AUTOMOTIVE PLASTICS NEWS
A PUBLICATION OF THE AUTOMOTIVE DIVISION OF THE SOCIETY OF PLASTICS ENGINEERS

December 2011 - Volume 41, Issue 2

SPE AUTOMOTIVE DIVISION ANNOUNCES WINNERS OF 41ST *AUTOMOTIVE INNOVATION AWARDS COMPETITION*

The Automotive Division of the Society of Plastics Engineers announced the category and Grand Award winners for its 41st-annual ***Automotive Innovation Awards Competition***, the oldest and largest recognition event in the automotive and plastics industries. After a pre-qualification round, surviving nomination teams presented their applications before a panel of automotive and plastics industry experts during two days of judging on September 29th and 30th.

Innovation Awards Program Chair Jeff Helms presents the Grand Award to Ford Motor Co. and the suppliers involved in the MUCELL Instrument Panel application.

Finalists selected from each category advanced to the *Blue Ribbon Judging* on October 10th where category and Grand Award winners were selected. Category and the event's Grand Award winners were announced on November 9 during the ***Automotive Innovation Awards Gala*** at Burton Manor in the suburbs of Detroit.

According to the 2011 ***Automotive Innovation Awards*** program chair, Jeff Helms, global automotive manager, Ticona Engineering Polymers, "We were really pleased with the number of nominations we received this year, the diversity of automakers represented, and the quality of innovation they displayed. At each round of the competition, our judges had a hard time selecting finalists and then winners from all the strong nominations we received. It's great to see that innovation is alive and well in the automotive plastics arena and that this industry is coming back stronger than ever with higher quality, better fuel economy, using more sustainable materials and manufacturing, and offering consumers greater features, value, and safety."

Continued Page 4

- ACCE Call for Papers Page 15
- AutoEPCON Page 26
- Automotive Division Calendar Page 2
- Chair's Message Page 3
- Councilors Report Page 2
- Education Report Page 30
- Technical Article Page 20
- VETA Award Winner Page 11

Councilor Report

Tom Pickett

The following summarizes the highlights of the SPE Council Meeting on November 12, 2011 in Barcelona, Spain. The Elections of SPE Officers and the approval of the budget were part of the meeting agenda. I attended the Councilor Meeting by virtual meeting and teleconference. SPE National indicated that the detail meeting minutes and supporting reports will be posted on the SPE Website.

Brent Strong, SPE Secretary coordinated roll call. Some Section and Division Councilors were not present. Three consecutive Councilor s missing the meeting will result in the Division or Section being defunct. President Russ Broome recognized several guests of in the room, SPE Staff and past Presidents in attendance. The Councilor Meeting Minutes from May ANTEC was approved.

Russ Broome reported that Lesley Kyle, SPE Conference and Event Planner, plans to resign from SPE for personal reasons. Russ and SPE appreciated her services.

Russ Broome reviewed the agenda. In his President's Remarks, Russ talked about embracing change. Past SPE President Ken Braney reported on the executive Director Search for replacement of Susan Oderwald. An outside search firm was used. A number of well qualified candidates applied.

November 29 and 30 there is a technical conference in India. The 2012 budget was proposed and approved.

Elections took place for President – Elect, Senior Vice President, Vice President and Council of the Whole Chair. Jon Ratzlaff elected President – Elect. Dick Cameron elected Senior Vice President. Gregory Campbell elected Vice President.

Steve McCarthy had the Councilors vote on student chapters to be placed on provisional status for not being active. Membership update from T. Conklin. Membership is 14,806.

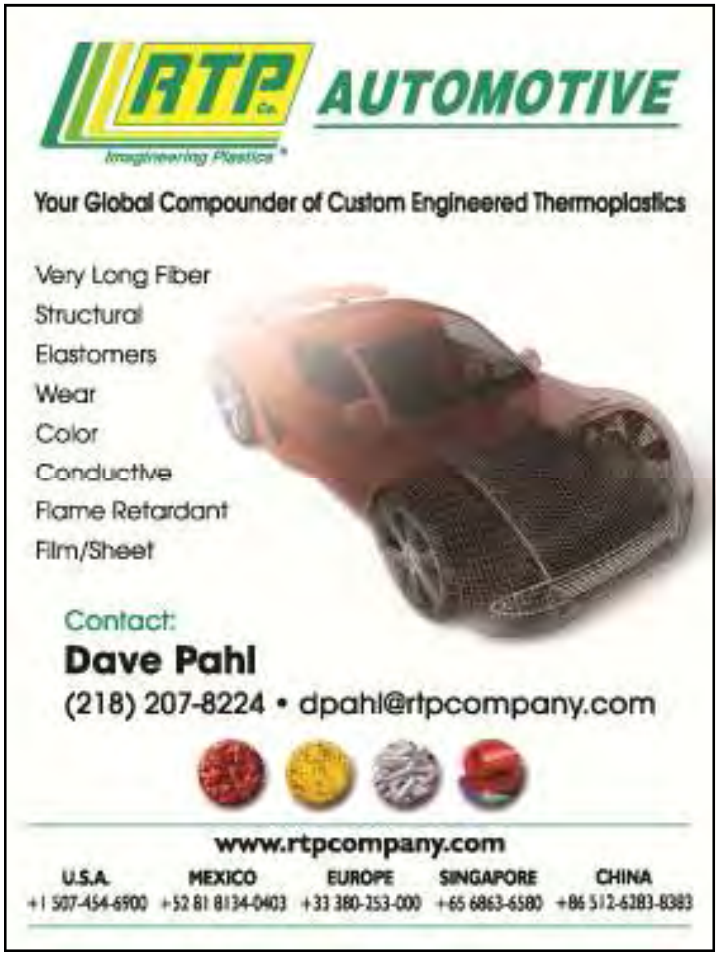
Jim Griffin, President Elect, talked about the schedule of meetings he plans for his term as SPE President. On April 2-4, 2012 he will have a meeting at ANTEC / NPE in Orlando, FL. On September 14-15, 2012 he will have a meeting in Dearborn, MI. He plans to host a cocktail party in Detroit on September 13. He felt Detroit was an appropriate place since it is where SPE was founded and we have an active Automotive Division and Detroit Section.

The next Council Meeting is February 24, 2012. It will be a Virtual / Teleconference Meeting.

Automotive Division Meeting Schedule and Special-Events Calendar

Automotive Division BOD Meeting—All invited ! American Chemistry Council, Troy, MI	January 30, 2012
Automotive Division BOD Meeting—All invited ! American Chemistry Council, Troy, MI	April 2, 2012
AutoEPCON MSU Education Center Troy, MI	May 1, 2012
Automotive Division BOD Meeting—All invited ! American Chemistry Council, Troy, MI	June 18, 2012

Automotive Division Board of Directors meetings are open to all SPE members. All our events are listed on our website at **http://speautomotive.com/ec**
Call Anthony Gasbarro at (248) 721.0276
for more information.



Chair's Message

Anthony Gasbarro

By the time this arrives to you it will be 2012 – Happy New Year!

I am writing this on a day I took off from work because I had volunteered to help out at my daughters pre-school. I try to help out around there whenever possible, but this time was a bit more involved than the rest.

I dressed up as Santa Claus and toured the 6 pre-school classrooms talking with the kids, handing out books as gifts and singing Christmas carols. It was a lot of fun looking back on it. I really got into the role, I loved seeing the joy on the kids face as I walked down the hallways ringing bells…it was good fun all around and I pray they will ask me again next year to do it again. I will in a heartbeat.

I bring this up because what I did was a little out of my comfort zone – not something I would ordinarily do. But I did it, I stepped out of my shell, I tried it and I really liked it. It was likely more rewarding for me than it was enjoyable for the kids. And really, that is what giving is all about. We can give really only three things. Time, Talents and Treasure.

