JUNE 2023

RubberWorld

134 years

THE TECHNICAL SERVICE MAGAZINE FOR THE RUBBER INDUSTRY VOLUME 268, NO. 3

Peroxide cure study
in HCR silicone

Thermoplastic-silicone elastomer composites
production by multi-component injection molding

Polyfarnesene branched butyl rubber:
An efficient, sustainable processability solution

Substitutions for specialty bases
in medical silicones

www.rubberworld.com

Rubber Division
American Chemical Society
ACS Events, page 56

@rubberworld

We've Got You Covered

SPECIALTY ADDITIVES FOR THE POLYMER INDUSTRY

ENGINEERED TO IMPROVE PROCESS AND PRODUCT PERFORMANCE THROUGHOUT AN EXTENSIVE ARRAY OF INDUSTRIES.

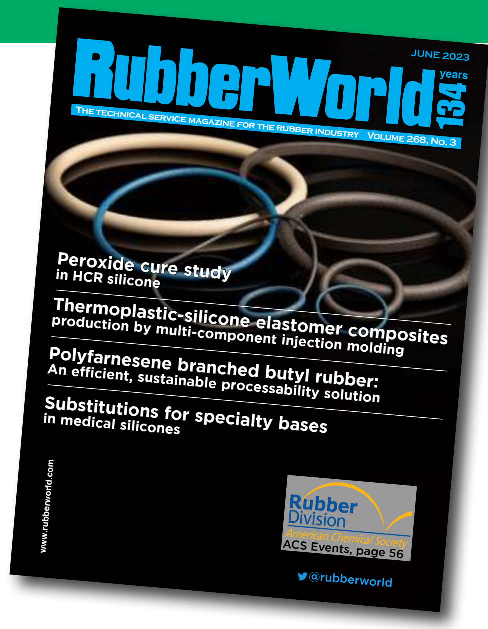
- Activators
- Dispersants
- Homogenizers
- Lubricants
- Metal Stearates
- Montan Ester Wax Alternatives
- Odor Control
- Peptizers
- Plasticizers
- Polyethylene Waxes
- Processing Agents
- Silane Coupling Agents
- Slip Agents (Amides)
- Tackifiers
- Viscosity Modifiers

STRUKTOL COMPANY OF AMERICA, LLC | Stow, Ohio | USA
330.928.5188 | CustomerService@struktol.com | www.struktol.com

Contents

Vol. 268, No. 3 June 2023

Features



Cover photo: Courtesy of Specialty Silicone Products

Departments

From the Editor

Jill Rohrer

USTMA cites legislative priorities

The U.S. Tire Manufacturers Association issued its 2023 federal legislative priorities letter to the 118th Congress, outlining key areas of continued cooperation to address the evolving areas of tire safety, environmental stewardship and innovation. USTMA has engaged with Congress on policies to promote innovative infrastructure technologies and to better position the U.S. tire manufacturing industry to tackle future challenges.

"Members of USTMA urge the 118th Congress to collaborate to address important issues facing the U.S. tire manufacturing sector and the American public," said Anne Forristall Luke, USTMA president and CEO. "Federal regulations, investment and research must keep pace with the advancements in automotive technology." The six policy areas include:

- A unified North American approach to consumer tire information and standards
- The expansion of sustainable and circular infrastructure solutions for scrap tires
- Research to identify mitigation solutions for road runoff
- Use and domestic manufacturing of retreaded tires
- Ensuring fair, equal and standardized access to digital vehicle data and infrastructure assets
- Developing domestic sources of natural rubber

Machinery, materials highlighted

Rubber World's upcoming **July** and **August** editions highlight **Machinery and Equipment** (July) and **Chemicals and Materials** (August). In addition, *Rubber World*'s annual **Machinery & Equipment Suppliers Directory** is published in the July edition. Both the July and August issues include a special **Corporate Profile** advertising section, where advertisers who schedule a full page ad in either issue earn a free Corporate Profile in the same issue. Corporate Profiles appear opposite the company's advertising to provide the impact of a two-page spread.

New product press releases, news releases and case studies are invited for these two important issues of *Rubber World*. Please submit your editorial material to my attention (jill@rubberworld.com) at your earliest convenience.

Details on advertising opportunities in *Rubber World* are available from Dennis Kennelly (dennis@rubberworld.com); Mike Dies (mike@rubberworld.com); or Pete McNeil (pete@rubberworld.com). Don't miss out on these excellent opportunities to promote your company's products in two of our biggest issues of the year!

Jill Rohrer

RubberWorld

Editorial Staff

Jill Rohrer	editor
David Schultz	technical editor
Don R. Smith	contributing editor
Michele Caprez	electronic publishing director
Matthew M. Raymond	creative director

Editorial Offices

1741 Akron-Peninsula Rd.
Akron, Ohio 44313-5157
Phone: (330) 864-2122
Facsimile: (330) 864-5298
Internet: www.rubberworld.com

Circulation

Richard Jarrett (GCSCS8@gmail.com)
Manage or renew online:
www.rubberworld.com/subscribe

Business Staff

Chip Lippincott	publisher
Dennis Kennelly	senior vice president, associate publisher
Mike Dies	marketing representative
Pete McNeil	sales consultant
Laura Comstock	office manager

Lippincott & Peto

- Rubber World
- Blue Book: Materials, compounding ingredients, and services for rubber
- Blue Book on CD
- Blue Book Online
- Rubber Red Book
- Red Book on CD
- Rubber World Digital Edition

RUBBER WORLD, (ISSN-0035-9572), June, 2023, Vol. 268, No. 3, Copyright: Lippincott & Peto, Inc. 2023; all rights reserved. J.H. Lippincott, Chairman. Published monthly at 1741 Akron-Peninsula Rd., Akron, OH 44313-5157 by Lippincott & Peto, Inc. Editorial and Executive Offices at 1741 Akron-Peninsula Rd., Akron, OH 44313-5157. Periodicals postage paid at Akron, OH and at additional mailing offices. POSTMASTER: Please send changes of address to RUBBER WORLD, Circulation Dept., P.O. Box 16123, St. Louis, MO 63105. Publication Mail Agreement Number: 1488902. CPC Publication Agreement Number: 40032646; Canada return address: BleuChip International, P.O. Box 25542, London, ON N6C 6B2. Subscription rates: United States, 1 year $49; Canada, $59; International, $169 in U.S. currency by U.S. bank draft or international money order. Single copies $20.00. June, 2023. All rights reserved.

Alliance for Audited Media

ARP|MATERIALS

Proudly Supplies

PCBL™

Carbon Black

- Full range of ASTM grades of carbon black produced from North American feed stock.
- Clean grades, and specialty grades are available to help tailor the physical properties for difficult to meet specifications.
- Carbonext 10 and 20 are designed for higher loading levels in rubber compounds.
- ISO 9001, ISO 14001, and ISO 45001 certification.

Contact us for a sample!

888.611.0220

arpsales@arpmaterials.com

Business Briefs

Arlanxeo to build 140 ktpa rubber plant

Acquisitions, Expansions

Arlanxeo (www.arlanxeo.com), The Hague, Netherlands, announced the planned construction of a world class rubber facility in Jubail, Saudi Arabia. The 140 kiloton per year (ktpa) plant will produce two high performance elastomers: ultra high cis polybutadiene (NdBR) and lithium butadiene rubber (LiBR). The planned construction follows the final investment decision by **Aramco** and **TotalEnergies** to build a world scale petrochemical facility in Saudi Arabia.

Bridgestone Americas (www.bridgestoneamericas.com), Nashville, TN, celebrated the expansion of its **Bridgestone Bandag, LLC** manufacturing plant in Abilene, TX, with an official groundbreaking ceremony. The 50,000 square foot, $60 million expansion of the Abilene plant is aimed at the growing demand for the company's tread rubber products, driven by the rapid growth of its retread business. The expansion includes an immediate increase in operational activity by running on six and seven day production schedules, as well as the construction of new mixing operations at the facility. The mixing operations are expected to be completed and in operation by January 2025. The investment in the facility and the additional days of operations increase the plant's output by 16%, furthering Bridgestone's commitment to sustainable solutions.

Covestro (www.covestro.com), Leverkusen, Germany, a manufacturer of polymer materials and their components, inaugurated a production line for high performance thermoplastic polyurethanes (TPUs) that will be used for production of paint protection films. The line is located at the company's existing site in Changhua, Taiwan.

Henkel (www.henkel.com), Düsseldorf, Germany, a global provider of adhesives, sealants and functional coatings, has officially opened its technology center in Bridgewater, NJ. Occupying 70,000 square feet, the center is said to provide a unique and interactive destination for the company's strategic partners and customers.

Trelleborg (www.trelleborg.com), Trelleborg, Sweden, a provider of engineered polymer solutions that seal, damp and protect critical applications in demanding environments, announced that **Trelleborg Marine and Infrastructure** will open a state-of-the-art manufacturing facility in Vietnam, with construction scheduled to be completed at the end of 2025, and production to commence in 2026.

Maxcess International (www.maxcessintl.com), Oak Brook, IL, a global manufacturer of automated web handling solutions, announced the opening of a state-of-the-art facility strategically located just west of Mumbai, India, to house sales and service support, research and development, offices and a repair center.

Business Briefs

Contracts, licenses

Smithers, U. of Akron partner on racing tires

Smithers (www.smithers.com), Akron, OH, a provider of testing, consulting, information and compliance services, is sponsoring the **University of Akron Formula SAE** team. Smithers also recently hosted the team at the **Smithers Tire & Wheel Test Center** for a tour and discussion about laboratory testing for automotive components. The University of Akron has participated in Formula SAE for over 30 years. Students are challenged to incorporate their classroom knowledge into effective automotive designs by designing, building and racing a Formula One style race car.

The **German Rubber Manufacturers' Association** (www.wdk.de), Berlin, Germany, has committed to reponsible procurement practices for raw materials and services in the rubber industry for many years. To advance the implementation of this goal, the association is now cooperating with **Together for Sustainability**, an international nonprofit initiative that raises CSR standards across chemical companies and their suppliers.

The **International Rubber Study Group** (www.rubberstudy.org), Singapore, welcomed **Bloom Integrated Services Limited**, a petroleum supplier said to be dedicated to providing high quality products and services to its customers in Nigeria, as an associate member.

Bridgestone Americas (www.bridgestoneamericas.com), Nashville, TN, in partnership with the **Indianapolis Motor Speedway**, **Penske** and **Shell**, made efforts to make the 107th running of the Indianapolis 500 the most sustainable Indy 500 in the history of the NTT Indycar Series. As the series' exclusive tire supplier, Bridgestone has incorporated ISCC Plus certified recycled butadiene, a monomer produced from hard-to-recycle used plastic shopping bags, film, stretch wrap and other flexible polymer packaging, developed in partnership with Shell, in all Firestone Firehawk race tires used at the race. Bridgestone will manufacture all race tires for the 2023 season at the ISCC Plus certified **Advanced Tire Production Center** in Akron, OH. Additionally, Bridgestone partnered with Penske and the Indianapolis Motor Speedway to transport the race tires.

Falken Tires (www.falkentire.com), Rancho Cucamonga, CA, a subsidiary of **Sumitomo Rubber Industries, Ltd.**,

Business Briefs

announced that **Subaru** has selected the Falken Ziex ZE001A All-Season as a tire of choice for the 2024 Subaru Crosstrek.

Yokohama Tire (www.yokohamatire.com), Santa Ana, CA, the North American manufacturing and marketing arm of Tokyo, Japan based **Yokohama Rubber**, is partnering with **FuelFest** for the fifth consecutive year. The traveling international automotive festival brings together music, culture, celebrities and cars in the name of charity.

Yokohama Rubber (www.y-yokohama.com), Tokyo, Japan, is supplying its Geolandar X-CV tires as original equipment for **Mazda Motor**'s new crossover SUV, the Mazda CX-90, sales of which were launched in the U.S. in April 2023.

Sentury (www.senturytireusa.com), Qingdao, Shandong, China, announced that it supplied products to **Nokian Tyres** in the first quarter of 2023. Writing in a stock exchange filing, Sentury representatives specified that the company has delivered Nokian brand winter tires.

Grupo Soledad (www.gruposoledad.com), Alicante, Comunidad Valenciana, Spain, announced that its member, **Insa Turbo**, reported that **Kraiburg** has been able to significantly expand its share in the Spanish retreading material market. Grupo Soledad is said to be a key player in the Spanish market, with its distribution network totaling more than 100 of its own shops, and a franchise network with 1,000 points of sale in Spain and Portugal. The two companies plan to cooperate more closely in the future.

Covestro (www.covestro.com), Leverkusen, Germany, a manufacturer of polymer materials and their components, has signed a 90 megawatt virtual power purchase agreement with **Orsted**, a clean energy leader in the U.S. market, headquartered in Denmark. With various agreements in place, Covestro is said to foster the growth of renewable energy projects around the world. This newest 15 year agreement secures a portion of power from the **Mockingbird Solar Center** in Lamar County, TX, marking Covestro's first renewable energy agreement in the U.S.

Xiamen Changsu Industrial Pte. Ltd. (www.changsufilm.com), Xiamen, Fujian, China, and **TotalEnergies Corbion** announced a strategic cooperation agreement that will further advance the polylactic acid (PLA) industry. They will work together on the market promotion, product development and research and development of new technologies and applications of biaxially oriented polylactic acid (BOPLA).

Quality registrations

Arburg (www.arburg.com), Lossburg, Germany, a global manufacturer of injection molding machines, has obtained certification for its information security according to the internationally recognized ISO 27001 standard. Arburg has been voluntarily certified to DIN ISO/IEC 27001 since March 2023.

Stahl (www.stahl.com), Waalwijk, Netherlands, a provider of coating technologies, announced that its near term greenhouse gas (GHG) emissions reduction targets have been validated by the Science Based Targets initiative (SBTi).

Business Briefs

DRI Rubber awarded for sustainability

CORPORATE, FINANCIAL NEWS

DRI Rubber (www.drirubber.com), Waalwijk, Netherlands, a global supplier of reprocessed and fiber reinforced rubber compounds, was awarded the title, Most Sustainable Rubber Recycling Company 2023, Netherlands, at the Business Excellence Awards. Provided by **Acquisition International**, the awards recognize outstanding

ARPM 2023 Safety Award winners announced

The **Association for Rubber Products Manufacturers** (www.arpminc.org), Indianapolis, IN, announced the 2023 Safety Award Winners, who were honored during the 2023 Environmental Health and Safety (EHS) Summit on May 24-25 in Columbus, OH. The prestigious Safety Awards program consists of two awards: the Safety Achievement Award and the Safety Best Practice Award. The Safety Achievement Award is a way to recognize safety in the industry and award facilities that have achieved a level of safety performance above the industry average. Awards are based on data reported on a company's annual OSHA 300 Log of Work Related Injuries and Illnesses. Winners are as follows:

Gold Safety Award
- BRC Rubber & Plastics (Bluffton, IN)
- BRC Rubber & Plastics (Ligonier, IN)
- Hamilton Kent LLC (Winchester, TN)
- Mechanical Rubber Products (Warwick, NY)
- Zeon Chemicals L.P. (Hattiesburg, MS)
- Zochem ULC (Brampton, Ontario, Canada)

Silver Safety Award
- Blair Rubber (Seville, OH)
- BRC Rubber and Plastics (Hartford City, IN)
- Zochem LLC (Dickson, TN)

Honorable Mention Award
- Eagle Elastomer (Cuyahoga Falls, OH)
- Prospira America (Upper Sandusky, OH)

In addition, the Safety Best Practice Award is a way to recognize the best practices that organizations have implemented to increase overall safety. Award submissions range from employee safety training and emergency training to tracking safety methods and mold change safety. ARPM recognized Hamilton Kent (1st place), Contitech Canada (2nd place) and Zeon Chemicals (3rd place) with a Safety Best Practices Award. These winners were voted on by the ARPM membership and are said to be a testament to the time, effort and investments these organizations are making to keep their employees safe. "The Safety Awards Program recognizes leaders in the rubber industry for committing to and achieving excellence in safety and health. These companies are making safety a top priority and have gone above and beyond to ensure their most valuable assets (their employees) are safe on the job," said Kaitlyn Triplett, ARPM managing director.

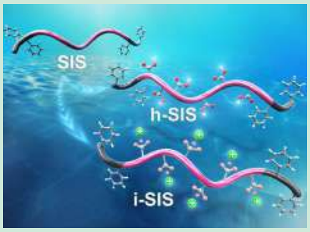
performances and achievements across various industries. DRI reprocesses rubber waste streams from the global tire and rubber industry into a wide variety of compounds.

Scandinavian Enviro Systems (www.envirosystems.se), Gothenburg, Sweden, announced that its major shareholder, **Michelin**, has developed a racing tire for this year's edition of the **Le Mans** 24 hour race that contains a full 63% sustainable materials, including recovered carbon black (rCB) from Enviro.

ExxonMobil Product Solutions (www.corporate.exxonmobil.com), Irving, TX, was presented with the Responsible Care Company of the Year award from the **American Chemistry Council**.

Nagoya University and Zeon researchers receive awards

Nagoya University (https://en.nagoya-u.ac.jp), Nagoya, Japan, announced that researchers from the university and **Zeon** received two awards in May 2023 for the development of tough noncovalently functionalized styrenic thermoplastic elastomers. They chemically modified Zeon's Quintac, a styrenic thermoplastic elastomer, to develop "tough functionalized styrenic thermoplastic elastomers." Since the newly developed SIS with noncovalently functionalized polyisoprene is a lightweight yet tough and highly impact resistant material, its development should contribute to the goal of reaching a net zero carbon and sustainable society, according to researchers.



The researchers received the 2022 SRJ Technology Award from the **Society of Rheology, Japan** (SRJ), a member of the **International Committee on Rheology** (ICR), and the 35th SRSJ Award from the **Society of Rubber Science and Technology, Japan** (SRSJ), a member of the **International Rubber Conference Organization** (IRCO). The SRJ Technology Award is given to people who have made outstanding achievements in rheology associated technology (including engineering and industrialization technology). Meanwhile, the SRSJ Award is given to those who have contributed to the development of science and technology in rubber and rubber related fields, or to the development of the industry field, where their achievements are extremely remarkable.

Responding to the demand for a new TPE that is light in weight, but has a higher strength and toughness in comparison to existing TPEs already on the market, a Nagoya University research group led by Atsushi Noro at the **Graduate School of Engineering** and the **Institutes of Innovation for Future Society**, in collaboration with Zeon, synthesized tough noncovalently functionalized styrenic thermoplastic elastomers by introducing more than a few mol% of non-covalent functional groups, such as hydrogen bonding functional groups and ionic functional groups, to the polyisoprene part (polydiene part) of Zeon's Quintac SIS. In particular, the tensile strength, toughness and impact resistance of ionically functionalized SIS (i-SIS) are three times higher than those of Zeon's Quintac SIS without functional groups. The awards were given to them due to the high novelty and scientific significance of the research achievements supported by publications of two peer reviewed papers.

Retread tire market to grow at 6% CAGR

The global retread tire market is projected to grow at a compound annual growth rate (CAGR) of 6% from 2023 to 2033, reaching a value of $11.2 billion in 2023, and $20 billion by 2033, according to a study by Future Market Insights.

The market is expected to experience significant growth, primarily influenced by the increasing prices of new tires, particularly for sport utility vehicles. This trend can be attributed to the rise in natural rubber costs and the volatility of crude oil prices. Additionally, the expanding number of commercial vehicles in operation worldwide is projected to be a major driving force for market growth.

Tire manufacturers have shown a strong interest in exploring new opportunities and meeting the growing market demand for tire retreading. They are increasingly recognizing the significance of this technology and its rising popularity among consumers. As a result, major tire manufacturers have initiated research and development efforts to align with this market trend and fulfill the demands of retread tire users, the study says.

In September 2021, Bridgestone unveiled its latest commercial vehicle portfolio, showcasing cutting edge mobility solutions and tire retreading concepts. Notably, the company highlighted the Bridgestone Duravis R002 premium tire, which is said to stand out for its exceptional wet grip, optimal fuel efficiency and durable carcass. Bridgestone expects that this retreaded tire will meet the demands of commercial vehicle users, offering high performance and reliability.

The tire retreading market is set to be propelled by the eco-friendly characteristics of retreaded tires and their cost-effectiveness compared to new tires. Retreading is known for its environmentally friendly nature, as it allows manufacturers to reuse existing tires, reducing the need for landfill space. Retreading helps decrease carbon dioxide emissions and saves significant quantities of oil that would otherwise be used in the production of new tires. These factors contribute to the sustainability and conservation of resources in the tire industry.

Key takeaways from the FMI study show the U.S. retread tire market is expected to grow with a CAGR of 5.8% during the forecast period, while China is expected to grow with a CAGR of 6.2%. Heavy commercial vehicles are projected to dominate the retread tire market. It is expected to grow with a significant CAGR of 6.5% during the forecast period.

By process, the pre-cure retreading segment is expected to grow with a CAGR of 6.6% throughout the forecast period.

"Increasing prices of sport utility vehicles are expected to drive market growth during the forecast period," according to an FMI analyst.

The retread tire market is highly competitive, with several key industry players investing heavily in the production of these tires. The key industry players are Continental, MRF, Yokohama Rubber, Rosler Tech Innovators, Michelin, Bridgestone, Goodyear, Carloni Tire, JK Tires, Eastern Treads, Nokian Tires, Kraiburg Austria, Pilipinas Kai Rubber, Kit Loong Commercial Tire Group, Fortune Tire Tech, Tread Wright Tire, CIO Tires, Vaculug Tires and King Meiler tires.

According to FMI, key market players are leveraging organic growth strategies like acquisitions, mergers, tie-ups and collaborations to bolster their product portfolio. This is expected to propel the global retread tire market.

Conductive silicone rubber market to grow at 8% rate

The global conductive silicone rubber market is anticipated to attain a compound annual growth rate (CAGR) of ~8% between 2023-2035, according to a report from Research Nester. The global conductive silicone rubber market size is expected to reach $30 billion by the end of 2035.

The market is segmented on the basis of product type into thermal conductive, electricity conductive and others, out of which the electricity conductive segment is projected to occupy the largest share over the forecast period, as this property of silicone rubber is beneficial in making parts of electric appliances. The growing application of electricity conductive silicone rubber in making wires is estimated to boost the segment growth.

The global conductive silicone rubber market is estimated to witness growth due to the higher flexibility, better elasticity, resistance to corrosion, longer life and electromagnetic shielding properties of silicone rubber. These are conductors of heat and electricity; but unlike metal conductors, they are highly flexible, making them optimum for making wires and small machinery parts. The growing adoption of conductive silicone rubber in the automotive industry for making parts of vehicle engines is estimated to boost the market growth. Moreover, the growing production of automotive, backed by rising sales of vehicles, is estimated to boost the market growth.

On the basis of geographical analysis, the global conductive silicone rubber market is segmented into five major regions, including North America, Europe, Asia Pacific, Latin America and the Middle East and Africa region.

The various properties of conductive silicone rubber, such as high elasticity, resistance to corrosion, flexibility and electromagnetic shielding, make it the most optimum material for making wires and parts of electric machines. These properties make silicone rubber excellent for electronics, as they reduce the chance of damage and improve the life of the devices. This is estimated to boost the market growth.

However, the higher cost of conductive silicone rubber is expected to operate as a key restraint to the growth of the global conductive silicone rubber market over the forecast period.

Polyurethane timing belts introduced

A new generation of polyurethane timing belts has been introduced by Continental in its "Truly Endless" product line onto the market under the name Synchromotion. Steel cord reinforced polyurethane belts are considered to be extremely flexible, abrasion resistant and durable. The polyurethane cover is said to ensure more efficient power transmission than is the case with other materials. With Synchromotion, customers may now choose between 11 different profiles in the length range from 1,500 to 14,500 mm, with a maximum width of 100 mm.

The Synchromotion can be manufactured in individual lengths, precisely down to one tooth. This gives customers greater design flexibility and additional freedom, for example in terms of center distances. It opens up new perspectives for applications that were not previously covered by Continental. "This allows us to offer our industrial customers a significantly larger standard range, and they can now access the full product portfolio from a single source," pointed out Sascha Heyde, who heads product management for industrial drive belts at Continental.

