SPE® COMPOSITES

SEPTEMBER/OCTOBER 2018

Composites Connection™

Official Newsletter of the SPE Composites Division

Reaching Over 1,000 Composites Professionals
In All Industries

Sponsored by:

ABARIS TRAINING
ADDCOMP Polymer Additive Solutions
BYK Additives & Instruments
ASAHI KASEI PLASTICS Advanced Material Solutions
BASF We create chemistry
DSCCONSUMABLES Incorporated
ELIUM by ARKEMA
eXstream ENGINEERING MSC Software Company
HUNTSMAN Enriching lives through innovation
intertek Total Quality. Assured.
JM Johns Manville A Berkshire Hathaway Company
Mitsui Chemicals
MITSUBISHI CHEMICAL
plasmatreat
PlastiComp Long Fiber Reinforced Composites
POLYSCOPE
Schmidt & Heinzmann COMPOSITE EQUIPMENT & MACHINERY
WILLIAMS, WHITE & COMPANY

SPE COMPOSITES
Sept/Oct 2018

Composites Connection™
Advancing Composites Technology Worldwide

Chairman's Message:

Ray Boeman, Ph.D.

The year has gone by incredibly fast, and I personally have never been more excited and optimistic about the future of our industry, and this division. Key elements of shaping this future are engaging new ideas and fostering a growing infusion of young talent through strong support for educational initiatives and programs that enrich the experience of young professionals.

With respect to education, the division continues to expand its activities. We received several excellent proposals this year for our university grant program. Grants were awarded to Auburn University; University of Alabama, Tuscaloosa; University of Southern California; and University of Wisconsin. More information on the grant program can be obtained from the Division's Education Chair, Prof. Uday Vaidya (uvaidya@utk.edu). The division also supports the SPE PlastiVan (www.4spe.org/spe-plastivan/) for which we are expanding our sponsorship from three events to five in the coming year.

I am pleased to report that Creig Bowland, John Gillespie, and Dale Grove were re-elected to their board seats and that Alex Kravchenko, an Assistant Professor at Old Dominion University, was newly elected to the board. I am also pleased to announce that Dale Brosius was re-elected as the Composite Division Councilor.

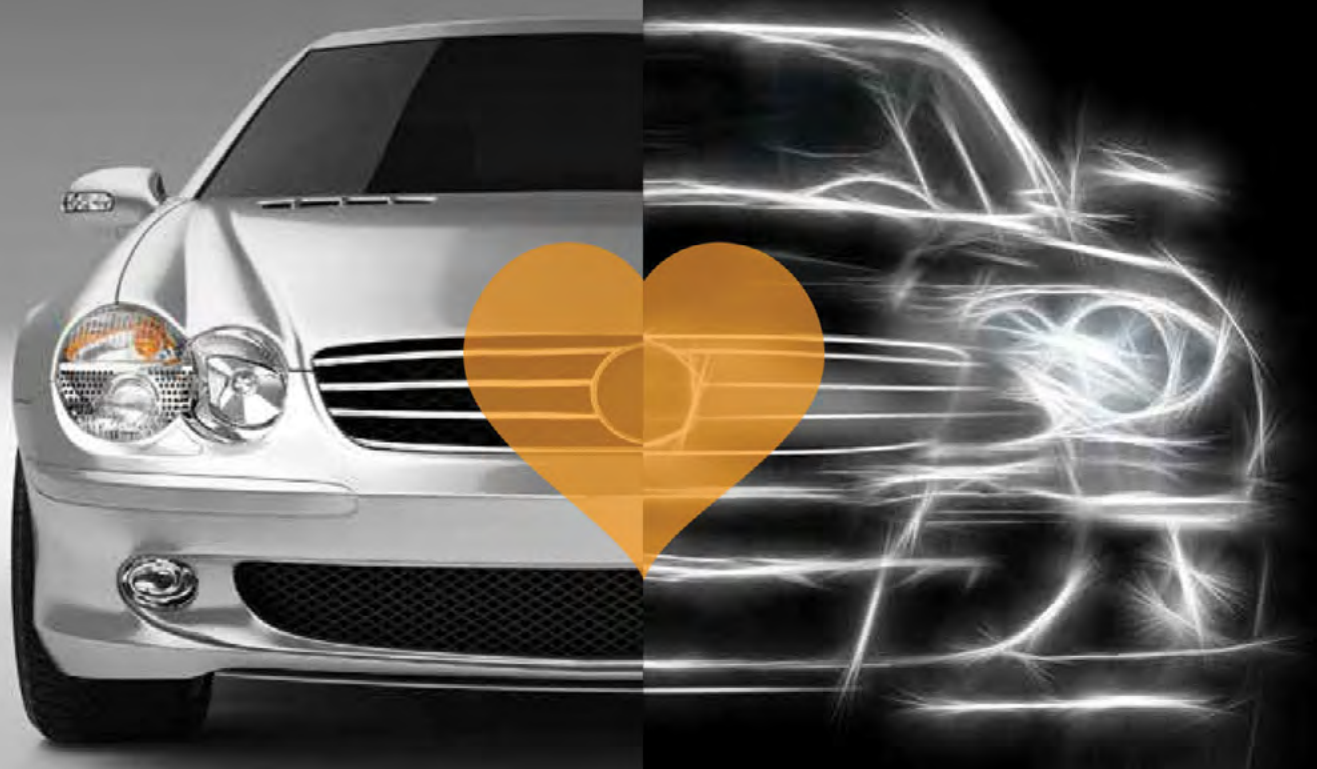
Three of our board members received awards this year in recognition of their leadership. Prof. John Gillespie, Jr. was recognized as Fellow of the Society, and Prof. Uday Vaidya was recognized as Honored Service Member (HSM). The division's Chair-elect, Ian Swentek has been recognized by SAMPE with a Young Professional Emerging Leadership Award. Additionally, the Composites Division has again received the SPE Pinnacle Gold award reflecting significant and committed efforts of our board members.

Under the leadership of Shankar Srinivasan and Rich Caruso, the division organized and moderated five sessions and two keynote presentations for another successful ANTEC conference in May. Please note that the timing for ANTEC has been moved up for 2019 – it will be held March 18-21 in Detroit. As you read this you may very well be attending another tremendously successful ACCE which continues to be this division's keystone event held jointly with the Automotive Division.

I am convinced the Composites Division (www.4spe.org/composites) and the industry overall have a bright future. Please feel free to reach out to me or any of the board members to get more involved and to share your thoughts on where the future may take us.

Best regards,
Ray

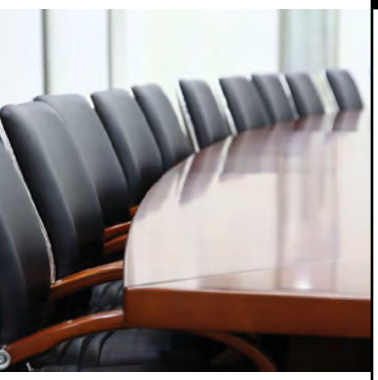
We create chemistry that lets beauty love brains.



BASF high-performance materials are smart — and yes, beautiful. Offering greater design flexibility, lighter weight parts, shorter production times and lower costs than traditional materials, our plastics and polyurethane solutions can be found inside and out of some of the world's most popular automobiles. From seating to instrument panels and consoles to suspension, we're at the heart of many intelligent design and manufacturing solutions. Because at BASF Performance Materials, we create chemistry for a more beautiful tomorrow. And a better ride.