I ask you – this New Year – this 2012 – will you step out of your shell to give a little more? Will you try something that sounds fun, but you also may be a little scared of? I was scared that little kids were going to pull on my fake beard, say that I didn't sound like Santa, say that I was too skinny (a first); on and on…I was fearful. Once I got into the role of Santa Claus it all came natural, my natural abilities took over and it was easy.

Challenge yourself this year – try something new, try something you never thought you would do, whether it be skydiving, skiing, volunteering for the Automotive Division of the SPE (You knew that was coming!) – try something new and enjoy it. Don't let the fear of failure get in your way – and you will be happy you tried something new. I know I am.
Now on to other news…I hope you made it to the Innovation Awards Gala in November – It was really a great event that was very well attended and showcased many exciting innovations.

We have also started planning our next Auto Epcon – one day conference on Engineering Plastics. This is a great multi session Technical Conference that also has Keynote addresses and Plenary Speakers.

Please check out more information at www.speautomotive.com/emc

I am always encouraging more attendance at our Board of Directors meetings. Our next meeting is scheduled for January 30th at the ACC offices on Crooks Rd. in Troy, MI. A call-in number is always provided – please get in touch if you would like more information. We would be happy to help you become involved. We are currently looking for someone to lead our efforts in organizing Social Events – if this is something you are interested in or you have a passion for, please let me know.

Thanks for your time – look for something to challenge you a little bit and take it on.

I look forward to seeing more of you at our events and feel free to say hello to me personally at anthonygasbarro@yahoo.com if you have any questions or comments about our Division.

Thank you and make it a great day.

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Innovation Awards Program

Continued from Page 1

Finalists and category winners selected from this year's pool of nominations include the following:

The Grand Award, the most prestigious award of the evening, went to the winner of the Process/ Assembly/Enabling Technologies category - the **MUCELL Instrument Panel** on the Ford Motor Co. 2012 MY Ford Escape SUV & Kuga CUV.

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Other category winners included:

Body Exterior

Ram Box Assembly with Lid
Chrysler Group LLC
2012 MY Dodge Ram pickup

Body Interior

Overmold-Cushion Suspension
Ford Motor Co.
2012 MY Ford Escape SUV & Kuga CUV

Chassis / Hardware

Power-Window Motor Output Gear & Shaft
Ford Motor Co.
2011 MY Ford All Focus compact cars (globally)

Environmental

Renewably Sourced PA for Biodiesel Fuel Lines
Fiat S.p.A.
2011 MY Fiat Diesel engines, various models

Materials

Volcanic-Filler Pillar Trim
Hyundai-Kia Automotive Group
2011 MY Kia Pride subcompact & Optima mid-size sedan and Hyundai Elantra compact car

Powertrain

Battery Pack
General Motors Co.
2011 MY Chevrolet Volt extended-range EV

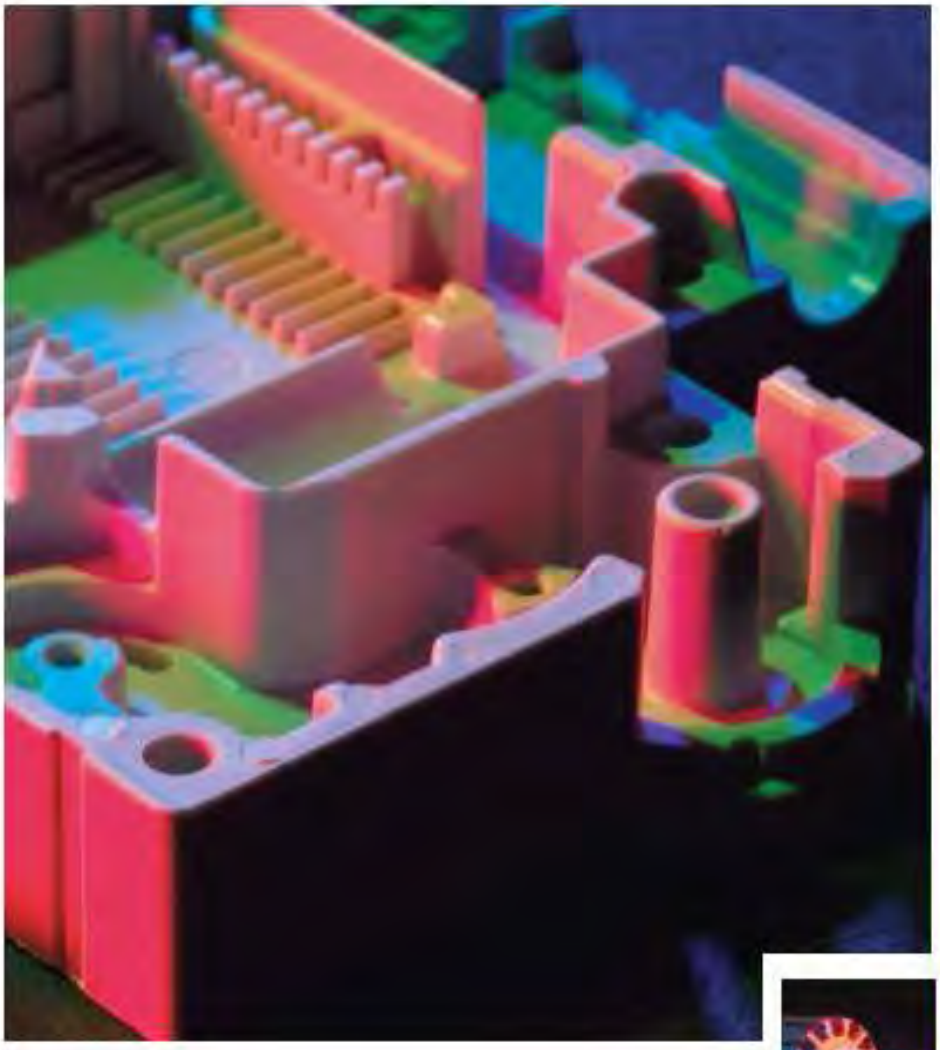
Safety

Reinforced Airbag Lid in Foam (RALF)
Ford Motor Co.
2011 MY Ford Focus compact car

Additional details on all 43 nominated applications can be found on our website at www.speautomotive.com/inno

SPE's Automotive Innovation Awards program is the largest competition of its kind in the world and the oldest recognition event in the automotive and plastics industries. Dozens of teams made up of OEMs, tier suppliers, and polymer producers submit nominations describing their part, system, or complete vehicle module and why it merits the claim as Year's Most Innovative Use of Plastics.

This annual event typically draws over 600 OEM engineers, automotive and plastics industry executives, and media. As is customary, funds raised from the event are used for SPE educational efforts and technical seminars, which help to secure the role of plastics in the advancement of the automobile.



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”Most Innovative Use of Plastics”

MUCELL INSTRUMENT PANEL

2012 MY Ford Escape compact SUV & Kuga compact CUV

OEM Make & Model: Ford Motor Co. 2012 MY Ford Escape compact SUV & Kuga compact CUV

Tier Supplier: Faurecia

Material Suppliers: SABIC Innovative Plastics
Flint Hills Resources

Toolmaker: Lamko

Materials: Stamax EXRP-49 30YK270 & AP3335-HF long glass / 30% talc-filled PP

Process: Microcellular injection molding

Description: This is the largest automotive component molded in the patented MuCell injection-molding process and the first instrument panel to be molded in this process. By creating the part in microcellular foam, weight is reduced over 1 lb, mechanicals are improved, cycle time is reduced 15%, and clamp tonnage is reduced 45%, saving an estimated $3 US / vehicle vs. solid injection molding.