The numerous profiles available enable replacement on existing equipment. The dimensions are fully compatible with competitors' products, and alterations are not necessary. In addition, the Synchromotion offers all the usual benefits of Continental PU timing belts. This is said to mean reliable power transmission, wear resistant PU material, low maintenance due to steel cord tension members with high tensile strength, and suitability for applications in demanding environments. The structure of the white belt reflects that of the Synchroflex, a PU timing belt already established on the market by Continental for the lower and medium power range, with an endless tension member made from steel. The plastic is identical to Continental's polyurethane for extruded products.

The Synchromotion is suitable for conveyance and power transmission drives across the power range. These include synchronous conveyor systems and transport devices with sliding rails, as well as positioning and reversing drives in linear and control engineering.

The Synchromotion will be produced at the PU specialized Dannenberg, Germany plant. Each order is produced to customer specification. The initial lead time to market launch will be around four to six weeks.

Kraiburg compounds approved for hydrogen applications

The German standards authority approval of elastomer compounds made by Gummiwerk Kraiburg for a range of hydrogen applications verifies H_2 compatibility according to SAE J2600. A supplier of rubber and silicone compounds, Kraiburg has had a range of its compounds tested for use in hydrogen applications. In the test cycles, the elastomer mixtures showed no signs of explosive decompression damage and attained approval following the SAE J2600 standard, as issued by the German technical standards supervisory body, abbreviated TÜV.

Kraiburg submitted a range of compounds for testing by the German technical standards and supervisory authority. The test cycles follow the North American standard SAE J2600 method and, having successfully passed them, confirm suitability for hydrogen applications. The high performance compounds are said to be distinguished by high dimensional stability in contact with hydrogen, and resilience to explosive decompression (a sudden drop in pressure which leads to a rapid release of gases and, as a result, to damages in the elastomer component).

The approval confirms that the compounds fulfill the highest standards of quality and meet the requirements for use in hydrogen plants, systems and vehicles. There is hardly an energy source more in focus than hydrogen (H_2). Mobility, power supply and industry are said to be rallying toward hydrogen technologies that pave the way into the future. There is said to be enormous potential, especially for green hydrogen generated from renewable energy sources, to become a sustainable energy carrier.

Developing the supply infrastructure requires specific solutions, especially in the choice of materials that are suitable for hydrogen applications, and that guarantee reliability and enduring safe function. This is a challenge, since H_2 is color and odorless; it is volatile and highly flammable, posing the risk of explosion. By employing the certified compounds made by Kraiburg, system and component manufacturers are in a position to ensure that their products fulfill the strictest standards.

The SAE J2600 approval testing method has established itself as a global safety standard for hydrogen vehicles and gas stations. The independent certification authority TÜV has adopted the North American standards into its own testing portfolio in order to test and approve materials for their suitability and safety in components and systems for hydrogen applications.

LATEST INNOVATIONS

SMARTmix TOP 7000 Pro

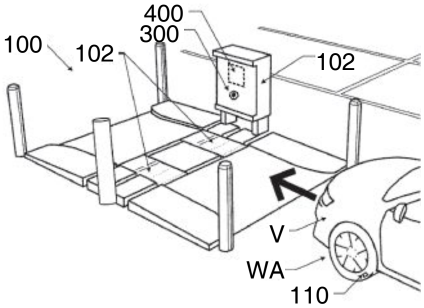
DOSING TECHNOLOGY

THE PERFECT MIX

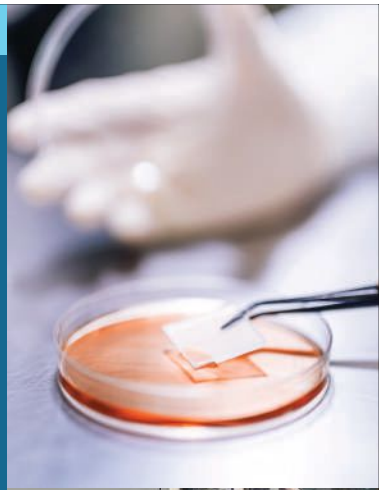
- Material utilization up to 99.6%
- Fully automatic drum change
- Automatic follower plates and drum recognition
- Easy exchange of 5 and 55 gal follower plates
- Smallest footprint (55 gal system) 1,150 x 790 x 1,950 mm (L/W/H)

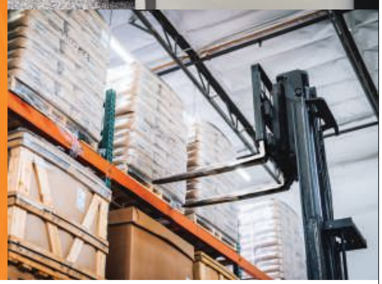
Patent News

System and method for acquisition of tire sidewall data from a moving vehicle
U.S. patent: 11,614,380
Issued: March 28, 2023
Inventor: Timothy A. Strege
Assigned: Hunter Engineering
Key statement: A drive-through vehicle inspection system acquiring information from engraved markings on the tire sidewalls of a moving vehicle. Optical imaging sensors disposed on opposite sides of the vehicle acquire images of the sidewall surfaces for each passing wheel assembly. The acquired images are evaluated by a processing system configured to identify, within the acquired images, visible markings engraved into the tire sidewall surfaces which include a first portion having a first optical reflectivity and a second portion having a second optical reflectivity which is different from the first optical reflectivity. Each identified marking is decoded to retrieve data stored therein, representative of the tire, wheel assembly and/or associated vehicle onto which the wheel assembly is installed. The retrieved data are incorporated into an inspection report and/or utilized by the vehicle inspection system to access vehicle-specific information contained within an indexed database.



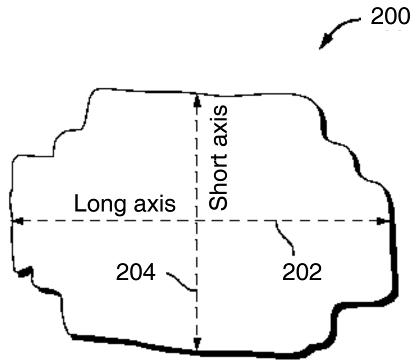
Rubber composition for tire tread and tire manufactured by using the same
U.S. patent: 11,613,631
Issued: March 28, 2023
Inventors: Ii Jin Kim, Ki Hyun Kim, Hyung Jae Lee, Won Ho Kim, Byung Kyu Ahn and Dong Hyuk Kim
Assigned: Hankook Tire & Technology
Key statement: Provided is an all-season tire tread rubber composition in which braking performance and wear performance are secured at the same time. A rubber composition for tire tread according to the present disclosure comprises: 100 parts by weight of raw rubber comprising solution polymerized styrene butadiene rubber which has a styrene content of 20 to 30 wt.% and a vinyl content within butadiene of 20 to 30 wt.% and is manufactured by a continuous method; 90 to 110 parts by weight of silica; and 20 to



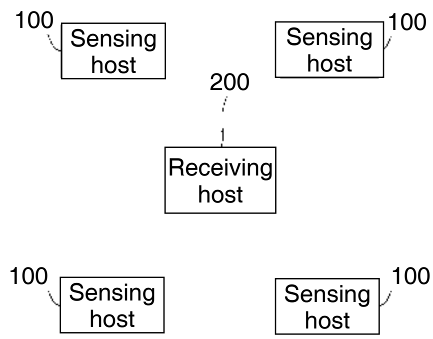


40 parts by weight of modified liquid butadiene rubber.

Spent vehicle tire lost circulation material (LCM)
U.S. patent: 11,613,943
Issued: March 28, 2023
Inventors: Adel Al-Ansari, Md Amanullah, Bader Al-Zahrani and Turki Al-Subaie
Assigned: Saudi Arabian Oil
Key statement: A lost circulation material (LCM) having flakes formed from waste vehicle tires. The LCM includes flakes produced from waste vehicle tires processed to remove steel components of the tires and produce flakes having a specific size. Also, methods of lost circulation control and manufacture of the waste vehicle tire LCM.



Bluetooth tire pressure monitoring system
U.S. patent: 11,618,287
Issued: April 4, 2023
Inventor: Shih-Yao Lin
Assigned: Sysgration
Key statement: A bluetooth tire pressure monitoring system (TPMS) includes a sensing host and a receiving host and the sensing host includes a battery, a control unit, a bluetooth transceiver unit, a boost/regulation circuit, a pressure sensing unit, an operational amplifier, a gravity sensing unit, a temperature sensing unit and a bluetooth antenna. The bluetooth TPMS utilizes low power bluetooth wireless communication technology to transmit and receive signals, so as to meet the requirement in low power consumption.




UTP VISION
VISUAL INSPECTION
IN THE EYE OF MACHINE VISION
UTPVision is a leading provider of turnkey vision inspection systems for rubber and plastic parts.
With a long experience in a variety of industries, UTPVision can develop solutions for virtually any application, precisely tailored to your needs.
DISCOVER MORE

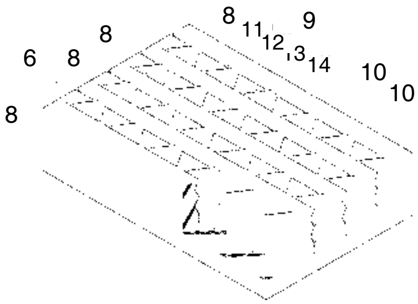
Patent News

Rubber composition for hollow ball and hollow ball
U.S. patent: 11,618,813
Issued: April 4, 2023
Inventors: Takehiko Hyodo, Masanori Taguchi, Kazuyoshi Shiga, Fumiya Suzuki, Hiroaki Tanaka and Kunio Niwa
Assigned: Sumitomo Rubber
Key statement: A rubber composition for a hollow ball includes a base rubber and an inorganic filler. A weight reduction rate TGA_{650} from room temperature to 650°C and a weight reduction rate TGA_{850} from room temperature to 850°C of the rubber composition are measured under an air atmosphere by thermogravimetry conforming to JIS K0129. The weight reduction rate TGA_{650} of the rubber composition is not less than 63% and not greater than 99%. A difference ($TGA_{850} - TGA_{650}$) between the weight reduction rates TGA_{850} and TGA_{650} of the rubber composition is not less than 0% and not greater than 7%. A hollow ball (2) includes a hollow core (4) formed from the rubber composition.

Tire composition
U.S. patent: 11,623,477
Issued: April 11, 2023
Inventor: Hyun Chang Lee.
Key statement: The present disclosure relates to a method and manufacturing method for a tire tread composition having absorption properties with high electric conductivity and excellent wear resistance. Specifically, the present disclosure relates to the fabrication of a tire composition to be used as a non-pneumatic tire; the tire composition can be used as a mobile electrode with a water supply means that can identify the location of defects in the buried conductor using the tire electrode manufacturing with improved conductivity and contact resistance with the ground, even though the tire compound has wear resistance by lowering the water swelling rate compared to the previous technology.

Tire
U.S. patent: 11,623,479
Issued: April 11, 2023
Inventor: Koichi Nakajima;
Assigned: Sumitomo Rubber Industries
Key statement: A tire having a tread portion that is provided with sipes. Four sipe segments of the sipe include a first sipe segment, a second sipe segment, a third sipe segment and a fourth sipe segment. At least one of the first sipe segment and the third sipe segment includes, in the cross section orthogonal

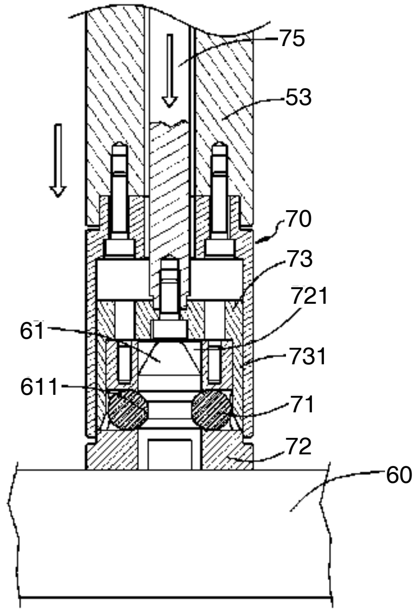
to the length direction, an oscillated portion which extends in the tire radial direction, while oscillating in the lateral direction orthogonal to the length direction.



Rubber sole thermoforming machine

U.S. patent: 11,623,384
Issued: April 11, 2023
Inventor: Wen-Sen Tian
Assigned: Dah Tyan Hydraulic Machine Industrial

Key statement: A rubber sole thermomolding machine includes a lower mold seat disposed on a hydraulic actuator of the machine seat. The lower mold seat ascends and descends with respect to the upper mold seat according to the hydraulic actuator, allowing the lower upper molds to close and open. The upper mold seat moves between a normal position and a tilt position according to the turning mechanism. The middle plate horizontally moves between the upper and the lower mold seats and has a push mechanism connected with the middle frame. When the pin of the middle frame and the fasten unit on the push mechanism are separated, the middle frame is stacked on the middle plate or the lower mold to move, facilitating the cleansing and material feeding operations. The user can cleanse the upper mold without being hindered by the middle frame, assuring the safe and smooth process.



Peroxide cure study in HCR silicone

by Erick Sharp, Kylie Knipp and Doug Foster, ACE Laboratories

The performance of different peroxides at varying levels in HCR silicone are comparatively evaluated in this article. Comparative measurables include crosslink density, rheology, physical properties, compression set and heat aging.

Peroxides evaluated

This study investigated diacyl peroxide di(1,4-dichlorobenzoyl) peroxide 50% active in silicone oil (DDCBP-50), dicumyl peroxide 40% active in silicone gum (Si-DCP-40) and 2,5-dimethyl-2,5-di(t-butylperoxy) hexane peroxide 50% active in silicone gum (Si-DBPH-50). The key properties of these materials are shown in table 1, and the chemical structures are pictured in figures 1-3.

The di(1,4-dichlorobenzoyl) peroxide (DCBP) is commonly used in silicone extrusion compounds. Its quick reaction temperature allows a complex extruded profile to quickly form a vulcanized skin and maintain its shape. It should be noted that, because of the low decomposition temperature of DCBP, caution must be taken during the mixing process. The low decomposition temperature also results in rigorous storage and transport environmental conditions. This is especially important in hotter climates and during the summertime. DCBP is a non-vinyl specific peroxide and can be easily inhibited by certain elements, including sulfur. When using DCBP in black silicone compounds, a non-carbon based black pigment is recommended, such as mixed metal oxide.

Dicumyl peroxide (DCP) is a popular curative for molded HCR silicone elastomers. The scorch safety allows for mold cavity fill. Dicumyl peroxide is a vinyl specific peroxide, making it better protected against cure inhibition. In addition to molding applications, dicumyl peroxide can also be used as a secondary peroxide in HCR silicone elastomer extrusion compounds. When used in combination with a fast reacting non-vinyl specific peroxide, the vinyl specific dicumyl peroxide can help increase crosslink density and improve compression set properties.

The 2,5-dimethyl-2,5-di(t-butylperoxy) (DBPH) is similar to dicumyl peroxide. It is often used as a primary or solo peroxide in HCR elastomer molded compounds. The decomposition and activity are also within range of dicumyl peroxide. Similarly, DBPH is a vinyl specific peroxide and can be used as a secondary peroxide to a non-vinyl specific peroxide in HCR silicone extrusion applications.

All peroxides used in this study were in a silicone binder. DCBP can only be commercially sourced to the industry in binder form due to its explosive nature. Dispersion of dicumyl peroxide and DBPH peroxide is greatly improved with silicone polymer bound dispersions over powder carriers or the fully active liquid form.

Control formulation

To reduce variables and opportunities for inhibition, a basic formulation of an HCR silicone base plus peroxide was used, as shown in table 2. Xiameter RBB-2001-65 is a 70 durometer,

Table 1 - key peroxide properties

Peroxide	MW	% active oxygen	One hour half life (°C)
Dicumyl	270.3	5.9	137
DBPH	290.44	5.5	139
DCBP	380.07	4.21	55

Table 2 - formulations

Ingredient	phr level
Xiameter RBB 2001-65	100.0
Crosslinking agent (DDCBP-50, Si-DCP-40 or Si-DBPH-50)	0.5, 0.8, 1.0 or 1.2

Figure 1 - di(1,4-dichlorobenzoyl) peroxide

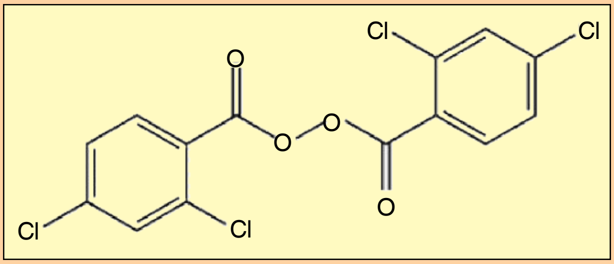


Figure 2 - dicumyl peroxide

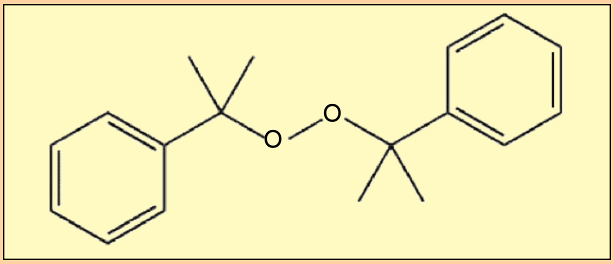


Figure 3 - 2,5-dimethyl-2,5-di(t-butylperoxy) hexane

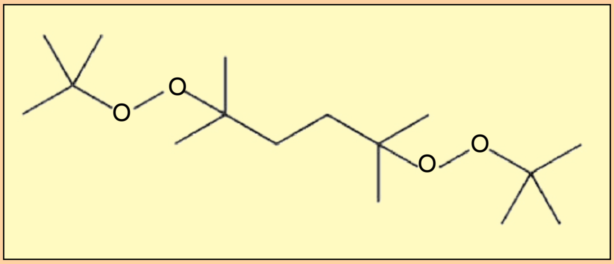


Table 3 - moving die rheometer; 15 minutes at 100°C

MDR (15' at 100°C)				
Property		*DDCBP-50*		
	0.5	*0.8*	*1.0*	*1.2*
MH (dNm)	7.04	9.85	11.63	12.87
ML (dNm)	1.26	1.22	1.25	1.20
Tc90 (minutes)	4.03	3.44	3.17	3.03
		Si-DCP-40		
Property	*0.5*	*0.8*	*1.0*	*1.2*
MH (dNm)	1.10	1.10	1.10	1.03
ML (dNm)	1.06	1.04	1.05	0.83
Tc90 (minutes)	11.37	10.17	13.27	6.67
		Si-DBPH-50		
Property	*0.5*	*0.8*	*1.0*	*1.2*
MH (dNm)	1.10	1.08	1.06	1.09
ML (dNm)	1.04	1.03	1.01	1.04
Tc90 (minutes)	10.67	11.67	11.27	11.97

Table 4 - moving die rheometer; 15 minutes at 177°C

MDR (15' at 177°C)				
Property		*DDCBP-50*		
	0.5	*0.8*	*1.0*	*1.2*
MH (dNm)	5.82	0.00	8.61	9.22
ML (dNm)	5.78	7.28	8.57	9.18
TS2 (minutes)	-	-	-	-
Tc90 (minutes)	14.96	-	14.96	14.96
		Si-DCP-40		
Property	*0.5*	*0.8*	*1.0*	*1.2*
MH (dNm)	25.57	26.12	25.67	26.60
ML (dNm)	0.97	0.91	0.89	0.96
TS2 (minutes)	0.52	0.44	0.42	0.37
Tc90 (minutes)	2.50	1.79	1.60	1.42
		Si-DBPH-50		
Property	*0.5*	*0.8*	*1.0*	*1.2*
MH (dNm)	25.38	25.41	24.79	24.57
ML (dNm)	0.93	0.92	0.86	0.84
TS2 (minutes)	0.64	0.51	0.46	0.43
Tc90 (minutes)	2.75	1.99	1.73	1.53

translucent, general purpose silicone base. Peroxide type was one variable, and peroxide loading level was the second variable in this study. The loading levels chosen were 0.50 phr, 0.80 phr, 1.00 phr and 1.20 phr.

The mixing of the formulations was done on a chilled two-roll mill. The silicone base was passed three times through the mill rolls before the peroxide was added. After the addition of the peroxide, the material was passed 20 times through the mill. For each pass, the material was rolled off and vertically re-added to the nip of the mill.

Rheology

Due to the low decomposition temperature of the DCBP, all batches were tested on the MDR at 100°C and 177°C for 15 minutes. Summaries of the results can be seen in tables 3 and 4 and figures 4-7.

The maximum torque (MH) can be used as a general correlation to crosslink density. At 100°C, the DCBP peroxide

Figure 4 - maximum torque (MH); 15 minutes at 100°C

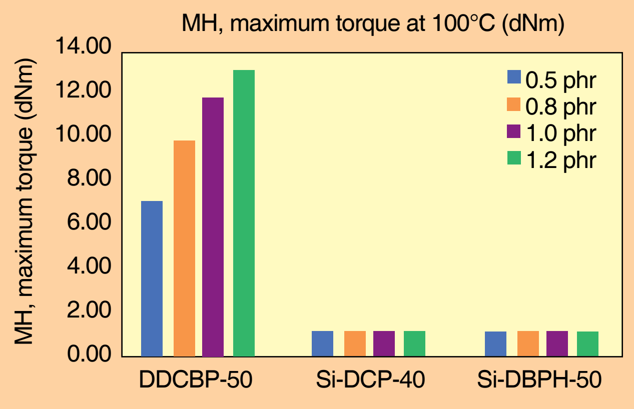
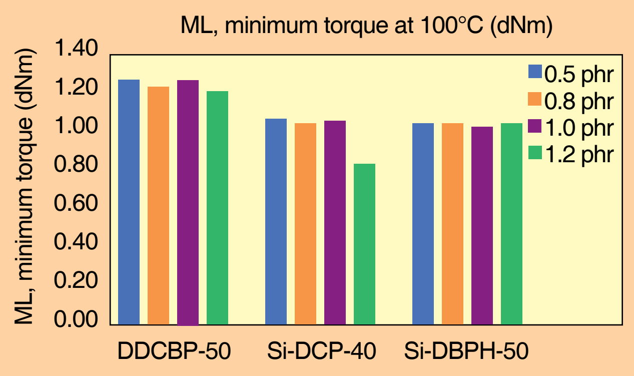


Figure 5 - minimum torque (ML); 15 minutes at 100°C



showed a consistent step change in MH value based on the loading level (figure 4). The higher loadings of DCBP were increasing the crosslinking throughout the compound. The dicumyl peroxide and DBPH peroxide remained within the standard margin of deviation, despite the increase of loading levels. This indicates that additional volumes of peroxide did not result in additional crosslinking in the compound.

The minimum torque (ML) can be used as a general corre-

Figure 6 - cure time (Tc90); 15 minutes at 100°C

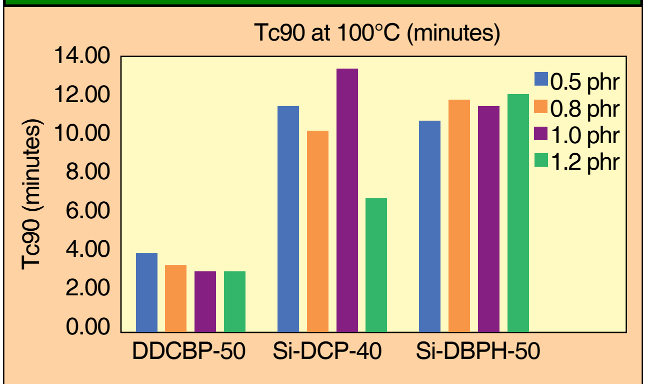


Figure 7 - cure time (Tc90); 15 minutes at 177°C

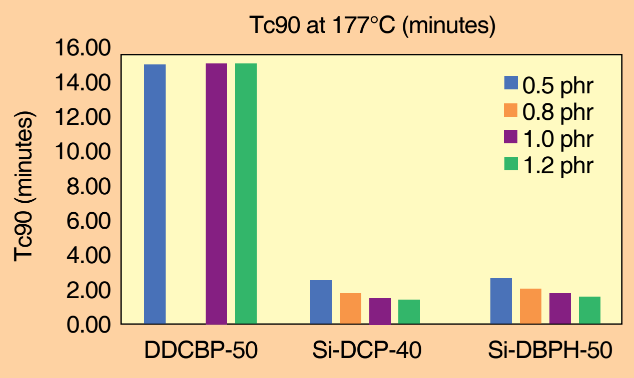
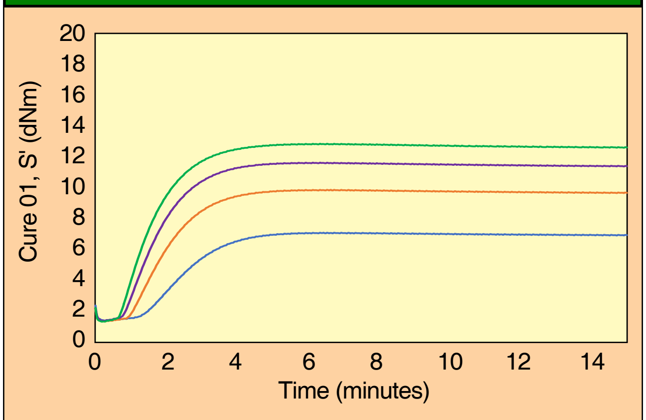


Figure 8 - DCBP; 15 minutes at 100°C



lation to the expected viscosity or plasticity. Peroxide type should not have much bearing on this value, nor should loading level. At 177°C, a step change on the DCBP results was seen; however, this was due to the very fast decomposition temperature (figure 5). The compound was crosslinking almost immediately upon closing the MDR platens.

