Maryam Saeeda[1], Ahmed usman[2], Muhammad Zahid[1], Zulfiqar Ahmad Rehan[2]

[1]Department of chemistry, University of Agriculture, Faisalabad, Pakistan

[2]Department of Polymer Engineering, National Textile University, Faisalabad, Pakistan

Presenting Author: Sidra Kanwal (kanwalsidra55@gmail.com)

Textile industries are the biggest industrial zone that is spreading extreme water pollution. The wastewater discharged by the textile industry consists of different composite chemical substances that involve inorganic salts, heavy metals, solvents, sulfates, oils, detergents and dyes. Different technologies have been used for the treatment of textile wastewater and among these technologies' membrane-based ultrafiltration has been used for wastewater treatment. In the present study, synthetic textile wastewater mimicking textile wastewater discharged from the industrial sector was treated by fabricating polysulfone membrane incorporated with carboxylated graphene oxide (c-GO) nanostructure through NIPS method and ultrafiltration assembly was applied for the removal of different dye effluents. Graphene oxide synthesis will be carried out by using modified Hummer's method and then it will be carboxylated through the facile method. The surface morphology of polysulfone membrane was characterized by Scanning Electron Microscopy (SEM), Fourier transform infrared (FTIR) was used to characterize the various functional groups present on the surface of the membrane, X-Ray Diffraction (XRD). Contact angle will be found out to assess the hydrophilicity as well as water permeability of membranes having different concentrations of carboxylated graphene oxide. The thermal stability of the polysulfone membrane was checked through a differential scanning calorimeter (DSC). The inhibitory zone procedure was used to assess the antibacterial activity of the composite membrane. The water permeability of the polysulfone (PSF) membrane with c-GO concentration was greater. With the addition of the c-GO composite, the membrane's contact angle was reduced even further, and these hybrid membranes also have strong antibacterial properties. the c-GO composite was discovered to be an excellent membrane material that improved membrane characteristics.

Keywords: water pollution, wastewater, technologies, treatment, Composite.

FABRICATION AND CHARACTERIZATION OF C-GO EMBEDDED THERMOPLASTIC POLYURETHANE NANO COMPOSITE MEMBRANE FOR TEXTILE WASTEWATER

Maryam Saeeda[1], Sidra Kanwal[1], Muhammad Zahid[1], Zulfiqar Ahmad Rehan[2]

[1] Department of Chemistry, University of Agriculture Faisalabad, Pakistan

[2] Department of Polymer Engineering, National Textile University, Faisalabad 37610, Pakistan

Presenting Authors Email: Maryam Saeeda (maryamsaeeda110@gmail.com)

Water has an important role in our life as it affects various aspects of our life, but nowadays the shortage of fresh and health-friendly water has become a serious issue due to contamination of water by industrial wastes. This contamination of water may be caused by the release of heavy metals and dyes from the textile industries which cause serious health problems. Different technologies have been used for the purification of water and membrane technology is one of them. In the present study, pore-forming agents, nanoparticles and solvents will be added to enhance the performance of polymeric membranes. For this, graphene oxide (GO) was produced using Hummer's technique and then carboxylated graphene oxide was functionalized using chloroacetic acid in the presence of sodium hydroxide. TPU membranes were made using the phase inversion technique with various concentrations of graphene oxide and carboxylated graphene oxide. Scanning electron microscopy (SEM) was used to examine surface morphology, Fourier transforms infrared spectroscopy (FT-IR) was used to detect attached functional groups, and X-ray diffraction (XRD) was used to evaluate crystallinity. The thermal stability of the c-GO membranes was determined using DSC analysis. The contact angle technique was used to assess the hydrophilicity of the carboxylated graphene oxide (c-GO) based thermoplastic polyurethane membrane, as well as the water permeability. The inhibitory zone technique was used to assess the anti-biofouling activity of the composite membrane. The water permeability of the TPU membrane with c-GO concentration was greater. With the addition of the c-GO composite, the membrane's contact angle was reduced even further, and these hybrid membranes also have strong antibacterial properties. C-GO composite was discovered to be an excellent membrane material that improved membrane characteristics.

Keywords: water, industrial waste, heavy metals, contamination, technologies

PREPARATION AND EVALUATION OF POLYMER-BASED ULTRASOUND GEL AND ITS APPLICATION IN ULTRASONOGRAPHY

Sadia Afzal[1], Muhammad Zahid[1], HM Fayzan Shakir[2], Zulfiqar Ahmed Rehan[2]

[1] Department of Chemistry, University of Agriculture, Faisalabad, Pakistan

[2] Department of Materials, School of Engineering and Technology, National Textile University, Faisalabad, Pakistan

Presenting Author: Sadia Afzal (sadiaafzal1408@gmail.com)