Also named Process/Enabling Technologies Category Winner

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Body Exterior Category Winner

Ram Box Assembly with Lid

OEM:	Chrysler Group LLC
Make & Model:	2012 MY Dodge Ram pickup
Tier Supplier:	Penda Corp
Processors:	Penda Corp., Evco Plastics, River Bend Industries
Material Supplier:	Asahi Kasei Plastics North America
Toolmakers:	Cavalier Tool & Mfg. Ltd. Tooling Technology LLC
Material:	Thermylene P8-40FG-4611 , P6-15FG-0741; P6-15FG-0754

Description: Twin-sheet thermoforming replaces blow molding to create the structure and ribbing of this tough storage box with lid. The result is a more uniform, more dimensionally accurate part whose length was increased from 5 ft 7 in. to 6 ft 4 in., requiring greater emphasis on the "heavy-duty" nature of the structure's design and materials of construction. A special new grade of GR-PP eliminated the need to upgrade to heavier and more costly PA 6/6, avoiding a 9% weight and 20% cost increase.

Environmental Category Winner

Renewably Sourced Nylon for Biodiesel Fuel Lines

OEM:	Fiat S.p.A.
Make & Model:	2011 MY Fiat Diesel engines, various models
Tier Supplier:	Hutchinson
Material Supplier:	DuPont Automotive
Material:	Zytel RS 1610 PA 10/10

Description: This is the first automotive use of PA 10/10 and the first bio-based PA 10/10 application. It is used in a diesel fuel line replacing PA 12. The bio-based resin provides superior temperature and chemical resistance, as well as heat-aging performance in biodiesel fuel blends vs. PA 12. This specific composition also contains a minimum of 60% bio content by weight for a more sustainable solution.

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Chassis & Hardware Category Winner

Power-Window Motor Output Gear & Shaft

OEM:	Ford Motor Co.
Make & Model:	All Focus compact cars (globally)
Tier Supplier:	Brose Fahrzeugteile GmbH & Co. KG
Processor:	Mitsuba Corp.
Material Supplier:	DuPont Automotive
Toolmaker:	Camoplast Inc.
Material:	Hytrel TPC-ET polyester

Description: This power-window motor changed from a steel output pinion to a new injection-molded polyester one for a quieter/lighter motor to meet customer targets while still complying with window velocities. It is industry's first plastic output pinion that ensures functionality. Additionally, the design allows for regulator plug-'n-play capability into the power drum for better motion control. Packaging of the involute onto the spline gear to the accommodating drum spline was critical to the customer. The application saved $450,000 USD direct and $250,000 indirect cost savings annually.

Body Interior Category Winner

Overmold-Cushion Suspension

OEM:	Ford Motor Co.
Make & Model:	2012 MY Ford Escape SUV & Kuga CUV
Tier Supplier:	Flex-O-Lators Div. of Leggett & Platt
Material Supplier:	Washington Penn
Toolmaker:	Advanced Mold Engineering Inc.
Material:	PPC5UF0 PP

Description: The injection-molded PP design reduces part count from 5 to 1 / seat, piece cost $0.56 USD per seat, tooling costs $288,000 USD, and per-vehicle mass by 1.93 kg vs. the previous design. The single-piece design provides wire harness routing and retention, seat-cushion and back-trim retention, and climate-control system retention – functionality that previously required 6 parts to achieve. Now there are 5 fewer parts to manage, control, and install and fewer opportunities for potential failure modes.

Chrysler wins 2011 Vehicle Engineering Team Award

The interiors of the 2011 model year (MY) Chrysler® 200 and Dodge® Avenger® mid-size sedans, which were developed and launched as part of vehicle facelifts in just over a year, won Chrysler Group LLC and its interiors supplier, Faurecia, the 2011 *Vehicle Engineering Team Award* (*VETA*) from the *Automotive Division of the Society of Plastics Engineers* as part of the group's 41st-annual *Automotive Innovation Awards Competition*, the oldest and largest recognition event in the automotive and plastics industries. James N. Lyijynen, system responsible – Interior Cockpit, System & Component Engineering, at Chrysler Group LLC accepted the award on behalf of all OEM and supplier team members during SPE's annual *Automotive Innovation Awards Gala* on November 9, 2011.

VETA recognizes the technical achievements of entire teams comprised of automotive designers and engineers, tier integrators, materials suppliers, toolmakers, and others whose work—in research, design, engineering, and/or manufacturing—has led to significant integration of polymeric materials on a notable vehicle. Chosen by a panel of Blue Ribbon judges and SPE Automotive Division board members from nominations by automakers, the winning team was selected, in the words of one judge, "because of the incredibly tight timing and the highly integrated team approach taken with key suppliers."

All new interiors for both the 2011 Dodge Avenger and Chrysler 200 sedans were developed in a record 54 week time period, just over 12 months from surface freeze to start of production (SOP). The previous-generation Chrysler Sebring and Dodge Avenger interiors were developed on a 30 month time line. Partly as a result of the 2008 global economic downturn and the ownership change of Chrysler Group LLC in 2009, the new company was at risk of not having a competitive sedan in the D segment, the second-largest segment in the automotive market. To remain competitive, Chrysler Group needed a solution that could be brought to market rapidly.

Not only did the team face a compressed development cycle, but other challenges also presented themselves, including ongoing product changes (e.g. late theme and feature/content changes); no plan for a design/validation test phase or prototype vehicles; short lead times to build (hard) production tooling and limited tool-trial runs planned

before launch; as well as unknown model year phase out/phase timing at the start of the program.

Dedicated Chrysler support for both surface approvals and graining, and executive oversight by both the automaker and Faurecia helped support the timeline and facilitated rapid decision making. Co-location of a dedicated Chrysler console stylist at Faurecia, and management of Class A design for consoles and door trim by Faurecia employees, plus a daily "war room" huddle kept both companies fully engaged in the process. And owing to Faurecia's global organization, team members in the U.S., Mexico, France, India, and China participated, allowing for a true 24/7 response to the development effort.

Thanks to the unique collaboration and team discipline, the new Chrysler 200 and Dodge Avenger sedans launched with beautifully updated interiors featuring premium materials, ambient lighting, and other accents, all at a lower cost than the outgoing models. Other benefits of the collaboration included halving the normal delivery time; use of nickel-shell tools, which allow for quick and accurate duplication as production demands increase but provide a quality equivalent to electroplated tooling; higher quality parts with smaller and more accurate tolerances; and an increase in the perceived quality for grain definition.

To prepare for sales globally, production of interior components now takes place in the U.S., Mexico, Spain, and China to serve global demand. The interior of both vehicles makes use of 183 primary tools for both injection and thermoforming and represents the first production application of rapid nickel-shell in-mold grain tools.

Safety Category Winner

Reinforced Airbag Lid in Foam (RALF)

OEM: Ford Motor Co.
Make & Model: 2011 MY Focus compact car
Tier Supplier: Faurecia Interior Systems
Material: PET & PUR

Description: RALF technology is an optimized instrument panel / passenger airbag door system that uses a reinforced structural 3D-skeleton of PET mesh textile and polyurethane foam lid. RALF replaces the traditional metal or plastic airbag lid door and offers much improved airbag lid positioning with less risk of windshield breakage. It offers significant weight savings over traditional foam-in-place airbag construction and is cost-neutral.