The lack of Ts2 (onset of scorch) for DCBP at 177°C means that an accurate minimum torque was not detected, so no 2 point rise could be calculated. This means the DCBP was in-

Figure 9 - Si-DCP-40; 15 minutes at 177°C

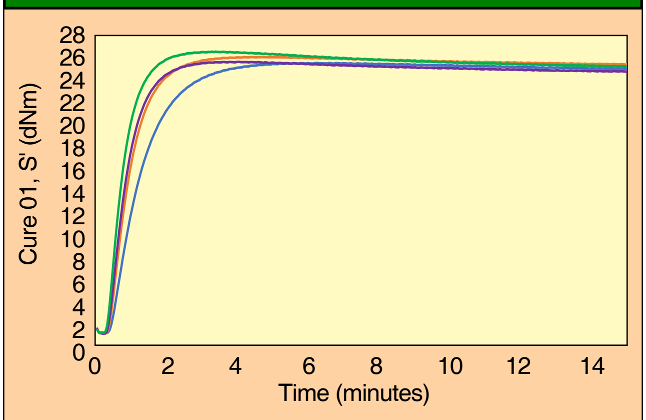
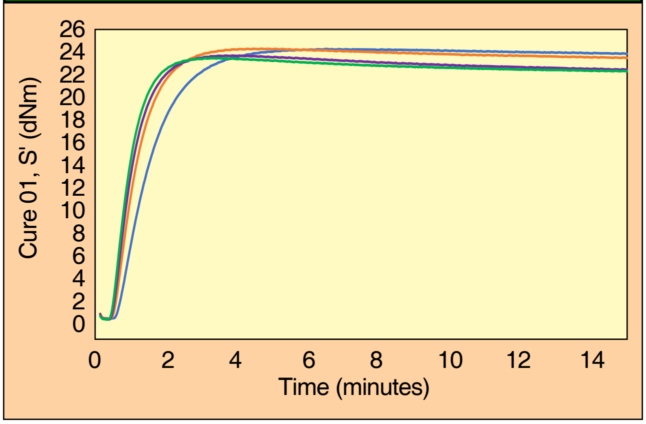


Figure 10 - Si-DBPH-50; 15 minutes at 177°C



stantly decomposing at 177°C when the platens closed. At 100°C, the reaction was readable; however, it was still so quick that the calculation of Ts2 could not be made. Increasing the loading level of peroxides does increase the amount of crosslink reaction; however, the decomposition temperature always stays the same. Despite this, a step change reduction in time to scorch was seen as dicumyl and DBPH peroxide levels were increased (figure 6). On both the dicumyl and DBPH peroxides, the biggest step change came when increasing from 0.50 phr to 0.80 phr.

The Tc90 (cure time) showed similar trends to what was seen with scorch time. At 100°C, the DCBP showed a small step change of reduction in cure time as loading levels increased (figure 6). Dicumyl and DBPH peroxides showed inconsistencies on cure time at 100°C. At 177°C, the dicumyl and DBPH peroxides showed small step changes of reduction in cure time in correlation with an increase of loading level (figure 7). At 177°C, the DCBP provided skewed numbers because the ML and MH values were inaccurate due to the instant decomposition of the DCBP. The ODR curves based on tables 3 and 4 are shown in figures 8-10.

Crosslink density: State of cure

A solvent swell method developed internally at ACE Laboratories based on ASTM D6814 (Determination of Percent Devulcanization of Crumb Rubber Based on Crosslink Density) and the Flory-Rehner equation was used for this analysis. The results are shown in table 5 and figure 11.

The DCBP peroxide showed a significant step change increase in crosslink density as the loading levels increased. This

Table 5 - crosslink density via Flory-Rehner method

	Crosslink density (mol/cm^3)		
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	3.14E-04	9.30E-04	7.78E-04
0.8	5.55E-04	9.64E-04	7.93E-04
1.0	6.84E-04	9.82E-04	7.96E-04
1.2	7.92E-04	9.71E-04	7.93E-04

Figure 11 - crosslink density via Flory-Rehner method

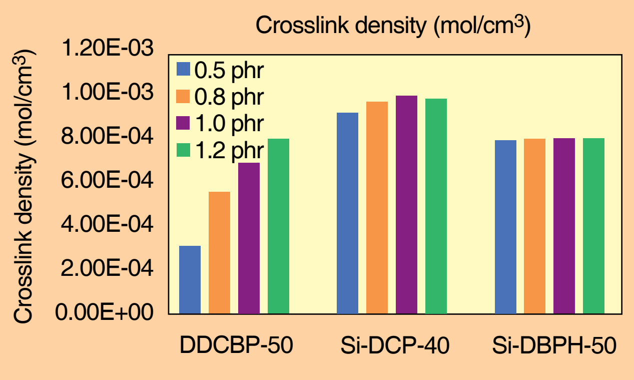


Figure 12 - unaged hardness (durometer A)

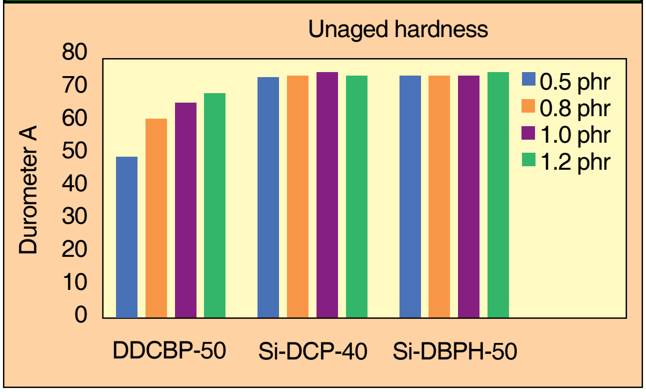
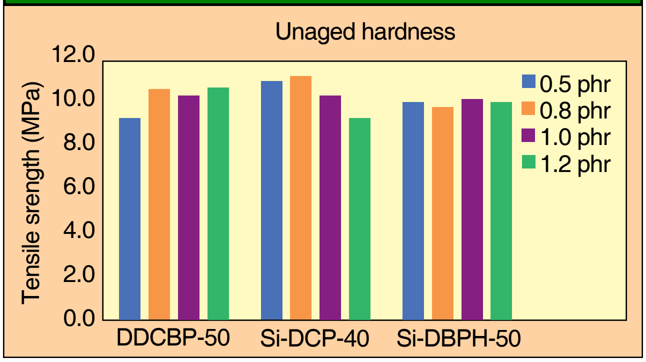


Figure 13 - unaged tensile strength (MPa)



correlates with the MH values measured on the MDR testing system. The more DCBP that is made available to the polymer, the more the state of cure and total crosslink density of the compound increased.

On the other hand, the dicumyl and DBPH peroxides showed minimal changes as loading levels increased. Both showed the most change when increasing from 0.50 phr to 0.80 phr; however, overall change was very minimal. This indicates that adding higher levels of these peroxides does not necessarily provide increased crosslinking.

Standard physical properties

All sample preparation was done in accordance with ASTM D3183. DCBP compound test plaques were vulcanized at 100°C for 10 minutes, while compression set buttons were vulcanized at 100°C for 12 minutes. Dicumyl and DBPH peroxide test plaques were vulcanized at 177°C for 8 minutes, and compression set buttons were vulcanized at 177°C for 10 minutes. Cure times were kept consistent within each peroxide type to maintain consistency.

All physical testing was conducted in triplicate, with the average values reported in tables 6-17 and figures 12-23. None of the physical testing had any datapoint skews within the triplicate sets.

Durometer A testing was done in accordance with ASTM D2240. The DCBP batches showed a substantial increase when going from a 0.50 loading level to a 0.80 loading level (table 6 and figure 12). The increase to 1.0 phr and 1.2 phr yielded incremental step increases. The dicumyl and DBPH peroxides did not yield any change to durometer A hardness with the increase in loading levels.

Tensile testing was done in accordance with ASTM D412. While the DCBP saw relevant changes in durometer, the tensile properties remained stable between the four loading levels (table 7 and figure 13). The main step change was in the increase from 0.50 to 0.80 phr. The dicumyl peroxide started to slightly decrease after topping out at the 0.80 phr loading level. The DBPH peroxide compounds remained within standard deviation across all loading levels.

Elongation was also conducted in accordance with ASTM D412. While the DCBP samples did not see much change in tensile properties, there was a consistent decreasing step change in elongation properties as loading levels increased (table 8 and

Table 6 - unaged hardness (durometer A)

	Hardness (durometer A)		
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	49	72	72
0.8	60	73	72
1.0	64	73	73
1.2	67	73	73

Table 7 - unaged tensile strength (MPa)

	Tensile strength (MPa)		
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	9.4	11.0	10.1
0.8	10.7	11.3	9.9
1.0	10.4	10.5	10.2
1.2	10.8	9.4	10.1

Table 8 - unaged ultimate elongation (%)

	Ultimate elongation (%)		
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	810	365	354
0.8	566	360	344
1.0	467	341	348
1.2	420	311	331

Figure 14 - unaged ultimate elongation (%)

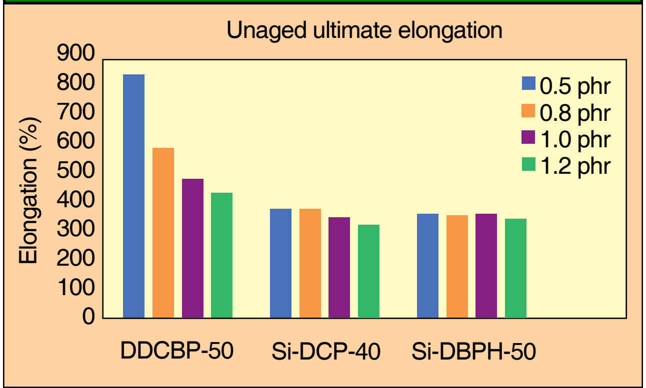


figure 14). The rate of change in tensile property increase did not match up with the rate of decrease in elongation properties. Typically, these properties would correlate more in unison. The dicumyl and DBPH peroxide compounds' elongation values stayed within normal testing tolerance, despite the increase in loading levels.

The DCBP compounds maintained a consistent step change increase in modulus properties as loading levels increased (tables 9 and 10, and figures 15 and 16). The dicumyl and DBPH peroxides remained within standard testing deviation, despite the loading level increases.

Tear testing was done in accordance with ASTM D624 and

Table 9 - unaged modulus at 100% elongation (MPa)

	100% modulus (MPa)		
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	0.9	2.8	2.7
0.8	1.5	2.9	2.8
1.0	1.9	2.9	2.8
1.2	2.3	3.0	2.9

Table 10 - unaged modulus at 300% elongation (MPa)

	300% modulus (MPa)		
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	2.3	8.6	8.5
0.8	4.7	9.2	8.9
1.0	6.2	9.1	8.7
1.2	7.5	9.0	9.0

Table 11 - unaged tear resistance; die B (kN/m)

	Die B tear resistance (kN/m)		
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	35.3	19.9	21.2
0.8	29.8	19.9	21.2
1.0	26.0	19.0	19.2
1.2	22.3	21.0	21.3

Figure 15 - unaged modulus at 100% elongation (MPa)

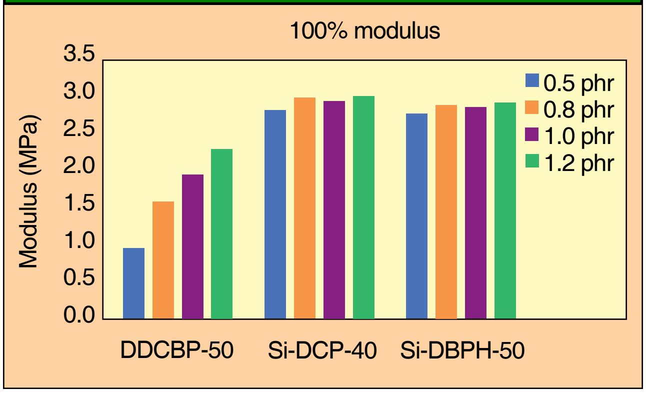
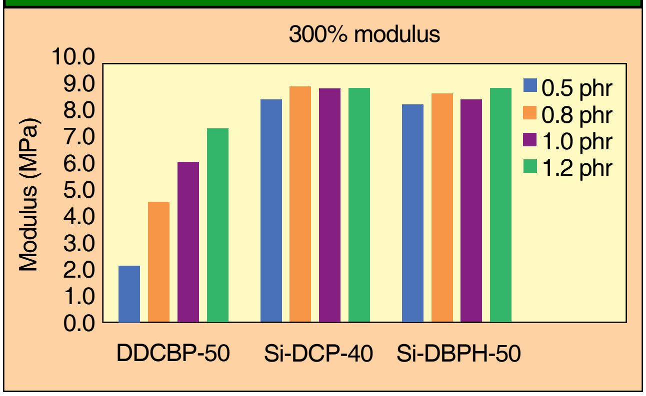


Figure 16 - unaged modulus at 300% elongation (MPa)



utilizing the die B specimens. The DCBP peroxide compounds yielded a consistent decline in tear properties as the loading level of the peroxide increased (table 11 and figure 17). The dicumyl and DBPH peroxide compounds remained within standard testing deviation, despite the increase in peroxide levels.

Compression set and heat aging

Compression set testing was done in accordance with ASTM D395. Testing conditions were 150°C for 22 hours with a 30

Figure 17 - unaged tear resistance; die B (kN/m)

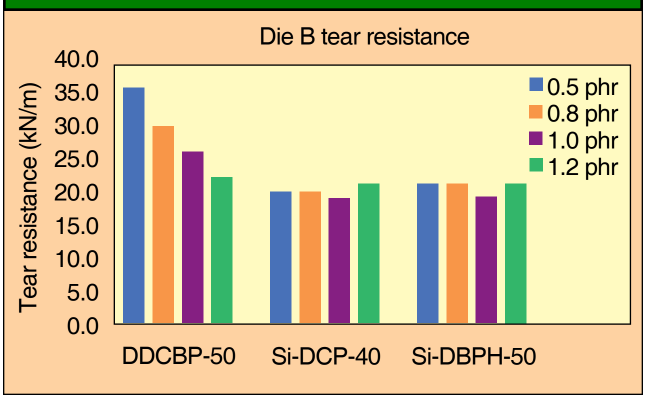


Table 12 - compression set aged 22 hours at 150°C

Compression set (%), 22 hours at 150°C			
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	44.1	4.4	4.4
0.8	21.0	4.0	3.8
1.0	17.6	4.8	3.5
1.2	14.9	4.3	3.6

Table 13 - heat aged durometer A hardness change (150°C for 72 hours)

Change in hardness (durometer A)			
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	7	3	2
0.8	3	2	1
1.0	2	1	1
1.2	3	2	1

Table 14 - heat aged tensile change (150°C for 72 hours)

Heat aged change in tensile strenth (%)			
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	-8.0%	-12.3%	-1.4%
0.8	-2.1%	-16.8%	4.7%
1.0	-5.8%	-9.4%	-4.2%
1.2	2.5%	-7.1%	-8.1%

Table 15 - heat aged elongation change (150°C for 72 hours)

Change in hardness (durometer A)			
phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	-11.9%	-12.6%	-6.1%
0.8	-2.1%	-16.5%	-2.4%
1.0	-5.8%	-12.3%	-9.5%
1.2	0.9%	-10.9%	-10.1%

minute recovery period. The DCBP compounds yielded a considerable improvement in compression set properties when loading levels were increased from 0.50 to 0.80 phr, going from 44.1% to 21% (table 12 and figure 18). There were smaller step changes at 1.00 and 1.20 phr loading levels. Dicumyl peroxide compounds varied slightly throughout; however, within standard testing ranges. DBPH peroxide compounds did trend with slight improvement.

Heat age analysis was done in accordance with ASTM D573. Conditions for the heat age analysis were 150°C for 72 hours. The DCBP peroxide compounds reflected a sharp improvement in hardness change after oven aging, when loading levels increased from 0.50 to 0.80 (tables 13-15 and figures 19-21). Values remained stable when increasing to 1.00 and 1.20. The dicumyl and DBPH peroxide compounds showed the biggest shift when going from 0.50 phr to 0.80 phr; however, it was still minimal in comparison to the DCBP. Tensile change values were

Figure 18 - compression set aged 22 hours at 150°C

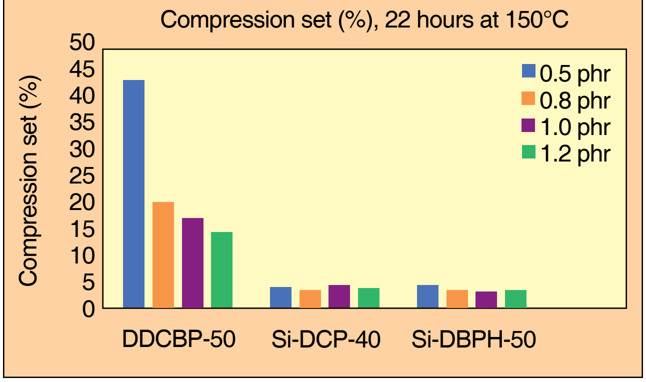
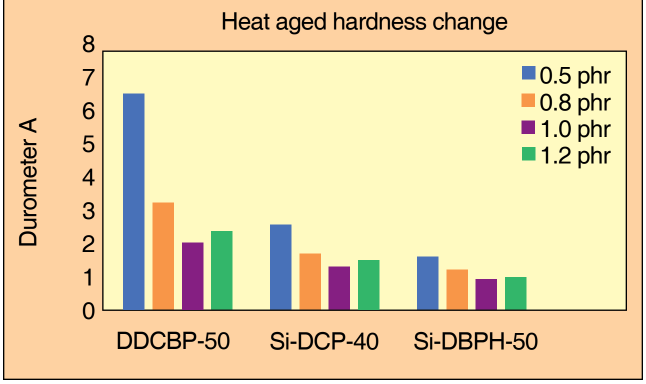


Figure 19 - heat aged durometer A hardness change (150°C for72 hours)



inconsistent and not a steady trend on all three peroxides. DCBP did reflect a trend on elongation change improvement, with the 1.00 phr loading being an outlier. The DBPH peroxide compounds reflected a slight negative trend on elongation in ratio to loading level increase, with 0.80 phr loading being an outlier.

Post-cured samples

All compounds were post-cured for 60 minutes at 177°C, and then retested for compression set and heat aged durometer

Figure 20 - heat aged tensile change (150°C for 72 hours)

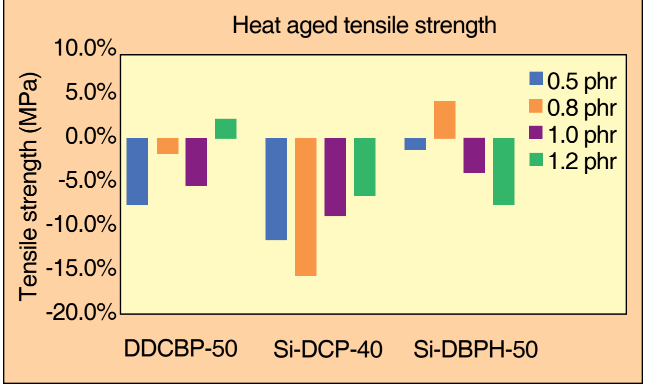


Figure 21 - heat aged elongation change (150°C for 72 hours)

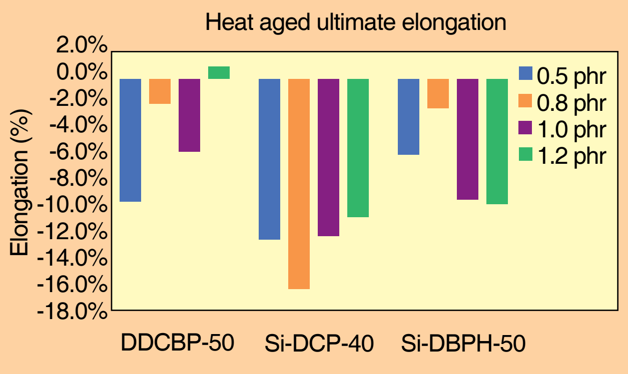


Figure 22 - compression set aged 22 hours at 150°C (post-cured samples at 177°C for 60 minutes

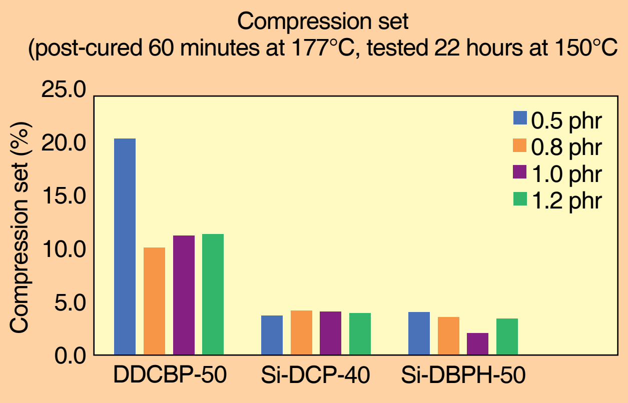
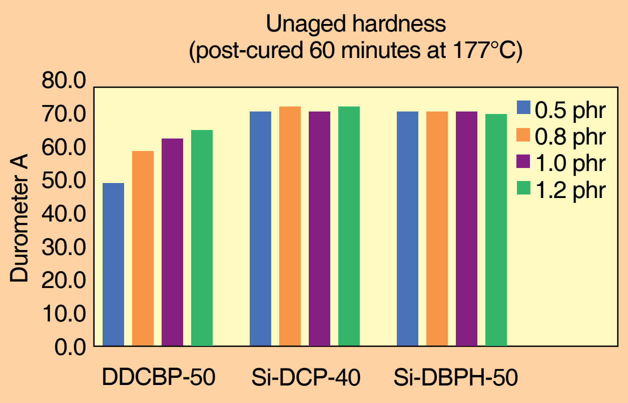


Figure 23 - heat aged durometer 22 hours at 150°C (post-cured samples at 177°C for 60 minutes



change. The purpose of this analysis was to see if the additional curing time reduced some of the variation and provided clearer trends.

The DCBP peroxide compounds had a sharp improvement in compression set when going from 0.50 phr to 0.80 phr (table 16 and figure 22). After this increase, the results leveled off. The dicumyl and DBPH peroxide compounds remained stable at all loading levels.

Table 16 - compression set aged 22 hours at 150°C (post-cured samples at 177°C for 60 minutes

Compression set (22 hours at 150°C)
Post-cured samples (60 minutes at 177°S)

phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	20.5	3.8	4.4
0.8	10.4	4.2	3.8
1.0	11.3	4.0	2.1
1.2	11.3	4.0	3.8

Table 17 - heat aged durometer 22 hours at 150°C (post-cured samples at 177°C for 60 minutes

Unaged hardness (durometer A)
Post-cured samples (60 minutes at 177°S)

phr level	*DDCBP-50*	*Si-DCP-40*	*Si-DBPH-50*
0.5	49.9	72.0	72.6
0.8	60.4	73.1	72.1
1.0	63.8	72.8	72.7
1.2	66.6	73.6	72.1

Similarly, the hardness change after heat aging for DCBP had a sharp improvement when increasing from 0.50 phr to 0.80 phr, and leveling off at 1.00 and 1.20 phr (table 17 and figure 23). Dicumyl and DBPH compounds were all within the standard testing margin, despite the loading level increase.