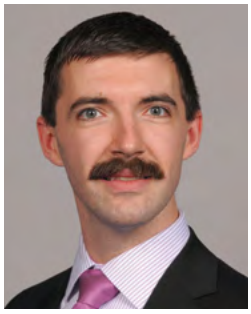
www.performance-materials.basf.us

BASF
We create chemistry



Board of Directors

Ray G. Boeman, Ph.D.
SPE Composites
Director, & Chair
Dir, Energy Partnerships
Energy and Environmental Sciences, Oak Ridge National Laboratory
boemanrg@ornl.gov



Ian Swentek
SPE Composites
Director & Chair-Elect
Applications
Deelopment Engineer
Hexion
London, ON, Canada
Ian.Swentek@hexion.com

Michael Connolly
SPE Composites
Director & Membership Chair
Program Manager-Urethane Composties Huntsman Polyurethanes
Auburn Hills, MI
michael_connolly@huntsman.com

John P. Busel
SPE Composites Director, Intersociety Chair & Secretary
VP, Composites Growth Initiative
American Composites Manufacturers Association
Arlington, VA
busel@acmanet.org

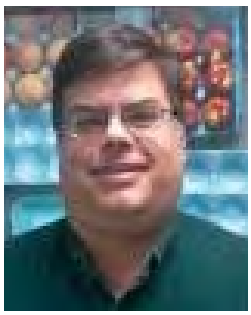
Tim Johnson
SPE Composites
Director & Treasurer
Owner, President at TJohnson LLC
Dayton, OH
TJohnsonLLC@gmail.com

Dale Brosius
SPE Composites Director & Councilor
Chief Commercialization Officer
IACMI
Knoxville, TN
dbrosius@iacmi.org

Uday Vaidya, Ph.D.
SPE Composites Director & Education Chair
Professor in Mechanical, Aerospace & Biomedical Engineering
Chief Technology Officer (CTO), Institute for Advanced Composites Manufacturing Innovation (IACMI)
University of Tennessee
uvaidya@utk.edu

Jim Griffing
SPE Composites Director & Ex-President
Technical Fellow
The Boeing Company
Seattle, WA
james.s.griffing@boeing.com

Pritam Das
SPE Composites Director & Newsletter Chair
Technical Manager
Toray Composites Materials American (CMA)
Tacoma, WA

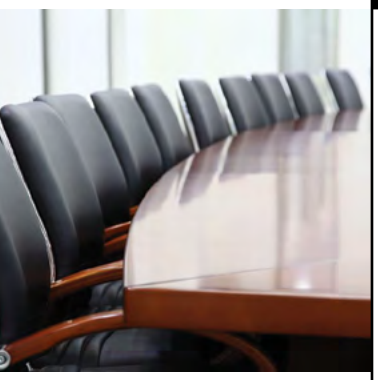


Dale Grove
SPE Composites Director & Award Chair
US Silica
Senior Technology Product Development
grove.dale@hotmail.com

Andrew Rich
SPE Composites Director & Communications Chair
Element 6 Consulting
Hanover, MA
andy@element6consulting.com

Shankar Srinivasan
SPE Composites Director & ANTEC Program Chair
Iowa State University Economic Development Core Facility
Ames, IA
srigshan@iastate.edu

This Issue:



Board of Directors continued...

Frederick S. Deans
SPE Composites Director
Principal
Allied Composite Technologies, LLC
Rochester Hills, MI
fdeans@alliedcomptech.com

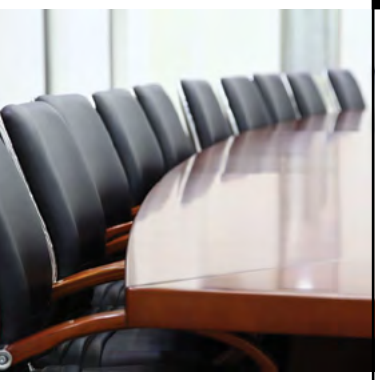
Creig Bowland
SPE Composites Director & Vice President
President, Colorado Legacy Group, LLC
Charlotte, North Carolina
Cbowland@coloradolegacy.com

Antoine Rios
SPE Composites Director
The Madison Group
Madison, WI
Antoine@madisongroup.com

Rich Caruso
SPE Composites Director
CEO Inter/Comp LLC
Falmouth, MA
rpcaruso@gmail.com

Professor Jack Gillespie
SPE Composites Director
Director, Center for Composite Materials
Donald C. Phillips Professor of Civil and Environmental Engineering
University of Delaware
Newark, DE 19716
gillespi@udel.edu

This Issue:



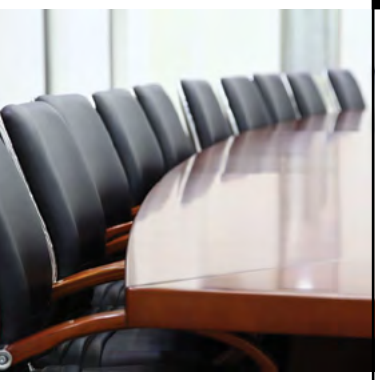
Board of Directors continued...

Enamul Haque, Ph.D.
SPE Composites Director
VP & General Manager of Research and New Product Development
Cooley Group
Pawtucket, RI
haquee@cooleygroup.com

Nippani Rao
SPE Composites Director
President,
RAO Associates
nippanirao@aol.com

Steve Bassetti
SPE Composites Director
Group Marketing Manager Industrial Manufacturing Group, Michelman
Cincinnati, OH
stevebassetti@michelman.com

Mingfu Zhang
SPE Composites Director
Johns Manville
Research Manager, Corporate R&D
Littleton, CO
mingfu.zhang@jm.com



Board of Directors continued...

Christoph Kuhn
SPE Composites Director
Volkswagen
Group Research
Materials And
Manufacturing Methods
Germany
christoph.kuhn@
volkswagen.de

Hicham Ghossein
SPE Composites Director
The University of
Tennessee – Knoxville
PhD student
Knoxville, TN
hghossei@utk.edu

Daniel T. Buckley
SPE Composites
Director (Retired)
Manager of R & D
American GFM
Shrewsbury, VT
dbuck@vermontel.net

Design. Materials. Process.

Building Lighter and Safer Cars for Tomorrow.

FORGED
The NEW Look of Carbon Fiber
Carbon Fiber Thermoset Composites

SymaLITE®
Low Weight Reinforced Thermoplastics (LWRT) Composite Materials

KyronMAX™
Advanced Chopped Carbon Fiber Engineering Thermoplastic Compounds: PA, PPA, PPS, PEI, PEAK, PAEK

GMT
Glass Mat Reinforced Thermoplastics

GMTex®
Structural Thermoplastic Composite Materials

FUNCSTER™
Long Glass Fiber Polypropylene Composites

MITSUBISHI CHEMICAL CARBON FIBER AND COMPOSITES | comusa | PIPER PLASTICS, INC. | MITSUBISHI CHEMICAL COMPOSITES AMERICA | GEMINI | QUADRANT PLASTIC COMPOSITES

Mitsubishi Chemical and our group companies are dedicated to the automotive industry, with R&D and growth in high performance composites aimed at interior, exterior and functional applications. Our focus is on developing and bringing to market lightweight, sustainable, high value and premium asthetic solutions. Look to Mitsubishi Chemical for the ultimate in range, innovation and value.

MITSUBISHI CHEMICAL

THE KAITEKI COMPANY Mitsubishi Chemical Holdings Group

Treasury Report

By: Tim Johnson, Treasurer

The Composite Division continues to maintain a positive budget. Currently the Division has cash on the order of $94K and $74K in investment. With increased income from the ACCE, and Sponsorship of the Newsletter that continues to exceed costs, the Division has steadily increased awards. Notably, the Board recently approved increased support of the SPE Plastivan Program for the coming year, and a substantial increase in the support of Education matching grants which will exceptionally draw on reserves.

The Composites Division continues to provide significant support for student activities at ANTEC and ACCE, and looks forward to the expanded outreach through the Plastivan and Education Grant programs.

Award Winners

By: Dr. Dale Grove

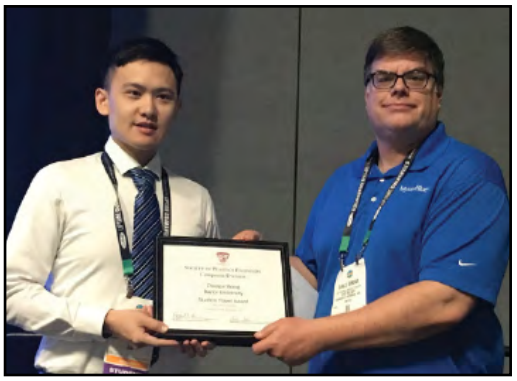
2018 Travel Award Winners

It is with great pleasure that I announce the travel award winners for 2018: Connor Armstrong from the University of Maryland and Zhaogui Wang from Baylor University. Connor is presently striving for his Master's degree as he studies the orientation behavior of carbon microfibers in 3D printing through divergent dies as well as self-healing thermoplastic composites, while Zhaogui plans to get a PhD as he models various fiber orientation models combined with different matrix constitutive algorithms including complex viscoelastic matrix models.

I enjoyed meeting both of them, and I wish them continued success in their endeavors.

continued on page 11...

Connor Armstrong



Zhaugui Wang

2018 Harold Giles Award Winners

The 2018 Harold Giles Scholarship award winners are Mr. Yourri-Samuel Dessureault and Mr. Matthew Swift. Sixteen applications were received this year. It is always a difficult job to select winners based on the many talented applications that the judges received.

continued on page 12...

Mr. Matthew Swift
Undergraduate Student Winner

Mr. Yourri-Samuel Dessureault
Graduate Student Winner

Award Winners continued...

