spe COMPOSITES

FALL/WINTER 2023

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Official Newsletter of the SPE Composites Division

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Chairman's Message:

Oleksandr G. Kravchenko, Ph.D.

Dear All,

It is my great pleasure to step into the position of SPE Composites Division (CD) Chair. I remember attending SPE conferences as a student and appreciating the ability to learn from and meet leading researchers in the field, who come from various backgrounds, including academia, industry and national labs. I have since had the privilege of first volunteering on the CD Board while a postdoctoral research associate at Case Western Reserve University and later on the CD Board after joining Old Dominion University. All these years I have enjoyed the ability to serve on the CD Board in various capacities from co-organizing ACCE and ANTEC meetings to participating in various student Awards Committees and serving as a Chair-Elect over the last two years.

The synergy between students and professionals in our society is a key component of what drives and advances innovation in plastics and composites and will continue to help foster future leaders of the Division and Society. This connection is what the entire CD Board is looking to further enhance and grow by fostering student professional engagement. During my tenure as Division Chair, I plan to work with our Board leadership team to roll out new initiatives to provide various opportunities for mentorship and increase participation from all of our members, especially those just starting out in the profession. We seek to create closer connections between students and early career professionals in CD with our mid-career and senior members. Established CD members can provide a wealth of experience that will be beneficial to anyone starting their career and can also benefit by interacting with the next generation of composite leaders.

As we work with SPE Headquarters on initiating these new opportunities, we will be reaching out to all of you for your support in making these initiatives into reality. I look forward to working with the SPE family to better serve our membership and further strengthen our great Division and Society. Please do not hesitate to reach out to me if you would like to learn more or get involved.


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Award Report

SPE Composites is always looking for ways to enable students to take their education to the next level in the field of composites. The SPE Composites Division Board of Directors would like to congratulate the following students in getting selected for the following scholarships.

2023 SPE Composite Division & Automotive Herold Giles Scholars, ACCE, Dr. Jackie Rehkopf Scholars and Automotive & Composites

Dear SPE Composites Division,

The SPE Foundations is pleased to share a report of the 2023 SPE Composites Division Scholarships including the Harold Giles Scholarship, the ACCE, Dr. Jackie Rehkopf Scholarships and Automotive & Composite Division Scholarships. Thank you for your support of some of our industry's most outstanding scholars. We invite you to view the entire list of our 2023 scholarships at www.4spe.org/scholarships.

Thank you for making a difference for Emmaline Lenz, Md Nayeem Hasan Kashem, Amit Deshpande, Suyash Oka, Amy Kurr, Rachel Van Lear, Orville Tacket, and Youyi Zhou. We are grateful for your investment and commitment to our future plastics professionals and hope you enjoy reading about their interest in plastics and future career plans.

Sincerely,

Eve Vitale, Chief Executive,
SPE Foundation

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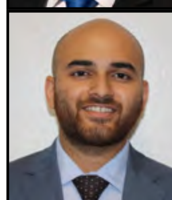
Emmaline Lenz
Harold Giles: $3500

Md Nayeem Hasan Kashem
Harold Giles: $3500
Division ACCE: $2000

Amit Deshpande
Division ACCE: $2000



Suyash Oka
Division ACCE: $2000

Amy Kurr
Dr. Jackie Rehkopf: $2500

Rachel Van Lear
Dr. Jackie Rehkopf: $2500

Orville Tacket
Auto & Composites: $1000

Youyi Zhou
Auto & Composites: $1000

This Issue:

EMMALINE LENZ

2023 SPE Composite Division
Harold Giles Scholar, $3500

As a recipient of your scholarship, I am writing to thank you for your contribution that will help me to finish my degree with far less stress! I believe I received this scholarship because I am a plastics and composites engineering student who has had experience working with composite materials during my internship at Alaska Airlines and through my university courses. This unique combination has allowed me to learn both composite layup skills and repair skills and has given me a new perspective on how composites are used in industry.

I grew up and went to high school in Buckley, a small logging town in the foothills of Mt. Rainier.

My mom, an artist and picture framer taught me design, drawing, and painting, and my dad, an aircraft mechanic taught me to use tools and solve problems with our appliances and cars. Being exposed to these two different worlds in my life has helped me be practical and creative, a combination that works well in engineering classes for coming up with new solutions.

I wasn't sure of what I was getting into when I signed up for polymers materials engineering here at Western, but after taking classes I knew I had come to the right place. In addition to teaching the basics of how to apply plastics and composites in industry, Western also prioritizes teaching about sustainability and recycling of these materials. Because of this I've had the opportunity to research how best to create new useful products from recycled materials, and it has been the most rewarding experience of my life. I plan to go into recycling or sustainability after I graduate, and help companies find ways to use their waste in new ways.

Because I received this scholarship, I'll now be able to go through my senior year without having to work on top of finishing out my degree, which really brings me and my family a great sense of relief. Thank you so much for your kindness!

Emmaline is an undergraduate student at Western Washington University, majoring in plastics and composites engineering and completing Western's Honors college program. She grew up in a small, ex-logging town in the foothills of Mount Rainier where she was raised by an artist and an aircraft mechanic.

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This Issue:

Award Report continued...

Together, they taught her to be both creative and practical, beauty-oriented, and functionality-oriented, and to always carry a sense of curiosity and wonder about the world. At Western she spends her time searching for new ways to use recycled plastic materials with the Waste to Products Research team and intends to keep that dream alive by going into a sustainability-minded workplace.

In the future, I want to see myself working as a professor at a university or a researcher at a national lab researching in this field to solve various problems with my knowledge and hard work. Being awarded a prestigious Foundation Scholarship from a very respected society in my research field like the Society of Plastic Engineers (SPE) is a great honor that I am very grateful for and feel motivated to work harder. The scholarship will also provide me with financial support to devote my time to completing my research and continuing my extracurricular efforts. It will also enrich my portfolio and make me unique in the competitive pool of applications for faculty positions.

Thank you again for your generosity and support.

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Award Report continued...

MD NAYEEM HASAN KASHEM

2023 SPE Composite Division Harold Giles Scholar, $3500

2023 SPE Automotive & Composites Division ACCE Scholar, $2000

As a recipient of the prestigious SPE Automotive & Composites Division ACCE and Composites Division Harold Giles Scholarships 2023, I am writing this letter to express my sincere gratitude to the SPE Automotive & Composites Division. This honor will motivate me to work harder and contribute to the polymers and plastics industry.

Currently, I am a 4th year PhD student in the Department of Chemical Engineers at Texas Tech University. My research is related to developing polymeric composite materials for different industries i.e., automotive industries. Thus far, I have developed various thin film coatings with sensitive color-changing, self-healing, UV-resistance, and anti-fogging properties which can be applied to window glasses and automotive bodies. Moreover, I have also worked with flexible polymeric composite materials embedded with hard magnetic particles as small-scale actuators with a rapid and precise shape-shifting ability. As a graduate engineering student working with polymeric materials/plastics, I am spellbound by the potential of this field and feel the responsibility to encourage the next generation of graduates in pursuing a career in this field. Hence, I joined the Society of Plastic Engineers (SPE) TTU Chapter in 2019. Currently, I am working as the President of the chapter since August 2022 and previously worked as a treasurer from August 2021 to August 2022.

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Award Report continued...

In the future, I want to see myself working as a professor at a university or a researcher at a national lab researching in this field to solve various problems with my knowledge and hard work. Being awarded a prestigious Foundation Scholarship from a very respected society in my research field like the Society of Plastic Engineers (SPE) is a great honor that I am very grateful for and feel motivated to work harder. The scholarship will also provide me with financial support to devote my time to completing my research and continuing my extracurricular efforts. It will also enrich my portfolio and make me unique in the competitive pool of applications for faculty positions.

Thank you again for your generosity and support.

Md Nayeem Hasan Kashem is a 4th-year Ph.D. student in the Chemical Engineering department at Texas Tech University (TTU). With an MSc from TTU in 2021 and a BSc from Bangladesh University of Engineering & Technology in 2017, both majoring in Chemical Engineering, he has a strong academic background in this field. His PhD research focused on developing polymeric composite materials for nano- and micro-film fabrication and manufacturing of soft magnetic robots. Currently, he serves as the President of TTU's student chapter of SPE. He is passionate about continuing his research in this field and aspires to make significant contributions.

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AMIT DESHPANDE

2023 SPE Automotive and Composites Division ACCE Scholar, $2000

I was thrilled and humbled to learn that I was selected as the recipient for the prestigious SPE Automotive & Composites Division ACCE Scholarship!

This is one of the most prestigious scholarships I am aware of in my field and has been an accolade I have been aspiring towards ever since I participated in my first SPE ACCE conference. I have worked with composites since the start of my undergraduate studies, almost a decade ago, and I truly believe that composite materials are the solution to a lot of the challenges facing the automotive industry as we transition to a more sustainable and eco-friendly future. I consider this recognition as a statement of support and encouragement from the community in sharing this belief.