Materials Category Winner

Volcanic-Filler Pillar Trim

OEM: Hyundai-Kia Automotive Group
Make & Model: 011 MY Kia Pride subcompact & Optima mid-size sedan and Hyundai Elantra compact car
Tier Supplier: Plakor Co. Ltd.
Material Supplier: Hyundai EP Co. Ltd.
Material: Supol HL345CL PP

Description: This lightweight, injection-molded PP pillar trim provides the texture and appearance of more costly fabric-wrapped trim through use of a unique filler combination consisting of volcanic rock, fiber pile, and glass spheres replacing talc-filled PP and fabric-wrapped PP. No special tooling was required but process control was important so as not to crush the glass spheres and to distribute the fiber pile evenly during compounding and molding. A 10% weight and a 50% direct cost savings was achieved. Other benefits gained from using the volcanic mineral are that it emits negative ions (to reduce pollutants) and far-infrared energy.

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Powertrain

Battery Pack

OEM:	General Motors Co.
Make & Model:	2011 MY Chevrolet Volt extended-range EV
Tier Supplier:	General Motors Co.
Processor:	MANN+HUMMEL GmbH
Material Supplier:	BASF Corp.
Toolmaker:	Omega Corp.
Material	Ultramid 1503-2F PA66 33%GF, HS

Description: Thermoplastic battery frames are an integral part of electric-vehicle thermal management, channeling coolant to and from the cells. The use of injection-molded hydrolysis-resistant PA 6/6 for thermal-cycling management is a lightweight enabling material for this design, which required exacting manufacturing consistency and high levels of repeatability and reproducibility.

Hall of Fame

First Integrated Door-hardware Module

OEM:	General Motors Co.
Make & Model:	1997 Chevrolet Venture and Malibu, Pontiac Transport, Oldsmobile Silhouette and Cutlass, and Opel Sintra
Tier Supplier:	Delphi Interior & Lighting Systems *Now Inteva Products, LLC*
Material Supplier:	GE Plastics *Now SABIC Innovative Plastics*
Material	Ultramid 1503-2F PA66 33%GF, HS

Description: As the first all-plastic door-hardware module, it reduced components and fasteners by up to 75% by molding features into a single gas-assist injection-molded composite frame that literally “plugged-into” the inner door on the vehicle-assembly line, improving ergonomics and quality, saving labor time and costs, and reducing warranty claims. Industry sources estimate that over 250-million integrated composite door-hardware modules have been produced globally by all suppliers since 1997 and used on over 60-million vehicles worldwide.

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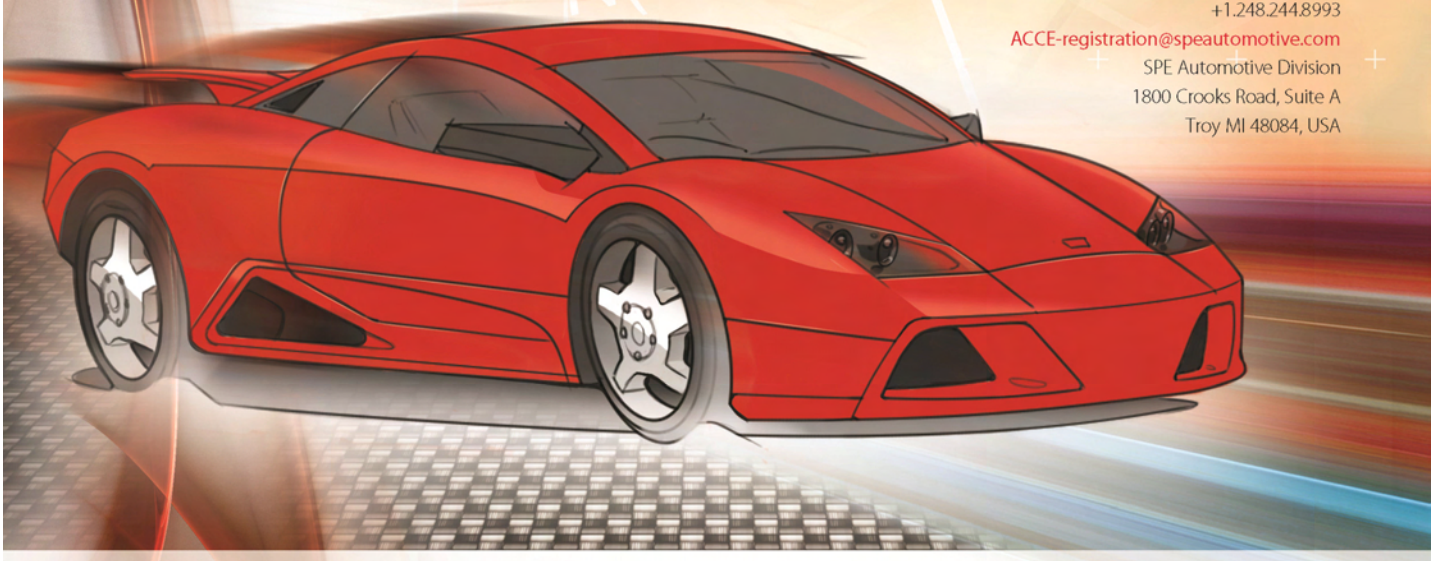

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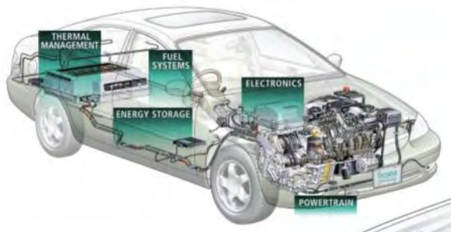