Mr. Dessurealt presently attends Florida State University and is pursuing a PhD degree in Industrial and Manufacturing Engineering. He has an under-graduate degree from Winona State University in Composite Materials Engineering. Active in societies including SPE and SAMPE, plus campus groups Diversity in Research and Engineering of Advanced Materials (DREAM) and Retaining Engineers Through Research Entrepreneurship and Advanced-materials Training (RETREAT), Yourri stood out amongst the other candidates. In addition to reaching out beyond himself, he maintained a high GPA (3.7/4.0). Currently, his research is investigating incorporation of carbon nanotubes (CNTs) into hybrid structures as a means of decreasing the resin layer between prepreg sheets, the overall weight of the structure, and increasing the multifunctional capabilities of the composite. Yourri is also the graduate student lead for the Florida A&M University Orion Spacecraft Collaboration with Lockheed Martin.

Mr. Matthew Swift attends Iowa State University and is pursuing a degree in Materials Engineering with Polymeric Specialization. Mathew was the Composites Manager for the Prisum Solar Car Program, to compete in the World Solar Challenge to race across the continent of Australia in 2017. He has worked as a research assistant in the Soft Materials and Structures Lab as well as the Osteoceramics Lab. He has also maintained an exceptional GPA (3.97/4).

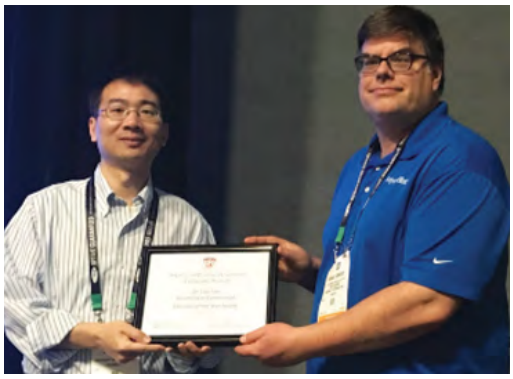
The Composite Division Award Committee is delighted to award to Mr. Yourri-Samuel Dessureault and Mr. Matthew Swift the Harold Giles Graduate Student Scholarships for 2018. The Composite Division will continue to offer the Harold Giles Scholarship to worthy candidates in the future; the scholarship was developed to honor the late Dr. Harold Giles, a past Composite Division Awards Chair. As a former University Professor at the University of North Carolina, Azdel employee, and GE employee, Harold knew full well the value of scholarships to students. He was always a proponent of awarding worthy students and served the society well in this capacity. Harold would have been pleased to know that students like Yourri-Samuel Dessureault and Matthew Swift received this award. So, if you believe that you know of other worthy candidates, please apply in 2019.

Humbly submitted by,
Timothy A. Johnson

continued on page 13...

2018 Educator of the Year Award

The Composite Division of the Society of Plastic Engineers proudly recognizes Dr. Luyi Sun from the University of Connecticut as the 2018 Educator of the Year Award. What drew the judges' attention to this candidate was the large number of students (50 undergraduate researchers / 7 Masters Students / and 12 PhD candidates) that have worked under Dr. Sun's supervision, and the work that he has done in biopolymer, nanosheet, Li ion battery, spray coating, barrier, structural, fluoropolymer coating, and photocatalytic composites areas.



Dr. Luyi Sun
Accepting the 2018 Educator of the Year Award

We hope to honor additional, well qualified Educators on the years to come, so if you are aware of such candidates, please enter them into 2019's Educator of the Year award.

Respectfully submitted,– Dr. Dale A. Grove
Composite Division Awards Chair

SPE Council Summary

By: Dale Brosius

May 7, 2018, Orlando, FL

The SPE Council meetings were held prior to ANTEC 2018 in Orlando, Florida. At the beginning of proceedings, President Raed Al-Zubi called for a moment of silence to honor the passing of two distinguished SPE members, Dr. Costel Denson and Mr. Gautam P. Shah.

The new SPE President, Dr. Brian Grady, introduced himself to Council and presented his thoughts on the state of the Society and the role of the SPE Foundation. He shared his list of priorities which include enhancing the ANTEC experience, committing to SPE's global presence and working on membership retention. He also restated the Executive Board's commitment to full transparency. In addition, this meeting marked the arrival of newlyelected Executive Board members who were seated between Council I and II:

continued on page 15...

This Issue:

SPE Council Summary continued...

- Dr. Raymond Pearson (VP Technology & Education)
- Mr. Scott Eastman (VP Sections)
- Dr. Brian Landes (President-Elect)

Clear and relevant governance is the foundation of a well-run society and SPE continues to refine its policies and by-laws. Several items were amended and approved during Council thanks to the diligent leadership of Councilor Bruce Mulholland. At the Council Committee of the Whole (CCOW), Councilor Babli Kapur was re-elected as Chair.

All presentations and data discussed during Council meetings are available on The Chain on Leadership Lane. We encourage everyone to take the time to review this information to get a full understanding of the Society.

Financial Review

The 2017 audit process is complete and there were no findings. The payment of $1.5MM from Wiley Publishing was re-booked as deferred income over a 10-year period following advice from the auditors. There were no questions from the floor.

The 2018 budget was presented to Council. This budget was approved by the Finance Committee and the Executive Board in March 2018. SPE is projecting a small loss for the year. CSE Farrey reviewed the cost control measures implemented to-date, including the new technology platform and the winding down of earlier contracts. Stephanie Clark continues to generate new non-dues revenue through corporate sponsorships and other programs.

At the time of writing, ANTEC registrations were at 1500. Chief Staff Executive Pat Farrey noted that there were changes to the ANTEC pricing model in 2018 and that 180 volunteer members will attend at no charge. Farrey stated that ANTEC was projected to generate $140k in profit.

SPE Foundation

SPE Foundation Director, Eve Vitale, reviewed the mission and board structure of the organization. She presented the new Impact Report which illustrates the good works provided by the Foundation. She reviewed the PlastiVan successes in 2017 which included the addition of several new educators. The Foundation is looking for assistance in the Western US and with more corporate sponsors. The value of scholarships and grants YTD is $54k.

Strategic Commentary

CSE Farrey outlined his 4 priorities for the Society:

- Technology
- ANTEC
- Staffing
- Profitability

continued on page 16...

This Issue:

Farrey presented the new SPE organizational chart and reviewed future activities and strategic actions which include establishing the Plastics For Life™ event as a major international industry award. He echoed President Grady's commitment to SPE's global members and volunteers after having spent time in Europe, Middle East and East Asia. He stressed the importance of SPE as a people-centric organization.

Farrey outlined the chapter support model as it exists today. He directly addressed the conflict and differences of opinion between what SPE HQ offers, what it charges for services, and what chapters perceive as valuable. Farrey presented detailed slides on all service offerings from SPE which can be viewed on The Chain. Farrey challenged councilors to review ANTEC programming and the new website as examples of improved functionality and new capabilities delivered by SPE staff. From a business perspective, SPE currently spends $600k on servicing small events for a return of $300k. This is not sustainable and is a primary cause of negative operational results for the society.

Related to technology implementation, proposed changes to the member dues model were hotly debated on the Council floor. Several Section councilors objected to a proposed variable pricing dues model that would allow individual chapters to assign a dollar value to their membership. The previous model automatically included 2 group affiliations, including a geography-based Section assignment. A majority of councilors ultimately voted to revert to the previous model.

Executive Board Reports

The Executive Board members continue to work in functional roles as outlined by the new governance model. As such, individual members provided detailed updates on their

continued on page 17...

SPE Council Summary continued...

respective portfolios. Notably, the VP of Technology & Education presented new and exciting details on a partnership with Virginia Tech on Additive Manufacturing coursework. The technical review will take place in the 2nd half of 2018 with an initial course offering scheduled for 2019. This is an excellent opportunity for SPE to create real value for members while providing important technical oversight in a dynamic area for plastics professionals.

After several rounds of fireside chats and continued dialog, Sections and Divisions still have room to maximize the value they can deliver to SPE members. The EB and Council recognize that many members do not crosspollinate and more can be done to ensure vibrant TopCons and networking opportunities. Section and Division leaders can do more to connect with each other and learn about each other's events.