I want to thank you for the generous financial support and encouragement as it has lightened my financial burden significantly, allowing me to focus on impactful research. I hope one day I will be able to help other SPE student members and fellow plastics and composites enthusiasts in achieve their goals just as the SPE community has helped and encouraged me today.

Thank you once again!

Amit Deshpande is a PhD student at the Center for Composite Materials at University of Delaware, working to enhance use of sustainable and lightweight composites technologies for automotive applications. His research is focused on advanced composites manufacturing processes, and development of digital life cycles for composite manufacturing processes that capture the process-structure-property relationships. Amit holds a master's degree in automotive engineering from Clemson University International Center for Automotive Research (CUICAR) with a focus on structural design, NVH, and advanced manufacturing. His efforts have contributed towards the successful development and demonstration of the world's first thermoplastic composite door for production vehicles.

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This Issue:

This Issue:

SUYASH OKA

2023 SPE Automotive and Composites Division, ACCE Scholar, $2000

I'm sincerely honored to be a recipient of the SPE Automotive & Composites Division ACCE Scholarship; I thank you for your generous $2000 fellowship. I was elated and appreciative to learn that I was selected as the recipient of your illustrious fellowship.

I am a 4th year Ph.D. student in chemical engineering with a GPA of 3.52/4.00, and my research is focused on developing fast-charging, structural batteries for low-temperature applications using redox-active polymers. I'm currently developing polymer (PTMA-based) structural cathodes for fast-charging, high-power battery applications. I worked as a battery cell engineering process development intern with Tesla in the summer of 2022 and now as a battery cell engineering product development intern with Apple in the summer of 2023, where I got wonderful opportunities to apply my knowledge about chemical engineering and batteries for developing electrodes and cells for the respective corporations. In my senior Ph.D. years, I'll be focusing on developing carbon fiber-based composites for structural energy storage that may be potentially used in a body's structural elements. I plan to pursue an industrial career in composites for sustainability and energy storage, specifically battery technology, upon graduating from Texas A&M. Thanks to you, I am thoroughly motivated to further my goal.

By awarding me the SPE Automotive & Composites Division ACCE Scholarship, you have motivated and pushed me to work harder and focus on the most important aspect of my Ph.D., learning. Your generosity has inspired me to help others and give back to the community. One day I will be able to help students achieve their goals just as you have helped me.

Oka was selected as a recipient of the SPE Automotive & Composites Division ACCE Scholarship. He received his Bachelor of Technology in Dyestuff and Organic Chemistry Technology from the Institute of Chemical Technology (ICT), Mumbai, India, and joined Texas A&M University's Chemical Engineering Doctoral Program in 2019. He is working with Dr. Jodie Lutkenhaus, and his research focuses on developing mechanically strong and fast-charging structural batteries for low-temperature applications using organic redox active polymers. Five peer-reviewed journal articles, one of them as a first author in ACS Applied Materials & Interfaces, another first-author article on its way, and multiple national conference presentations has been his contribution so far. He worked as a Battery Cell Engineering Process Development intern with Tesla in summer 2022, and as a Battery Cell Engineering intern with Apple in summer 2023. He looks forward to focusing on learning and making a tangible difference towards composites in sustainable energy.

Award Report continued...

AMY KURR

2023 SPE Automotive and Composites Division, Dr. Jackie Rehkopf Scholar, $2500

Thank you, Society of Plastics Engineers (SPE) Automotive & Composites Division, for selecting me as a recipient of the Dr. Jackie Rehkopf Scholarship valued at $2,500. I will be putting the scholarship money towards (1) my student-led and student-proposed research project "a student-led and student-proposed research project and conference attendance with publication: Degradation of electrical cables in electric vehicles which I will eventually defend for my doctorate (2) conference attendance with publication and (3) industry tours. I will be traveling to Baltimore, MD in the coming month to present my work at Underwriters Laboratories Fire Safety Research Institute. Additionally, I will tour Jensen Hughes and Exponent – two forensic engineering consulting firms that have large polymer fire research areas. In August I will be traveling to Volkswagens production facilities in Chattanooga, TN to tour their electric vehicle lines. Lastly, I will present my research at the 2023 American Society of Materials Conference. Thank you for your investment in me, my research, and my efforts to share it with the public this year. I also appreciate your financial support as it facilitates opportunities to share my involvement in SPE with the various collaborators, professional engineers, and students I meet in fire protection, materials science and engineering, and the automotive and manufacturing industry. I like bringing my work full circle and it is enjoyable to teach other technical experts about the specifics of polymer engineering.

Ms. Amy Kurr is a polymer engineer with three years of experience as an electromechanical design engineer for Schneider Electric where she served as a technical product owner for electrical protective devices (e.g., shunt trips, miniature circuit breakers, electrical cables). She holds a bachelor's degree in Materials Science and Engineering from Iowa State University and a master's degree in Macromolecular Science and Engineering from Case Western Reserve University. Ms. Kurr completed her Spanish Business Certificate from the University of Wisconsin – Madison. She is currently pursuing a Ph.D. in Energy Science and Engineering from the University of Tennessee's Bredesen Center. In her free time, Ms. Kurr sits on the Standard Technical Panel for Underwriters Laboratories UL-746 (polymer materials) and serves as a professional development facilitator for Tau Beta Pi's – The Engineering Honor Society – Engineering Futures Program and the National Science Foundation-funded CyberAmbassadors Program.

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This Issue:

RACHEL VAN LEAR

2023 SPE Automotive and Composites Division, Dr. Jackie Rehkopf Scholar, $2500

My name is Rachel Van Lear and I am a second year graduate student working towards a PhD in mechanical engineering. I wish I could fully express in words the impact the SPE Automotive & Composites Division Dr. Jackie Rehkopf Scholarship will have on me! These funds will provide a means for me to purchase necessary textbooks, pay required student fees, as well as room and board, but also to participate in conferences that may have been financially out of reach. These conferences, such as ACCE, will help to inspire innovation in my research and hopefully result in lifelong professional connections.

Your kindness will allow me to fully dive into my research, rather than worrying about financial obligations, enabling me to attempt to get two journal papers published by my first year and a half of graduate school. Focusing on barely visble impact damage in carbon fiber laminates, my research has been able to make use of phased array transducers within ultrasonic testing to dramatically reduce the scanning time for impact damages by 95%. This was done without sacrificing accuracy in the quantification of damage. I have also worked towards correlating detected impact damage sizes to residual compressive strengths to eventually be used in a future predictive algorithm. My hope is that this upcoming school year will be just as productive or more so due to the opportunities your scholarship has provided.

Thank you again for the funds and support! I ensure you that they are being put to good use by investing in my schooling. Have a blessed year!

Rachel Van Lear graduated with a bachelor's in mechanical engineering in 2022 at Baylor University. She has additionally participated in four internships at Lockheed Martin's Missile and Fire Control, with experience ranging from systems to lethality engineering within the company. Continuing her education at Baylor University, she is now pursuing her PhD in mechanical engineering in hopes of graduating in 2026. Her research is in the area of ultrasonic testing and materials characterization of carbon fiber laminates. Currently she is working towards increasing the accuracy, agility, and automation of ultrasonic testing detection and quantification of damage within carbon fiber laminates.

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This Issue:

Award Report continued...

ORVILLE TACKET

2023 SPE Automotive and Composites Division Scholar, $1000

My name is Orville Tackett, and I am a first-generation student from southern Ohio. I am a sophomore attending Shawnee State University majoring in plastics, with minors in CAD and electromechanical engineering. First, I would like to say how grateful I am for this scholarship. The investment in my future means more than a simple thank you letter can express. Growing up in an area of poverty, I know first-hand the importance of investing in the community, and the impact higher education has on those communities. This scholarship brings me one step further in my journey to better impact those around me, and the field of engineering. Your continued support will not be forgotten, as this is an immense motivator and vote of confidence in my future. Thank you again for this life-changing opportunity!

Orville Tackett is a sophomore of Shawnee State university, majoring in Plastics Engineering, minoring in CAD and Electromechanical Engineering. Born and raised in Southern Ohio, Orville enjoys the outdoors, and spending time with loved ones. Being a first-generation student, his passion for engineering developed through the continued support and exploration provided by his parents and family. Taking pride in your work and knowing the value of teamwork are core values of his and ensure a bright future. Once obtaining his degree, Orville hopes to further the engineering community through hard work and dedication in his chosen field.

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This Issue:

YOUYI ZHOU

2023 SPE Automotive and Composites Division Scholar, $1000

I am delighted and honored to receive the news that I have been selected as a recipient of the $1,000 Scholarship from the SPE Automotive & Composites Division. I would like to express my sincere gratitude to the Automotive & Composites Division for their generous support and for recognizing my achievements.

I am thrilled to accept this award, and I am deeply grateful for the opportunities it will provide me in pursuing my studies in Composite Materials Engineering. The scholarship will have a significant impact on my academic journey and will help me further my professional aspirations in the field.