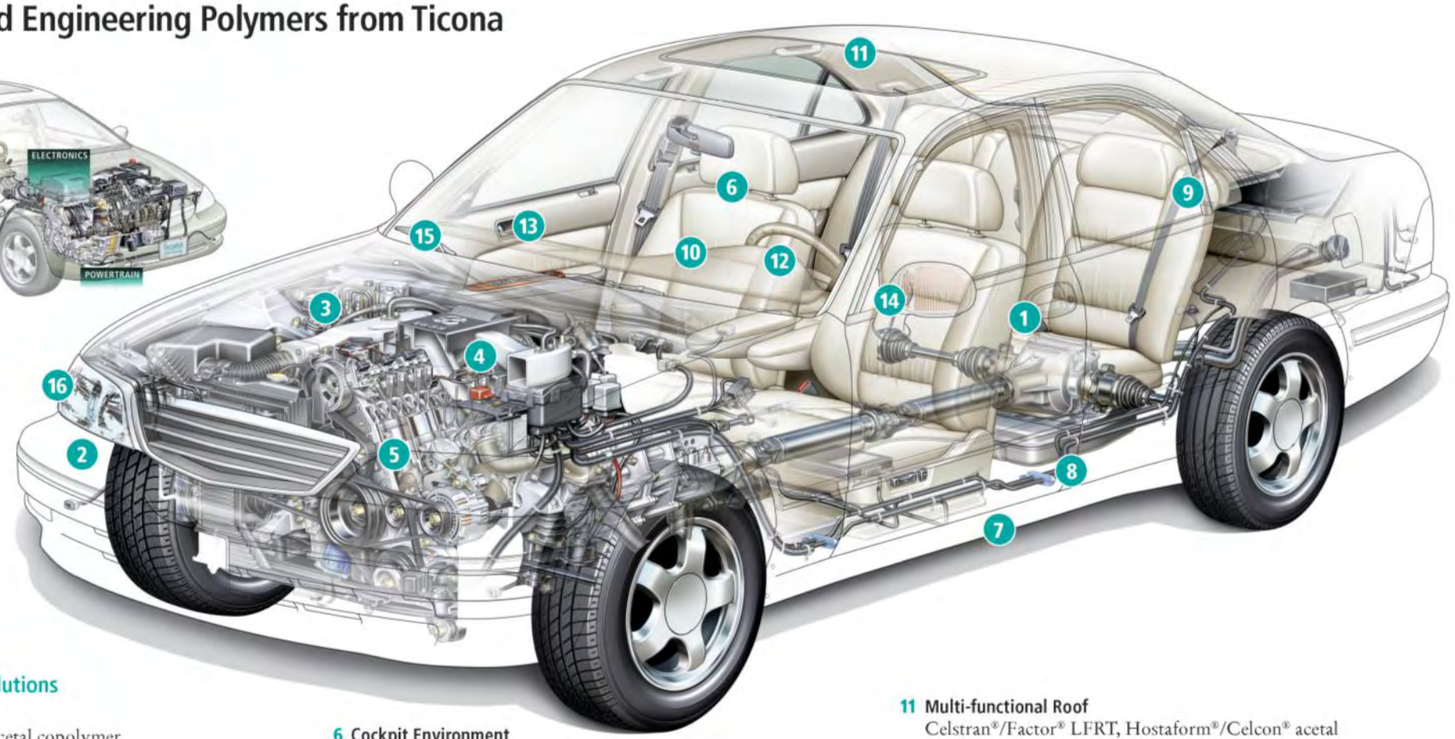

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8 Advanced Fuel Delivery
Hostaform®/Celcon® acetal copolymer, Fortron® PPS, Celanex® PBT, Riteflex® TPC-ET

9 Seating and Restraint
Hostaform®/Celcon® acetal copolymer, Celstran®/Factor® LFRT, Riteflex® TPC-ET, Celanex® PBT, Vandar® PBT

10 Safety Systems
Celanex® PBT, Vectra®/Zenite® LCP, Fortron® PPS, Hostaform®/Celcon® acetal copolymer, Celstran®/Factor® LFRT

11 Multi-functional Roof
Celstran®/Factor® LFRT, Hostaform®/Celcon® acetal copolymer, Celanex® PBT, Fortron® PPS

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Reed honored with Lifetime Achievement Award

David (Dave) B. Reed P.E., who worked for then General Motors Corp. (GM) for 45 years in Product Engineering and helped develop many innovative automotive-plastics applications, has been named the eleventh recipient of the prestigious ***Lifetime Achievement Award*** from the Automotive Division of the Society of Plastics Engineers.

The award recognizes the technical achievements of automotive industry executives whose work – in research, design, and engineering, etc. – has led to significant integration of polymeric materials on vehicles.

Dave Reed was selected as this year's Lifetime Achievement award winner for his leading role on many of GM's composite-bodied vehicles as well as numerous plastics innovations. He began his career at GM in 1963 while a co-op student at then General Motors Institute (GMI, renamed Kettering University) and joined the Chevrolet Materials Group in 1967. He held many positions of increasing responsibility over the years, and contributed to many new applications, including: nylon Type 11 fuel lines, painted TPO bumper-filler panels, painted PUR (RIM) bumper fascias, composite body panels, enhanced interior materials, as well as polycarbonate (PC) lenses for truck rear tail lamps.

Reed has a long history of service to engineering societies. He is a recipient of SAE International's Forest R. McFarland Award for work on innovative technical sessions on such topics as Advances in Automotive Composite Body Panels, New Composite Cars, New Developments in Asian Plastics Applications, and Automotive Plastics Recycling. He also organized and led a technical session on Challenges in SMC Finishing at SPE's own inaugural Automotive Composites Conference & Exhibition (ACCE), and has been a long-time director on the board of the SPE Automotive Division.

David Reed accepts the Lifetime Achievement Award from Fred Deans.

The 41st Anniversary Innovation Awards Program was one of the best attended programs in many years. Over 600 plastics professionals, OEM engineers, suppliers, and media were in attendance. All 43 of the nominated applications submitted for this years competition were on display, as were numerous recently introduce vehicles, including the 2011 Ford Explorer, 2012 Ford Taurus Police Interceptor, 2012 Dodge Ram, 2011 Chevrolet Volt, plus many others. Receptions before and after the awards program provided ample opportunities to network with leading engineers and executives in the auto industry.

Pictures from the entire event can be viewed and/or downloaded at **http://alturl.com/kr2za**

Enabling Faster Resin Infusion Processing of Automotive Composites:

A "Nano-Nectar" Technology Leading Epoxy to High Performance and Low Viscosity

W.H. Zhong, School of Mechanical and Materials Engineering
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Abstract

Graphitic carbon nanofibers (GNFs) were first made into a "nano-nectar", which is "liquid nano-reinforcement" (LNR) with reactive nanofibers (r-GNFs). Due to the uniform dispersion of r-GNFs in the LRN, simply mixing the LNR with an epoxy led to a nano-modified epoxy with uniform dispersion of nanofibers, a so-called nano-epoxy. More importantly, the nanofibers were involved in the cross-linking structures of the epoxy through covalent bonding between the epoxy matrix and the nanofibers. Results showed that the nano-epoxy possesses dramatically reduced viscosity and enhanced multiple mechanical and thermal performances by simply mixing two kinds of liquids: a very small amount of LNR, functioning as a "nector" and a base epoxy matrix. The simplicity of the "nano-nectar" approach leading to reduced viscosity (e.g. 50% lower than the pure epoxy) can lead to faster Resin Infusion processing for automotive composite manufacturing due to reduced power requirements for flow and part consolidation.

Introduction

A resin matrix with good processability (e.g. low viscosity) and advanced comprehensive performance including high mechanical

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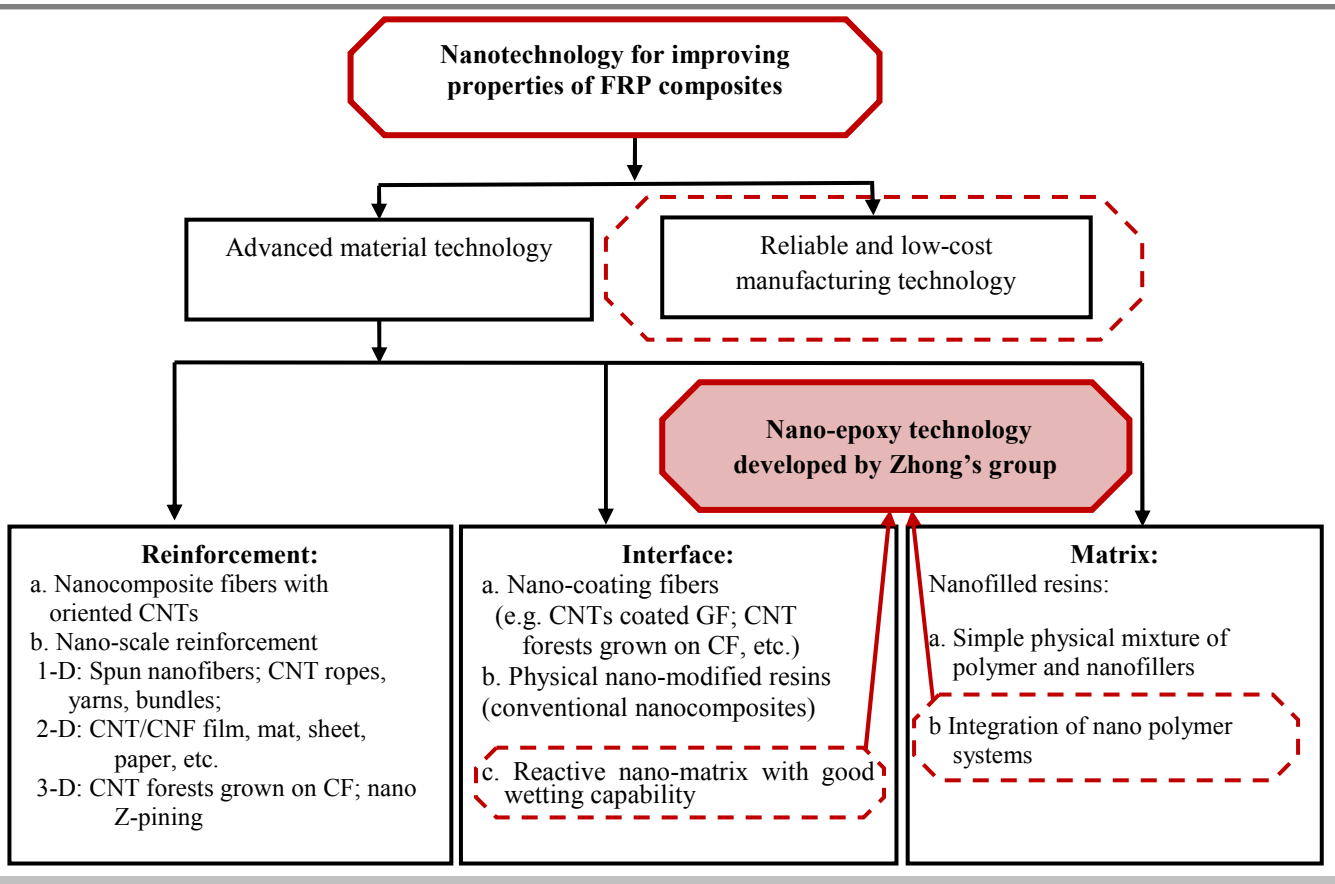