The next Council meeting will be held in Charleston, SC on September 21-22.
Respectfully submitted,
Conor P. Carlin
EB Secretary
VP Marketing & Communications

This Issue:

Award Winning Paper

Hybrid Cellulose-Inorganic Reinforcement Polypropylene Composites: Lightweight Materials For Automotive Applications

Mariana D. Reale Batista, Lawrence T. Drzal
Chemical Engineering and Materials Science Department,
Michigan State University, East Lansing, Michigan, 48824, USA
Composite Materials & Structures Center, Michigan State University,
East Lansing, Michigan, 48824, USA

Alper Kiziltas, Deborah Mielewski
Sustainability and Emerging Materials,
Ford Motor Company, Dearborn, Michigan, 48124, USA

Abstract

Cellulose fibers are attracting considerable attention within the transportation industry as a class of reinforcing agents for polymer composites owing to their low cost, low density, high mechanical properties, and considerable environmental benefits. The objective of this study was to develop hybrid composites combining cellulose fiber with long glass fiber, short glass fiber or talc in a polypropylene (PP) matrix to optimize the overall composite properties. Tensile, flexural and notched Izod impact tests revealed that in general the mechanical properties decreased with increasing cellulose content, however, adding an optimum concentration of the cellulose fiber is a promising alternative to reduce or replace the utilization of inorganic fibers. For applications in automotive 'under-the-hood' and body interior components, the hybrid cellulose-inorganic reinforcement composite approach not only leads to superior weight and cost savings, but also environment benefits over the inorganic reinforced composites.

Introduction

The growing environmental awareness and the demand for the utilization of renewable sources to develop sustainable and recycled materials have promoted the incorporation of cellulose fibers as reinforcement for polymer composites [1]. Cellulosic fiber reinforced polymer composites have been used for many applications such as automotive components, aerospace parts, sporting goods and in the construction industry [2]. The interest in using this material is due to its sustainable nature, low cost, acceptable mechanical properties, elimination of abrasive damage to processing equipment, abundant availability and reduced health concerns [3-7].

Cellulose fiber has a lower density compared to glass fibers and talc fillers, approximately 1.5 g/cm^3 versus 2.5 and 2.8 g/cm^3, respectively. Therefore, its usage in the automotive industry is a central strategy for meeting light weighting and fuel economy standards. Reducing a vehicle's weight by 10 % can improve the fuel economy by 3 to 7 % [8] and contribute to attaining the CAFE standards. Despite the attractiveness of natural fiber reinforced

continued on page 19...

This Issue:

polymer composites, they exhibit lower modulus and strength as well as inferior moisture resistance compared to synthetic fiber reinforced composites, such as glass fiber reinforced polymer composites [9].

Hybridization of cellulose fiber with inorganic fibers is one possibility to improve the mechanical properties of the composites. The advantage of combining two or more fiber types in a single matrix is that the unique properties of one type of fiber could complement what is lacking in the other [10,11]. Hybridization is also a means to combine different fiber properties to develop a multifunctional composite. In this sense, hybrid composites made with cellulose fibers possess advantages in weight reduction, sustainability and higher mechanical properties.

The objective of this study was the development of hybrid composites, investigating the synergistic effects of combining cellulose fiber with long glass fiber (LGF), short glass fiber (SGF) or talc in a polypropylene (PP) matrix. The focus was on increasing the biobased content by reducing the amount of inorganic reinforcement. The mechanical, thermal and morphological properties of the resulting composites were evaluated in terms of feasibility for automotive applications to decrease the environmental impact while maintaining the product safety, durability, and quality.

Experimental

Materials

PP homopolymer pellets were supplied from three commercial sources (Company X, Company Y and Company Z) listed in Table I. Cellulose was obtained from a commercial source combined with PP in the form of pellets from two sources of production of 2014 (Cellulose A) and 2016 (Cellulose B). The inorganic reinforcements were supplied in the form of master-batch pellets and their 'as received' composition can be observed in Table I.

continued on page 20...

Table I: *As received pellets compositions*

Pellets compositions	
Composition	**Comments**
Homopolymer PP pellets	Kindly obtained from local sources: Neat PP X from Company X (4.0 g/10 min, ASTM D1238) Neat PP Y from Company Y (37 g/10min, ISO 1133) Neat PP Z from Company Z (17 g/10min, ISO 1133)
30 wt. % Cellulose filled PP pellets	Kindly provided by local source: Cellulose A from 2014 Cellulose B from 2016
30 wt. % LGF filled PP pellets	Used in instrumental panel substrates
40 wt. % (SGF / Mica) filled PP pellets	Used in console substrate
42.5 wt. % Talc filled PP pellets	Used in head lamp housing
33 wt. % SGF filled PP pellets	Used in console substrate

This Issue:

Award Winning Paper continued...

Processing

The composites were prepared by injection molding (Boy Machines Model 80M) and the total fiber mass content was fixed at 30 wt. %, with the cellulose concentration varying gradually from 0 wt. % up to 30 wt. %. Table II summarizes the composite compositions and sample identification codes, for each constituent source. To achieve the desired inorganic reinforcement/cellulose concentration, the as received master-batch pellets from Table I were mixed and diluted with neat PP as needed.

Table II: *Sample identification codes and composite composition for each constituent source*

LGF / Cellulose hybrid composites			
Sample code	**LGF (wt. %)**	**Cellulose A (wt. %)**	**PP from Company X (wt. %)**
Neat PP X	0	0	100
LGF/Cellulose A (30/0)	30	0	70
LGF/Cellulose A (20/10)	20	10	70
LGF/Cellulose A (15/15)	15	15	70
LGF/Cellulose A (10/20)	10	20	70
LGF/Cellulose A (0/30)	0	30	70
(SGF / Mica) / Cellulose hybrid composites			
Sample code	**(SGF/Mica) (wt. %)**	**Cellulose B (wt. %)**	**PP from Company Y (wt. %)**
Neat PP Y	0	0	100
(SGF/Mica)/Cellulose B (30/0)	30	0	70
(SGF/Mica)/Cellulose B (20/10)	20	10	70
(SGF/Mica)/Cellulose B (15/15)	15	15	70
(SGF/Mica)/Cellulose B (10/20)	10	20	70
(SGF/Mica)/Cellulose B (0/30)	0	30	70
Talc / Cellulose hybrid composites			
Sample code	**Talc (wt. %)**	**Cellulose B (wt. %)**	**PP from Company Y (wt. %)**
Neat PP Y	0	0	100
Talc/Cellulose B (30/0)	30	0	70
Talc/Cellulose B (20/10)	20	10	70
Talc/Cellulose B (15/15)	15	15	70
Talc/Cellulose B (10/20)	10	20	70
Talc/Cellulose B (0/30)	0	30	70

This Issue:

Award Winning Paper continued...

SGF / Cellulose hybrid composites			
Sample code	SGF (wt. %)	Cellulose B (wt. %)	PP from Company Z (wt. %)
Neat PP Z	0	0	100
SGF/Cellulose B (30/0)	30	0	70
SGF/Cellulose B (20/10)	20	10	70
SGF/Cellulose B (15/15)	15	15	70
SGF/Cellulose B (10/20)	10	20	70
SGF/Cellulose B (0/30)	0	30	70

Prior to injection molding, the pellets were dried at 60°C overnight to reduce moisture content. Then they were mixed and fed into the hopper on the injection molding machine. No extrusion process was used in this research. Therefore, it is worth mentioning that it consists of an efficient one-step injection process that can speed up part production. To avoid cellulose degradation the maximum injection temperature was limited to 193°C (380 F). Composites were molded into ASTM test specimens and conditioned in a room at 23 ± 2°C and 50 ± 5% relative humidity for 7 days before conducting mechanical tests.

continued on page 22...

This Issue:

Award Winning Paper continued...

Testing procedure and characterization

Mechanical test

Tensile and flexural tests were conducted in an Instron 3366 in general compliance to ASTM D638-10 and ASTM D790-10, respectively. The tensile test used a crosshead speed of 5.0 mm/min, a 5kN load cell and a 50 mm extensometer was attached to the gauge section of the specimen to measure the displacement. The stress at maximum load, strain at maximum load and Young's modulus were determined. At least six specimens were tested for each data set.

The flexural tests also used a 5kN load cell, at a rate of 1.0 mm/min and a support span length of 50 mm. The stress at 5% strain and flexural modulus were determined.

The impact strength of notched Izod specimens was measured according to ASTM D256-10. Tests were conducted on a Testing Machines Inc. 43-02-03 model impact test machine with a 2 lb. pendulum, and the results are the average from ten specimens of each data set.

All the mechanical tests were run in an environmentally conditioned room at 23 ± 2°C and 50 ± 5% relative humidity.

Thermal characterization

Melting and crystallization behavior of the neat polymer matrix and the composites were measured using a TA Instruments Q2000 differential scanning calorimetry (DSC). To remove the thermal history, samples were heated from room temperature to 250 °C at a rate of 20 °C/min and held isothermally at 250 °C for 5 minutes. Then, they were cooled to -50 °C at a rate of 10 °C/min and held at -50 °C for 5 minutes before reheating to 250 °C at a rate of 10 °C/min.