Conclusions

DCBP peroxide compounds reflected increased crosslink density and physical performance as loading levels increased. The primary jump in properties happened when increasing from 0.50 phr to 0.80 phr. Compression set properties continued to improve all the way up to a 1.20 loading level for DCBP. Post-curing of the samples did level out results, with the 0.50 phr to 0.80 phr step change being the only relevant swing.

Dicumyl and DBPH peroxides showed slight improvements in crosslink density when increasing from 0.50 to 0.80 phr. Physical properties did not swing much at any of the loading level increases. Based on standard loading levels of HCR silicone elastomers, many likely have residual dicumyl and DBPH peroxide remaining. The amount needed will increase based on filler loading, inhibition and vinyl content of the silicone polymer being used.

References

1. Xiameter RBB-2000-35 base. Dow (n.d.). https://www.dow.com/en-us/pdp.xiameter-rbb-2000-35-base.01953621z#properties.
2. P.J. Flory and J. Rehner, Jr., J. Chem. Phys., 11, 521 (1943).
3. Chemical search engine. ChemicalBook (n.d.). https://www.chemicalbook.com/.
4. ASTM International, Standards Worldwide (n.d.). http://www.astm.org/.

Thermoplastic-silicone elastomer composites production by multi-component injection molding with polycarbonate and polypropylene

by H.-P. Heim, Ralf-Urs Giesen, Annette Rüppel, Michael Hartung and Mohammad Ali Nikousaleh, University of Kassel

In plastics technology, the processing of silicone rubber is attracting more and more attention. In medical technology, liquid silicone rubber (LSR) is frequently used because of its good processability and physiological safety. In automobiles and trucks, silicone rubbers are often used because of their good elastic properties over a wide temperature range from -50°C to +200°C, especially for sealing applications and hoses. Likewise, silicone elastomers are becoming more and more interesting for optical applications because of their excellent transparency and very good light conducting properties in flexible applications (refs. 1-3).

In all these areas, it will become increasingly interesting to process LSR in combination with thermoplastics in the future. Multi-component injection molding is very well suited for this purpose. For certain material combinations, such as polyamide (PA) and polybutylene terephthalate (PBT), there are already numerous applications on the market (ref. 4). Material manufacturers such as Wacker Chemie, Shin-Etsu Silicone and Momentive Performance Materials offer LSR grades that contain additional organofunctional silanes, and thus act as adhesion promoters between the inorganic Si-O chains of the silicone rubber and the functional groups on the surface of the thermoplastic.

Standard thermoplastics such as acrylonitrile butadiene styrene (ABS) and polyethylene (PE) cannot be produced by multicomponent injection molding with LSR, because LSR normally crosslinks in the mold at temperatures above 130°C. This is why LSR is not suitable for multi-component molding. ABS and PE cannot withstand these temperatures, as they are then already in a plastic state. For polypropylene (PP), no adhesive LSR grades are currently available on the market; and for polycarbonate (PC), there is only availability to a limited extent.

Surface pretreatment methods for thermoplastics, such as PP and PC, can help in this application. These include, for example, UVC pretreatment (ref. 5) and the silicatization of thermoplastic substrates.

UVC pretreatment uses light in the wavelength range of 100-280 nm. The light can be generated, for example, by a low pressure mercury lamp. Exposure times are about 5-10 seconds for PC, and about 30 seconds for PP. The simple lamp technology and the short exposure times are very well suited for multicomponent injection molding, so that the cycle time of the injection molding process is little affected if a robot can be used at the injection molding machine (refs. 6 and 7). In the silicating process, a propane-butane mixture containing actuating components is completely converted into silicate particles by a high temperature flame (approximately 1,300°C), and a silicate layer consisting of silicone oxides is formed on the thermoplastic surface (refs. 8 and 9).

In addition to the pretreatment methods described above, UV curing liquid silicone rubbers are also available for the production of standard thermoplastic LSR components by injection molding. Furthermore, there are LTC (low temperature curing) LSR grades that cure at temperatures around 90°C (refs. 10 and 11).

Experimental

Materials used

The following thermoplastics were used for the tests: PC Calibre Megarad 2081 from Trinseo, and a PP 575P from Sabic. Siloprene 2742 from Momentive Performance Materials was available as an adhesive LSR. The materials used are suitable for medical applications.

Specimen and test equipment

Figure 1 shows the specimen for the tests. The hard component has the dimensions 150 mm x 50 mm x 2 mm, and the soft component measures 210 mm x 20 mm x 2 mm. The test specimen is thus based on the VDI guideline 2019. The specimen was tested in a peel test with a universal testing machine from Hegewald & Peschke at a test speed of 100 mm/minute.

Equipment used and specimen production

An Arburg Type 370-600 70/70 injection molding machine was used to produce the test specimens. The machine was equipped with a liquid injection molding (LIM) unit on the main axis for processing LSR. The thermoplastic unit was mounted in the L position. The machine has a three-axis robot, which can be used for the transfer process in the mold, as well as for depositing the test specimens. An LSR metering unit from Reinhardt Technik GmbH fed the material into the LIM unit. The 2C injection mold for producing the test specimen was built by EDEGS Formen-

Figure 1 - test specimen based on VDI guideline 2019

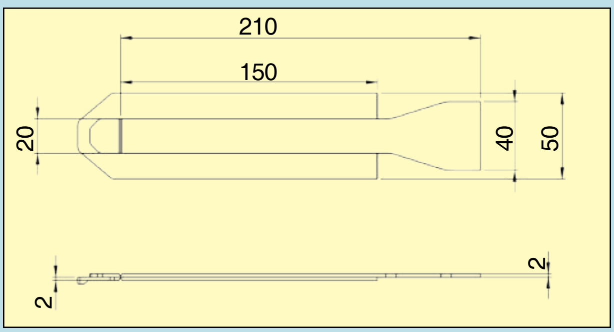


Table 1 - post-treatments of the 2K composites

Post-treatment	*Description*
Freshly molded	Direct measurement of peel resistance after composite production
Untempered	Storage of composites at standard climate for 24 hours
Tempered	1 hour at 100°C in convection oven
Sterilization (gamma)	At B. Braun Melsungen AG
Sterilization (EO)	At B. Braun Melsungen AG
Aging	60 days under variation of temperature (-20°C to 55°C) and humidity (20% to 80%)

bau GmbH. A UV pretreatment unit was integrated on the three-axis robot. For silicatization, a flaming unit was used, which is adjustable in height. The sample was placed on a mobile carriage. This allowed the pretreatment speed and flame distance to be adjusted. For the tests, a speed of 0.4 meters/second was selected with a flame distance to the substrate of 15 mm.

The PC was injected into the thermoplastic cavity at a melt temperature of 300°C; the mold temperature was 100°C. After a cooling time of 15 seconds, the thermoplastic part was removed by the robot and pretreated with UV radiation for 5 or 10 seconds during the transfer process. The premolded part was then placed in the LSR cavity and overmolded. At a mold temperature of 140°C, the silicone cured within 60 seconds (ref. 12).

The PP was injected with a compound temperature of 190°C at a mold temperature of 60°C. The surface was then activated with silicatization. In the next step, the soft component (LSR) was overmolded at a melt temperature of 20°C and a mold temperature of 140°C. The crosslinking time during which the two components remain in the mold is about one minute. The crosslinking time during which both components remain in the mold is 50 seconds.

Results

Figure 2 shows the adhesion of LSR polycarbonate composites after different post-treatment processes. For adhesion generation, two UVC irradiation times (5 and 10 seconds) were first selected, with which the PC component was activated before overmolding with LSR. The LSR PC composites produced were then subjected to the post-treatment processes shown in table 1.

The results show that UVC pretreatment produces very good adhesion after only very short irradiation times (no adhesion without irradiation). Compared with the two irradiation times, there are no significant differences for the freshly sprayed, annealed and unannealed composites. Due to the post-treatment process of sterilization, the characteristic values increase, especially for an irradiation time of 10 seconds. The results of the sterilization process are not significant. Due to the artificial aging process, which involves stressing the composites with a 60 day variation in temperature and humidity, the characteristic values drop slightly at an irradiation time of 5 seconds, but not significantly below the initial value of the freshly injected samples.

For the 10 minute irradiation, there are no differences to the sterilized samples, except for a slightly increased scatter. In general, the characteristic values at an irradiation time of 10 seconds are at a higher and more stable level than the 5 seconds irradiated composites.

The results show that UVC pretreatment can produce a good adhesive bond between polycarbonate with self-adhesive LSR. Cohesive failure (tear off directly at tab or at least more than 50% remaining silicone on the hard component) occurs in all tested samples. The composites are stable, even with a wide variety of post-treatment processes. A loss of adhesion is not evident, even after 60 days of aging.

Figure 3 shows the results of the bonded joints produced with silicatization of the PP after storage time at room temperature. As expected, without the surface activation, it is not possible to produce an adhesive bond between the two components. With silicatization, composites with very strong adhesion can be produced. After curing the composites at room temperature, the characteristic values do not change significantly.

Figure 2 - adhesion between polycarbonates with LSR after different post-treatment processes

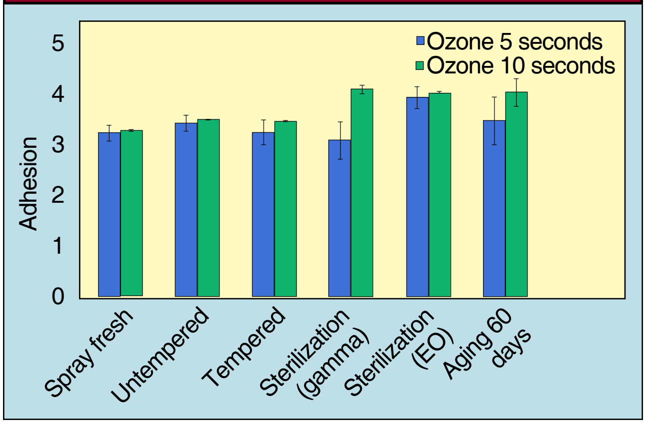
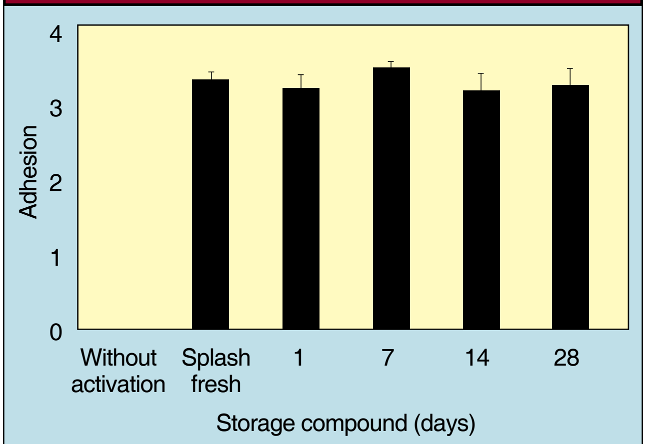


Figure 3 - adhesion between polypropylene and LSR with and without silicatization



There is constant adhesion with cohesive failure over the entire period up to 28 days.

Conclusions and outlook

The results presented here with silicatization and UVC pretreatment show that very good composites of PP and/or PC with LSR can be produced. UVC pretreated polycarbonates show a long lasting adhesion, even after different post-treatment processes. Thermoplastics that have been silicatized also show very good adhesion, despite long storage times. These results show that composites of LSR and thermoplastics, such as PC and PP, are certainly ready for the market. In addition, costs can be reduced by new material combinations (cf. PP: 2 Euro/kg; PA: 6 Euro/kg), and savings can be made in manufacturing costs.

References

1. O. Franssen and H. Bayer, "Die erfolgsgeschichte der siliconelastomere," GAK Gummi Fasern Kunststoffe, Fachmagazin für die Polymerindustrie, July 2012.
2. B. Keck, "Transparente ielfalt," KGK, October 2014.
3. T. Maucher, "Molded LSR optics in innovative headlamp systems," Silicone Elastomers World Summit, Munich, Germany (2017).
4. C. Baumgart, B. Höll, T. Neumeyer and V. Altstädt, "Ein ungleiches paar hält zusammen," Kunststoffe, August 2016.
5. C. Dölle, "Licht als werkzeug: Einsatz von vakuum-UV-excimerstrahlung zur aktivierung von polymeren," AiF-Schlussbericht IFAM Bremen (2012).
6. M. Hartung and R.-U. Giesen, "UV light: The ideal pretreatment method for LSR-thermoplastic composites," Silicone Elastomers World Summit, Cologne, Germany (2016).
7. R.-U. Giesen, M. Hartung, A. Rüppel and H.-P. Heim, "Hartweich-verbunde aus LSR und UV-licht-aktivierten polycarbonaten," SKZ Fachtagung Siliconelastomere, Würzburg, Germany (2017).
8. SURA Instruments: Handbuch GVE2/HB, Pyrosil SURA Instruments GmbH (2004).
9. J. Tiller, S. Lee, K. Lewis and A. Klibanov: "Polymer surfaces derivatized with poly(vinyl-N-hexylpyridinium) kill airborne and waterborne bacteria," Biotechnology and Bioengineering, 79, pp. 465-471, DOI: 10.1002/bit.10299 (2002).
10. P. Beyer and H.-P. Wolf, "Low temperature cure LSRs: Exploring benefits and applications," LSR innovations 2018, Cologne, Germany (2018).
11. B. Ganter, S. Boßhammer and U, Irmer, "UV-vernetzende silikonkautschuke erschließen neue anwendungsfelder," GAK, February 2013.
12. R.-U. Giesen, M. Hartung, A. Rüppel and H.-P. Heim, "Mehrkomponentenbauteile aus flüssigsilikonkautschuken (LSR) und UV-licht aktivierten polycarbonaten," GAK, October 2017.

Polyfarnesene branched butyl rubber: An efficient, sustainable processability solution

by Jeremy L. Bourque, Sarah J. Elliott, Jon A. Bielby, Kevin Kulbaba and Gregory J.E. Davidson, Arlanxeo

Butyl rubber (IIR) is formed from the cationically initiated copolymerization of isobutylene and isoprene at reaction temperatures below -90°C. Commercially available grades have between 0.5 to 2.5 mol% of isoprene monomer available along the polymer backbone for curing or further functionalization reactions. The unique properties of IIR are due to the isobutylene units, which are sterically hindered by the presence of two bulky methyl groups positioned on alternating carbon units along the backbone; see, for example, R.H. Boyd et al. (ref. 1) and P.V. Krishana Pant et al. (ref. 2). To accommodate the bulky methyl groups, the polymer backbone must elongate and twist, causing the butyl rubber chains to adopt a more densely packed structure. This distortion and increased packing density in butyl rubber results in excellent permeation resistance to gases and moisture. In addition, the extremely low level of unsaturation of IIR ensures excellent thermal, oxidative and chemical stability.

IIR can be halogenated by the addition of bromine or chlorine to the isoprene unit to yield bromobutyl rubber (BIIR) or chlorobutyl rubber (CIIR), respectively (figure 1). Halogenation allows for increased vulcanization rates and improved cure compatibility with high diene rubber types such as polybutadiene, polystyrene butadiene or natural rubber. Various reviews have been published on the production and halogenation of butyl rubber; see, for example, H. Brandt et al. (ref. 3) and M. Happ et al. (ref. 4).

Both CIIR and BIIR retain the key properties of the parent IIR elastomer, including low gas and liquid permeation rates compared to other elastomers (including low water absorption). In addition, due to the nature of the manufacturing process, halobutyl rubber (XIIR) has low extractable or leachable materials with good compatibility (i.e., low reactivity) towards active ingredients which may be present in pharmaceutical preparations or biological samples (i.e., blood collection). A low glass transition temperature (-68°C) allows butyl rubber compounds to remain flexible over a wide temperature range, which also enables XIIR to be used in the lyophilization process (freeze drying) of pharmaceuticals. Compounds made of XIIR can be designed with good sealing and resealing properties, as well, to allow, for example, easy needle penetration without significant fragmentation. The combination of these properties makes XIIR ideal for use in the medical industry, as highlighted in a previous Arlanxeo publication in *Rubber World* (ref. 5).

Butyl rubber is a relatively linear polymer, mostly due to a low comonomer content. In some instances, higher molecular weight/high Mooney butyl containing compounds can suffer from poor processability, while lower molecular weight/lower Mooney butyl containing compounds conversely can suffer from poor green strength. One method to decouple these dependencies of the processing properties on the molecular weight is to produce a branched butyl rubber. This can be achieved during polymerization through the addition of a branching agent. Branching agents for butyl rubber have traditionally been based on styrene-butadiene copolymers, where the butadiene fragment is active in the branching process. As shown in figure 2, growing butyl polymer chains terminate onto the unsaturation of the branching agent, leading to the generation of a high molecular weight branched fraction and lower molecular weight linear chains. It has been shown that compounds derived from this branched butyl rubber possess improved green strength and flow stability, while also demonstrating better processability.

Arlanxeo has recently developed a new platform technology for producing a branched butyl rubber using polyfarnesene as the branching agent. Polyfarnesene is a biobased polymer generated from high purity trans-β-farnesene, produced through a yeast fermentation process (ref. 6). Unlike traditional branching agents based on butadiene, polyfarnesene adopts a "bottlebrush" structure due to the presence of relatively long side chains (ref. 7). This structure results in significantly more of the unsaturated sites being accessible during the course of the polymerization; and thus, polyfarnesene is a significantly more efficient branching agent than previously utilized styrene butadiene derivatives. Polyfarnesene is approximately 10 times more effective as a branching agent in comparison to styrene butadiene derivatives used for existing technology (figure 2). Arlanxeo has applied for patent protection of this platform technology (ref. 8).

Polyfarnesene butyl rubber (PF-IIR) can also be halogenated to produce polyfarnesene halobutyl rubber (PF-XIIR). A significant benefit of using polyfarnesene as a branching agent as opposed to those based on butadiene is the cleanliness of the resulting polymer. As polyfarnesene is highly efficient, PF-IIR contains minimal residual or unincorporated branching agent. As a result, after halogenation, the polymer remains colorless, unlike branched halobutyl rubbers made using styrene butadiene based branching agents. The reaction of the residual unsaturation of the polyfarnesene branching agent with halogen adopts the same structure as the isoprene comonomer in the butyl rubber chains. In the case of butadiene branching agents, the bromination leads to a mixture of products that are highly colored and

Figure 1 - chemical structure of butyl rubber (IIR) and halobutyl rubber (XIIR, X = Br or Cl)

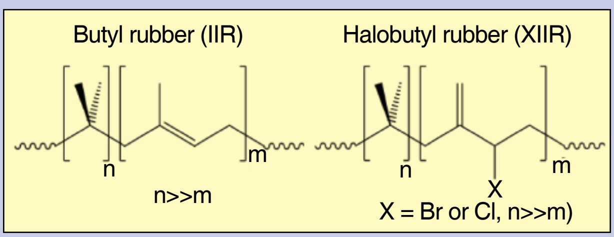
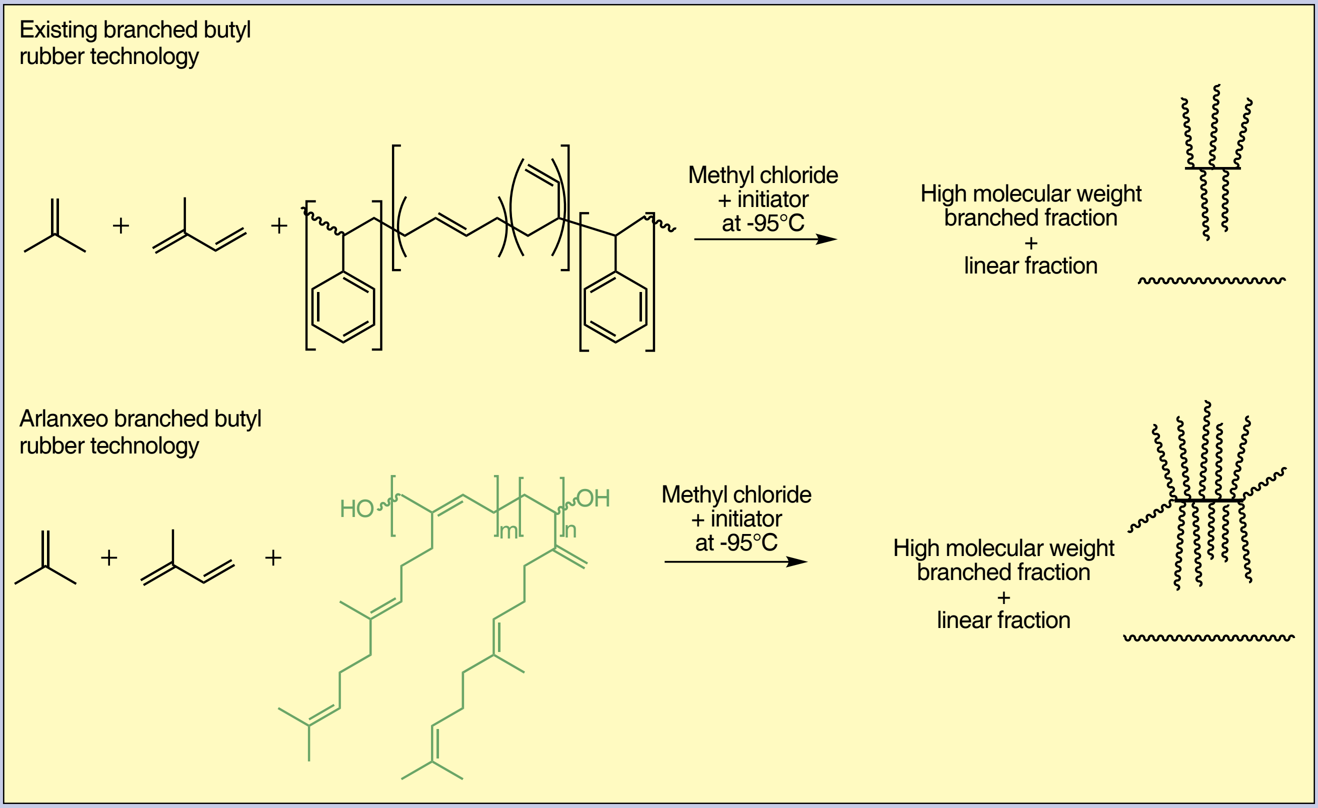


Figure 2 - existing approaches used to produce branched butyl rubber (top); Arlanxeo approach to branched butyl rubber using highly efficient polyfarnesene as a branching agent (bottom)



can easily eliminate hydrogen bromide (HBr).

This article describes a series of branched butyl rubbers produced using polyfarnesene and their use in a variety of rubber compounds, including both pharmaceutical and innerliner formulations.

Experimental

Butyl rubber samples

A series of PF-IIR samples was prepared using traditional laboratory procedures for butyl rubber polymerization. This included polymerizing isobutylene and isoprene in methyl chloride at -95°C in the presence of polyfarnesene (Total Cray Valley) using aluminum chloride as the initiator. The properties of the prepared polymers are shown in tables 1 and 2. The PF-IIR was brominated following standard laboratory techniques using Br_2 as the bromine source.

Polymer testing

For raw polymer rheology, measurements were made with an Anton Paar MCR stress controlled rheometer equipped with 25 mm plates using 1 mm thick specimens. Linear viscoelastic frequency sweep tests at temperatures from 20°C to 110°C were performed covering a frequency range of 10^{-3} to 10^{+2} rad/s. Time-temperature superposition mastercurves of G' and G" were constructed at a reference temperature of 20°C. Vertical corrections were made to compensate for the temperature dependence of the modulus.