Figure 1: Nanotechnology for FRP composite property enhancement. [1]

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Technical Paper

Continued from Page 20

properties, thermal stabilities, good wetting and adhesion capability are highly desired for fiber reinforced polymer (FRP) composites. Through nanotechnology, properties of FRPs could be enhanced through developing high performance reinforcements and resin matrix materials, as well as increasing interfacial adhesion properties between the fiber and matrix (Figure 1) [1].

Though the absolute properties of carbon nanofibers (CNFs) in the length direction, such as mechanical properties and electrical conductivity, are not as high as CNTs, there are several advantages available for CNFs. Firstly, because of the high purity components of graphitic structures (extremely low contents of free carbon and non-carbon ingredients), there is little or no need to do any purification for commercial CNF products, which have much lower price and stable quality. Secondly, the stacked geometry of CNFs provide an abundance of reactive edges at the ends of the graphene sheets along the fiber direction, which can be used to enhance nanofiber chemical modification – edge sites are far more reactive than surface sites. Thus, CNFs can be surface-functionalized with reduced processing time. This can lead to great potential for applications in structural FRP composites with bulk volume needs.

Preparation of Liquid Nano-reinforcement (LNR)

Detailed procedures for preparing surface-functionalized herringbone CNFs with (3, 4'-oxydianilino)amidyl (ODA) linker molecules, 4', formed into CNF-ODA suitable for covalent incorporation into epoxy resins were provided in [2-4]. The subsequent treatment procedures that resulted in the "liquid nano-reinforcement", LNR, include cutting the as-received GNF-ODA nanofibers into shorter ones using appropriate ultra-sonication methods with controlled sonication conditions [5], and then these CNFs were further reacted with a "small epoxy", butyl glycidyl ether (BGE, a reactive diluent of epoxy) (Figure 2) under special conditions [7]. This is because BGE has the epoxide group similar to the epoxy but being smaller molecules than typical epoxy molecules, thus it functioned as a reactant that can react with CNF-ODA.

On the other hand, BGE was used as a dispersant for cutting GNF-ODA nanofibers through ultra sonication methods. After the reaction with the GNF-ODA to obtain the reactive nanofibers, r-GNFs, as shown in Figure 2 [7], a controlled amount of BGE with uniform dispersion of r-GNFs will be kept. Because BGE is a reactive diluent the main function for conventional epoxy processing is to lower the viscosity of the epoxy. Through the series studies, an optimum ratio of r-GNFs to BGE in the solution was obtained. Through addition of a very small amount of this solution into the epoxy showed a dramatically improved multiple performances; in particular, the viscosity is decreased dramatically. Thus, the nanofibers were converted into a liquid form, the so-called "liquid nano-reinforcement", with a controlled ratio of the reactive nanofibers to BGE. This stable and uniform solution was then simply added to the epoxy resin. Because the nanofibers were evenly dispersed in the LNR, simply mixing two kinds of liquid: LNR and pure epoxy resulted in the nano-modified epoxy with good dispersion of the nanofibers. Thus, a nano-epoxy matrix with low concentration of nanofibers, such as 0.3 wt% r-GNFs, was obtained.

By developing a nano-epoxy based on the conversion from the dry nanofibers into the LNR,

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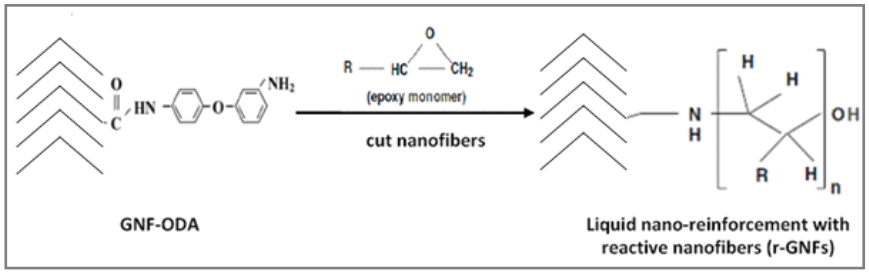

Figure 2: Structure of GNF-ODA and formation of an r-GNF [7]

Technical Paper

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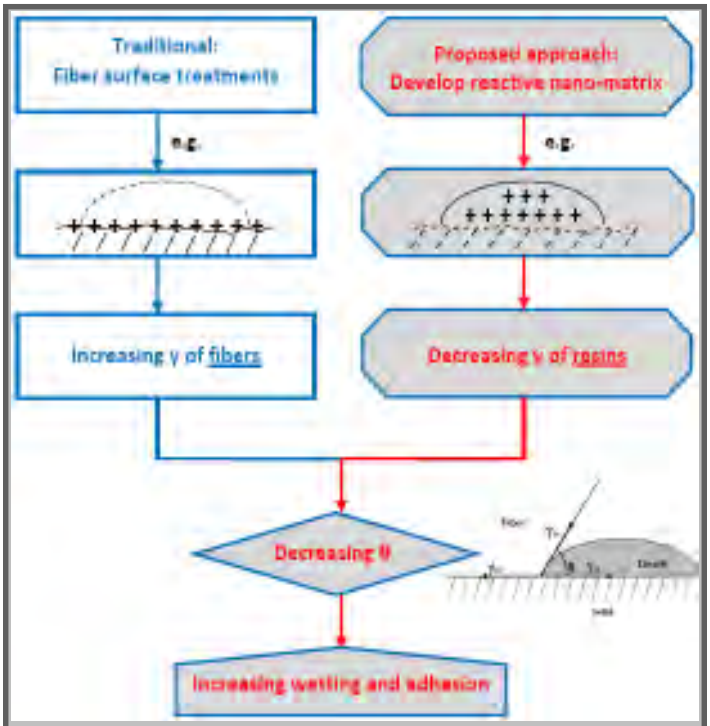

Figure 3: Approaches for increasing wetting and adhesion

we have solved several key problems including: (1) strong interaction between graphitic nanofibers and epoxy resin through further treatment to achieve covalent bonding level; (2) uniform dispersion of the graphitic nanofibers in a polymer; (3) curing mechanisms for optimization of cure cycles [7-8]. Theoretically, strong interactions from covalent bonding between the nanofibers and polymer resins and good dispersibility have the capacity of enhanced properties for composite applications. Subsequent further work is underway to fully characterize the various properties and advantages of this nano-epoxy.