The melting and crystallization behavior were collected from the heat flow versus temperature curves. Melting temperature (T_m) was assigned as the peak minimum of the endothermic melt transition, and crystallization temperature (T_c) as the peak maximum of the exothermic crystallization transition. The enthalpy of melting (ΔHm) and enthalpy of crystallization (ΔHc) were also measured from these curves. Specimen weight was in the range of 7 to 9 mg and the results were averaged from three specimens of each sample.

The thermal stability of the neat PP and the composites was investigated by thermal gravimetric analysis (TGA) curves using a TA Instruments Q500. The thermograms were obtained under constant air flow rate of 50 $mL \cdot min^{-1}$ and the samples were heated up to 600 °C at a rate of 10 °C/min. The sample weight was in the range of 8 to 10 mg. Three replicates of each sample were performed.

Scanning electron microscopy (SEM)

A Carl Zeiss EVO LS 25 scanning electron microscope with accelerating voltage of 15 keV was used to observe the morphology of the impact fracture surface of the samples. The samples were sputter-coated with platinum to prevent surface charging.

Results and discussion

Mechanical properties

Tensile properties

Figures 1, 2 and 3 show the effects of different fiber combinations on the tensile properties of the composites, along with the neat PP. Overall, the addition of inorganic fibers and cellulose led to a considerable increase in the maximum tensile stress (Figure 1) and Young's modulus (Figure 2) in comparison to the neat PP. The inorganic fibers produced the greatest

continued on page 24...

This Issue:

From high-performance structural adhesives to stronger, faster composite resin systems, Huntsman understands the demands for faster processing and reduced production cycles. With over 60 years' experience developing adhesive and composite resin technologies, Huntsman scientists work with designers and engineers every day to help solve increasingly complex design issues.

Give us your challenge and see what we can do.

For more information, visit:
www.huntsman.com/auto

HUNTSMAN

Enriching lives through innovation

Award Winning Paper continued...

improvement in these properties. An increase of 232% and 401% for tensile stress and modulus, respectively, was observed for LGF/Cellulose A (30/0) composites compared to neat PP X (Figures 1a, 2a). As the cellulose content was increased to replace a portion of the LGF, SGF/Mica or SGF, the tensile stress and modulus of the composites decreased. For these composites which contain glass fiber, this trend is expected due to the stronger and stiffer properties of the inorganic fiber compared to cellulose [12]. As reported in the work of Thwe and Liao [9], the tensile strength and modulus of hybrid composites of bamboo fiber and glass fiber in PP gradually increased with increasing glass fiber to bamboo fiber ratio.

Note that even with the incorporation of 30 wt. % cellulose, the tensile stress and modulus of the composites are still higher compared to neat PP. The addition of 30 wt. % Cellulose B promotes an increase of 18% and 129% for tensile stress and modulus, respectively, in comparison with neat PP Y (Figures 1b, 1c, 2b, 2c). SGF/Cellulose B (15/15) hybrid composites increased the tensile stress and modulus by 58% and 171%, respectively, in comparison with neat PP Z (Figures 1d, 2d) and is suitable for body interior (console substrate, wiring harness) and under-the-hood (battery and power distribution box covers) applications.

The tensile stress at maximum load for the composites made of talc and cellulose did not follow the previous trend (Figure 1c). Talc/Cellulose B (10/20) composites exhibited an increase of 15% for the tensile stress in comparison with Talc/Cellulose B (30/0) composites, which represents an advantage of the hybrid composite over the composite reinforced with talc only.

continued on page 25...

Award Winning Paper continued...

The tensile strains at maximum load of the composites were markedly lower than neat PP (Figure 3) with no considerable difference in strain as a function of fiber content.

Overall, the mechanical properties in tension show that the hybridization of cellulose with inorganic reinforcements produced beneficial enhancements.

Flexural properties

Figures 4 and 5 show the flexural properties of the polymer matrix and the composites. Flexural properties exhibited a similar trend as the tensile results, revealing that in general the mechanical properties decreased as the amount of cellulose increased. The stress at 5% strain achieved a 59% enhancement for LGF/Cellulose A (0/30) compared to neat PP X (Figure 4a).

The presence of cellulose increased the stress at 5% strain for Talc/Cellulose B composites (Figure 4c) with the highest strength of 56.3 MPa for Talc/Cellulose B (10/20) hybrid composites. It represents an increase of 10% in comparison with Talc/Cellulose B (30/0) composites.

Similar to the tensile modulus results, all composites showed higher flexural modulus than neat PP (Figure 5).

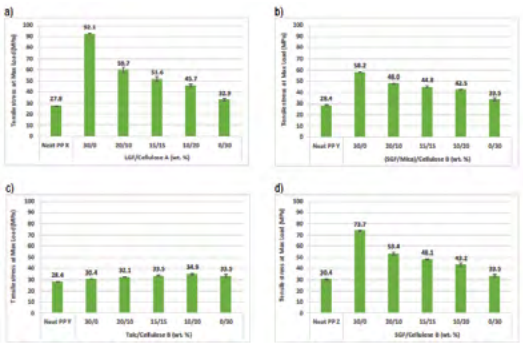


Figure 1: Tensile stress at maximum load of a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

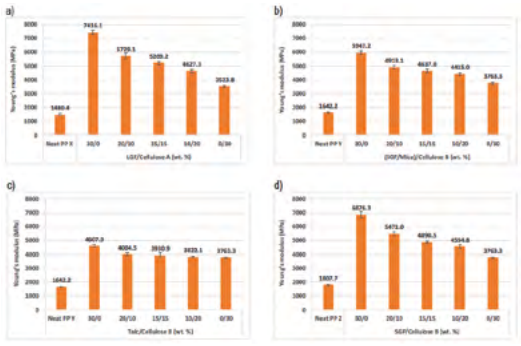


Figure 2: Young's modulus of a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

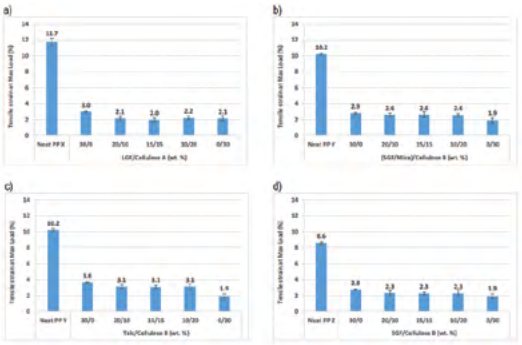


Figure 3: Tensile strain at maximum load of a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

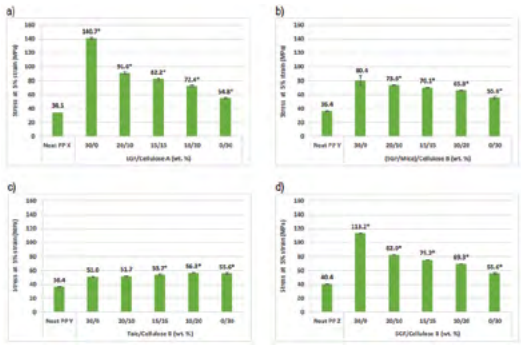


*Figure 4: Stress at 5% strain of a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP. *Specimens broke before 5% strain; maximum stress value used.*

This Issue:

Award Winning Paper continued...

Impact properties

The addition of cellulose fibers acted as stress concentrators and reduced the impact strength of the composites, as shown in Figures 6a, 6b and 6d. A decrease in impact strength of PP was also observed when sisal fibers were added to PP by unnotched Izod impact test [13].

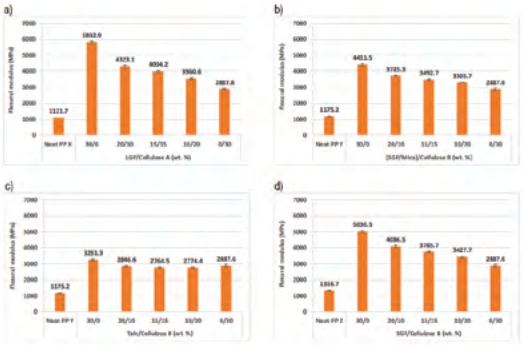


Figure 5: Flexural modulus of a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

Figure 6a shows that LGF/Cellulose A (15/15) composites exhibited an impact strength 91% higher than LGF/Cellulose A (0/30). As reported by Panthapulakkal and Sain [14] for hemp/glass fiber/PP composites, the impact strength is enhanced with an increase in glass fiber content due to the improved resistance offered from the glass fibers in the composites. For the hybrid composites made of SGF/Cellulose B (Figure 6d) the impact strength is still preserved in comparison with the neat PP Z. The SGF/Cellulose B (20/10) composites increased the impact strength by 34% and the SGF/Cellulose B (10/20) composites still exhibited 16% increase compared to neat PP Z. No change in impact strength was observed when adding cellulose to talc composites (Figure 6c).