Table 1 - bromobutyl rubber samples used in pharmaceutical compound study

Property	*Arlanxeo X_BUTYL BB 2030*	*Arlanxeo X_BUTYL BB X2*	*PF-BIIR 1*	*PF-BIIR 2*	*PF-BIIR 3*
Mooney (MU; 1+8, 125°C)	34	47	56	51	41
Ca (ppm)	1,386	1,413	1,420	1,115	1,371
Br (wt%)	1.76	1.82	1.81	1.83	2.18
Level of branching	0	0	++	+	+++

Table 2 - bromobutyl rubber samples used in innerliner compound study

Property	*Arlanxeo X_BUTYL BB 2030*	*Arlanxeo X_BUTYL BB X2*	*PF-BIIR 4*	*PF-BIIR 5*	*PF-BIIR 6*
Mooney (MU; 1+8, 125°C)	34	47	33	50	34
Ca (ppm)	1,386	1,413	1,456	1,218	1,148
Br (wt%)	1.76	1.82	1.98	1.88	1.87
Level of branching	0	0	+	+++	++

Table 3 - formulation for pharmaceutical closure compound with bromobutyl rubber

Component	*Tag*	*phr*
Bromobutyl rubber	1A	100
Glomax LL (kaolin clay)	1B	70
Maglite K (magnesium oxide)	2A	5
Spider sulfur	2A	1

Mixing procedure:
Stage 1: Internal laboratory mixer, 60 rpm, with initial temperature of 60°C
0 seconds: add polymer, 1A
60 seconds: add filler, 1B
240 seconds: perform a sweep
300 seconds: drop batch

Stage 2: Laboratory mill, 40°C
Band compound on mill and add curatives, 2A
Refine compound with six 3/4 cuts and six endwise passes

Table 4 - formulation for innerliner compound with bromobutyl rubber

Component	*Tag*	*phr*
Bromobutyl rubber	1A	100
Carbon black N660 Sterling V	1B	60
Sunpar 2280 (paraffinic oil)	1B	7 or 5
SI Group SP-1068	1B	4
Akrochem stearic acid TP	1B	1
Spider sulfur	2A	0.5
Vulkacit DM/C (MBTS)	2A	1.3
Kadox 911 (zinc oxide)	2A	3

Mixing procedure:
Stage 1: Internal laboratory mixer, 60 rpm, with initial temperature of 60°C
0 seconds: add polymer, 1A
60 seconds: add filler and additives, 1B
240 seconds: perform a sweep
300 seconds: drop batch

Stage 2: Laboratory mill, 40°C
Band compound on mill and add curatives, 2A
Refine compound with six 3/4 cuts and six endwise passes

For compound testing, compound Mooney viscosity measurements were conducted according to ASTM D1646 at 100°C. The tc90 and delta torque values were determined according to ASTM D-5289 with the use of a moving die rheometer at 170°C for mineral filled compounds (160°C for carbon black filled compounds). Rubber process analyzer (RPA) analysis was performed to determine the Payne effect at 60°C at a frequency of 0.5 Hz and strain sweep between 0.06% to 300%. RPA analysis was also performed for a compound frequency sweep from 0.1 Hz to 40 Hz at 100°C. Green strength specimens were molded at 100°C, followed by measurement according to ASTM D6746. Samples for stress strain, tear and permeability testing were cured at 170°C for mineral filled compounds (160°C for carbon black filled compounds) for tc90 + 5 minutes and for tc90 + 10 minutes for compression set testing. Stress strain analysis was completed following ASTM D412, with hardness tested according to ASTM D2240. Die B and C tear testing were completed following ASTM D 624. Permeability measurements were taken with O_2 at 40°C based on ASTM D 1434 with convergence by cycle (two cycles). Compression set values were obtained following the ASTM D395 procedure.

Further details on compounding and key properties of butyl rubber can be found in the Arlanxeo Rubber Book, H. Dikland et al. (ref. 9).

Compound formulations
Data for the pharmaceutical closure compound and the low oil innerliner compound are presented in tables 3 and 4.

Results and discussion
Raw polymer properties
The PF-BIIR samples were analyzed to determine rheological properties. To show the relative level of branching observed in the polymers, a van Gurp-Palmen plot was generated to demonstrate the differences between commercial Arlanxeo bromobutyl rubber and PF-BIIR. The plot, shown in figure 3, demonstrates that at low G* (x-axis), samples with a lower δ (y-axis) indicate a more branched material (ref. 10). Additional information concerning the number of short chains can be gained from figure 3, by comparison of the δ at G* = 300,000 Pa. Here, a higher δ denotes more short polymer chains; whereas a lower δ denotes fewer short chains. The PF-BIIR samples generally follow a trend where samples with more polyfarnesene show more branching (lower δ at low G*); and those that are lower polyfarnesene loading are less branched (higher δ at low G*).

Pharmaceutical stopper compounding study for demonstration
A series of polyfarnesene bromobutyl rubber samples (PF-BIIR 1-3) was compounded using a general pharmaceutical stopper formulation, alongside Arlanxeo commercial X_BUTYL BB 2030 (1.8 ± 0.2 wt% Br, ML [1+8] 125°C: 32 ± 4 MU) and

Figure 3 - van Gurp-Palmen plots of Arlanxeo bromobutyl rubbers (X_BUTYL BB 2030, X_BUTYL BB X2) and laboratory produced polyfarnesene bromobutyl rubbers (PF-BIIR 1-6)

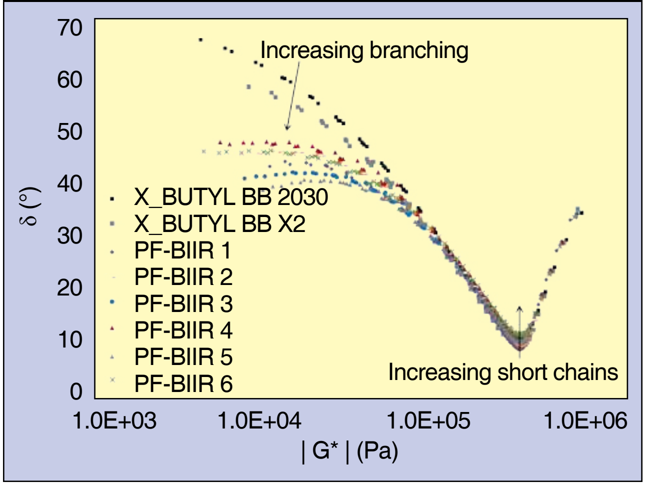
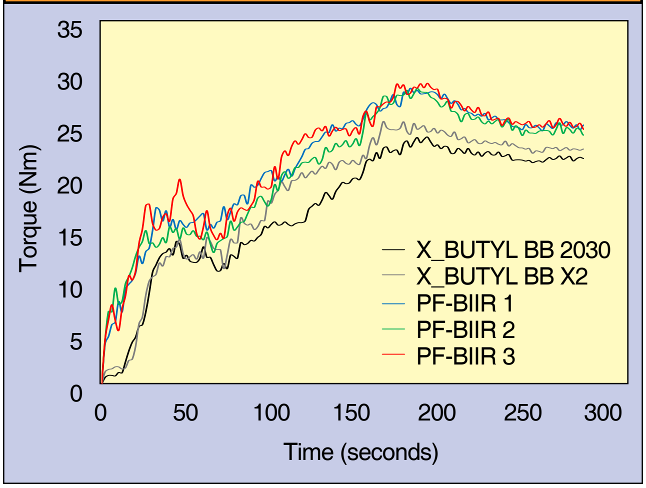


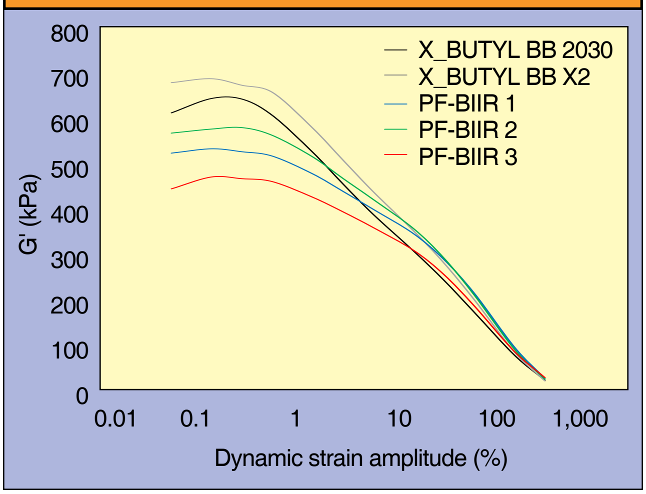
Figure 4 - mixer torque (Nm) over time (seconds) for a bromobutyl pharmaceutical closure compound



X_BUTYL BB X2 (1.8 ± 0.2 wt% Br, ML [1+8] 125°C: 46 ± 4 MU) as controls. The compound data are summarized in table 5. X_BUTYL is a registered trademark of Arlanxeo.

As shown in figure 4, the PF-BIIR compounds demonstrated increased mixer torque in comparison to the linear Arlanxeo control samples. The increased torque can be attributed to the branching in the PF-BIIR samples, and is independent of the Mooney viscosity of the polymers. The Payne effect of the compounds, tested using the RPA (figure 5), shows improved filler dispersion for the PF-BIIR compound examples in comparison to the Arlanxeo BIIR controls. With the increased mixer torque and improved filler dispersion observed in the PF-BIIR compounds, equivalent filler dispersion could potentially be achieved with less mixing time (and possibly less energy input) in comparison to linear bromobutyl rubbers.

Figure 5 - Payne effect (or strain sweep) plot measured at 60°C of a bromobutyl pharmaceutical closure compound showing improved filler dispersion with lower G' at 0.06% dynamic amplitude



The processability of bromobutyl rubber is improved when branching is introduced. As shown in figure 6 with the increase in tan delta, the PF-BIIR samples show better processability in comparison to their respective Arlanxeo controls. PF-BIIR 1 and 2 have Mooney viscosities higher than that of X_BUTYL BB X2 (56 MU and 51 MU versus 47 MU); but due to the low molecular weight linear fraction of the PF-BIIR samples, the processability is improved. This effect was also observed in the comparison of PF-BIIR 3 (41 MU) and Arlanxeo X_BUTYL BB 2030 (34 MU).

The impact of the branched fraction of PF-BIIR on the green strength of its compounds is demonstrated in table 5, which shows that the peak green strength of the PF-BIIR, independent of the raw polymer Mooney viscosity, is higher than that of the Arlanxeo controls. As an example, PF-BIIR 3, which has the lowest Mooney viscosity (41 MU), but highest polyfarnesene content of the three PF-BIIR samples in this study, has the highest peak green strength of all the samples in the compounding study, including the X_BUTYL BB X2 control with a Mooney viscosity of 47 MU.

The cured properties of the bromobutyl rubber pharmaceutical closure compounds also show benefits from using PF-BIIR. An improvement in compression set is observed, especially when comparing rubber samples of similar Mooney viscosity (table 5). PF-BIIR 1 and PF-BIIR 2 (56 MU and 51 MU, respectively) have a 16% relative improvement in compression set in comparison to X_BUTYL BB X2 (47 MU). In addition, the PF-BIIR compounds also provided a higher modulus at 300% and increased tear strength compared to the linear control BIIR compounds. The permeability of the PF-BIIR samples is unchanged, despite the introduction of a new comonomer for branching, likely due to the very low loading that is required to impart significant changes to the polymer architecture and resulting physical properties.

Innerliner compounding study

PF-BIIR samples were also compounded in an innerliner formulation for tubeless tires. As improvements in processability were

Figure 6 - tan delta versus frequency (Hz) plot of a bromobutyl pharmaceutical closure compound showing improved processability with increased tan delta

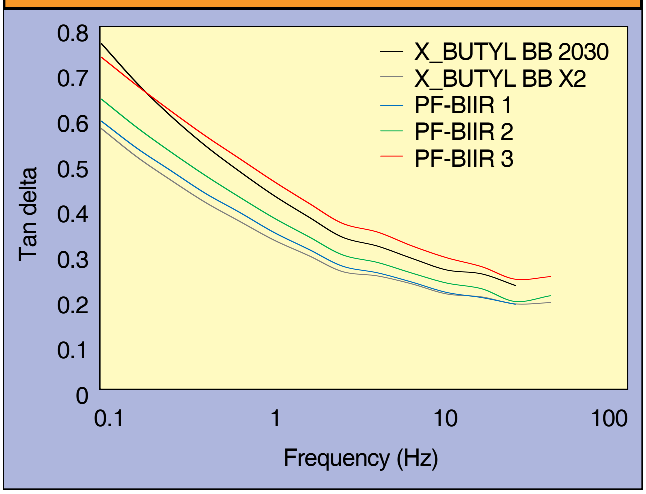


Table 5 - pharmaceutical closure compound properties with bromobutyl rubber

Property	*X_BUTYL BB 2030*	*X_BUTYL BB X2*	*PF-BIIR 1*	*PF-BIIR 2*	*PF-BIIR 3*
Peak mixer torque (Nm)	24.4	26.0	30.5	29.2	29.8
G' (kPa; dynamic amplitude = 0.06% at 0.5 Hz, 60°C)	617	682	530	573	452
Compound Mooney viscosity (MU; 1+4+4 at 100°C)	75	88	98	93	79
Area under Mooney curve (1+4+4 at 100°C)	852	1,902	2,564	2,167	1,676
Tan delta (25 Hz at 100°C)	0.25	0.21	0.21	0.22	0.27
Peak green stress (MPa)	0.25	0.32	0.33	0.31	0.36
M_H (dNm; 1° arc at 170°C)	17.8	18.4	18.7	18.4	16.6
M_L (dNm; 1° arc at 170°C)	2.8	4.0	4.1	3.6	2.8
M_H-M_L (dNm; 1° arc at 170°C)	15.0	14.4	14.6	14.8	13.8
ts2 (minutes; 1° arc at 170°C)	2.4	2.4	2.1	2.1	2.7
t90 (minutes; 1° arc at 170°C)	10.1	10.0	10.6	10.5	11.4
Hardness (points)	45	48	49	48	44
Ultimate tensile (MPa)	11.8	11.5	10.6	11.7	9.6
Modulus at 300 % (MPa)	2.6	3.1	3.7	3.8	3.0
Ultimate elongation (%)	976	859	757	787	815
Compression set (%, 22 hours at 70°C)	19	18	15	15	18
Die C tear strength (kN/m)	22.4	25.6	27.2	30.0	26.6
Die B tear strength (kN/m)	28.5	32.0	33.1	33.1	33.1
Permeability (cc mm/(m^2 day atm); O_2 at 40°C)	123	121	115	119	121

observed in the pharmaceutical closure formulation with branched bromobutyl rubber, a lower loading (2 phr lower) of processing oil was chosen for the PF-BIIR compounds to further demonstrate the utility of these novel butyl polymers. PF-BIIR samples were compared to Arlanxeo control samples compounded with both the normal (7 phr) and reduced (5 phr) oil loading. The data from these compounds are shown in table 6.

Despite having less process oil in the formulation, the PF-BIIR samples have similar compound Mooney viscosities compared to their respective Arlanxeo control materials at full oil content. They also demonstrate similar filler dispersion to their full oil counterparts (figure 7); whereas X_BUTYL BB 2030 and X_BUTYL BB X2 have increased compound Mooney viscosity and worsened filler dispersion when the oil is decreased. The low molecular weight fraction of PF-BIIR is believed to act similarly to a processing aid, plasticizing the compound during mixing; therefore, less oil was used in the formulation. The plasticizing effect was illustrated for the PF-BIIR compounds, which show a substantial improvement in processability compared to the Arlanxeo controls of similar Mooney viscosity, as shown in figure 8. It should be noted that PF-BIIR 5, a sample with a Mooney viscosity of 50 MU and only 5 phr oil, has 'equivalent processability' to the Arlanxeo X_BUTYL BB 2030 control at 34 MU with 7 phr oil in the frequency range tested. At the same time, the branched fraction of the PF-BIIR polymers is increasing the green strength and flow stability properties of the rubber compounds. Improved flow stability (increased green strength) can be a benefit when forming larger sheets, and for shape retention during the tire building and curing processes. The permeability of the PF-BIIR compounds with less oil is improved, since the oil serves to increase the mobility of the butyl chains in the matrix, allowing for gas molecules to pass through more easily. A lower permeation coefficient will result in greater air retention for the car tire when less oil is used. Proper tire inflation pressures can cause a significant improvement in fuel economy, safety and lifetime of the tire. As

Table 6 - innerliner compound properties with bromobutyl rubber using varied process oil loading

Property	*X_BUTYL BB 2030 7 phr oil*	*X_BUTYL BB 2030 5 phr oil*	*X_BUTYL BB X2 7 phr oil*	*X_BUTYL BB X2 5 phr oil*	*PF-BIIR 4 5 phr oil*	*PF-BIIR 5 5 phr oil*	*PF-BIIR 6 5 phr oil*
Peak mixer torque (Nm)	28.4	29.6	30.5	30.8	34.1	35.5	36.2
G' (kPa) at dynamic amplitude = 0.06% at 60°C	854	997	827	886	893	831	858
Compound Mooney viscosity (MU, 100°C, 1+4+4)	63	68	70	75	64	73	64
Area under Mooney curve (100°C)	697	844	1,269	1,409	941	1,583	1,114
Tan delta (18 Hz at 100°C)	0.34	0.33	0.29	0.30	0.38	0.33	0.37
Peak green stress (MPa)	0.26	0.28	0.28	0.35	0.31	0.34	0.30
M_H (dNm) at 160°C	11.3	11.5	11.3	12.2	10.0	9.8	9.1
M_L (dNm) at 160°C	3.0	3.3	3.7	4.0	2.6	3.2	2.6
M_H-M_L (dNm) at 160°C	8.3	8.2	7.6	8.2	7.4	6.6	6.5
ts2 (minutes) at 160°C	2.8	2.8	2.5	2.3	2.1	1.9	2.1
t90 (minutes) at 160°C	8.1	8.0	7.2	7.3	12.4	13.3	14.2
Hardness (points)	55	57	55	57	59	56	58
Ultimate tensile (MPa)	11.5	11.2	10.9	10.2	10.2	10.7	9.8
Modulus at 300% (MPa)	4.8	4.9	4.9	6.0	5.0	5.0	4.6
Ultimate elongation (%)	681	663	609	499	647	677	691
Permeability (cc mm/(m^2 day atm); O_2 at 40°C)	183	167	182	170	165	166	164

Figure 7 - Payne effect (or strain sweep) plot measured at 60°C of a bromobutyl innerliner compound showing improved filler dispersion with lower G' at 0.06% dynamic amplitude

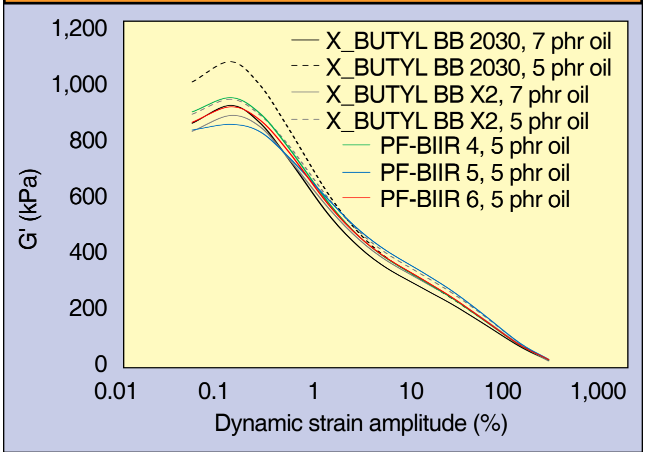
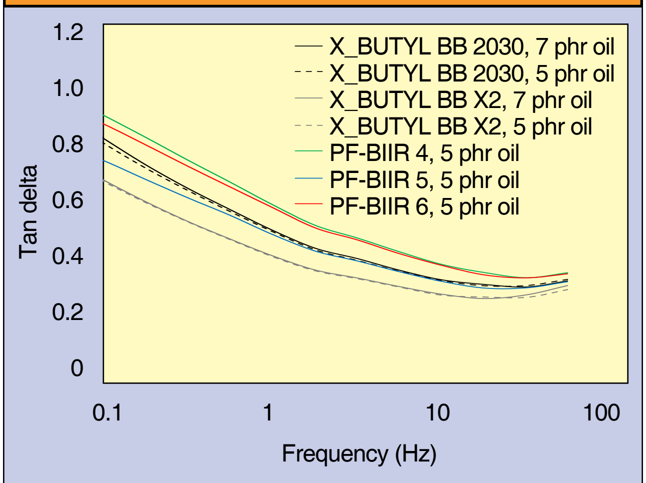


Figure 8 - tan delta versus frequency (Hz) plot of a bromobutyl pharmaceutical closure compound showing improved processability with increased tan delta

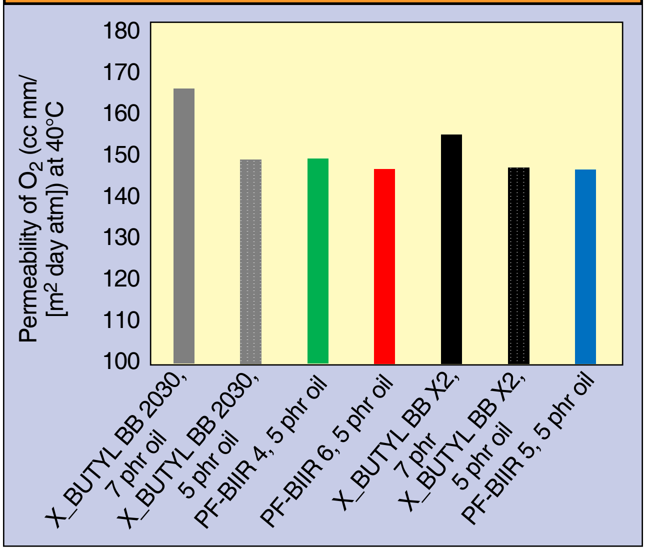


shown in figure 9, there is an approximate 10% improvement in the permeability of the innerliner compounds with 5 phr oil in comparison to the Arlanxeo X_BUTYL BB 2030 and X_BUTYL BB X2 controls with 7 phr oil; and with improved processing performance in the PF-BIIR compounds.

Summary and conclusions

Halobutyl rubber is ideal for use in pharmaceutical closure applications due to superior permeation resistance, low extractables and excellent sealing performance. Branched halobutyl rubber offers improvements for certain applications of halobutyl rubber; however, PF-BIIR in particular has shown significant improvements in the cured compound properties which are of use for pharmaceutical closure applications, as well as tire innerliners. The green compound improvements observed with

Figure 9 - permeability (cc mm/(m² day atm) of O_2 at 40°C) data for a bromobutyl innerliner compound



PF-BIIR could lead to reduced mixing times, less energy input during mixing, better compound strength during calendering, and better injection molding. The platform technology developed by Arlanxeo, based on polyfarnesene as a sustainably sourced, highly efficient and clean branching agent, has shown benefits in many compound properties, including better processability, better filler dispersion, higher green strength, lower permeation coefficients and lower compression set behavior.

Different compounding strategies may be employed which lead to other improvements in the permeation resistance and physical properties of branched butyl rubber compounds. Such benefits imparted by polyfarnesene branched butyl rubber could also find utility in other industries, including adhesives and sealants, where the branched structure can be tuned to provide improved cohesive strength and creep properties. The impact of different filler systems, additives and alternative cure systems is beyond the scope of this article, but has been the subject of additional internal studies by Arlanxeo.

References

1. R.H. Boyd and P.V. Krishana Pant, "Molecular packing and diffusion in polyisobutylene," Macromolecules, Volume 24, 6325 (1991).

2. P.V. Krishana Pant and R.H. Boyd, "Molecular dynamics simulation of diffusion of small penetrants in polymers," Macromolecules, Volume 26, 679 (1993).

3. H.-D. Brandt, W. Nentwig, N. Rooney, R.T. LaFlair, U.U. Wolf, J. Duffy, J.E. Puskas, G. Kaszas, M. Drewitt and S. Glander, "Synthesis of butyl rubber by cationic polymerization," in Ullmann's Encyclopedia of Industrial Chemistry, electronic release, 5, Wiley-VCH, Weinheim, Germany (2010).

4. M. Happ, J. Duffy, G.J., Wilson, S.D. Pask, H. Buding and A. Ostrowicki, "Halobutyl rubber," chapter 8 in Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH, Weinheim, Germany (2012).

5. K. Kulbaba, D. Adkinson, G. Davidson and S. Elliott, "Effects of steam sterilization and gamma irradiation on halogenated butyl rubber compounds," Rubber World, Volume 266, 26, June 2022.

6. https://farnesene.net/#, Amyris, retrieved February 28, 2023.

7. C. Iacob, T. Yoo and J. Runt, "Molecular dynamics of polyfarnesene," Macromolecules, Volume 51, 4917 (2018); S. Henning and T. Yoo, "Synthesis and characterization of farnesene based polymers," Rubber Chemistry and Technology, Volume 90, 308 (2017).