Currently, I am working as an undergraduate researcher in Purdue University SURF program. I am doing research on air purification with photocatalysis and acoustic filtering under Dr. David Warsinger. I have worked as a research assistant with my advisor Dr. Beckry from last summer break to now for composite material drop weight impact research and worked as a research assistant with Chemistry department professor Dr. Kopitzke last semester. I found I am very interested in materials science and polymer sciences field. I like materials science very much and am willing to run for it thought my whole life. I am interested in aerospace materials, composite materials, polymer materials, etc.

Thank you for your support again. I am looking forward to the possibility of applying for future scholarships and having more connections in the SPE community.

I am an international transfer student from Guizhou, China. My professional goal is to successfully enter a top university's Ph.D. program, and my career goal is to be a professor in the United States. I like materials science and am willing to run for it thought my whole life. I am interested in aerospace materials, composite materials, polymer materials, etc. Currently, I am working as an undergraduate researcher in Purdue University SURF program. I am doing research on air purification with photocatalysis and acoustic filtering under Dr. David Warsinger. I have worked as a research assistant with my advisor Dr. Beckry from last summer break to now for composite material impact research and worked as a research assistant with Chemistry department professor Dr. Kopitzke last semester. I found I am very interested in materials science and polymer sciences field.

This Issue:

ACCE Lifetime Achievement Award

SPE® Announces "Lifetime Achievement Award Winner" –

Kevin N. Pageau Will Be Honored

At SPE Automotive Innovation Awards Gala Nov. 8, 2023
At Burton Manor In Livonia, MI

TROY, (DETROIT) MICH. –

Kevin Pageau, owner and president of International Marketing Alliance and a major contributor to the SPE Automotive Division Innovation Awards Program for many years, has been named the 2023 Lifetime Achievement Award winner by the Automotive Division of the Society of Plastics Engineers (SPE®). For over 40 years, Pageau has led key advancements in the automotive plastics industry including being an early pioneer in the application of CAE Technologies – Pageau ran GE Plastics first 3D finite element moldflow analysis and provided technical analysis of numerous leading edge applications at GE. He also developed one of the first warp analysis tools, where the melt flow angle for each element was calculated and used to predict fiber orientation in glass filled materials – leading to additional roles at GE as Project Engineer, Business Development Specialist and Business Development Manager; As Director of Engineering at Plastics Engineering & Technical Services (PETS) he developed proprietary methods, computer programs and algorithms to optimize the analysis of hot and cold runner systems for complex automotive molds, as well as implementing some of the first commercial "mold cooling" analysis projects.

Pageau has also led a team of tooling engineers, project engineers, and quality engineers in the development of decorative plastics molds and processes as Director of Advanced Engineering at Dott Industries. As a Manufacturer's Representative at Mayne-McKenney, he built significant business for Principals in the areas of satellite radio antennas, engineered foam and injection molding.

Pageau joined International Marketing Alliance (IMA) in 2003 and helped build it into a leading sales and marketing firm for automotive components. IMA represents seven domestic and international companies, with product areas including injection molding, decorative plastics of all types, engineered foam, LED lighting systems, and advanced seat comfort systems, generating revenues of approximately $100 million dollars annually.

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This Issue:

Lifetime Achievement Award continued...

His involvement in SPE goes back to his GE Plastics Days, where he was on the development team that won an SPE award for the Chrysler 1990 Eagle Premier Azdel bolster. He became active in the Automotive Division in 1992 as newsletter editor, where he upgraded the quality of the newsletter, and increased ad revenue to make the newsletter break even for the first time in years. He then held other positions in the Automotive Division leadership, including Secretary, Treasurer, Vice-Chair and Chairman. He was recognized as an Honored Service Member of SPE in 2004.

The SPE Automotive Innovation Awards Competition and Gala has grown over the years to become known as the "Academy Awards of the Automotive Industry" with Pageau's leadership. In addition to being Awards Program Chair for a few years, he has managed and streamlined the nomination and judging process, worked with the team to upgrade the audio visual and other program features, and reduced the "run of show" time to two hours, while still recognizing all winners and finalists in a very professional event. He continues to manage the nomination and judging process, write the script for the show and produce the presentation files for the event.

ACCE Best Paper Finalists

Effect of Environmental Factors on Mechanical Properties of Resin, Interface And Composites

Sagar M. Doshi, Alex Schneider, Paul D. Samuel, Joseph M. Deitzel,
Center for Composite Materials, University of Delaware, Newark, DE
John W. Gillespie Jr.,
Center for Composite Materials, University of Delaware, Newark, DE, Department of Civil and Environmental Engineering, Department of Mechanical Engineering, Department of Materials Science and Engineering, and Department of Electrical and Computer Engineering, University of Delaware, Newark, DE

Abstract

Composites are used increasingly for automotive applications where they are subjected to various environmental conditions, from different temperatures to varying humidity. The environmental conditions influence the composite's structural and energy absorbing properties. Composites used in automotive applications need to be damage tolerant and may also be designed for energy absorbing parts in crash scenarios where they may be subjected to strain rates of ~100-1000 1/s. In this research, we discuss a framework to study environmental factors' effect on composite materials' performance by characterizing neat epoxy resin, interface, and glass-epoxy composites.

A toughened epoxy resin, SC-15, is used in this study, where the key mechanical properties such as yield stress and Young's modulus are characterized at quasistatic and high strain rates (using Hopkinson bar) at different temperatures and moisture conditions. An Eyring type curve is generated to predict properties at varying strain rates. Interfacial properties between the SC-15 resin and 463-sized glass fiber are characterized using a single fiber pullout test at the ends of the operating temperature range (-55C, 76C) and moisture conditioning. Lastly, composite panels are subjected to low velocity impact tests at operating temperatures. Force displacement, force-time, stiffness before and after impact, and delamination area are analyzed for each specimen. A correlation is shown between key resin properties such as yield strength with the apparent interfacial shear strength calculated through pullout tests and the stiffnesses of the composite panels with the resin Young's modulus. A detailed study of the testing of composites and their constituent materials is conducted under a wide range of environmental conditions to understand the effect on performance and durability.

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ACCE Best Paper Finalists continued...

Introduction

The amount of polymer composites used in automotive applications is increasing to keep up with the demands of making lightweight, crash-worthy automotives. Other advantages such as near net shape manufacturing, corrosion resistance, and decreasing costs of raw materials also lead to an increased usage of composites. Epoxy resins are commonly used in structural composites due to their ease of manufacturing (pressure required due to low viscosities and cure temperatures), thermal stability, and mechanical properties. However, unlike sheet metal used in traditional automotives, the properties of epoxy resins and their composites change significantly due to environmental conditions such as temperature and moisture.

The operating temperature range for automotive applications is vast due to geographical location changes, altitudes, and in some cases, proximity to power units. For example, per AEC-Q100 (Automotive Electronics Council) qualification test standards, there are different grades defining the operating temperature range from -40C to 150C for Grade 0 and -40C to 85C for Grade 3. Per MIL 810 STD, -51C [1] has been reported in cold conditions, and the maximum temperatures could be as high as 71C. However, the temperature that a composite material may be exposed to could be higher due to other factors such as solar radiation and closeness to heat-producing automotive components. In addition to temperatures, high relative humidity could also severely influence the composites' properties and performance. Not only could it lead to hygrothermal stresses, but the presence of moisture in the polymer could suppress the glass transition temperature and therefore deteriorate the performance at elevated temperatures.

In addition to external environmental factors, the key properties of a polymer composite material are also dependent on the rate of loading or strain rates. For example, composites designed for energy-absorbing structures in the event of a crash may be subjected to strain rates as high as 500 s-1. However, the local strain rates could be even higher, and Smerd et. al. [2] conducted their test at strain rates as high as 1500s-1. It is therefore necessary to study and evaluate the fundamental mechanical properties at various strain rates, from quasistatic to high strain rates. The complete set of properties would enable the creation of more accurate finite element models to determine the crashworthiness of critical components.

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ACCE Best Paper Finalists continued...

Not only do the properties of the epoxy resin matter, but also the bonding between the epoxy resin and the reinforcing material such as glass or carbon fiber. The interfacial properties play a significant role in energy dissipation mechanisms and maintaining the composites' structural integrity. The energy absorbed depends on multiple mechanisms ranging from delamination to fiber break and matrix plasticity, and interfacial debonding. Ganesh et. al. [3] showed that the energy absorbed after a dynamic single fiber break depends on matrix properties (yield strength) and interfacial properties. It is therefore essential to characterize the interfacial properties under different environmental conditions and varying strain rates. Tamrakar et. al. characterized the strain rate-dependent interfacial properties for glass-epoxy composites using a microdroplet test [4].