Morphological properties

Figures 7, 8, 9 and 10 show the impact fracture surface of LGF/Cellulose A, (SGF/Mica)/Cellulose B, Talc/Cellulose B and SGF/Cellulose B composites, respectively, along with the neat PP. In the micrographs, the direction of impact is from right to left. The samples investigated are neat PP and composites reinforced with inorganic reinforcement/cellulose at 30/0, 15/15 and 0/30 (wt.%).

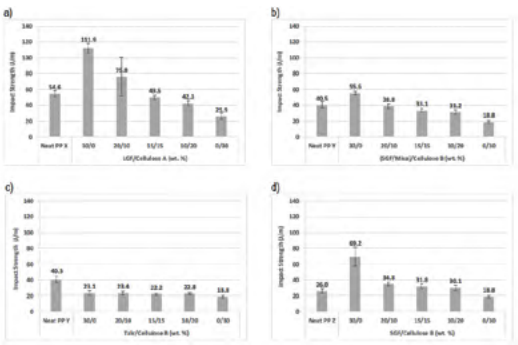
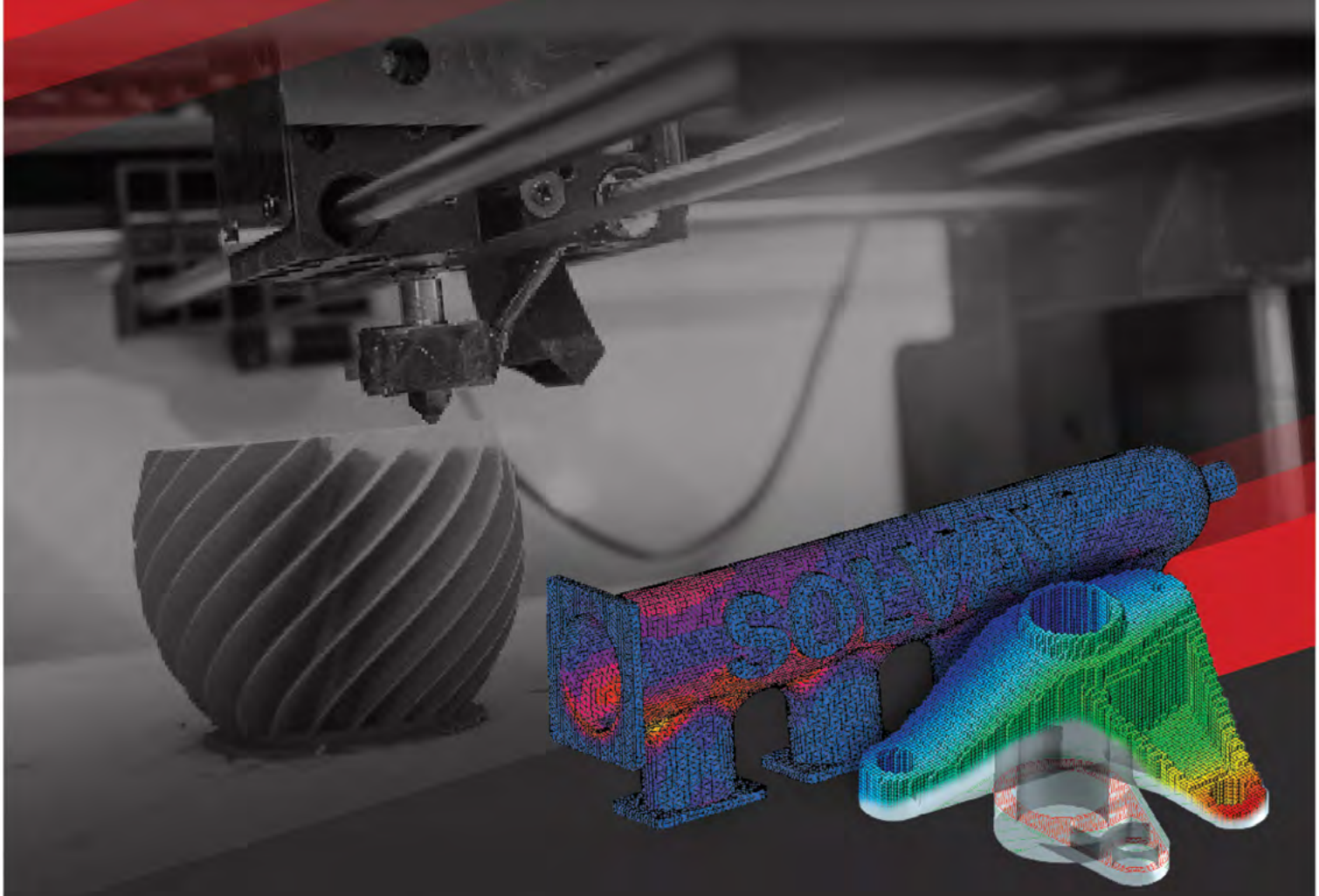


Figure 6: Impact strength of a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

It can be observed that the basic deformation mechanism of all unmodified PP is shear yielding (Figures 7a, 8a, 9a, 10a). There was no significant difference between the surface morphologies of the Cellulose A and Cellulose B composites (Figures 7d, 8d, 9d, 10d). Since the cellulose fiber is hydrophilic the micrographs do not show evidence of interfacial interaction between the cellulose and the matrix, and this incompatibility may reduce the mechanical properties. This observation is in agreement with the reduced tensile, flexural and impact properties measured on the cellulose reinforced composites. Cellulose fiber fracture is also clear from Figure 7d.

continued on page 28...

This Issue:



Print Right The First Time

Additive Manufacturing Simulation for Plastics

Digimat

Award winner holistic simulation platform for additive manufacturing of polymers and composites, delivering a unique combination of material engineering, process simulation and structural analysis solutions.

e-Xstream

MSC Software Company

HEXAGON

www.e-Xstream.com/additive-manufacturing

Award Winning Paper continued...

The micrographs of specimens reinforced with glass fiber (long or short) exhibited fiber pull out (Figures 7b, 8b, 10b) that indicates poor interfacial adhesion between the glass fiber and matrix. This behavior is in agreement with results reported by Arbelaiz et al. [11]. The distribution of the fibers in the matrix appears to be good however.

With the incorporation of 15 wt. % cellulose (Figures 7c, 8c, 10c), holes from the pulled out glass fibers are still observed. In the SEM micrographs glass fiber can be distinguished from cellulose by their difference in diameter. Good distribution of the hybrid fibers is observed.

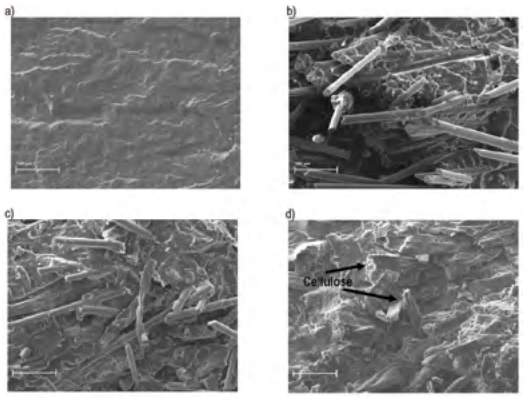


Figure 7: SEM *micrographs of a*) *Neat* PP X, *b*) LGF/*Cellulose* A (30/0), *c*) LGF /*Cellulose* A (15/15) *and d*) LGF/*Cellulose* A (0/30).

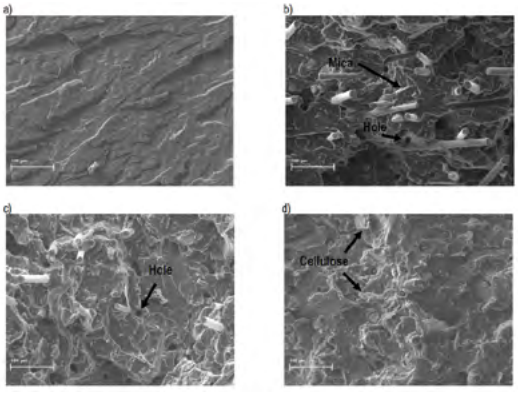


Figure 8: SEM *micrographs of a*) *Neat* PP Y, *b*) (SGF/*Mica*)/*Cellulose* B (30/0), *c*) (SGF/*Mica*)/*Cellulose* B (15/15) *and d*) (SGF/*Mica*)/*Cellulose* B (0/30).