8. G.J.E. Davidson, A.H. Murray and J.L. Bourque, "Branched butyl rubber polymers," WO2023000096A1; J.L. Bourque and S.J. Elliott, "Branched butyl rubber compounds," WO2023000099A1.

9. H. Dikland, T. Früh, T. Gross, C. Hassmann, N. Sary, R. Schmidt and M. van Duin, Handbook of Synthetic Rubber, Arlanxeo Performance Elastomers, chapter on Butyl Rubber: X_Butyl (XIIR), (2020).

10. S. Trinkle and C. Fredrich, "Van Gurp-Palmen plot: A way to characterize polydispersity of linear polymers," Rheologica Acta, Volume 40, 322, internal Arlanxeo Technical Reports (2001).

Rubber Division
American Chemical Society

rubber.org

NEVER STOP LEARNING!

CONVENIENCE: Most all our learning opportunities are virtual only with some in-person courses at our partner's locations.

CEUs: We have partnered with The University of Akron to offer CEUs for many of the courses we offer, as well as for our Basic, Intermediate and Advanced Rubber Technology Self-paced Learning opportunities.

TRAINING PASS: You can purchase a training pass to attend all our virtual courses and webinars for ONE YEAR for ONE PRICE. Individual passes, as well as company level passes with tiers of up to 50 trainees are available.

Visit rubber.org/training for details about these courses, including full descriptions and pricing.

UPCOMING LEARNING OPPORTUNITIES

- **June 22, 2023**
  Webinar: *How to Extend Lifetime of Elastomers & Rubber Products*
- **June 23, 2023**
  Formulating Fridays Webinar: *Silica-Silane*
- **June 30, 2023**
  Formulating Fridays Webinar: *Bulk Fillers*
- **July 7, 2023**
  Formulating Fridays Webinar: *Process Oils*
- **July 12, 2023**
  Course: *Essentials of Silicone Rubber*
- **July 14, 2023**
  Formulating Fridays Webinar: *Specialty Plasticizers*
- **July 19, 2023**
  FREE Webinar: *Global Economic Challenges & Rubber Division, ACS Update*
- **July 21, 2023**
  Formulating Fridays Webinar: *Sulfur & Accelerators*
- **July 21, 2023**
  Communications Workshop & Luncheon (In-person Only)
- **July 26, 2023**
  Course: *Introduction to Compounding, Mixing & Testing (In-person Only)*
- **July 27, 2023**
  Course: *Intermediate Rubber Compounding (In-person Only)*
- **July 28, 2023**
  Formulating Fridays Webinar: *Peroxides*
- **August 3, 2023**
  Course: *Sponge Rubber 101*
- **August 4, 2023**
  Formulating Fridays Webinar: *Anti-degradants*
- **August 9, 2023**
  Course: *Setting Up a Rubber Molding Process*
- **August 11, 2023**
  Formulating Fridays Webinar: *Process Aids*
- **August 18, 2023**
  Formulating Fridays Webinar: *Formulating Wrap Up*
- **August 21, 2023**
  Course: *Elastomers for Selective Gas Separation, including Carbon Capture*
- **August 24, 2023**
  Webinar: *Maintaining High Performance in Challenging Testing Laboratories*

All webinars are FREE for Rubber Division, ACS Members and all Rubber Division, ACS courses are FREE for undergraduate Student Members (discount for masters & graduate Student Members)!

Substitutions for specialty bases in medical silicones

by Sarah Lewis, Taylor Smith, Amelia Berry and Dominic Testo, Specialty Silicone Products

The silicone shortage highlights the risk of overreliance upon a single supplier of specialty bases, especially when comparable off-the-shelf offsets do not exist. The techniques and approaches to modifying the properties of silicones are well known, but it is important to take a systematic approach regarding potential substitutions. This article describes how Specialty Silicone Products (SSP) identifies formulations with a specific combination of properties, and uses various fillers, initiators, cure mechanisms and other additives, such as functional polymers. Applications include USP Class VI medical silicones.

Initial trials

Initial trials for current work began with the addition of varying amounts of fillers, initiators and other additives. Plots showing the various properties as a function of loading are shown in figure 1 (Minusil, 5U quartz filler) and figure 2 (di(2,4-dichlorobenzoyl) peroxide or DCLBP initiator). The observed trends were neither new nor unexpected; however, the results helped established loadings that were used to target compound durometers of 50A.

Experimental details

Samples were formulated at the laboratory scale on either an 8” two-roll mill, or the combination of an 0.25 gallon laboratory scale dough mixer and an 8” two-roll mill. For highly filled formulations, the filler was combined with the silicone base in the dough mixer before catalysts and any additives were added to the two-roll mill. ASTM 6” by 6” test slabs were press cured at 177°C for 10 minutes and post-baked for 4 hours at 200°C, except for specific samples that used alternate peroxides requiring different press

Figure 1 - properties as a function of filler content using Minusil, 5U

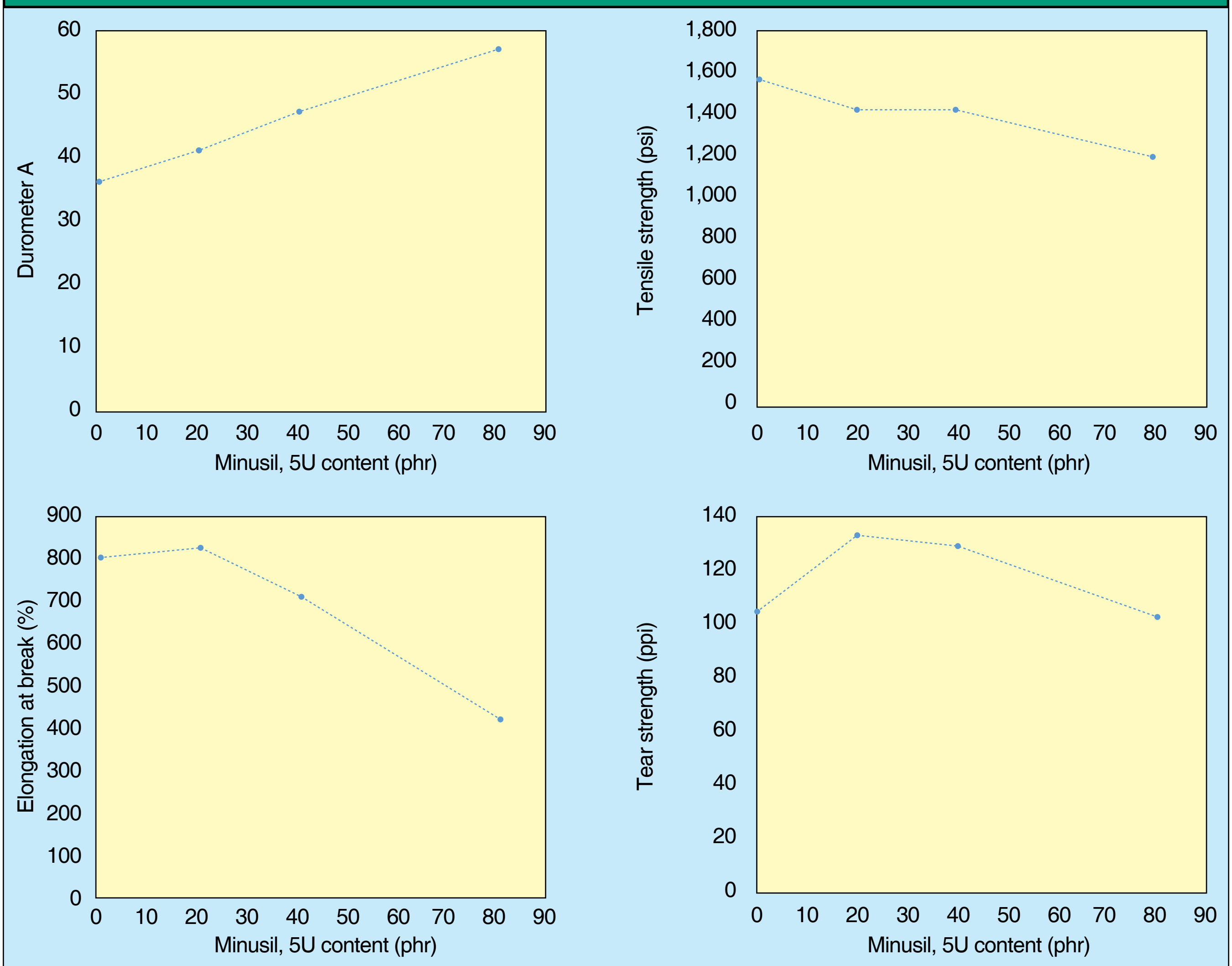
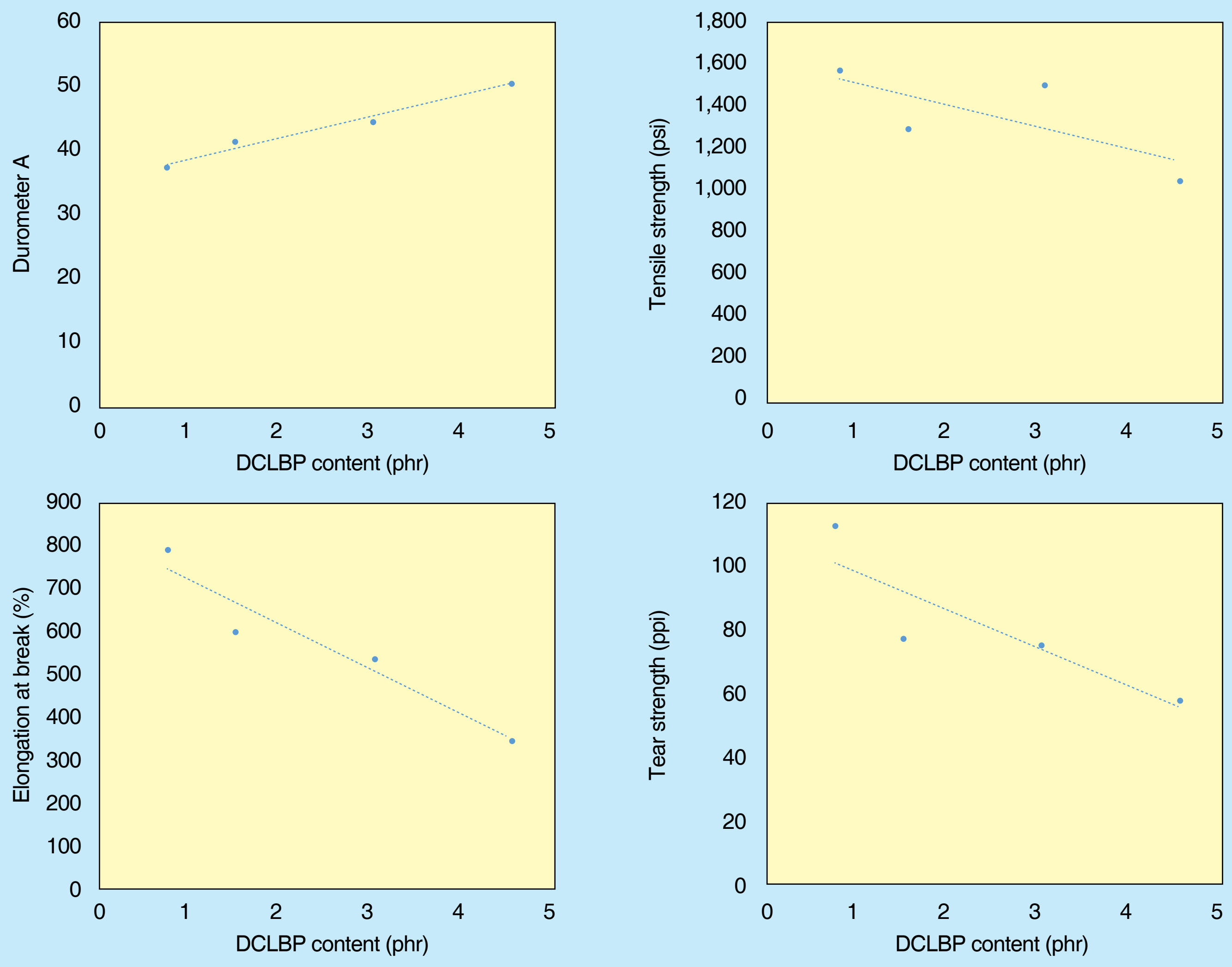


Figure 2 - properties as a function of initiator content using DCLBP



cure temperatures. Tested properties were selected from ASTM D2000 and other requirements. The tested properties were:

- Durometer A (ASTM D2240)
- Tensile strength, elongation at break and tensile stress at 50%, 100% and 200% elongation (ASTM D412)
- Tear strength (ASTM D624)
- Specific gravity (ASTM D792)
- Shrinkage after press cure and after post-bake; the shrinkage samples can be used to cut other samples for testing (internal test method SSP-55)
- Compression set as ply 22 hours at 175°C and as ply 70 hours at 150°C (ASTM D395)
- Heat aged 70 hours at 225°C to measure durometer change, tensile change, elongation change and weight loss (ASTM D573)
- Low temperature brittleness at -55°C, -60°C and -65°C (ASTM D2137)

The curing characteristics of all samples were measured using an Alpha Technologies ODR 1000 at 3° angular displacement and 350°F. The sample made with di(2,4-dichloro benzoyl)peroxide was tested at 240°F.

Sample details

All samples used a commercially available 40 durometer general purpose base, with the exception of the control sample, which also used the 60 durometer version of the base from the same series and same manufacturer to provide a 50 durometer baseline. Except where noted, all samples were cured using 1.7 phr 34% 2,5-dimethyl-2,5-di(t-butylperoxy)hexane (DBPH). Samples were press cured for 10 minutes at 177°C, and then post-cured for 4 hours at 200°C. Samples that were cured using di(2,4-dichloro benzoyl)peroxide used a 50 wt% paste and cure conditions of 10 minutes at

Table 1 - sample identifications and formulations used for the current work

Sample ID	*Formulation*
TS-03-016	Control
TS-03-011	53 phr Minusil, 5U
TS-03-014	35 phr Aktisil Q
AB-12-140	15 phr Celite 350
AB-12-144	3.5 phr HS-5 fumed silica
TS-03-019	Addition cured sample
AB-12-136	4.5 phr DCLBP paste
TS-03-022	5 phr high vinyl gum
AB-12-148	10 phr low vinyl gum

Table 2 - basic physical properties of the various samples

Sample ID	Tensile strength (psi)	Elongation at break (%)	Tensile stress at 100% elongation (psi)	Tear strength (ppi)
TS-03-016	1662	708	140	130
TS-03-011	1094	632	116	115
TS-03-014	1293	732	144	98
AB-12-140	1294	533	258	120
AB-12-144	1785	762	130	135
TS-03-019	1597	798	133	190
AB-12-136	1087	367	201	62
TS-03-022	1309	624	245	230
AB-12-148	1032	379	222	127

116°C. Addition cured samples used 1 phr of a commercially available HCR platinum catalyst blend and 0.4 phr of a low viscosity methyl hydrogen fluid.

Sample identifications and formulations are provided in table 1. For all of the formulations, the measured durometer A was 50 ± 2.

Results and discussion

Basic physical properties

Table 2 shows the samples' basic physical properties. For each property, the minimum and maximum observed values are shaded in gray. In the previous screening work that focused on how properties changed as the amount of a specific additive was changed, the properties measured were highly interdependent, as would be expected where the mechanism of the impact on the measured properties is the same because the same additive is always used. When the amount of quartz filler was increased, the durometer rose, and the tensile strength and elongation at break decreased (figure 1).

In those screening experiments with a single additive, each of the properties could not be varied independently. With the range of additives used in the current work, the trade-offs between the various properties were not as pronounced. Figure 3 plots the various physical properties from table 2 to show the breadth of the observed mechanical properties. The measured tensile strength varies about 700 psi, the elongation at break is about 430%, the tensile stress at 100% elongation varies about 130 psi, and the tear strength varies about 170 ppi. These broad ranges were obtained while maintaining a consistent durometer. The red dots represent the baseline material without modification.

The relative independence of the various physical properties is illustrated in some selected example regression plots in figure 4. This is of prime importance when formulating silicones to externally controlled specifications, or to legacy specifications that exist as a function of selecting a very specific specialty base when the part specifications were initially set.

Processing considerations

A key constraint of replacing existing materials in existing processes that is overlooked includes processing considerations such as scorch, cure time and shrinkage. A good materials solution will cause as little disruption as possible to existing tooling and processing conditions. Table 3 shows the linear shrinkage values and select ODR data for the various samples. With the exception of the alternate curing mechanisms (TS-03-019 and AB-12-136), there is no great impact on the scorch time, with the exception of the Aktisil Q filler. The overall cure time is extended by the addition of fumed silica (AB-12-144) and the two vinyl gums (TS-03-022 and AB-12-148).

For the gum containing samples, the increase in T90 is about 50%, suggesting that special attention will need to be paid to existing cycle times if such formulations are to be offered as replacements. However, the addition of gums has a relatively small impact on the shrinkage of cured parts; whereas the highly filled formulations, as would be expected, show significantly less shrinkage when compared to the control. This has implications for existing tooling, and illustrates why consideration of other properties outside of specified basic physical properties is key to formulating appropriate offsets.

Figure 3 - plot showing the range of measured physical properties from table 2

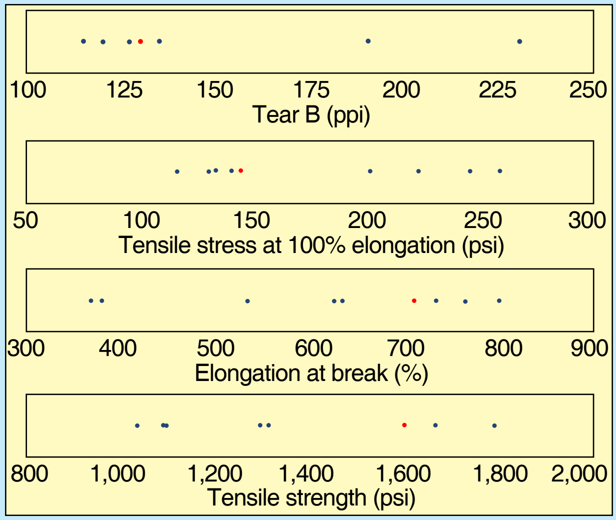


Table 3 - linear shrinkage and select ODR data for the various samples

Sample ID	Linear shrinkage on cure (%)	Linear shrinkage on post-cure (%)	TS2 (minutes)	T90 (minutes)
TS-03-016	3.8	4.0	0.94	2.33
TS-03-011	2.8	3.3	0.79	2.27
TS-03-014	3.2	3.3	0.55	2.02
AB-12-140	3.0	3.4	0.95	2.58
AB-12-144	3.5	3.9	0.93	2.85
TS-03-022	4.0	4.5	0.97	3.33
AB-12-148	3.7	4.3	1.07	3.51
TS-03-019	3.0	3.3	0.55	1.98
AB-12-136	1.9	3.0	0.41	1.95

Figure 4 - example linear regression plots illustrating the lack of dependence of some physical properties

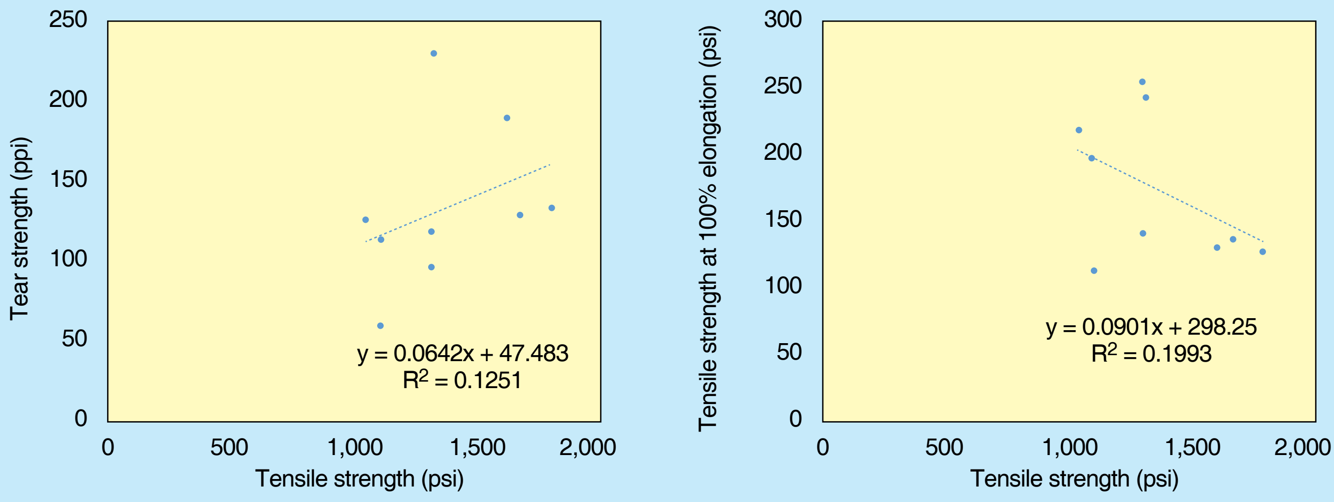


Table 4 - heat aged and compression set data for the various samples

Sample ID	Heat aged 70 hours at 225°C				Compression set (%)	
	Durometer change (points)	Tensile change (%)	Elongation change (%)	Weight loss (%)	22 hours at 175°C	70 hours at 150°C
TS-03-016	-5	-46	-41	5.4	32.3	23.2
TS-03-011	+4	-23	-32	0.9	27.4	28.0
TS-03-014	+3	-30	-17	1.1	22.1	12.7
AB-12-140	+2	-29	+24	1.4	21.2	16.9
AB-12-144	+4	-42	-24	1.0	25.7	30.6
TS-03-022	+24	-82	-97	2.5	28.3	28.1
AB-12-148	+21	-64.8	-87.9	1.9	17.2	20.8
TS-03-019	+7	-49	-58	1.4	33.1	34.5
AB-12-136	+10	-31.8	-56.7	1.2	69.3	65.0

The constraints of existing tooling and shrinkage can often be overlooked or perceived as less important than specifications around physical properties. However, this can lead to difficulties in the final testing and acceptance of custom compounds.

Application/environment properties

Specifications may include properties that are important to the performance of the part in the final application environment. Examples include compression set or heat aged properties. Table 4 shows heat aged property changes and compression set under two different conditions for the various tested formulations. Overall, the additions of Celite 350, Aktisil Q and the low vinyl gum resulted in the best compression set properties. The filled formulations (Minusil, 5U, Celite 350, Aktisil Q and fumed silica) had the best overall heat aged properties.

While the low vinyl gum had low compression set at both test temperatures, the heat aged properties were very poor. This difference in high temperature properties shows the importance of considering the impact of additives on the whole range of desired properties; and especially when some properties are not explicitly called out in specifications, but are still of vital importance to a product's end use. For example, an existing specialty base may have a low compression set, and this property is essential to the proper functioning of the final part; however, if the compression set is not defined as part of the specification, a custom compound could meet all of the specified requirements, but still be unsuitable for the final application.

Alternate curing mechanisms

Using a DCLBP type catalyst at very high loading results in a final material with poor physical properties. This is expected because of the high crosslink density that results from the chains' ability to become crosslinked at any point along their length, rather than only where there are available vinyl groups. The reduced physical properties may preclude the use of this formulation in many applications; however, there may be niche applications where the reduced shrinkage on curing makes the formulation attractive.

Controlling the network structure with functional gums

The primary interest in the addition of the vinyl bearing gums was to understand if the introduction of additional vinyl groups on flexible chains could impact the stiffness of the final rubber, independent of the durometer. Previous work with traditional fillers and oligomeric vinyl species resulted in formulations with higher tensile stress at 100% elongation, but also much higher durometers than the specifications called for. In the current work, it can be seen that the tensile stress at 100% elongation can be controlled with vinyl bearing gums.