Ultrasound imaging is a widely used technique in every health care center and hospital. Ultrasound gel is used as a coupling medium in all ultrasound procedures to replace air between the transducer and the patient's skin as ultrasound waves have trouble traveling through air. This research was performed to formulate an inexpensive alternative to commercially available ultrasound gel as it is expensive and imported from other countries. Different formulations with different concentrations of carbopol 980 (CAR 980) and methylparaben were prepared with natural ingredients such as aloe vera gel and certain available chemicals that have no harmful effects on the skin. To justify the efficiency of the formulations; necessary physicochemical characteristics such as visual clarity, homogeneity, transparency, skin irritation, antibacterial activity, pH, stability, spreadability, conductivity, viscosity, and cost, etc. were evaluated. Moreover, a comparison study was also conducted with commercially available ultrasound gel that was utilized as a control. All samples showed excellent transparency and no microbial growth. The one formulation named S1 met all the requirements as commercial ultrasound gel and produced similar images as commercial ultrasound gel produced. So, this formulation could be used as an alternative to expensive commercial ultrasound gel for taking images in hospitals and medical centers.

Keywords: Ultrasound, commercially, physicochemical, formulation

SILK MEDIATED CHITOSAN FILMS FOR POTENTIAL MEDICAL APPLICATIONS

Muhammad Shoaib ur Rehman[1], Zulfiqar Ali Raza[2], Zulfiqar Ahmad Rehan[1]

[1] Department of Materials, National Textile University, Faisalabad, Pakistan

[2] Department of Applied Sciences, National Textile University, Faisalabad, Pakistan

Presenting Author Email: (rehamanshoaib@gmail.com)

In the present study, silk-mediated chitosan films were prepared using the solvent evaporation technique using a suitable crosslinker. The prepared films were characterized using advanced analytical techniques for their physicochemical, mechanical, and antibacterial activities. The FTIR spectroscopy results indicated some strong hydrogen bonding between silk and the chitosan matrix. The prepared films showed thermal stability above 300°C. The silk reinforced significantly improved the tensile strength and elongation at break. The films exhibited good antibacterial acidity and stability in the aqueous media with an appropriate swelling ratio. The films were observed to be hydrophilic to some extent; thus, could be used to attach some polar drugs for possible biomedical applications.

Keywords: antibacterial, chitosan, film, medical, silk

APPLICATIONS OF BIODEGRADABLE POLYMERS FOR BONE REGENERATION: MINI-REVIEW

Muhammad Nouman Haider

Department of Chemistry, Government College University Faisalabad, 38000, Punjab, Pakistan

Presenting Author Email: (maryambatool6666@gmail.com)

In the past, Orthopaedic surgery and bone regeneration involved the use of non-biodegradable substances. These substances, however, find limitations in their uses because of their non-biodegradability and stress-shielding effects. However, biodegradable materials, on the other hand, gained much attention from researchers and play a crucial role in severe bone defects repair. Among biodegradable polymers find an extensive application and are effective to use because when scaffolds are made up from such kinds of biodegradable materials such as polymers then these kinds of scaffolds serve as a crawling bridge for new bone tissues and provide a platform to cells and growth factors to play their physiological role which then will be degraded, absorbed, and replaced by new bone tissues. The bone regeneration technique is one of the promising techniques these days for treating bone fractures and their renewal. This review article focuses on the applications of various kinds of biodegradable materials such as polymers for bone regeneration. Polymers used for bone regeneration may be natural or synthetic. Natural polymeric materials include collagen, chitosan, fibrin, and silk fibroin, etc. while synthetic polymers include PLA, PCL, PLGA, PGA and PHB, etc. Synthetic biopolymers have several advantages over natural polymers and are more widely used for bone renewal as compared to natural biopolymers. The novelty of this review article is that it gives an overview of various types of polymers used for bone regeneration in a very effective and summarized way.

Keywords: Bone regeneration. Polymers. Ceramics. Metals. Biomaterials

PREPARATION OF BIODEGRADABLE GREEN POLYMERS HYBRID AS ORGANIC POLLUTANT SCAVENGERS

Nayab Siddique, Erum Akbar Hussain

Department of Chemistry, Lahore College for Women University, Jail Road, Lahore

Presenting Author Email: (nayabsiddique999@gmail.com)

Corresponding Authors Email: (erum.hussain@gmail.com)

Water storage and recycling are two major concerns in developing countries like Pakistan. The contaminated water reduces the water quality, is hazardous to aquatic life and causes serious human health problems like diarrhea and leukemia. Due to the lack of proper water recycling infrastructure, different non-biodegradable and costly techniques are used. Alginates-based hybrids have emerged as one of the promising solutions that also help in fulfilling the sustainable development goal of clean water and sanitation and life below water. They served as biosorbents for the treatment of wastewater due to radical characteristics such as hydrophilicity, swelling ability and modifiability. In this research, modified hybrids have been prepared and their swelling behavior was assessed for removal of organic pollutants. The resulting hydrogels were characterized by FTIR and thermal methods of analysis TGA/TDA.