In this study, we characterize the properties of a toughened epoxy resin SC-15 at quasistatic and high strain rates at various temperatures covering the operating range. Specimens are also tested after saturating with moisture. Eyring curves are generated to show the capability to predict yield stresses across a wide range of strain rates, from quasistatic to high strain rates, which cover the critical strain rates of interest from an automotive viewpoint. Single fiber pullout tests are conducted at different temperatures and conditioned with moisture. Apparent interfacial shear strength (IFSS*) is determined as a function of the temperature. Lastly, low velocity impact tests are conducted on 8-ply composites made of S2 glass fabric with SC-15 epoxy resin. These tests are performed at the ends of the operating temperature range, and key results such as the force-displacement, force-time, delamination areas, and stiffness retention are discussed.

Test Type	Specimen Geometry	Test Conditions	Rate/energy	Equipment Used
Compression of neat resin	Right cylinder, 5mm dia, 5mm thick	-55 to 76C, 95C, moisture saturated (2.1% by weight)	0.1 s^{-1}	Instron 4484
Compression of neat resin	Right cylinder, 5mm dia, 1mm thick	-55 to 76C, 95C, moisture saturated (2.1% by weight)	3300 s^{-1}	Split Hopkinson Bar, REL inc.
Single Fiber Pullout Tests	Single glass fiber embedded in resin	RT dry, RT with moisture conditioning (~2.7% by weight when tested)	0.1 mm/min, embedded length ~ 57 µm	Favimat - TexTechno
Single Fiber Pullout Tests	Single glass fiber embedded in resin	-55C, 76C	0.1 mm/min	Instron 5848 with temp. chamber
Low velocity impact testing	100mm x 150mm x 5mm thick (8 plies)	-55C, RT, 76C	40 Joules	Dynatup 9200 drop tower
Composite stiffness testing	100mm x 150mm x 5mm thick (8 plies)	-55C, RT, 76C	1.27 mm/min	Instron 4484

Table 1: Test configurations and testing parameters for the experiments conducted for resin, interface, and composites testing in this study.

This Issue:

Experimental

The key objective of this study is to test composites and their constituent materials – resin and interface under different environmental conditions. Neat resin is tested using uniaxial compression tests at quasistatic and high strain rates (Figure 1a). The interface is characterized using single fiber pullout tests, and the composites are subjected to low velocity impact testing. The operating temperature for this study is considered to be from -55C to 76C based on [1]; however, some resin testing is also conducted at 95C. The table below summarizes the tests conducted in this study and the parameters used. Note that some additional compression tests (not mentioned in the table) for neat resin at different strain rates were also done to generate the Eyring curve (yield stress-strain rate relationship).

Materials

The resin system used for this study is a two-part epoxy resin, SC-15, which is rubber toughened low viscosity resin suitable for vacuum-assisted resin transfer molding (VARTM). SC-15 has a glass transition temperature of 85~90C as measured by DSC (mid-point). S2 glass fabric, plain weave (style 240, 814 gm/m2) with 463 silane-based sizing, which is compatible with epoxy resin, is used. Single fibers used for interfacial testing are of the same type. However, they are cut from a roll of fiber tow procured separately and not pulled from the woven fabric.

Specimen Fabrication and Conditioning

SC-15 part A and part B were weighed in the ratio of 100:30 and then mixed using a high-speed mixer at 2000 rpm, followed by degassing. The resin is then poured between parallel glass plates. The cured resin is cut into cylindrical specimens using a core drill. The diameter of all specimens is 5 mm. The thickness used for quasistatic specimens is 5 mm and 1 mm for SPHB.

For preparing specimens for single fiber pullout testing, the resin was mixed using the same process. The resin was then transferred into customized crucibles with a micropipette, dispensing about 10 μL for each specimen. The fiber was embedded in the resin filled crucible using Textechno FIMABOND equipment. A single glass fiber was inserted in a hollow needle and inserted into the resin droplet using

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a stage driven by a stepper motor (Figure 1b). The samples were partially cured in-situ until the resin gelled and then batch cured in an oven. All specimens – composites, pullout, and resin, were cured for 2 hours at 60C, followed by post-curing for 4 hours at 121C. The composite specimens were prepared using a conventional VARTM procedure using eight plies of the plain weave S2 glass fabric, with a nominal fiber volume fraction around ~54% measured using burnoff tests. Specific details about VARTM processing for these types of panels are discussed in this research [5].

For neat resin specimens, the conditioning was done in an environmental chamber set to 76C and 88% RH. The samples were conditioned till they reached saturation (a mass increase of 2.1%). For pullout tests, the conditioning was done in a hot water bath maintained at 76C because the air convection in the environmental chamber damaged the specimen.

Testing Methodology

A screw-driven testing machine (Instron 4484) was used for quasistatic testing in a displacement-controlled setting. For high strain rate testing, a split Hopkinson pressure bar was used. For additional details about both quasistatic testing and parameters used for Hopkinson bar testing, please refer to our prior work [6].

Room temperature pullout tests were conducted using FAVIMAT, and tests at elevated/low temperatures were conducted using an Instron MicroTester 5848 equipped with a temperature chamber (Figure 1b). After the completed test, the pulled fiber is collected using a sticky tape and analyzed using an SEM microscope to measure the fiber diameter and embedded length. The interfacial shear stress is calculated by dividing the peak force by the embedded surface area, given by the equation below:

$$IFSS = \frac{Peak\ Load}{Embedded\ Surface\ Area} = \frac{P}{\pi * d * L_e}$$

Where P is load, d is the fiber diameter, and Le is the embedded length of fiber in resin. Please refer to Chen et. al. [7] for additional details about single fiber pullout testing.

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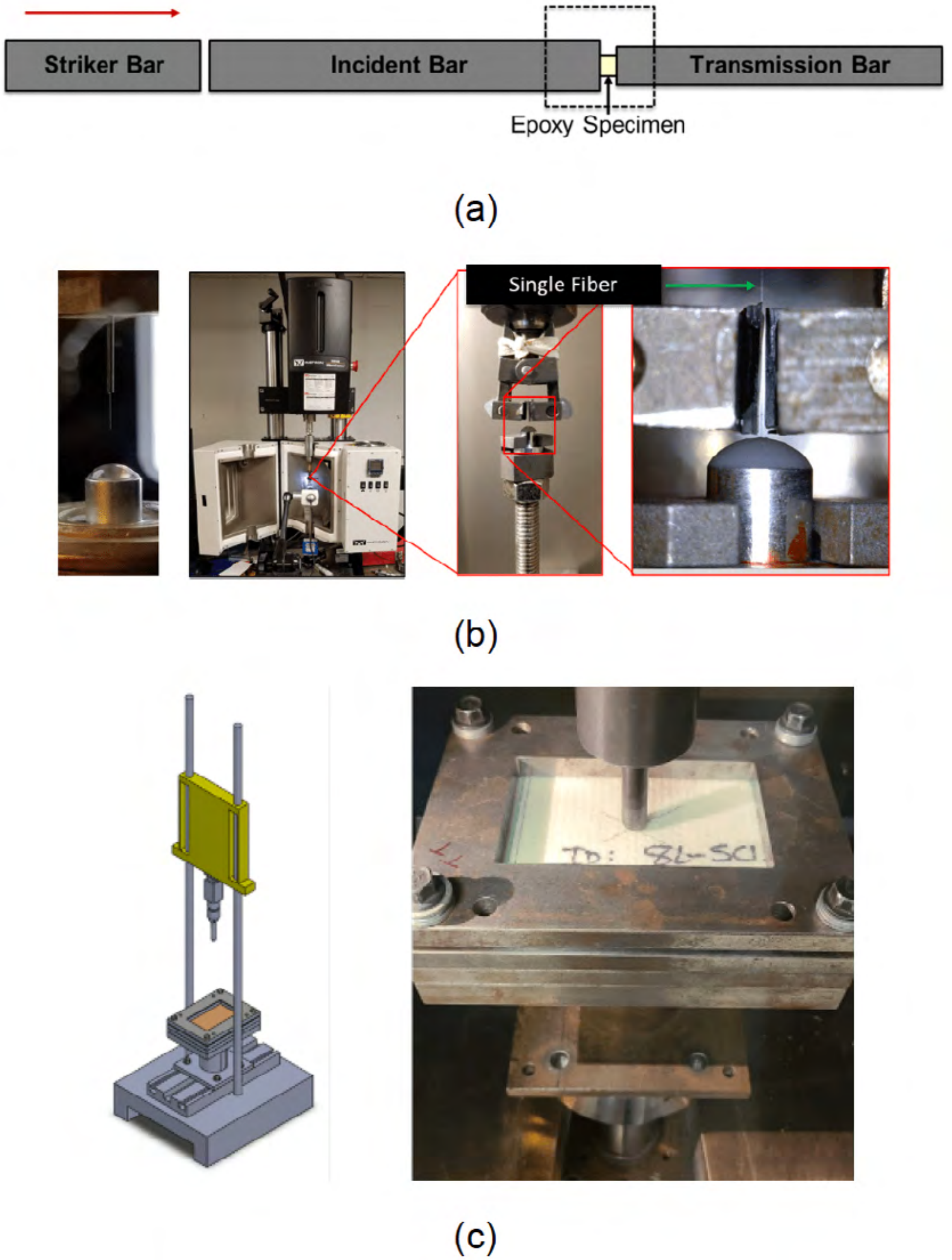

Figure 1: (a) A schematic of the split Hopkinson pressure bar used for high rate testing, (b) photographs showing the sample preparation and testing for single fiber pullout tests, and (c) a schematic of the drop tower used for LVI testing and photograph of the test setup used for measuring the stiffness of composites.