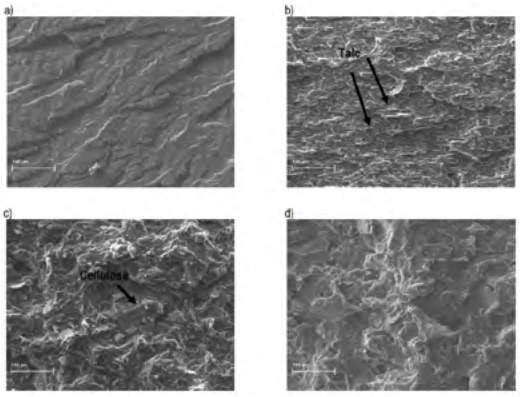


Figure 9: SEM *micrographs of a*) *Neat* PP Y, *b*) *Talc/Cellulose* B (30/0), *c*) *Talc/Cellulose* B (15/15) *and d*) *Talc/Cellulose* B (0/30).

Figure 8b identifies a mica particle and Figure 9b identifies the platelet talc filler. Micrographs show good talc distribution in the matrix with no large aggregates present.

Overall, the composites show good fiber distribution, confirming that the one step injection process with no compatibilizer successfully blended the hybrid materials in the PP. It shows the advantage of using these pre-compounded pellets to speed up the process production.

Thermal properties

TGA

Figure 11 summarizes the thermal stability of the composites, where Td is assigned as the temperature at the maximum rate of decomposition determined from the derivative thermogravimetric (DTG) curves. All composites are more stable than the neat PP and the Td of the inorganic reinforced composites manifested the greatest increases. The incorporation of 30 wt. % cellulose also increased the thermal stability relative to PP but to a lesser degree. The inorganic reinforcement/cellulose composites reinforced at 20/10, 15/15 and 10/20 (wt. %) have similar thermal stability. This provides an opportunity for hybrid composites made of cellulose to be considered for challenging conditions on under-the-hood applications.

Award Winning Paper continued...

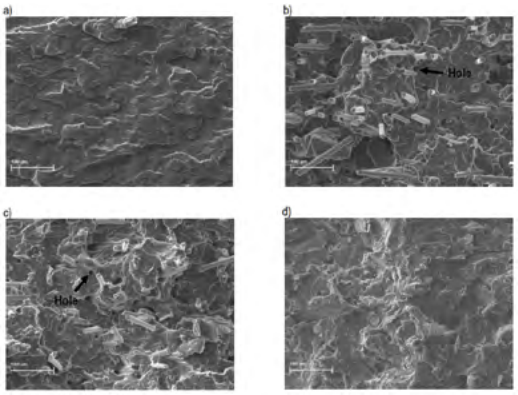


Figure 10: SEM micrographs of a) Neat PP Z, b) SGF/Cellulose B (30/0), c) SGF/Cellulose B (15/15) and d) SGF/Cellulose B (0/30).

Thermal stability was also defined by the temperature at which 1% and 10% weight loss occurred, T_1 and T_{10}, respectively, as shown in Figures 12 and 13. All hybrid composites are more thermally stable than the neat PP. The composites that contain cellulose possess lower T_1 and T_{10} compared to the composites with inorganic reinforcements only. However, this behavior is not observed for LGF/Cellulose A composites (Figures 12a, 13a).

Figure 14 shows the residual weight percent at 587 °C. The residue decreased with cellulose content at this temperature and the residue is mainly from the inorganic reinforcements.

DSC

Figure 15 summarizes the T_c and T_m of PP and the composites. It indicates an increase in the T_c for all composites compared to neat PP, which reveals that the fibers act as nucleating agents leading to a faster crystallization of PP matrix. This is a beneficial development which can increase the rate of part production. The DSC measurements indicate that the addition of cellulose had minimal effect on the melting temperatures.

continued on page 30...

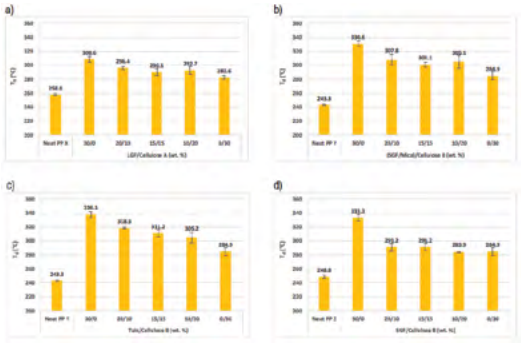


Figure 11: Temperature at the maximum rate of decomposition determined from DTG curves for a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

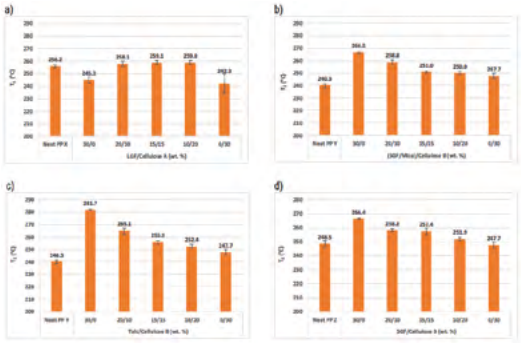


Figure 12: Temperature at 1% weight loss from TGA curves for a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

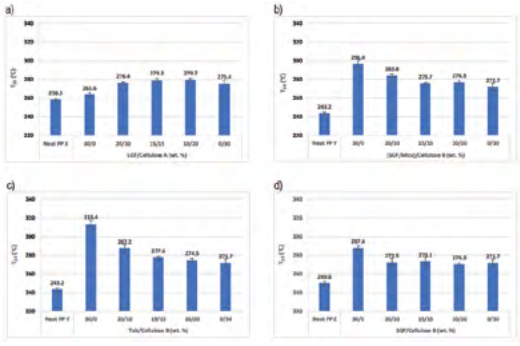


Figure 13: Temperature at 10% weight loss from TGA curves for a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

This Issue:

Award Winning Paper continued...

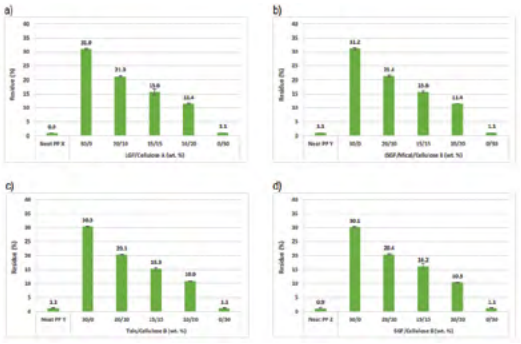


Figure 14: Residual weight percent at 587 °C from TGA curves for a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites along with neat PP.

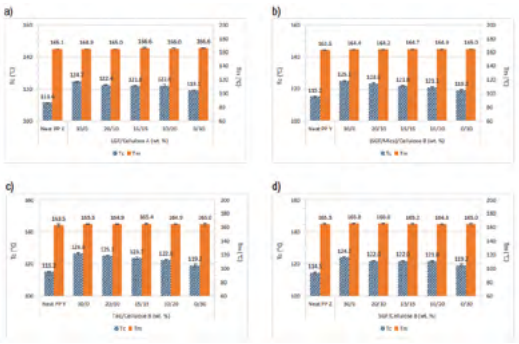


Figure 15: Crystallization and melting temperatures for a) LGF/Cellulose A, b) (SGF/Mica)/Cellulose B, c) Talc/Cellulose B and d) SGF/Cellulose B composites.

The ΔH_c and ΔH_m decreased with the incorporation of fibers (Table III), with no significant dependence on fiber loading. This trend is in agreement with the results of Huda et al. [15], where a reduction of the melting and crystallization enthalpies of the composites was observed with the addition of recycled newspaper cellulose fibers and talc compared to neat PP.

Composites reinforced with 30 wt. % cellulose have, marginally, the lowest enthalpies. It may be that cellulose was hindering polymer chain movement during heat cycling, as observed by Langhorst et al. [8].

Summary and Next Steps

In this study, we investigated the hybridization of cellulose fiber with several inorganic fibers to reinforce a PP matrix for automotive applications. Composites were processed by injection molding with total reinforcement content kept at 30 wt. %. Overall, it was found that the hybrid fibers acted as an effective reinforcement. Good synergetic effects on the mechanical, thermal and morphological properties of the hybrid composites were observed.

Results from tensile, flexural and notched Izod impact tests show that in general the mechanical properties decreased with increasing cellulose content. However, composites with an optimum amount of cellulose fiber may reduce or replace a portion of the inorganic reinforcements in many applications. LGF/Cellulose A composites exhibited the best mechanical properties. However, when comparing thermal properties, (SGF/Mica)/Cellulose B, Talc/Cellulose B and SGF/Cellulose B composites exhibited similar or even superior properties.

continued on page 31...