Keywords: Modified hybrid, Adsorption, Alginate, Biocomposite, Waste-water treatments

PREPARATION OF POLYSACCHARIDE BASED BIOCOMPOSITES FOR INORGANIC POLLUTANTS REMOVAL FROM WASTEWATER

Samra Hussain, Erum Akbar Hussain

Department of Chemistry, Lahore College for Women University, Jail Road, Lahore

Presenting Author Email: (samrahussain888@gmail.com)

Corresponding Author Email: (erum.hussain@gmail.com)

The contemporary living style other than advantages also resulted in adverse effects on the environment in the form of air and water pollutants, thus risking human health. The major responsible factors are the water pollutants from industries as treatment of wastewater is not done properly. Among other feasibilities, biocomposites with a three-dimensional (3D) network have the ability to remove these organic and inorganic pollutants from water due to their properties as adsorption potential, porous structure and different functional groups for interaction with pollutants. Among various materials, biocomposites of polysaccharides have attained significant attention due to its biocompatibility, biodegradability, inexpensiveness and non-toxicity. In this research, biocomposites of guar gum were prepared by the conventional method. Swelling behavior and adsorption capacity were determined for the effective removal of pollutants from aqueous media. The biocomposites were confirmed by physiochemical techniques such as FTIR. The prepared biocomposites possess biocompatibility, biodegradability and non-toxicity can have application as adsorbents for removal of pollutants from industry effluents.

Keywords: human health, water pollutant, wastewater, three-dimensional, biocomposites.

DEVELOPMENT AND CHARACTERIZATION OF ABS/RECYCLED PET BLEND FOR ELECTRONIC HOUSING PRODUCTION

Mahnoor Shahzad, Khubab Shaker

Department of Materials, National textile University, Faisalabad, Pakistan

Presenting Author Email: (Noorshahzad4747@gmail.com)

In Pakistan, more than 3.3 million tons of plastic is wasted each year with most of it ending up in landfill sites, unmanaged dumps, or strewn about land water bodies across the country. Not even 30% of the total plastic waste is recycled in Pakistan. The purpose of this research was to make a blend for electronic housing production by incorporating recyclates. Recycled PET (Polyethylene terephthalate) was obtained by mechanical recycling of PET bottles collected from waste. A blend of recycled PET with virgin ABS (Acrylonitrile butadiene styrene) was made as ABS is typically used for electronic housings. ABS possesses excellent impact resistance and antistatic properties, and it is also low cost. Compression moulding was used to make one sheet from virgin ABS and three sheets from ABS/recycled PET blend for characterization. Mechanical properties of ABS/ recycled PET blend and virgin ABS were compared to check whether ABS/recycled PET blend is a suitable substitute for electronic housing production.

Keywords: landfill, plastic waste, recycled, electronic, characterization

CHITOSAN COATED ENVIRONMENT-FRIENDLY FERTILIZERS

Anum Mansoor
Presenting Author Email: (anumansoor514@gmail.com)

Chitosan is a type of biopolymer well known for its biodegradability and non-toxic behavior. The study is based upon chitosan-coated environment-friendly fertilizers. Ordinary Chemical fertilizers are preferable because of their cost-effective property. But little do we know that there are some hidden dangerous and harmful effects to living organisms. Thus, this idea is based on the minimization of the harmful effect by coating the fertilizers with a biopolymer. Chitosan-based fertilizers are easy to prepare due to their abundance in nature, found in shrimps and cramps. These fulfil the nutrients demand of plants just like the chemical fertilizers. Also, having less wastage of resources and leaching prevention makes them cost-effective. Chitosan-based fertilizers also pave the way to the solution of the fertilizer issues in the world in areas like Sub-Saharan African Countries. The increasing soil fertility factor makes them soil-friendly. This would also give birth to opportunities for different people.

Keywords: Biodegradability, Chitosan, non-toxic behavior, biopolymer, fertilizer issues, Sub Saharan African Countries, living organisms.

FABRICATION AND CHARACTERIZATION OF COMPOSITE FROM SUGARCANE BAGASSE AND WASTE PLASTIC FOR DOMESTIC THERMAL INSULATION

Noor Fatima, Khubab Shaker

Department of Materials, National Textile University, Faisalabad, Pakistan

Presenting Author: Noor Fatima (nfprvaz1234@gmail.com)

On this contemporary age the composite materials are become the first material for any engineering production because composite materials have various specific properties like extraordinary strength to weight ratio, low cost, and easiness of fabrication, tensile strength, compressive strength, impact strength, high resistance to thermal which does not realize in pure material or non-composite material. Because of its vast applications, an engineer should skills to fabricate and test a material. In this project, It has been use of two disposable materials i.e., bagasse (wastage of sugarcane) as a natural fiber and plastic waste to produce a composite which will be short random type fiber reinforcement. The composite can be used for thermal insulation that we can use on our rooftops or in any place where we can reduce heat transfer. A key element of our project is to produce something useful with waste material.

Keywords: Sugarcane Bagasse, Fibers, Composites, Thermal properties, Thermal analysis, Waste plastic

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Department of Materials
National Textile University, Faisalabad
Website: www.ntu.edu.pk/icpc
Email icpc@ntu.edu.pk