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For LVI testing, a Dynatup 9200 drop tower with a 20,000 lb load cell is used. A variable mass slider (set to 13.37 kg) and a hemispherical tup, 12.7 mm in diameter, is released from a height of ~0.3 m to create an impact with the energy of 40J. The specimen is clamped in the fixture using four bolts at the corners tightened to a torque of 75 lb-in. The impact velocity was measured using an external sensor and was 2.4 m/s. The dropped weight is manually caught after the first impact to prevent additional impacts/damage. For more details about the experimental procedure, stiffness testing, and data reduction procedure, please refer to our prior work [8].

Results and Discussion

Quasistatic and High Strain Rate Testing of Neat Resin

Figures 2(a) and 2(b) shows the true stress-true strain relationship for the quasistatic compressive tests for baseline and conditioned specimens. The machine compliance was measured for the specific test set-up and subtracted from the stress-strain response. The slope of the linear part in the initial section of the true stress-true strain curve is used to calculate the modulus. Yield stress is calculated when the stress-strain curve's derivative first goes to zero. The shape of the curves and the general trend is similar for both sets of graphs. After the initial linear increase, the curve is non-linear till it reaches a peak, which is the yield stress. This is followed by strain softening, followed by plastic flow before the failure due to disruption of the chemically crosslinked molecular network.

The Young's modulus and the yield stress are proportional to the temperature, as is typically expected for epoxy resin and glassy polymers in general [9]. The peak for the yield stress and the following softening is less prominent in the conditioned samples than in the unconditioned (baseline) samples. This is likely because of the plasticization caused due to the presence of moisture in the conditioned samples. At 95C, the stress-strain curves are different; the conditioned specimen has no clear yield point. Even for the baseline specimen at 95C, the peak for yield stress is not as prominent as at lower temperatures. This vast difference is due to the decrease of glass transition temperature due to moisture. While the baseline specimen is at or near the glass transition temperature of a dry SC-15 resin, the conditioned specimen is significantly over the glass transition temperature. Therefore, no clear yield point is visible.

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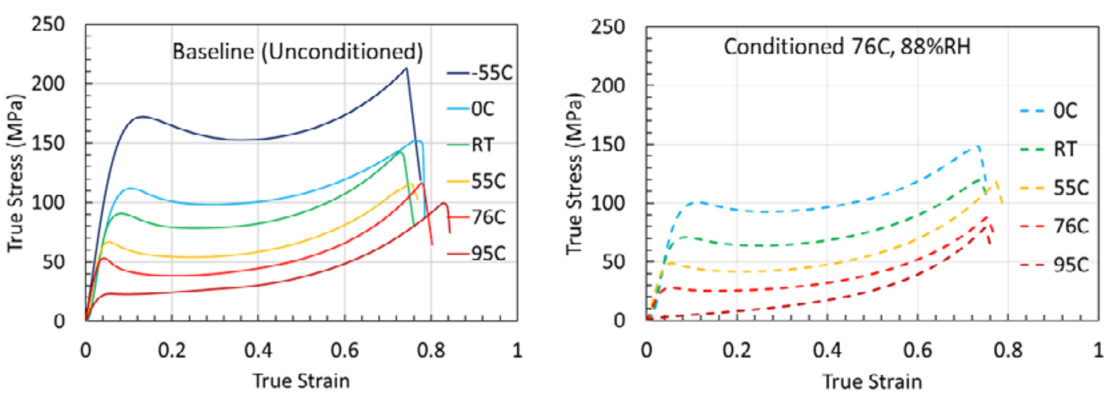

Figure 2. True stress-strain curves at different temperatures for quasistatic compression tests for neat SC-15 resin for (a) baseline (non-conditioned) specimen and (b) specimens conditioned till saturation at 76C, 88%RH (2.1% mass increase).

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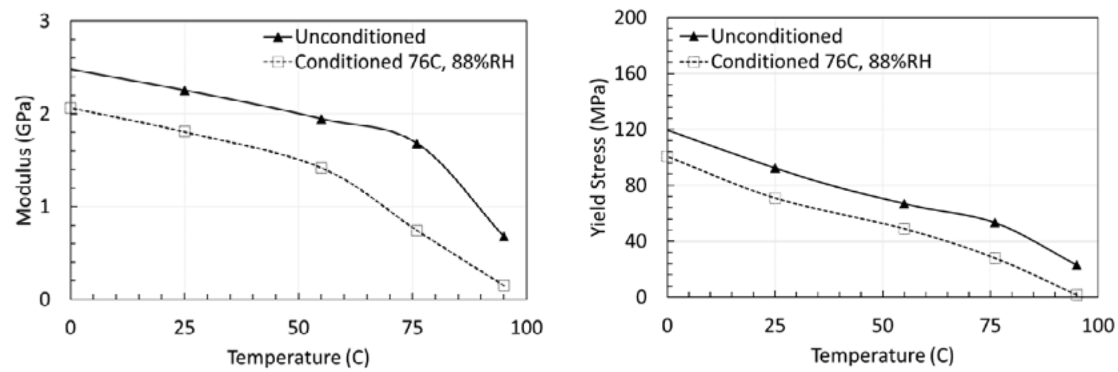

Figure 3. Decrease in (a) modulus and (b) yield stress as a result of an increase in temperature for baseline (unconditioned) and conditioned specimens.

Variations of Young's modulus and yield stress are plotted as a function of temperature in Figures 3(a) and 3(b), respectively. The solid triangles represent the baseline (unconditioned) specimens, and square hollow markers are for the conditioned samples. As expected and evident in the true stress-strain curves, both Young's modulus and yield stress decrease with increasing temperature. For Young's modulus, the reduction is linear till 76C, and then a sharper drop is observed for the test at 95C. This is because the glass transition temperature is ~85-90C.

Interestingly, a similar inflection point or change in slope for the conditioned specimen is observed after the 55C tests. This suggests that the glass transition temperature has been suppressed due to moisture and is now near or below 76C. A similar trend is also observed for yield stress curves but not as prominent. For the conditioned samples tested at 95C, the yield stress tends to zero, similar to the modulus of the conditioned samples at 95C, another indication of the suppression of glass transition temperature and this test being conducted well beyond the glass transition temperature. The stress-strain curve for the 95C specimen looks like a curve for a rubber-like material, with no well-defined yield point and behavior similar to an elastomer subjected to strain hardening.

Figures 4(a) and 4(b) show the true stress-true strain response for tests conducted using the split Hopkinson bar at a strain rate of 3300 s^{-1} for the baseline and conditioned specimens, respectively. As expected, and similar to quasistatic rates, the yield stress is inversely proportional to temperature; it decreases as temperature increases. For the test conducted at cold temperatures, epoxies could be brittle, and the drop in stress post yielding could be due to damage. At room temperature tests, strain softening is observed due to the adiabatic nature of these tests since the test duration is extremely small and the time for heat dissipation is insufficient. Tamrakar et. al. [10] measured the temperature to be 70C for epoxy resin DER 353 when tested at room temperature at a strain rate of 5000 s^{-1}.

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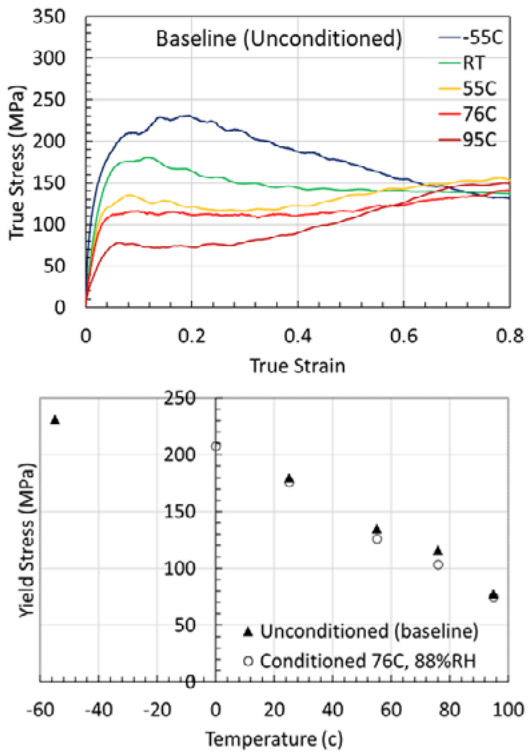

Figure 4. True stress-true strain response of neat SC-15 resin tested using split Hopkinson bar at a strain rate of 3300 s-1 at different temperatures for (a) baseline (unconditioned) specimens and (b) conditioned specimens. (c) variation of yield stress with temperature for conditioned and unconditioned specimens.