Viscosity and Wetting of Nano-epoxy with (LNR)

Durability and reliability of a composite structure highly depends on the fiber/matrix interface, which can be a weak area of structural integrity and overall performance. Utilization of treatment methods can increase the surface energy of the reinforcements, which leads to improved wetting along the fiber/matrix interface. Our proposed approach (Figure 3) is to fabricate a reactive matrix with low surface energy [8], which is a cost-effective way for manufacturing more durable composites. Thus far, there have been no reported studies on the improvement of fiber/matrix interface adhesion through fabricating reactive nano-matrix materials, besides the author's group's research.

Viscosity is one of the important factors that influence wetting of a liquid on a fiber surface. The more viscous or the higher the viscosity of a matrix, the longer the time it takes for the matrix to spread on the fiber surface. Since viscosity is temperature-dependent, even in the environmental temperature range of 23–27 °C, the viscosity fluctuates. However, in this case we found that compared to that of pure epoxy, the variation rates (decrease rates) of viscosity for various samples are fairly stable. The decrease rates of viscosity of five types of samples in

Samples	Concentration of Nanofibers, (wt%)		
	0.2	0.3	0.5
Nano-epoxy:	42	52	68
Epoxy + GNFs	30	12	-2
Epoxy + GNFs (non-cut)	20	8	N/A

*Note: Error is less than 2 %

Table 1: Viscosity decreases: nano-epoxy vs. pure epoxy [8]

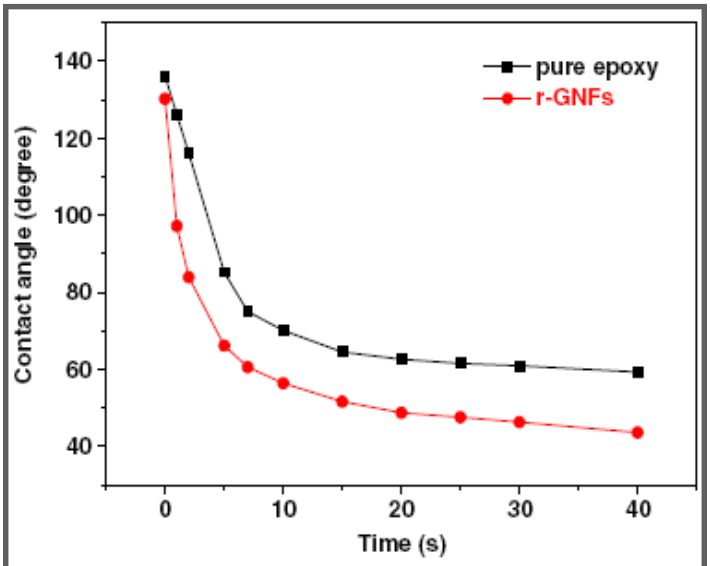

Figure 4: Wetting behavior of pure epoxy and nano-epoxy[9]

Continued page 26

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Technical Paper

Continued from Page 24

comparison with pure epoxy were calculated and shown in Table 1 [8].

Wetting the surface of reinforcing fibers with polymeric matrices is one of the critical aspects for obtaining good interfacial adhesion during the processing stage of fiber/polymeric composites. The term, wettability, is used to describe the extent to which a liquid spreads on a solid surface. The state of wetting between a resin matrix and a fiber can considerably affect the interfacial adhesion. It is evident that insufficient wetting generates interfacial defects and reduces the bonding strength. The wettability of a polymeric matrix on the surface of a fiber is characterized by the contact angle between the fiber and the polymer.

As comparison, wetting behavior of the nano-epoxy and pure epoxy samples on smooth surfaces were characterized using contact angle analysis method and are shown in Figure 4 [9]. It can be seen that although variations in geometric shapes and contact angles between two matrix systems were observed on the smooth surfaces, it cannot fully reflect the differences in the practical application because in reality fewer solid surfaces are truly smooth.

Figure 5 shows the wetting behaviors of nano-epoxy and pure epoxy on glass fabric surface [10]. It can be seen that the nano-epoxy matrix had significantly different wetting characteristics on the glass fabric surface from the pure epoxy. The nano-epoxy quickly spread and easily filled up the grooves on these rough fabric surfaces and hence showed a zigzag-like contact line on the rough fabric surfaces. However, the droplets of pure epoxy sat on the top of these rough fabric surfaces without filling up the grooves of the woven fibers so that air was enclosed between the droplet and the fabric substrate.

This difference in wetting state of the two epoxy systems on the rough fabric surfaces reflected the influences of addition of the r-GNFs into epoxy resin. However, from this study it is seen that the conventional contact angle analysis approach and equipment cannot realize quantitative characterizations of wetting behavior of the nano-epoxy on rough or fabric surfaces as shown in Figure 5. To investigate in-depth how the r-GNFs in the format of LNR affect the wetting behavior of the resulting epoxy system is our future research task, which is believed to be significant for the application of nanotechnology in manufacturing FRP composites.

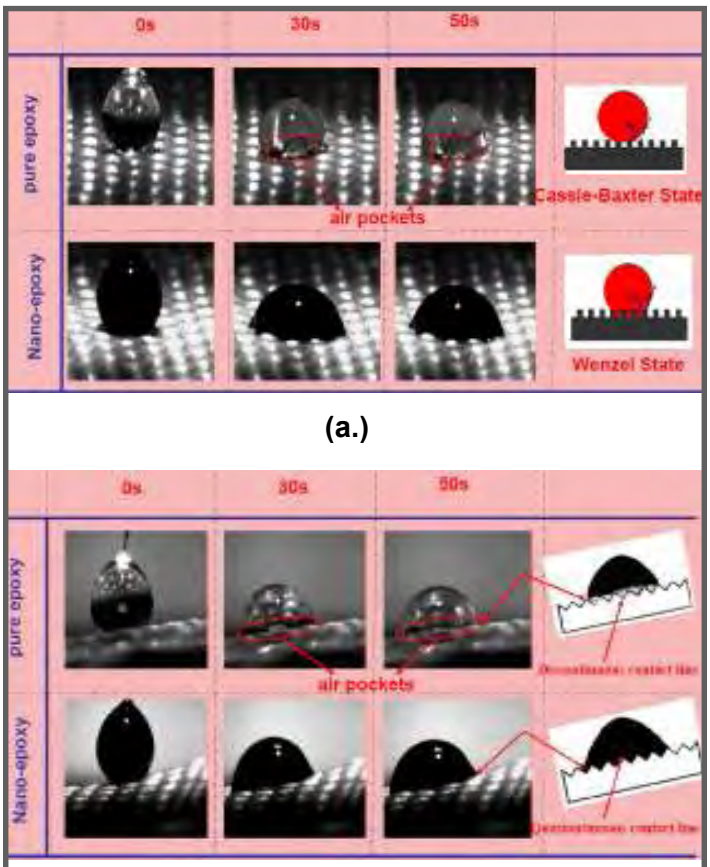

Figure 5: Dynamic wetting phenomena of pure epoxy and nano-epoxy on the glass fiber fabric surfaces [9]: (a) horizontal surface; (b) on tilted surface

Continued page 28

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Continued from Page 26

Property Summary of the Nano-epoxy with LNR

The previous research indicated that such nano-matrices, in which the covalent bond in nanofiber/epoxy resin and nanofibers are in the form of LNR, possessed greatly enhanced comprehensive performance with broad ranges of improvement [10-20]. The results showed that the nano-epoxy has very low nanofiber concentration (0.3 wt %) and interestingly, it showed lower viscosity compared with the pure epoxy [17]. Property enhancements for the developed nano-epoxy with 0.3 wt% r-GNFs vs. pure epoxy are summarized as follow [11-20]:

Enhanced mechanical properties (three-point bending):

- Strength (30%);
- Modulus (>35%);
- Toughness (45%)

Increased thermal properties (DMA and TMA):

- Higher Tg (14˚C higher);
- Stable Coefficient of Thermal Expansion (CTE)

Improved processability for manufacturing FRPs (contact angle, viscometer and rheometer):

- Faster wetting rate on UHMWPE fiber surface (45%);
- Lower viscosity (50%) and better resin infusion performance;
- Improved overall rheological properties for commercial processing

Improved interfacial adhesion property with UHMWPE fibers (by pullout tests):

- Initial debonding force (35%);
- Maximum pullout force (25%);
- Energy to debonding (65%)

Improved mechanical (tensile) properties of UHMWPE fiber composites:

- Higher at RT: longitudinal stiffness and ultimate tensile strength
- Hygrothermal effects:Lower diffusivity (60%) (60˚C, water, 30 days)
- Hygrothermal + UV effects: Less effect (UV, 60˚C, water, 4 hours)

Conclusion Remarks

This paper summarized the application of carbon nanofibers in modifying polymer resins used as matrices of structural fiber composites, and introduced the new nano-matrix technology that resulted in a nanofiber-reinforced epoxy matrix with greatly enhanced comprehensive properties. The developed nano-epoxy matrix has successfully tackled several daunting barriers for carbon nanofiber use. Through making carbon nanofibers into liquid nano-reinforcement (LNR), and then compounding with epoxy, the functionalized carbon nanofibers effectively translated their extraordinary performance to end products through covalent bonding between matrix and nanofibers. The liquid nano-reinforcement can easily be dispersed in the base epoxy matrix and proves highly effective for reinforcing and toughening the epoxy resin as well as contributing to dramatically reduced viscosity, which is significant to FRP composites manufacturing energy efficiency (reduced power requirements for flow and part consolidation).

Acknowledgements

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Jim Kolb, Strong SPE Supporter, to Retire as Head of American Chemistry Council's Automotive Center

James (Jim) Kolb – a good friend and strong supporter of SPE's Detroit-area programs even in a challenging economy – is retiring mid-January 2012 from the American Chemistry Council's (ACC's) Automotive Center (ALC) in Troy, Mich., the very facilities that have been home to the SPE Automotive Division and Detroit Section since 1998.

Kolb has been senior director-Automotive Programs for the Plastics Division of the ACC since 2007 and was formerly vice-president-Automotive for the American Plastics Council from 2003 to 2007. Throughout this time, he has been responsible for representing the plastics industry before automotive OEMs, tier suppliers, and allied associations such as United States Council for Automotive Research (USCAR), Automotive Industry Action Group (AIAG), and Original Equipment Suppliers Association (OESA). He also has led several key initiatives in the ACC's *"Plastics in Automotive Markets Vision and Technology Roadmap,"* including research, government advocacy and automotive plastics infrastructure improvement.

Kolb's automotive and plastics expertise spans nearly 30 years of experience with a number of suppliers, including Dow Automotive, Essex Specialty Products, and Bayer USA. He has held positions in sales, commercial development, and marketing and has participated in a number of automotive-plastics "firsts" in bumper systems, body panels, instrument panels, and passenger safety systems. Prior to joining the ACC, Kolb worked for Omni Tech International Ltd., a global consulting firm for the chemical and plastics industries, where he led automotive business and market development, including commercialization of bio-based industrial materials. He holds a bachelor's degree in Business from Kent State University and is a member of SPE, the Society of Automotive Engineers, and the Detroit Executive Service Corps.

A retirement party to honor Kolb's accomplishments and send him on his way to retirement is planned for the first week of January.

Education Report

Monica Prokopyshen

Record numbers of students from many countries attended and contributed to the success of this year's Automotive Composites Conference & Exhibition (ACCE), held September 13-15, 2011 at the MSU Management Education Center in Troy, Mich., U.S.A.

ACCE Poster Contest Winners Announced

Thirteen finalists, from eight schools competed in the third annual poster and presentation contest co-sponsored by SPE's Automotive and Composites Divisions (who co-organize the conference) and PPG Industries, which donated monetary awards totaling $3,000 USD for the top three poster topics in both graduate and undergraduate categories.

The contest showcased emerging technologies in the area of automotive and ground-transportation composites. Represented were students from Georgia Institute of Technology, University of Alabama at Birmingham, Tuskegee University, University of Akron, University of Southern Mississippi, Oklahoma State University, Michigan State University and Winona State University. First place, a plaque, and a check for $750 USD went to Alfred Tcherbi-Narteh of Tuskegee University; the second place winner (who received a plaque and a check for $500 USD) went to Anchita Monga of Michigan State University; and third place (a plaque and a check for $250 USD) were earned by Melike Dizbay-Onat of the University of Alabama at Birmingham.

Since no undergraduate posters were entered in the competition, the remaining 10 students each were mailed a check for $150 USD to help cover their travel expenses to the conference.

Two Graduate Level Scholarships Awarded

For the fifth consecutive year, SPE's Automotive & Composite Divisions jointly awarded two $2,000 USD scholarships for graduate research in polymer composites with impact on ground transportation. Winners of the 2011-2012 scholarships for graduate-level research in polymer composites were announced at the Automotive Composites Conference & Exhibition. David Inglefield, a Ph.D. candidate pursuing a dual degree in Chemistry and Biomedical Engineering at Virginia Polytechnic Institute & State University (Virginia Tech, Blacksburg, Va.) was selected for a research project involving the synthesis of functionalized carbon nanotubes for optimized properties in polymer composites, a project that could have broad application in automotive composites. Thomas (Tom) G. Loken, a doctoral candidate in Mechanical Engineering at University of Wisconsin-Madison (Madison, Wisc.) as well as a project engineer at The Madison Group (Madison, Wisc.) was selected for a research project analyzing the effects of processing conditions on fiber-length distribution in short-fiber composites. Both students will present results of their research at the next SPE ACCE, September 11-13, 2012

In addition, 10 students from the Center for Creative Studies attended the second day of the conference to review posters, meet attendees, see exhibits, and learn more about composites usage in ground transportation.

CCS Students Tap Composite Experts for Material Selection Tips

The American Chemistry Council - Plastics Division (ACC-PD) kicked off the 2011 transportation design project at the automotive education center in Troy, Michigan on Sept. 14th, followed by field trips which included a visit to the DuPont pilot facility and ACCE for hands-on lessons on material selection, ideation, product development and molding of polymers. Students met with industry experts at the ACCE while researching materials for race vehicle designs.

Students from local universities attending the 2011 Automotive Division Innovation Awards Program.

SPE Recognizes Students at Innovation Awards Program

On November 10, 2011 over 600 people from around the world gathered at the Innovation Awards Program, to celebrate the greatest innovations in design, applications, processes and enabling technologies—in short, glimpses of the automotive plastics industry's future.

A singular treat was the special recognition accorded the real "future" of the plastics industry, namely the student volunteers, who combined a long day of study, travel and assisting at the gala. With charm, grace and professionalism, these inspiring students helped set up and man displays, organize awards and trophies, and direct attendees at the event. After the ceremony, students helped pack up parts and displays.

Special thanks to Jackie Rehkopf (SPE Automotive Division) and James Keeler (SPE Detroit Section), who coordinated the student volunteers. In the attached photo Dr. Helms, IAG Program Chairman, thanks students from the five participating universities and introduces the audience to the industry's future.

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