An immediate application for this was in the replacement of a specialty base that had been experiencing significant supply issues, even after many other bases had seen increased availability. For the final application, the key requirements were

Table 5 - properties with and without the addition of a low vinyl gum to a platinum cured system for a customer application

Property	*Typical*	*SSP2390-55D*	*SSP2390-55D + 5 phr gum*	*Specification*
Durometer A	52	52	56	50-60
Tensile stress at 100% elongation (psi)	195	143	205	N/A
TS1 (minutes)	1.15	0.68	1.03	0.8

Table 6 - ODR data collected at 215°F for various formulations developed to meet the required processing conditions

Sample ID	*Notes*	*TS2 (minutes)*	*T90 (minutes)*
TR-02-122A	Standard catalyst	No cure	No cure
TR-02-122B	Commercial low temperature catalyst	0.91	5.66
SL-01-122	SSP low temperature catalyst	0.71	8.50
AB-04-006	Custom catalyst	2.65	6.87

durometer (the specification is 50-60), tensile stress at 100% elongation (needs to match the existing material as closely as possible), TS1 time at 320°F (0.8 minutes, and preferably as close to the current material as possible in order to ensure adequate fill of the complex mold), and that the material be platinum cured.

The low vinyl gum was added to SSP's existing standard SSP2390-55D formulation (USP Class VI platinum cured one-part compound), resulting in the desired increase in the tensile stress at 100% elongation. The combination of the gum and a slight modification to the platinum catalyst also brought the TS1 into the appropriate range (table 5).

Conclusions on controlling mechanical properties

Understanding the breadth of accessible properties with various modifications to general purpose bases permits lower costs, more stable supply chains and the dual sourcing of bases to protect customers from supply issues that are associated with single sources. Some specifications require specialty bases that are among the most challenging to source during the recent shortages. The current work enables the displacement of specialty bases and their substitution with more flexible formulations. For example, some applications require high tensile strength and high tear strength. Both can be met through the addition of a high vinyl gum to a general purpose base, rather than sourcing a specialty base.

Case studies in custom compounds

80 durometer USP Class VI compound

In this application, the customer required an 80 durometer USP Class VI material that is overmolded onto a plastic insert. Because of part constraints and processing conditions, the customer specified a TS2 time of 2.5 to 3.5 minutes, and a T90 time of 5 to 7 minutes. SSP2390-80D is SSP's existing platinum cured USP Class VI 80 durometer material; however, this material is designed for much higher cure temperatures than those required by this application. Figure 5 shows an example ODR curve for SSP2390-80D collected at 350°F. The TS2 for this specific sample was 0.68 minutes, and the T90 was 3.40 minutes.

Switching to a commercially available low temperature platinum catalyst resulted in an acceptable T90, but a TS2 that was too fast. The internal SSP low temperature catalyst had a TS2 that was too fast and a T90 that was too long. Further work was then performed with custom mixed platinum catalysts made internally. A series of custom catalysts was made with varying platinum and inhibitor (diallyl maleate), and regression analysis was applied to the values of TS2 and T90 as a function

Figure 5 - example ODR curve for SSP2390-80D at 350°F

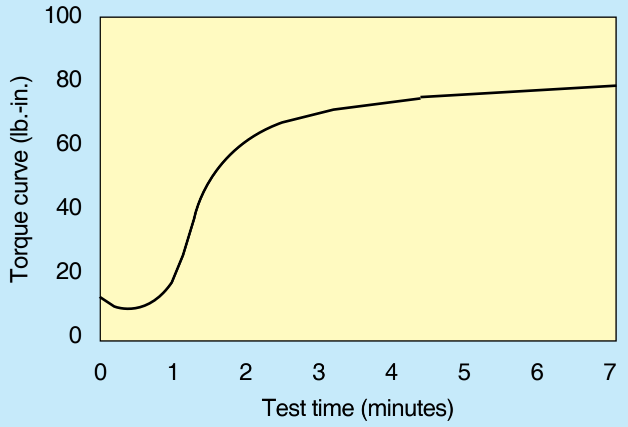
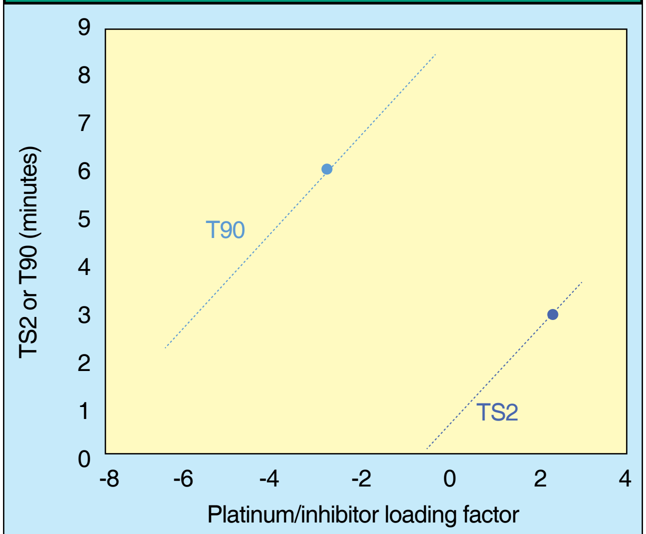


Figure 6 - fitted data for TS2 and T90 based on platinum and inhibitor loadings



of platinum and inhibitor loading. Applying the model to calculate the required platinum and inhibitor loadings revealed that 32 ppm of platinum and 0.72 wt% diallyl maleate would be required to attain the required cure conditions (figure 6).

While these values would theoretically provide the appropriate cure, the excessive addition of catalyst and inhibitor results in higher costs for the customer. The experiments were repeated with an alternate inhibitor (1-ethynyl-1-cyclohexanol), and the results of the final formulation that required approximately an order of magnitude lower addition of catalyst and inhibitor are shown as sample AB-04-006 in table 6. The final formulation was supplied to the customer as a two-part compound specifically designed for their manufacturing process and made with USP Class VI compliant bases.

Conclusions

Silicone compounders can mitigate the risks caused by overreliance on specialty bases from a single supplier. By understanding the scope of accessible properties and making appropriate modifications to general purpose bases, compounders can protect customers from shortages. Although it can be challenging to find flexible formulations for some specialty bases, the benefits of dual sourcing include not just more stable supply chains, but also include lower costs.

Liquid silicone rubber conference planned

LSR 2023, organized by Executive Conference Management, will be held September 11-14 at the Sonesta Charlotte Executive Park in Charlotte, NC. LSR 2023 unites professionals from various industries and disciplines to discuss technological and scientific developments in liquid silicone rubber and related materials. Attendees will explore new commercial uses for LSR in various markets, including medical, automotive, electronics, consumer products, and more.

LSR 2023 is said to be a unique opportunity to learn about new silicone chemistry, novel processing and manufacturing techniques, emerging technologies, market dynamics and new business directions of LSR; meet key decision-makers and industry experts representing LSR suppliers, processing equipment manufacturers, molders, fabricators and end-users; showcase company strengths, technologies and products; network and establish new business contacts and explore future opportunities; and display company products, technology and services at the exhibit.

Liquid silicone rubber is said to be a unique material that offers a wide range of benefits and uses. LSR is a synthetic elastomer made from silicone, which is a versatile material that can be found in many products, including medical devices, automotive parts and electronics, according to organizers.

One of the key benefits of LSR is said to be its excellent resistance to heat, which makes it an ideal material for high temperature applications. LSR can withstand temperatures up to 200°C (392°F) without losing its properties, making it suitable for use in demanding environments.

Another advantage of LSR is said to be its flexibility and durability. LSR is highly resistant to tears, abrasions and

Rubber Group News

The **Chicago Rubber Group** will hold its Chicago golf outing July 20 at the Village Links in Glen Ellyn, IL. The CRG will hold its Wisconsin golf outing September 13 at the Hawk's View Golf Club in Lake Geneva, WI. Further information on the CRG golf outings is available at www.chicagorubbergroup.org.

The **Detroit Rubber Group** will host Tech and Teardown on June 20 at A2Mac1 in Belleville, MI. During the event, participants will receive a facility tour of A2Mac1, review A2Mac1's extensive database, and have a hands-on look at each individual piece, rubber and all, of a recently released automobile. The cost to attend the technical program is $50 for DRG members, $65 for non-members and $25 for OEMs and students. Lunch is included in the cost of attendance. A one-year membership to the DRG is included in the non-member cost. All proceeds from the event go to the DRG Scholarship Program. The Detroit Rubber Group will hold a fishing outing July 13 at the Toledo Beach Marina in LaSalle, MI. Attendees are requested to arrive at the marina at 6:30 a.m. The boat is scheduled to depart at 7 a.m. and return at noon. The cost to attend is $195 per person and includes only the outing. Event sponsorships are available, with the suggested sponsorship amount being $100. All proceeds from the event go to the DRG Scholarship Program. The Detroit Rubber Group will hold a golf outing August 22 at the Bay Point Country Club in West Bloomfield Township, MI. Details are available at www.rubber.org/detroit-rubber-group-inc.

The **Mexico Rubber Group** will hold the course, "How To Improve Rubber Compounds, Part 2," instructed by Jose Gazano, on July 27 at the Rubber Chamber Auditorium in Mexico City, Mexico. The MRG will hold the course, "Rubber Compounds, Part 1: Chemical Reactions Mechanism," instructed by Soul Leonides, on September 7 at the Rubber Chamber Auditorium in Mexico City, Mexico. Further information is available at www.rubber.org/mexico-rubber-group.

The **MidAtlantic Rubber and Plastics Group** will hold a Lunch and Learn online event June 22 on PFOA, PFAS, PFCA, FKM, So Many Ps and Fs, What Does It All Mean for the Rubber Industry. The MARPG announced that its 2023 scholarship is officially open for applications. As a membership benefit, members can sponsor one scholarship applicant. To apply online, visit https://marpg.org/scholarships/. The deadline for scholarship applications is July 30. The MARPG will hold a Lunch and Learn online event July 27 on ChemTrend Product Technologies. The MARPG will hold a social event August 10 at Workhorse Brewing in King of Prussia, PA. The MARPG will hold a Lunch and Learn online event August 24 on Sustainability of Rubber and Plastics. Details are available at www.marpg.org.

The **New England Rubber & Plastics Group** will hold its annual golf outing August 1 at Blackstone National Golf in Sutton, MA. Further information is available at www.nerpg.org.

The **Ohio Rubber Group** will hold a golf outing August 28 at Silver Lake Country Club in Stow, OH. The ORG will hold a technical meeting on September 26 at the Hilton Garden Inn in Twinsburg, OH. Details are available at www.ohiorubbergroup.org.

The **Ontario Rubber Group** will hold a golf tournament September 13 at the Royal Ontario Golf Club in Milton, Ontario, Canada. Further information is available at www.rubber.org/ontario-rubber-group.

The **Twin Cities Rubber Group** will hold a golf event August 3 at Williger's Golf Club in Northfield, MN. The TCRG will hold a technical meeting September 21 at Cowboy Jack's in Bloomington, MN. Details are available at www.twincitiesrubbergroup.org.

punctures, making it an ideal material for use in applications that require high durability, such as seals and gaskets, according to organizers. LSR is also said to have excellent electrical insulation properties, and offers a range of aesthetic benefits.

The technical program for LSR 2023 will include the following presentations:

Tuesday, September 12: "Opening remarks," Amos Golovoy, conference chair; "Keynote Address: Silicones, trends and a focus on LSR," Bertrand Mollet, Elkem Silicones USA; "Medical molding: Navigating the risks and regulations before taking the plunge," Emily Logsdon, PTG; "Silicone rubber enables safe and reliable electric vehicles," Jake Steinbrechner, Dow Performance Silicones; "Advancements in low temperature curing liquid silicone rubber," Rob Rudolph, Momentive; "Maximizing output with a 96 + 96 cavity solution," Samuel Saldarriaga and Umberto Carchia, Simtec; "High volume silicone molding considerations," Rob Theriaque, Dymotek; "Successful processing of LSR," Kurt Mannigater, Elmet; "How part design, flow simulation, tool concept and quality intertwine," Tavo Kolling, EMDE; and "Continued navigation of the ever evolving regulatory landscape of low level impurities in liquid silicone rubber."

Wednesday, September 13: "Panel discussion: Dosing systems," Daniel Ehrlich, Kracht; Christian Hose, Wagner Group; Craig Lustek, R.D. Abbott; and Mike Flander, NeXus Elastomer Systems; "CTQ considerations in LSR overmolding," Ben Binyamin, Extreme Molding; "Mold concepts to suit the molders' needs versus the mold-maker needs," Joachim Kruder, Rico; "Scientific molding approach for cold deck valve gated micro molding," Roberto Hernandez, RHL Plastics; "Utilizing simulation software for gate and process optimization," Jake Michaelson, Sigmasoft; "How to reduce foreign material rejects in silicone medical device manufacturing," Bruno Giraldo, Life Sciences Foamtec International; "2K compact mold for LSR," Catia Ruivo and Flaminio Sales, Turtle Petals; "Micro precision parts made of LSR: From prototype phase to serial production," Wolfgang Roth, Wittmann Battenfeld, Ryan Hall and Scott Baird, Starlim; and "LSR molding and machine considerations from micro to big silicone molding," Thomas Gradl, Engel.

A tour of Elkem's facilities will be held on Thursday, September 14.

Further information on LSR 2023 is available at www.executive-conference.com.

Registration opens for 2023 IEC

Registration and housing are open for the 2023 International Elastomer Conference (IEC), to be held October 16-19 at the Huntington Convention Center of Cleveland. The IEC is organized by the Rubber Division of the American Chemical Society (ACS).

IEC is said to be the one place, one time of year, where attendees will find the best of the industry all under one roof. It is an event where connections are made, knowledge is shared, and new products, new technology and new ideas are introduced, business is conducted, developed and gained, fun is had, encouragement and empowerment happen, and the future is embraced, according to the Division.

The 2023 International Elastomer Conference will include the following components:

- Expo
- Technical meeting
- Educational symposium
- Women's event
- Student programs
- Networking events
- Special events (including the opening ceremony and keynote address, 5K walk/run, 25 year club luncheon, The Business of Rubber event, Career Catalysts presentations, Expo theater presentations and awards breakfast)

Those registering for the 2023 IEC before July 1 will save $200. Sponsorship and marketing opportunities are available. Visit www.rubber.org.

Support from companies in the rubber industry has provided the opportunity for Rubber Division to host many undergraduate students at the International Elastomer Conference over the past few years. This has proven to be a very successful program in making all aspects of the industry known to these students. It is a great opportunity for them to gain knowledge specific to the industry, make connections and show them how amazing the rubber industry is, and why they should be a part of it.

Rubber Division is seeking support to assist with covering several students' hotel, meal and transportation costs. The number of students the Division can host depends on the amount of support it receives. The cost to sponsor a student is $750.

Student sponsorships will take some coordination, so the sooner the Division receives support commitments, the better. Email Gretchen Cermak (gc@rubber.org) by August 15 if interested in providing support for students.

On July 19, Rubber Division will hold a free webinar: Global Economic Challenges and Rubber Division, ACS Update. Paul Hodges, a global expert on the chemicals industry with the World Economic Forum will focus on the twin challenges impacting the global economy: the move into recession, plus the need to develop new products or services for the net zero/new normal world. Details are available at www.rubber.org.

Calendar

Rubber Division American Chemical Society

Future Meetings/ Expos

2023
Cleveland October 16-19

2024
Pittsburgh September 9-12

www.rubber.org

University of Akron, Akron Polymer Training Services, Rubber Adhesion and Adhesives course, www.uakron.edu/apts/ - June 19-21.
Detroit Rubber Group, Tech and Teardown, A2Mac1, Belleville, MI, www.rubber.org/detroit-rubber-group-inc - June 20.
Smarter Shows, Adhesives & Bonding Expo 2023, Suburban Collection Showplace, Novi, MI, www.adhesivesandbondingexpo.com - June 20-22.
MidAtlantic Rubber and Plastics Group, Lunch and Learn: PFOA, PFAS, PFCA, FKM, So Many Ps and Fs, What Does It All Mean for the Rubber Industry online event, www.marpg.org - June 22.
Rubber Division, ACS, How to Extend Lifetime of Elastomers and Rubber Products webinar, www.rubber.org/training - June 22.
Rubber Division, ACS, Formulating Fridays Webinar: Silica-Silane, www.rubber.org/training - June 23.
Rubber Division, ACS, Formulating Fridays Webinar: Bulk Fillers, www.rubber.org/training - June 30.

July

Rubber Division, ACS, Formulating Fridays Webinar: Process Oils, www.rubber.org/training - July 7.
University of Akron, Akron Polymer Training Services, Rubber Technician Training course, www.uakron.edu/apts/ - July 10-12.
University of Akron, Akron Polymer Training Services, Rubber Extrusion Technology course, www.uakron.edu/apts/ - July 11.
Detroit Rubber Group, fishing outing, Toledo Beach Marina, LaSalle, MI, www.rubber.org/detroit-rubber-group-inc - July 13.
Rubber Division, ACS, Formulating Fridays Webinar: Specialty Plasticizers, www.rubber.org/training - July 14.
Rubber Division, ACS, Global Economic Challenges webinar and Rubber Division, ACS Update, www.rubber.org - July 19.
Chicago Rubber Group, Chicago golf outing, Village Links, Glen Ellyn, IL, www.chicagorubbergroup.org - July 20.
Rubber Division, ACS, Formulating Fridays Webinar: Sulfur and Accelerators, www.rubber.org/training - July 21.
Rubber Division, ACS, Communications Workshop and STEM Fair, Akron, OH, www.rubber.org - July 21-22.
Rubber Division, ACS, Introduction to Compounding, Mixing and Testing course, Elastomer Training Center, Akron, OH, www.rubber.org/training - July 26.
Mexico Rubber Group, How to Improve Rubber Compounds, Part II course, Rubber Chamber Auditorium, Mexico City, Mexico - www.rubber.org/mexico-rubber-group - July 27.
MidAtlantic Rubber and Plastics Group, Lunch and Learn: ChemTrend Product Technologies online event, www.marpg.org - July 27.
Rubber Division, ACS, Intermediate Rubber Compounding course, Akron Rubber Development Laboratory, Barberton, OH, www.rubber.org/training - July 27.
Rubber Division, ACS, Formulating Fridays Webinar: Peroxides, www.rubber.org/training - July 28.

August

New England Rubber and Plastics Group, golf outing, Blackstone National Golf, Sutton, MA, www.nerpg.org - August 1.
Rubber Division, ACS, Sponge Rubber 101 course, www.rubber.org/training - August 3.
Rubber Division, ACS, Formulating Fridays Webinar: Antidegradants, www.rubber.org/training - August 4.
Twin Cities Rubber Group, golf event, Willinger's Golf Club, Northfield, MN, www.twincitiesrubbergroup.org - August 3.
Hiplex, International Plastics Expo 2023, Hitex, Hyderabad, India, info@hiplex.co.in - August 4-7.
Rubber Division, ACS, Elastomers for Selective Gas Separation, Including Carbon Capture course, www.rubber.org/training - August 7.
University of Akron, Akron Polymer Training Services, Rubber Extrusion Technology course, www.uakron.edu/apts/ - August 8.
MidAtlantic Rubber and Plastics Group, social event, Workhorse Brewing, King of Prussia, PA, www.marpg.org - August 10.
Rubber Division, ACS, Formulating Fridays Webinar: Process Aids, www.rubber.org/training - August 11.
R.D. Abbott, Manufacturing with Silicone Rubber workshop, Barberton, OH, www.rdabbott.com - August 15-18.
Rubber Division, ACS, Formulating Fridays Webinar: Formulating Wrap Up, www.rubber.org/training - August 18.
Detroit Rubber Group, golf outing, Bay Point Country Club, West Bloomfield Township, MI, www.rubber.org/detroit-rubber-group-inc - August 22.
MidAtlantic Rubber and Plastics Group, Lunch and Learn: Sustainability of Rubber and Plastics online event, www.marpg.org - August 24.
Ohio Rubber Group, golf outing, Silver Lake Country Club, Stow, OH, www.ohiorubbergroup.org - August 28.

September

Mexico Rubber Group, Rubber Compounds, Part 1: Chemical Reactions Mechanism course, Rubber Chamber Auditorium, Mexico City, Mexico - www.rubber.org/mexico-rubber-group - September 7.
Executive Conference Management, LSR (Liquid Silicone Rubber) 2023, Sonesta Hotel, Charlotte, NC, www.executive-conference.com/conference/lsr-2023 - September 11-14.
Chicago Rubber Group, Wisconsin golf outing, Hawk's View Golf Club, Lake Geneva, WI, www.chicagorubbergroup.org - September 13.
Ontario Rubber Group, golf tournament, Royal Ontario Golf Club, Milton, Ontario, Canada, www.rubber.org/ontario-rubber-group - September 13.
Messe Düsseldorf North America, T-PLAS, International Trade Fair for the Plastics and Rubber Industries, Bangkok Trade & Exhibition Center (BITEC), Bangkok, Thailand, www.mdna.com - September 20-23.
Twin Cities Rubber Group, technical meeting, Cowboy Jack's, Bloomington, MN, www.twincitiesrubbergroup.org - September 21.
Center for the Polyurethanes Industry, American Chemistry Council, 65th Polyurethanes Technical Conference, Marriott Rivercenter, San Antonio, TX, https://www.americanchemistry.com/industry-groups/center-for-the-polyurethanes-industry-cpi/polyurethanes-technical-conference - September 25-27.
Ohio Rubber Group, technical meeting, Hilton Garden Inn, Twinsburg, OH, www.ohiorubbergroup.org - September 26.
Interplas Events Limited/Rapid News Group, Interplas Insights Conference 2023, National Exhibition Center (NEC), Birmingham, U.K., www.interplasuk.com - September 26-28.
Gerlach, Hot Air Vulcanization online seminar, www.gerlach-machinery.com - September 27-28.

Dual drive processing of silicone, rubber

New technologies, such as the company's Dual Drive concept, are said to help to handle the increasing requirements of the rubber and silicone industry. This system, based on the dual drive of the gear pump, is specially designed to process abrasive compounds. This innovation leads to a reduction in rotor and gear pump wear, an increase in the lifetime of the machines, and, therefore, to a long term increase in productivity, according to the company. In addition, maintenance costs are said to be reduced.

Economical and sustainable solutions for the fine mesh staining of rubber and silicone compounds provided by the company are said to be highly relevant in these times, as rubber processing presents enormous challenges, including the demand for a high level of product quality (which means the cleanest and purest rubber), as well as greater cost effectiveness. The Roll-Ex gear pump technology is said to ensure the particularly gentle extrusion of materials, and fast, easy compound changes.