Composition	LGF/Cellulose A		(SGF/Mica)/Cellulose B		Talc/Cellulose B		SGF/Cellulose B	
(wt. %)	ΔH_c (J/g)	ΔH_m (J/g)	ΔH_c (J/g)	ΔH_m (J/g)	ΔH_c (J/g)	ΔH_m (J/g)	ΔH_c (J/g)	ΔH_m (J/g)
Neat PP X	89.8 ± 3.3	86.4 ± 3.6	-	-	-	-	-	-
Neat PP Y	-	-	96.7 ± 0.2	95.8 ± 0.3	96.7 ± 0.2	95.8 ± 0.3	-	-
Neat PP Z	-	-	-	-	-	-	104.6 ± 2.9	104.0 ± 5.5
(30/0)	75.1 ± 0.6	75.7 ± 1.6	67.8 ± 1.8	67.3 ± 0.8	70.1 ± 1.4	69.9 ± 1.5	73.6 ± 1.6	72.0 ± 0.2
(20/10)	73.5 ± 1.5	73.4 ± 3.4	68.7 ± 3.1	67.8 ± 3.3	71.6 ± 1.7	68.6 ± 0.3	69.4 ± 3.0	67.9 ± 0.3
(15/15)	74.3 ± 3.8	63.6 ± 6.7	69.2 ± 2.8	66.8 ± 1.4	69.2 ± 2.7	64.2 ± 2.6	70.6 ± 3.8	71.3 ± 3.2
(10/20)	70.7 ± 3.2	68.1 ± 3.1	66.9 ± 2.8	68.0 ± 2.6	70.6 ± 0.7	68.0 ± 1.4	73.3 ± 1.0	71.6 ± 2.1
(0/30)	67.6 ± 3.3	63.0 ± 0.6	62.3 ± 5.0	62.5 ± 5.3	62.3 ± 5.0	62.5 ± 5.3	62.3 ± 5.0	62.5 ± 5.3

Table III: Enthalpies of crystallization and melting for neat PP and composites

This Issue:

Award Winning Paper continued...

The T_c for all composites increased in comparison to neat PP, revealing the fibers ability to act as nucleating agents and speed part production. SEM showed good fiber distribution, however due to the inherent lack of compatibility between cellulosic fibers and polymeric matrices such as PP, the use of a compatibilizer is recommended as future work to improve the adhesion of the fiber to the PP matrix leading to even greater mechanical and thermal performance of the hybrid composites.

Cellulose fiber polymer composite properties can be improved by the hybridization with inorganic reinforcements. This work shows that hybridization of cellulose fiber with inorganic reinforcements in polypropylene composites has the potential to reduce the use of inorganic fibers in different automotive applications, leading to weight and cost savings, and contributing to sustainability of composites.

Acknowledgements

We would like to thank you the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for a doctoral scholarship to Batista through the Science Without Borders program (99999.013655/2013-02). The authors also would like to thank the Sustainability and Emerging Materials Group at Ford Motor Company that contributed to this work during a summer internship, especially Amy Langhorst and Emily Pfaff. A special thank you to the MSU Composite Materials and Structures Center research staff, especially Mike Rich, Per Askeland, Brian Rook and Ed Drown for their assistance.

Bibliography

1. Saba, N., P. Tahir and M. Jawaid, "A Review on Potentiality of Nano Filler/Natural Fiber Filled Polymer Hybrid Composites", Polymers, 6:8, 2247-2273 (2014).
2. Jawaid, M. and H.P.S. Abdul Khalil, "Cellulosic/synthetic fibre reinforced polymer hybrid composites: A review", Carbohydrate Polymers, 86:1, 1-18 (2011).
3. Erbas Kiziltas, E., A. Kiziltas and E. C. Lee, "Structure and properties of compatibilized recycled polypropylene/recycled polyamide 12 blends with cellulose fibers addition", Polymer Composites, 2017.
4. Kiziltas, A. and E. C. Lee, "Sustainable Composites Based on Polyamides and Cellulose Fibers," SPE ACCE, Sept. 2014, Troy (Detroit), MI.
5. Kiziltas, A., D. J. Gardner, Y. Han and H.-S. Yang, "Mechanical Properties of Microcrystalline Cellulose (MCC) Filled Engineering Thermoplastic Composites", Journal of Polymers and the Environment, 22:3, 365-372 (2014).
6. Birch, A., C. Dal Castel, A. Kiziltas, D. Mielewski and L. Simon, "Development of cost effective and sustainable polyamide blends for automotive applications," SPE ACCE, Sept. 2015, Troy (Detroit), MI.
7. Zhu, J.H., A. Kiziltas, E. C. Lee and D. Mielewski, "Bio-based polyamides reinforced with cellulose nanofibers-processing and characterization," SPE ACCE, Sept. 2015, Troy (Detroit), MI.
8. Langhorst, A., A. Kiziltas, D. Mielewski and E. Lee, "Selective dispersion and compatibilizing effect of cellulose filler in recycled PA6/ PP blends," SPE ACCE, Sept. 2015, Troy (Detroit), MI.
9. Thwe, M.M. and K. Liao, "Effects of environmental aging on the mechanical properties of bamboo–glass fiber reinforced polymer matrix hybrid composites", Composites Part A: Applied Science and Manufacturing, 33:1, 43-52 (2002).
10. Thwe, M.M. and K. Liao, "Durability of bamboo-glass fiber reinforced polymer matrix hybrid composites", Composites Science and Technology, 63:3, 375-387 (2003).
11. Arbelaiz, A., B. Fernández, G. Cantero, R. Llano-Ponte, A. Valea and I. Mondragon, "Mechanical properties of flax fibre/polypropylene composites. Influence of fibre/matrix modification and glass fibre hybridization", Composites Part A: Applied Science and Manufacturing, 36:12, 1637-1644 (2005).
12. Romanzini, D., H.L. Ornaghi Junior, S.C. Amico and A.J. Zattera, "Preparation and characterization of ramie-glass fiber reinforced polymer matrix hybrid composites", Materials Research, 15:3, 415-420 (2012).
13. Jarukumjorn, K. and N. Suppakarn, "Effect of glass fiber hybridization on properties of sisal fiber–polypropylene composites", Composites Part B: Engineering, 40:7, 623-627 (2009).
14. Panthapulakkal, S. and M. Sain, "Injection-molded short hemp fiber/glass fiber-reinforced polypropylene hybrid composites—Mechanical, water absorption and thermal properties", Journal of Applied Polymer Science, 103:4, 2432-2441 (2007).
15. Huda, M.S., L.T. Drzal, A.K. Mohanty and M. Misra, "The effect of silane treated- and untreatedtalc on the mechanical and physico-mechanical properties of poly(lactic acid)/newspaper fibers/talc hybrid composites", Composites Part B: Engineering, 38:3, 367-379 (2007).

This Issue:

Sponsor the Newsletter

Quarter page ad or logo ad:
3.75" x 5" $500

Half page ad:
7.5" x 5.5", 5" x 7.5", 4" x 8.5".....$750

Full page ad:
7" x 10", 8.5" x 11" $1,250

Contact: Teri Chouinard CBC, APR
SPE Composites Division
Sponsorship Chair
C/O Intuit Group, Inc.
phone 248.701.8003
Teri@IntuitGroup.com

Please provide Logos as JPG and EPS files (send both if possible)
Please provide Ads as High Resolution PDF files
Advertising with the SPE Composites Division is inexpensive and easy. Please help us to promote the benefits of Composites in Industry.

Sponsoring the Newsletter enables the SPE to communicate the benefits of the composites in many industries, which fortifies your marketing efforts.

- **Support your SPE Composites Division**
- **Reach 1,000 Composites Professionals 3 Times a year via the E-Newsletter**
- **Also reach 1,070 SPE Composites Division Linked In Members 3 times a year and an additional 11,492 COMPOSITES Linked In Members Secondary group where the link to the newsletter is posted year-round**
- **Reach many more as a sponsorship also includes your logo on our website, www.composites.4speorg with a link to your company**
- **Maximize your exposure to the customers & the trade**
- **Stay informed on the latest composites activity**

Increase your presence on the web leading to more sales by sponsoring our Electronic Newsletter which is published on the SPE Composites Division Website and emailed to all Division Members (1,000 approx.) 3 times annually. Rates include 3 issues (not on calendar basis - published approx. Nov/Dec, Mar/April, July/August). All ads include a link to your website increasing your exposure on the worldwide web exponentially. Sponsorship also includes your logo ad with a link to your website on www.composites.4speorg further increasing your presence on the Web as a Leader in Composites Technology.