Figure 4(c) shows the dependence of yield stress on temperature for both baseline (non-conditioned) and conditioned samples. The influence of conditioning and the presence of moisture is not as significant for the tests conducted at high rates. The decrease of yield stress is fairly linear with increasing temperature throughout the range of tests. Interestingly, an inflection in the yield stress vs. temperature curve is not evident for the high rate tests. Additionally, the yield stress values at higher temperatures (95C) do not tend to zero, as observed for the quasistatic tests. This is because the yielding of glass polymers is controlled by more than one energy activation mechanism.

Figure 5 shows the variation of yield stress with average strain rate for three different temperatures, room temperature, -55C, and 76C. The dependence of yield stress on strain rate is easily evident from the figure. The yield stress at room temperature varies from ~75-95 MPa for the quasistatic rates and 160-230 MPa for the high strain rate testing conducted using the Hopkinson bar. The variation of yield stress is bilinear with strain rate due to the two rate processes involved in the deformation. Eyring's initial equation considered only a singular rate process and failed to predict the yield stress accurately; however, the modified Eyring equation – Ree-Eyring [11] can predict the bilinear relationship by assuming two rate processes. These processes are believed to be due to the different types of motion of the molecular chains/segments and not due to the different types of flow units [13].

The modified Eyring equation is given by:

$$\sigma_y(\dot{\varepsilon}T) = \sum_i \frac{2kT}{\nu_i} \sinh^{-1}\left[\frac{1}{C_i T}\frac{\dot{\varepsilon}}{\dot{\varepsilon}_{0,i}} exp\left[\frac{E_i}{kT}\right]\right]$$

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Where the model parameters include activation volume (v_i), activation energy (E_i), pre-exponential factors (ε_i) and model constant (Ci). k represents the Boltzmann constant; T is the temperature - 293 K. In our future work, we will use the shifting factors introduced by Bauwens-Crowet et. al. [14] to determine the yield strength as a function of strain rate at a reference temperature (room temperature) and then shift the curves to the operating temperature range (-55C, 76C) and compare it with our experimental results.

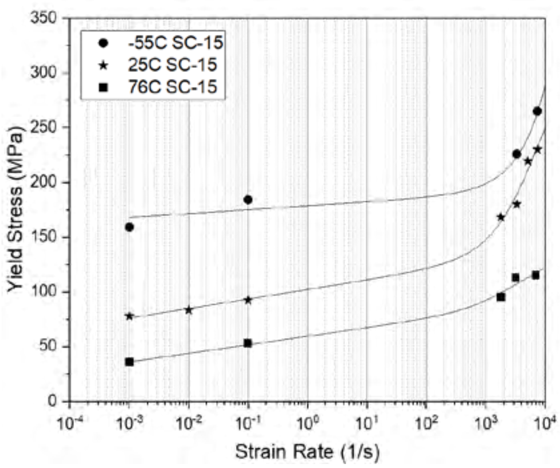

Figure 5. Variation of yield stress with average strain rate using a modified Eyring model for neat SC-15 resin for three different temperatures: -55C, RT, 76C.

Interface Testing using Single Fiber Pullout Tests

Figure 6(a) shows a typical force-displacement curve for a single fiber pullout test. One fiber end is held in the grips and pulled out of the resin. The initial part of the curve is linear, where the fiber-resin interface sees no damage and remains intact. As the load builds up and reaches a threshold value, debonding initiates, i.e., the bond between the fiber and matrix begins to break, and an interfacial crack is initiated. This is an inflection point, and a change in slope is noticeable. From this point onwards, the load is carried through the 'non-damaged' part of the interfacial bond and due to the friction in the debonded part. The load ultimately reaches a peak value, where the crack growth becomes unstable, and the fiber-matrix completely debonds, leading to a sharp drop. The load, however, doesn't drop to zero, and a 'frictional tail force' is noticeable due to the frictional force between the fiber and the resin. This frictional force gradually decreases to zero as the fiber is completely pulled out of the resin.

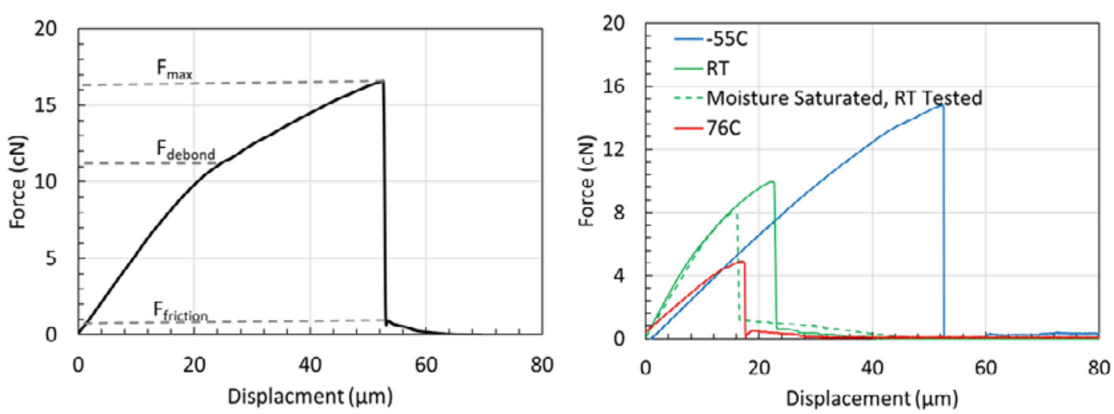

Figure 6. (a) A typical force-displacement curve for single fiber pullout tests and (b) representative force-displacement curves for pullout tests under various environmental conditions.

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	-55C	RT	76C	2.7% moisture, RT Tested
IFSS* (MPa)	139.1 ± 22.4	73.24 ± 3.6	40.0 ± 3.8	53.6 ± 2.7
Le (µm)	56.6 ± 10.0	56.6 ± 4.6	61.9 ± 10.5	61.7 ± 20.6
Fiber Dia (µm)	8.98 ± 0.46	8.71 ± 0.56	9.05 ± 0.29	8.81 ± 0.24

Table 2: IFSS*, embedded length, and fiber diameter values for the four types of specimens tested at different environmental conditions.

Figure 6(b) shows the representative curve of each type of pullout test specimen, -55C, RT, 76C, and moisture conditioned tested at RT. Table 2 shows the important test parameters and the apparent IFSS calculated from the force-displacement curves. The embedded length was similar for all test types, ~ 55-60 µm. The fiber diameter is measured for each specimen after failure using an SEM microscope. The IFSS values depend on temperature and moisture, as seen in Figures 6(b) and Table 2. The IFSS values decrease as temperature increases, and the moisture-conditioned specimen sees a decrease of about 26% in IFSS.

Figures 7(a) - (d) show a typical failure surface after a pullout test conducted at -55C, RT, 76C, and moisture conditioned at RT specimens, respectively. A reasonably clean adhesive or an interfacial failure is observed in all cases. However, at higher magnification, there may be evidence of a thin layer of resin on the fiber surface. There are two potential failure modes for debonding governed by the yield stress of the matrix and the peak traction stress describing the onset of progressive failure of the interface (it is common to model interfacial failure using cohesive traction laws where the peak traction is greater than the average IFSS value determined experimentally). Ganesh [13] et. al. considered the ratio of the interface peak traction/resin yield stress (R) to relate material properties to failure mode. In the case of R>1, interfacial failure is preferred. For R<1, debonding will occur in the resin near the fiber surface. The results presented in this paper show that the R-value and the associated failure mode can be expected to be temperature, strain rate, and moisture dependent. It is also noteworthy that during the load drop shown in Figure 6, the strain rate increases significantly due to unstable crack propagation, and one might expect a transition in failure mode along the length of the fiber.

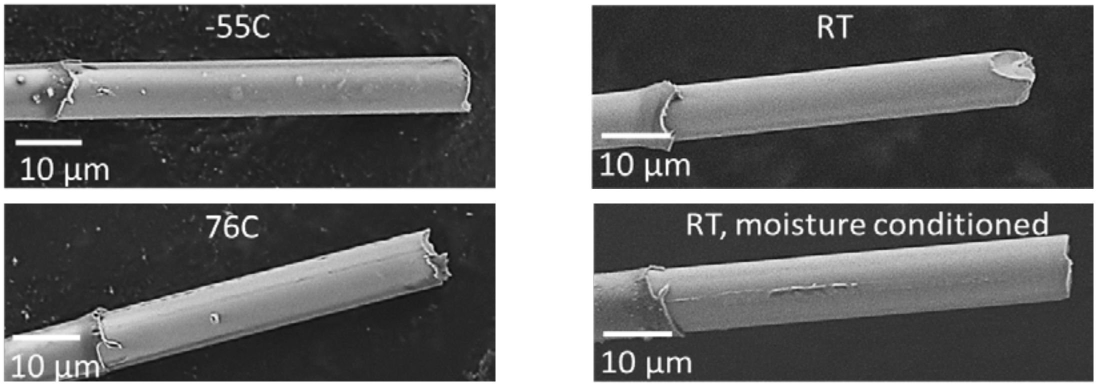

Figure 7. SEM micrographs showing the failure surfaces for all types of test specimens. An interfacial failure is observed for all the test specimens.

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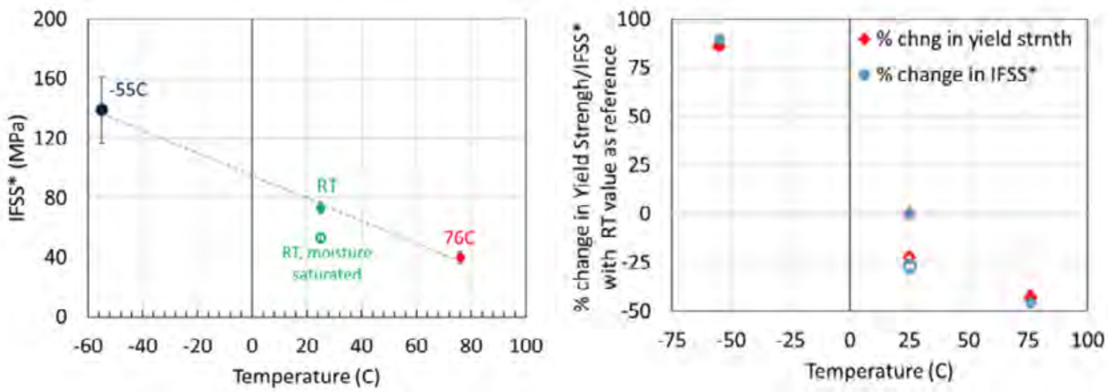

Figure 8. (a) Apparent IFSS plotted against temperature showing a linear correlation and (b) percentage change in apparent IFSS and yield strength calculated using RT value as a reference.

Figure 8(a) shows the plot of apparent IFSS against temperature. IFSS decreases linearly with increasing temperature. The standard deviation for tests conducted at -55C is higher than the other tests for multiple reasons – constituent materials are brittle, and the cold temperatures lead to ice formation on the rubber grips holding the fiber, causing a lot of invalid test failures. Given that the peak loads achieved and therefore the apparent IFSS calculated is affected by yield strength, the percentage change in yield strength and apparent IFSS is plotted in Figure 8(b). The room temperature value is considered the reference (baseline) for both datasets, and percentage change is calculated based on that value. An excellent correlation is observed between the change in IFSS and the change in yield strength. This positive correlation implies that the interfacial failure may be cohesive with a thin resin coating on the fiber since the probability of the temperature dependence of the interphase and the resin being identical is low. This is a topic for more in-depth characterization of the fiber surface.

Low Velocity Impact Tests of Glass Fiber-SC 15 Composites

The force-time and force-displacement curves for the low velocity impact tests conducted on SC-15 composites are shown in figures 9(a) and 9(b). The general trends for specimens at each temperature are similar. As the impactor makes contact, the composite specimen resists it, which increases force. The force reaches the maximum value, and then unloading occurs as the impactor loses contact with the specimen. The maximum force achieved depends on the specimen's stiffness and, therefore, on the temperature at which the test is conducted. The peak force is maximum for the coldest temperature, where specimen stiffness is highest, and the deflection is highest for the 76C specimen with the least stiffness.

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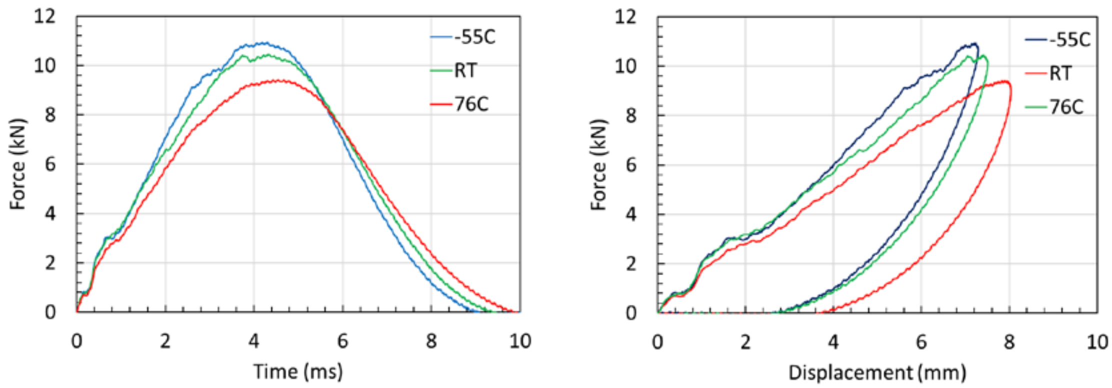

Figure 9. (a) Force-time and (b) force-displacement response of glass fiber-SC-15 composites subjected to 40J impact at room temperature and at the ends of operating temperature range

Figure 10 shows the ultrasound C-scans through transmission images of the impacted specimens. The dark regions in the pictures show the damage areas or the delaminations caused due to the impact. The damage areas for -55C and RT are comparable and about ~ 20% larger than 76C. A limitation of the through-thickness C-scanning is the inability to detect multiple damage planes. The C-scan will provide the largest delamination area, and other delamination areas smaller than that will remain invisible. Therefore, to compare the damage areas created using these images to characterize the amount of delamination and new surfaces made is inaccurate. The damage areas for -55C and RT show vertical lines near the left and right edge of the specimen. This is because the edges of the specimen were clamped. Once the delamination area has reached the edge, further delamination is prevented due to the clamping. That is also likely why the damage areas for -55C and RT look more circular, whereas, for 76C, it is more prominent along the principal axes. To comment more on the delamination resistance of this composite, additional details such as the area of each delamination should be calculated. Our future work will use the pulse-echo ultrasonic technique to investigate this.

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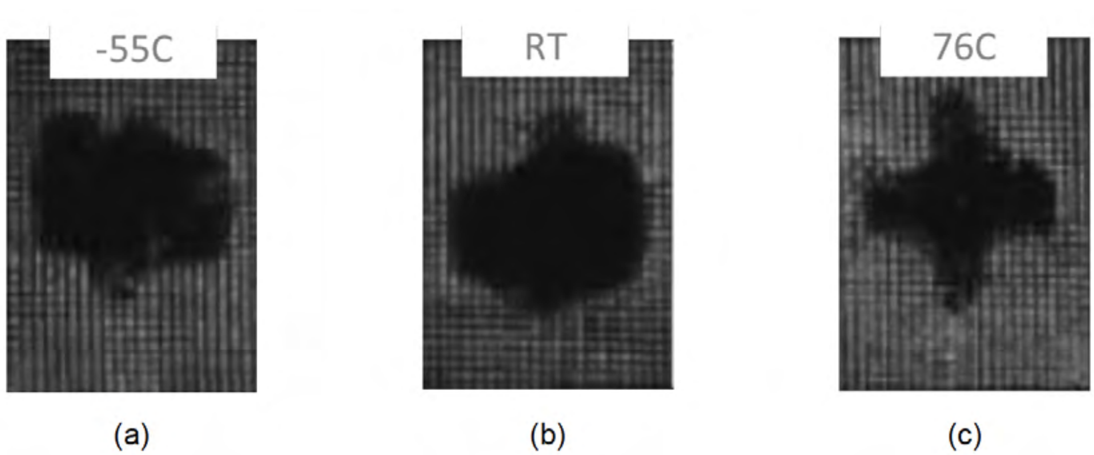

Figure 10. Through thickness C-scans for SC-15 composite specimens subjected to an impact of 40J at (a) -55C, (b) RT, and (c) 76C

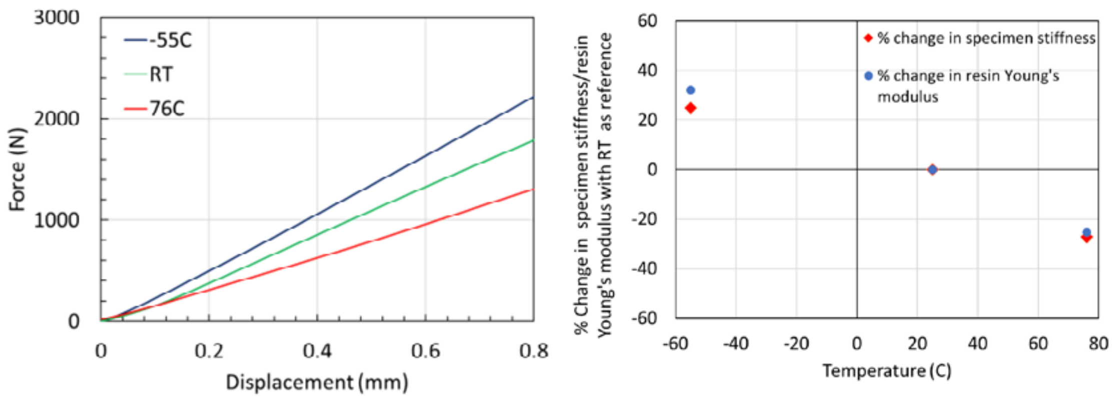

Figure 11. (a) Stiffness of the composite before impact at -55C, RT, and 76C, (b) % change in specimen stiffness, and young's modulus of resin calculated by taking room temperature value as a reference.

Figure 11(a) shows the stiffness of the composite specimens calculated pre-impact. As shown in figure 1(c), the boundary conditions for stiffness testing are the same as that used for LVI tests, clamped on all sides. As intuitively expected and similar to the LVI tests, the stiffness increases as temperature decreases, i.e., the -55C specimen has the highest stiffness. As the loading nose touches the specimen and pushes down on it, the specimen is under transverse loads. These transverse loads cause interlaminar shear deformations and also cause in-plane bending stresses. At higher displacement, it also causes stretching of the layers since the boundaries are clamped. From the above-discussed phenomenon, the resin properties significantly influence the transverse shear deformation of the laminate governed by the interlaminar shear modulus of the composite. Higher resin shear modulus leads to higher composite interlaminar shear stiffness and lesser shear deformation, and an increase in laminate structural stiffness in LVI testing. Figures 11(b) and table 3 show the correlation between specimen stiffness and resin modulus. Considering the room temperature value as a reference, shear modulus increases by 32%, and specimen stiffness increases by 25% at -55C. Similarly, at 76C, both values decrease by 25-27%.

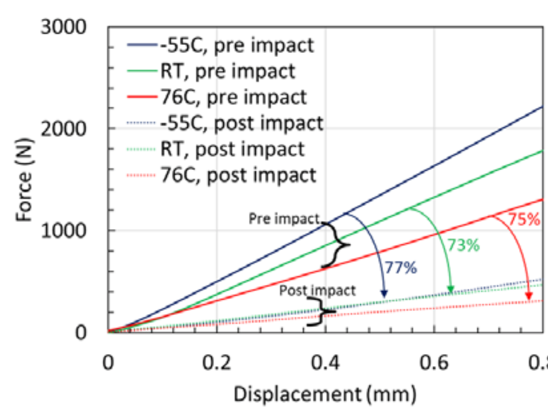

Figure 12. Pre and post impact stiffness for the composites subjected to 40J impacts at the three different temperatures, -55C, RT, and 76C. All specimens suffer about a 75% stiffness degradation due to the impact which is the result of the delaminations of the plies within the composite.

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Temperature at which LVI, Stiffness test Conducted	Stiffness (N/mm), Before Impact	% Change in stiffness due to temperature	Youngs Modulus (GPa, (Compression tests of resin)	Shear Modulus, GPa G = E / (2*(1+ν))	Stiffness (N/mm), After Impact, Tested at -55, RT and 76C	% Stiffness Loss Due Damage from Impact	Energy Absorbed (J)	Delamination Area (c-scan) mm²
-55C	2753	+24.8	2.97 (+32.0 %)	1.09	638	76.8	26.2	4261
RT	2205	0	2.25	0.82	591	73.2	26.5	4453
76C	1605	-27.2	1.68 (-25.3%)	0.61	393	75.4	29.6	3441

Table 3: Stiffness change due to temperature, impact, change in resin Young's modulus, energy absorbed, and delamination areas for the composite specimens subjected to LVI experiments.

About 75% drop in stiffness is observed for all specimens after impact testing at 40J due to the large delamination areas (Figure 12). The stiffness's absolute value for each specimen depends on the geometry of the panel, clamping conditions, and the amount of energy imparted. For example, the same energy imparted on a thicker specimen would lead to a comparatively lesser stiffness reduction. However, the results represent the damage tolerance of the composites and show that the stiffness change due to impact damage (for 40J) is significantly greater than the stiffness change due to temperature. From an automotive application viewpoint, as more composites are used in the primary structure, often to absorb energy during a crash, the fracture toughness of composites and stiffness retention as a function of temperature and strain rates becomes an important area of research. Typical epoxy resins become brittle as temperature decreases, potentially reducing the fracture toughness and energy absorbing capabilities and affecting safety.

Summary and Next Steps

The effect of environmental factors on the mechanical properties of the composites and their constituent materials, resin, and the interface is investigated. Neat resin, fiber-resin interface, and composites are tested at room temperature and the ends of the operating temperature range. The resin properties are characterized using uniaxial compression tests at various strain rates and saturated moisture. Key properties such as yield stress and modulus are calculated at different temperatures, and the influence of moisture on glass transition temperature and mechanical properties are also shown. Interface properties are characterized using single fiber pullout tests to calculate the apparent IFSS. IFSS shows a linear dependence on temperature for this specific resin-fiber combination and shows a good correlation with yield stress. Composites are subjected to low velocity impact tests at room temperature and the ends of the operating temperature range. The stiffness change due to temperature and impact damage is evaluated. The change in stiffness due to temperature correlates well with resin Young's modulus.

Since all the constituent materials play an integral role in both structural integrity and energy absorbing capabilities, characterization of the influence of environmen-

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tal factors provides critical insights into the durability, damage tolerance, and performance of these composites in a wide range of atmospheres. To design a component that can enhance and maintain the functional integrity in a temperature range of -55C to 76C, a resin with a higher glass transition temperature than SC-15 would serve better. Since the pullout tests showed an adhesive failure at all temperatures, the interface of the glass fabric has the potential to be tailored by depositing silanes to improve the interfacial bonding and enhance energy absorbing capabilities. To improve damage tolerance and impact resistance at frigid temperatures, resins with higher fracture toughness should be developed, or alternative means could be used, such as placing a compliant interlayer to enhance decoupling and reduce transverse shear stresses.

Acknowledgements

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This Issue:

Keynote Speakers at ACCE

Jason Coryell, P.E., FASM
Engineering Group Manager -
Advanced Materials Technology at
General Motors Company will present:

"A Role For Composites In GM's Vision For Simulation-Driven & Sustainable Material Impact"

at the SPE ACCE 2023, Sept 6 – 8, 2023

Jason is an Engineering Group Manager – Advanced Materials Technology at the General Motors Company. His team is responsible for leading material innovation across the company and material card development for virtual design, development, and validation. Prior to this role, Jason spent six years managing the Body Structures and Closures Materials Engineering team, three years as a Technical Integration Engineer in the Body Manufacturing – Advanced Technology Group, and ten years as a Project Engineer in the Body Materials Engineering Group, with special assignments in Research and Development. He holds a Master's of Science degree from the Colorado School of Mines and a Bachelor's of Science and Engineering degree from the University of Michigan – Ann Arbor. Jason is also a licensed Professional Engineer in the state of Michigan and a Fellow of ASM International.

This Issue:

Keynote Speakers at ACCE continued...

Joe Summers
Commercial Director Airborne and Managing Director Airborne UK will present:

"What Does Disruptive Electrification of Transport Mean for Industrialization of Composites"

at the SPE ACCE 2023, Sept 6 – 8, 2023

Joe Summers has been in the composites industry for nearly 25 years, starting his career at Gurit where he held various roles including Head of Engineering and Program Management, and Director of Business Development. He joined Airborne in 2017 and is Commercial Director for the automation business, along with being Managing Director of the UK subsidiary. Joe is also a director of Composites UK, the UK composites trade association.

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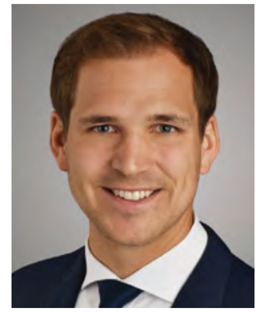

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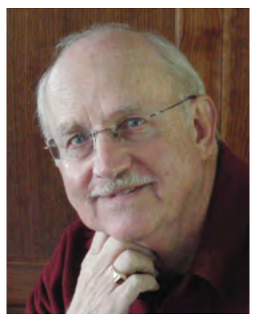

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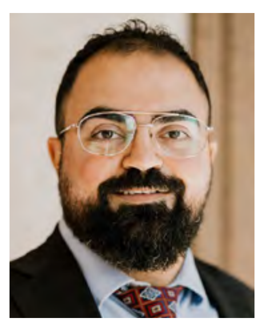

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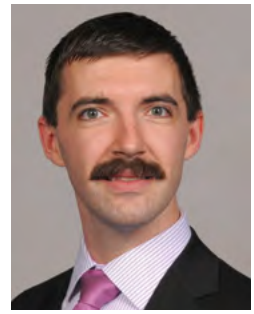

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