The company's solutions cover various fields of application, and include the modular Roll-Ex system combined with the two-roll feeder (TRF), the screw feeder (SF) or the conical twin-screw feeder (DSE), which allows a suitable configuration for all applications. The DSE component is, for example, part of the polymer dosing system which is also based on Roll-Ex gear pump technology, allowing the feeding, plasticizing and exact dosing of polymers of higher viscosity in a continuous mixing process. (*UTH GmbH*)

www.uth-gmbh.com

Self-adhesive silicones

Silicone products for medical applications include self-adhesive liquid silicone rubber for hard/soft combinations with polycarbonate, and silicone adhesives for wound dressings and fixing aids. Such adhesive gels not only reduce the pain of dressing changes; high strength adhesive products are also suitable for fixing sensors and medical aids. Pleasant to the touch, skin compatible and with good mechanical properties, silicone elastomers have been used in medical technology for many years. This high tech material is very versatile: Silicones are often used in the production of seals, tubes, catheters and orthopedic aids. In hard/soft combinations, too, which are typically made of rigid thermoplastics, manufacturers often choose silicones for the soft components. Silicone elastomers are chemically and biologically inert, can be easily sterilized, and have high rebound resilience and good elasticity over a wide temperature range, according to the company. (*Wacker Chemie AG*)

www.wacker.com

Liquid silicone processing

With a cycle time of just 35 seconds, the IntElect LSR package is said to produce 12 gram smart caps with absolute precision, according to the manufacturer. Featuring a 570 mm wide tie bar, the generous tool space is said to be especially suitable for accommodating multi-cavity and complex tools. Achieving outstanding process stability, the actual weight of the parts is 0.01 grams accurate, according to the company. Vacuuming and venting provide optimal tool support. The synchronized sequence of the axes is said to be highly precise and perfectly parallel to each other. Additionally, the system is said to be extremely efficient, characterized by very low energy consumption. (*Sumitomo Demag*)

www.sumitomo-shi-demag.us

LSR dosing system

The SMARTmix TOP 7000 Pro is said to show what is possible today in the field of liquid silicone rubber dosing systems. With a footprint of only 1,150 x 790 mm, it has the smallest footprint of all the dosing systems suitable for 200 liter drums on the market, according to the company. The completely overhauled pump unit has been simplified, and the number of individual parts has been minimized. Its slimmer design is said to make the unit, in spite of a working pressure of up to 210 bar, considerably more compact. At the same time, it is said to result in a significantly smaller volume of LSR in the system. This, in turn, increases the process reliability even further and reduces the purging volume, according to the company. (*Elmet*)

www.elmet.com

Silicone rubbers for seals

LSR and HCR based NEVSil products are said to be suitable for a wide range of sealing applications in vehicles powered by alternative energies, including e-mobility, hybrid concepts and fuel cell technology. In addition to a generally low compression set, their wide range of grades includes high temperature resistance, as well as flame retardancy, self-lubrication, low viscosity, low stiffness, fast curing, increased crack and aging resistance, good colorability and thermal conductivity, according to the manufacturer. The flame retardant NEVSil FR LSR and HCR grades with durometer A hardnesses ranging from 35 to 70 meet the requirements according to UL94 V-0 for 1 mm thickness with balanced mechanical properties and very good heat resistance. Typical applications include connectors and heat aging resistant molded components such as gaskets, o-rings, etc. Two NEVSIL SLFR grades offer both UL94 V-0 flame retardant properties coupled with self-lubricating functionality. (*Momentive Performance Materials*)

www.momentive.com

Flame resistant silicone

Answering an ongoing market demand, this company has recently completed a series of flammability tests on several silicone materials. So far, solid silicone compound MR60-60-34BK and closed cell silicone sponge compound MR60-242-RD-02 have both passed the following tests: 14 CFR Part 25.855(d) Amd 25-142 Appendix F Part 1(6), a 45-degree angle burn test; 14 CFR Part 25.853(a) Amd 15-116 Appendix F Part I(a)(1)(i), a vertical flammability test; and 14 CFR Part 25.853(a) Amd 25-116 Appendix F Part I(a)(1)(iv), a horizontal flammability test. Title 14 of the Code of Federal Regulations Part 25 is an airworthiness standard by the Federal Aviation Administration featuring over 1,800 regulations covering transport aircraft, like jets and propeller planes, according to the company. As an approved manufacturer for several major aerospace and defense companies, the firm is said to be consistently striving to ensure that its materials meet the most rigorous and stringent requirements. The company is currently putting other material through the same rigorous testing and will post results as available. Inquiries for this material, as well as other aerospace and defense inquiries are welcome. (*Mechanical Rubber*)

www.mechanicalrubber.com

Silicone mixing system

A patented silicone mixing system has been developed to replace the traditional mixing process. It is based on the use of a single machine, the CTM (conical twin mixer), which can mix all of the ingredients (silicone base, fillers, masterbatch, peroxide, color), and can even extrude the final compound in order to produce preformed strips to be used in later extrusion or injection molding processes. The CTM consists of a heavy steel weldment that forms the base of the unit, the gear box and two conical screws placed in a conical chamber. The rotation of the two screws continuously moves the compound from the back to the front side of the cylinder in order to obtain the final mixed batch. The mixing process is maintained at low temperature, as the screws, cylinder and the front head are temperature controlled. The mixing cycle is automated by the use of a pre-programmed mixing recipe that can change the speed of the screws, as well as their rotation, and control the compound temperature during the process. (*Colmec USA*)

www.colmecusa.com

Fast cure LIMS products

Advanced technical demonstrations in collaboration with industry leading machinery and equipment partners featured the company's fast-cure KEG-2001-60 LIMS (liquid injection molding system) product's advanced handling and molding properties being run in the production of silicone Wayfarer style sunglasses. KEG2001-60 is a very fast cure type LIMS silicone supplied as two A/B translucent components which are mixed in a 1:1 ratio to ensure easy and accurate blending, according to the company. The 60 durometer A hardness product features a viscosity low enough to allow easy pumping through most injection molding systems. Notably, the product features high tear strength, rapid cure time at elevated temperature and long pot life at room temperature, according to the manufacturer. Beyond the complex sunglass configuration at the demo, the USP class VI certified "workhorse" product is said to be ideal for typical applications, including o-rings, diaphragms, gaskets, medical devices, baby care components and consumer products. The company is said to be a major supplier of silicone materials to North America's medical, automotive, electronics, aerospace and manufacturing industries. (*Shin-Etsu Silicones of America*)

www.shinetsusilicones.com

LSR parts production

Featuring tie-bar-less servo-hydraulic clamping and electric injection units, the injection molding machines from the E-Victory series are said to be predestined for precision applications with liquid silicone rubber (LSR). The electric injection unit is said to ensure high precision injection. On top of this, the machine design features of this model support low flash, rework free processing of low viscosity materials. The moving platen follows the mold precisely, while clamping force is being built up, which is said to result in excellent platen parallelism. Patented force dividers ensure that the clamping force is distributed evenly over the entire platen face. Even for large multiple cavity molds, the cavities near the outer edge of the platen are kept closed with exactly the same clamping force as those nearer the center. In cases of batch fluctuations in the raw material, or environmental conditions, for example, due to weather conditions, digitalization is said to come into its own. Equipped with the iQ weight control smart assistance system from the firm's Inject 4.0 portfolio, the injection molding machine continuously analyzes the injection profile and readjusts quality relevant process parameters in the same cycle. (*Engel*)

www.engelglobal.com


DON'T WORRY
START TESTING
Testing is only the beginning, then you must retrieve stored data, compare results of different products and prepare a complete test report. All these tasks could be a nightmare if you don't use the right tools. Gibitre solution: a complete range of high-quality instruments with one software, SQL database, efficient remote assistance and accredited calibration service. Start smiling! Ask immediately for information about the professional solutions for your lab.
gibitre® INSTRUMENTS
www.gibitre.it/dont_worry
optimist.it

Spray gun technology

Patent pending rapid trigger air valve technology, along with the reduced needle diameter, allows for faster on/off switching performance, reducing overspray, minimizing material used and producing a near perfect spray pattern, according to the manufacturer. Air volume is said to be increased by 60% so that even highly viscous material can be atomized. With a switching frequency of up to 30 Hz, the patent pending pre- and post-air control is said to offer high precision and reproducibility in fully automated spraying systems. The rapid trigger air valve technology is said to be unique and unlike any existing technology. A new innovation in air-assistant airless technology, the DUO A 22, is designed for rapid and precise on/off switching dynamics. The rapid trigger air valve technology is said to provide a precise spray pattern, minimizing overspray and providing cost savings on materials, as well as requiring less energy to complete the spray cycle. The DUO A 22 is lightweight, with fewer parts, making it quick and simple to maintain, according to the company. With precise and rapid fan pattern development, the DUO A 22 is said to excel in sophisticated, fully automatic coating systems. (*Krautzberger North America*)

www.krautzberger.com

Hybrid extrusion tooling

The 800 Series Hybrid has been introduced. In some extrusion applications that utilize crossheads and inlines, layers of the exact same material are applied multiple times using a single die. This method is used to reduce the propensity for errors caused by gels breaking through a thin wall, weld lines, inconsistent wall thickness, plus material and process variations. Additional errors include difficult to process materials and demanding applications where there is zero fault tolerance. Seeking to design the next generation multi-layer die to overcome these challenges, engineers looked for a way to incorporate this technology into an updated version of the 800 Series. The inherent benefits of the 800 Series are retained, including compact design, low residence time and a common deflector bore that eliminates tolerance stack up. The hybrid design is said to incorporate the benefits of layer overlapping, while reducing unnecessary complexity and making the technology more cost affordable for customers. (*Guill Tool & Engineering*)

www.guill.com

Powering the evolution in tire recycling

U.S. based ECO Green has met evolving demand by developing next generation equipment, including its ECO Krumbuster cracker mill, a fine rubber processing mill powered by this company's direct drive hydraulic motors. Every year millions of tires are broken down into rubber crumb that is used to manufacture other goods, like athletic surfaces, rubberized asphalt and commercial flooring. In particular, larger rubber crumb, which is typically processed to sizes ranging from 5 mesh to 30 mesh, is used to make products like artificial sports fields and play surfaces.

There is also increasing global demand for commercial quantities of finer crumb rubber sizes or powder, such as 50 mesh material, which is about the size of table salt. Finer sizes can be mixed with recycled plastics to make plastic rubber pellets that can be injection molded or extrusion molded into a range of products.

Even smaller crumb rubber can be used to make asphalt binding or mixed into roofing materials like epoxies; applications that tend to bring the highest value for the rubber material. As a result, tire recyclers are looking for more productive milling machines, including alternatives to more traditional gearbox driven equipment, that can efficiently and cost effectively grind these smaller crumb particles.

These trends create challenges for many tire recyclers, because traditional gearbox driven mills are built to process mostly larger crumb rubber sizes, with the smaller crumb being a by product of big crumb processing. This is not an efficient way to produce small crumb in large volumes. For example, the production of 400,000 pounds of 8 mesh to 18 mesh may generate roughly 100,000 pounds of -20 mesh crumb; however, the amount of small crumb by product produced with traditional equipment is not enough to fulfill the growing need for the smaller sized materials. The ECO Green Krumbuster allows the processor the flexibility of producing very high volumes of both larger and smaller crumb rubber sizes with minimal effort required to change nip (roller spacing), friction ratios and roller corrugation design; thus offering the best option for both large and small crumb rubber production.

ECO Green designed its patented ECO Krumbuster fine grinding mill to process wire-free and fiber-free tires, which previously have been processed into rubber chips 6 mm or smaller, into rubber powder down to 0.850 mm and smaller, depending on the screening. The capability of this next generation cracker mill to process rubber into finer material allows tire recyclers to take potentially unusable large crumb rubber and produce smaller, higher value material that aligns with this upward demand.

Although the ECO Krumbuster has evolved since it was first introduced, the hydraulic grinding mill has always operated with two corrugated rollers, one small and one large, each powered by a compact and powerful CA 100 direct drive motor. (*Hägglunds/Bosch Rexroth*)

www.boschrexroth-us.com/hagglunds

Durometer testing system

The Max-Hand 3000 durometer is offered for the testing of specimens with creep. The Max-Hand 3000 has a max-hand and an active hand for observing the creep characteristics of a specimen. What makes the Model 3000 unique is the magnetic drag maximum reset mechanism, according to the manufacturer. The user simply rotates the reset knob on the front of the gauge to clear the previous reading. The simplicity of the reset mechanism is said to ensure a lifetime of use. Features include an NIST Calibration Certificate; conforms to ASTM D-2240, DIN 53505, ISO 868 and ISO 7619; large diameter grip; 18 mm diameter presser foot; holds reading until reset; one year warranty; custom made carrying case; reads maximum and creep; cost effective; hand operated; and jeweled movement. Durometers are available in ASTM D 2240 durometer types: A, B, C, D, E, DO, O, OO, OOO, OOO-S, M, R, as well as JIS, DIN ISO, ASKER and other custom durometer scales. (*Rex Gauge*)

www.durometer.com

Green tire measurement

The Green Tire Uniformity System is a sensor and software package used to scan green tires at any stage of production to measure the key geometry features that affect cured tire uniformity and balance performance. The system is available in two configurations, including portable and fixed. The portable, tripod mounted version can be moved from drum to drum, and from machine to machine, which provides a way to thoroughly study the carcass, belt/tread package and final shaped green tire for radial and lateral runout, and splice quality. This can be used by the setup technician to verify the TBM setup, and can be used by the uniformity engineer to troubleshoot tires with uniformity issues. The fix mounted version provides a means to perform 100% inspection at any drum for any parameter that is useful for understanding the population characteristics of green tire runouts and to alarm when limits are exceeded. GTU is available in several size combinations of width, depth and standoff distance. The GTU system utilizes the CrossCheck line laser sensor to scan green tires at any stage of production. GTU sofware has a suite of viewing and analysis tools for assessing all aspects of the green tire uniformity. (*Starrett Bytewise*)

www.starrett.com/bytewise

Recycled synthetic rubber

Recycling synthetic rubber is the focus of this company, which has a manufacturing plant in Denizli, Turkey. A team of chemists knows which material can be useful for customers. The firm matches its materials to its customers' needs. The company recycles 98% of the materials it receives with scrap synthetic rubber. Reprocessed synthetic rubber available from the company includes SBR 1502, 1500, 1723 and 1712; S-SBR dry (non-oil); S-SBR 1205 grade; S-SBR oil extended; high cis BR; low cis BR; and EPDM. Off-grade synthetic rubber available from the company includes SBR 150s, 1500, 1723 and 1712; S-SBR dry (non-oil); S-SBR oil extended; and high cis BR. The company is said to provide the following to its customers: trustable and high quality rubber solutions; cost reducing effective reprocessed rubber; European quality reprocessed rubber; green environmental solutions for rubber mixing; various types and grades of reprocessed synthetic rubber for different needs; after sales technical support; easy to use and environmentally friendly packaging with EVA bags that can be melted at 80°C; and a global transportation network to deliver goods worldwide with cheaper freight rates. (*Cinar Kaucuk*)

www.cinarkaucuk.com

Thermoplastic elastomers

This global manufacturer of thermoplastic elastomer products and customized solutions for a variety of industries is said to meet consumer demand for cost effective, high performance and sustainable TPE solutions for tooling handles. Tools are said to be indispensable devices that are used in industries and at home to perform specific tasks or functions, such as cutting, drilling, measuring, fastening or cleaning. From simple hand tools to more complex power tools, handles and grips can have a significant impact on a user's comfort, control, safety and the tool's durability. To ensure the best performance and safety, consumers are said to prefer tools with well designed handles made of high quality materials, such as thermoplastic elastomers (TPEs). This global manufacturer of thermoplastic elastomer products and customized solutions for a variety of industries is said to offer high quality TPE compounds for tool handles and grip applications. TPEs are said to provide ergonomic and safety benefits for tool designed applications. With the good characteristics of their mechanical properties, the TPE compounds are frequently used in applications requiring high strength, flexibility, durability and resistance to heat, chemicals and wear. (*Kraiburg TPE*)

www.kraiburg-tpe.com

See us at the show!

AGC
Your Dreams, Our Challenge
Booth # 100

McLube
RELEASE AGENTS AND LUBRICATION TECHNOLOGY
Booth # 623

POLYMERICS
Booth # 970

COLMEC
Advanced RUBBER EXTRUSION and COMPOUNDING Solutions
Booth # 631

120 years of Krautzberger
Booth # 649

RDAbbott
APPLIED CURIOSITY
Booth # 353

R.E. Carroll, Inc.
Specialty Chemicals • Petroleum Products
Booth # 742

Fulflex
Booth # 794

doss
let's check.
Booth # 235

UTP VISION
VISUAL INSPECTION
Booth # 866

ColorService
DOSING TECHNOLOGIES
Booth # 994

HF MIXING GROUP
Booth # 401

SI Group
Booth # 750

LAWER
dosing & dispensing systems
Booth # 495

ENTEX
The Planetary Roller Extruder
Booth # 707

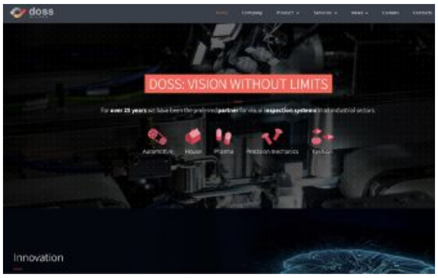
SOVEREIGN
CHEMICAL
Booth # 515

RENKERT
Specialty Oils and Products
Booth # 390

Vanderbilt Chemicals, LLC
A Wholly Owned Subsidiary of R.T. Vanderbilt Holding Company, Inc.
Booth # 453

Corporate Sponsor

Rubber World Industry Links



Doss Visual Solution (www.dossvisualsolutionusa.com) has been working closely with customers for over 25 years to offer increasingly innovative and customized solutions in the field of quality control and optical inspection. Passion and professionalism are the two drivers that have allowed DVS to become one of the top leaders in the sector worldwide.

Research, development and innovation have always been part of Doss Visual Solution's DNA, and Doss continues to invest in them to build its future; a future that Doss imagines more and more in the name of collaboration with its customers, considered as its true partners, to continue to offer the best solutions in the industry. All this is accomplished by implementing an increasingly precise and transparent communication strategy on which to base not only strategic partnerships, but also real relationships forged through reliability and trust.

Visual inspection requires precision, especially with small parts requiring tight tolerances, many parts moving along a production line and a quality assurance process that needs to deliver top quality products to customers. Machine learning is now an integral part of visual inspection processes, something Doss takes to new levels thanks to its deep learning capabilities.

Deep learning, rather than machine learning, utilizes scalability because of the available data and algorithms. Deep learning can classify over 200 different pieces of metal parts. It can also detect in-line non-conformity for o-rings, including when the top of the ring does not adhere to the bottom. Because deep learning aggregates layers and layers of data, the algorithm improves over time, mimicking how the human mind works.

From finding surface defects to sorting variable parts on the same line, deep learning can also look at serial numbers and assess product quality. A Doss system can autonomously classify data and structure them hierarchically, finding the most relevant and useful ones quickly as it strives to solve problems and improve its performance continuously. Traditional machine learning contains two to three layers of thinking, while deep neural networks can contain over 150 decision making algorithms that sort data into the most useful ones.

@ rubberworld.com

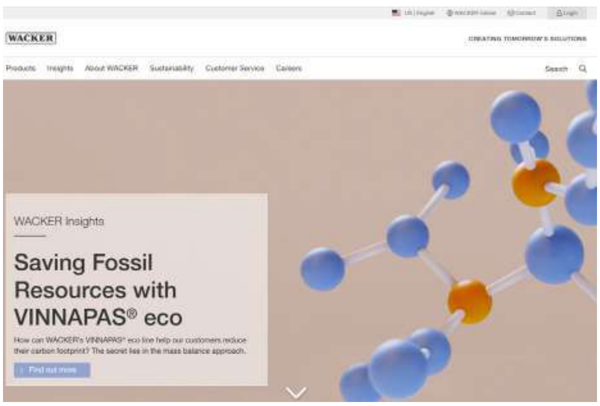
Davis-Standard (www.davis-standard.com), headquartered in Pawcatuck, CT, is a global leader in the design, development and distribution of extrusion and converting technology. Davis-Standard systems encompass more than ten product lines to support manufacturing applications and customers within every major industry.

Davis-Standard extruders provide unparalleled performance and durability. Davis-Standard extruders are so reliable that some are still operating after 50 years of continuous service. This track record, combined with high output rates and a rapid return on investment, makes Davis-Standard extruders the workhorses of the industry.

From single and twin screw extruders to specialty, reclaim, medical and elastomer extruders, the depth and availability of Davis-Standard's extruder offering are what make the company the global extrusion leader. Davis-Standard is also recognized for its coextrusion technology, supporting both vertical and horizontal coextrusion configurations. Regardless of application or location in the world, Davis-Standard has the extruder to suit customer requirements and budgets.

Davis-Standard's elastomer solutions support global markets for tires, automotive hoses, adhesives and sealants, recreational equipment, construction and medical applications. Davis-Standard is an industry leader in turnkey rubber and silicone technology to support a range of applications, including rubber hose, rubber and silicone gaskets, rubber barrier products, silicone tubing and weatherstrip.

With elastomer extruders in multipurpose, hot and cold feed, silicone, vacuum vented, pin barrel and smooth barrel designs, Davis-Standard's extensive offering of elastomer systems provides a specific solution for nearly every elastomer application. Engineers work with customers to supply elastomer equipment that meets their precise product requirements, including technology for product curing and in-line processing.



Wacker (www.wacker.com) is a technological leader in the chemical industry and manufactures products for all key global industries. It is active in the silicone, polymer, life sciences and polysilicon markets. With a range of more than 2,800 silicone products, Wacker ranks among the world's largest manufacturers of silanes and silicones. Wacker is also the market leader in key subsegments, with a product portfolio ranging from silanes through silicone fluids, emulsions, elastomers, sealants and resins to pyrogenic silicas. Thanks to their highly diverse properties, silicones offer virtually unlimited potential for intelligent, customizable solutions to numerous sectors. Key application areas include engineering, electronics, chemicals, cosmetics, textiles and paper.

Wacker's wealth of products, experience and expertise enables the firm to offer complete, customized solutions. Cooperating closely with customers, Wacker develops new products and innovative production processes to help customers cut costs and optimize their business. To this end, Wacker provides laboratory support for product formulation and approval, and for scale-up to full production. Wacker also assists customers with the development of supply chain and packaging strategies.

Non-vulcanized silicone rubber consists of polymers of different chain lengths. These so-called polysiloxane chains always contain a silicone-oxygen backbone, with two organic side groups, usually methyl groups, bound to each silicon atom. These polysiloxane chains determine the key material properties common to all silicone rubbers, such as heat resistance and electrical characteristics. The choice of additive determines the particular processing and material properties of Wacker's silicone rubber portfolio, extending the approximately 1,000 products. Crosslinkers, fillers and catalysts are among the most important additives. Wacker offers a wide range of different silicone rubber grades marketed under the trade names Elastosil, Geniosil, Powersil, Semicosil, Silmix, Silpuran and Wacker.

Wacker's integrated management systems represent the company's most comprehensive management tool to maintain sustainable business practices.

If you would like your web site featured here contact your sales rep
Dennis Kennelly, dennis@rubberworld.com, Mike Dies, mike@rubberworld.com or Pete McNeil, pete@rubberworld.com

People in the News

Seeley named president of Polymer Valley

Ed Seeley was elevated to the role of president of Polymer Valley Chemicals. **Michael R. Beck, Jr.**, owner and CEO of the mineral filler and specialty carbon black service provider, said, “We are beyond thrilled that (Ed) Seeley has agreed to take his exceptional leadership skills and vision for Polymer Valley Chemicals and apply them to our entire staff and operation.” Seeley will oversee the company’s entire operation, including the corporate headquarters and sales staff in Akron, OH, and the Macon, GA based production facilities, and direct the company’s overall strategy in terms of customer service, efficiency and growth.

Ed Seeley
Polymer Valley

Jeff Kasper
Struktol

Levi Cottington
R.D. Abbott

Ben Nosse
Sovereign Chemical

Management

Jeff Kasper joined Struktol Company of America as director of manufacturing.

Levi J. Cottington was named vice president, head of supply chain for R.D. Abbott. Cottington is responsible for driving speed and predictable results for R.D. Abbott’s customers through prioritization, risk mitigation and complexity management.

Giorgio Gramegna was appointed director of Europe for Global Rubber Industries (GRI), a specialty tire maker based in Sri Lanka. **Simon Michael** was appointed director for the Middle East and Africa (MEA) and South America.

Bosch Rexroth announced its president and chief executive officer, **Gregory Gumbs**, will leave the company July 1. In the interim, **Reinhard Schaefer**, current executive board member, will join the North American board to support the transition and identify the company’s next regional CEO.

Kristen Beck was promoted to president of the Holcim Building Envelope Americas Commercial Roofing Systems and Lining business unit.

Martin Baumann was named managing director of Arburg in Rocky Hill, CT, succeeding **Friedrich Kanz**, who is retiring.

Sales

Gabriel Rodriguez was appointed senior account manager in the northern territories of Mexico for R.D. Abbott de México de R.L. de C.V.

Ben Nosse joined Sovereign Chemical, a global supplier of chemicals to the tire and rubber industries, as business development manager.

Leandro Estrada has joined Hauschild SpeedMixer’s USA organization as regional sales manager, responsible for all customers in the northeast region.

Technical

Brian Swanton was named director of process engineering for Novation Solutions, LLC (NovationSI), the manufacturing subsidiary for R.D. Abbott.

Smithers, a provider of testing, consulting, information and compliance services for the rubber, elastomers and other industries, hired **Chad Atzemis** as a senior consultant.

Taylor Smith was appointed as a research development technician for Specialty Silicone Products (SSP).

Harwick promotes Buchanan and Potirakis

Monica Buchanan was promoted to sales, marketing and technical senior administrator at Harwick Standard Distribution. Harwick President and CEO **Ernie Pouttu** says Buchanan’s new title reflects the key areas she handles for Harwick, and the support she provides for these most important aspects of the business.

Helen Potirakis is now senior product manager for Harwick, handling key suppliers to the company, and taking on additional suppliers.

Pouttu expressed his appreciation to **Andreana Gonzalez** for her “willingness and enthusiasm on taking on some supplier responsibilities.” Pouttu additionally thanked **Cris Welch**, **Bryan Shields**, **Mike McCarty** and **Chuck Bonawitz** for their increased roles with the Harwick supplier base.

Harwick Standard Distribution is a supplier of raw materials for industries specializing in rubber, plastics and other polymer related fields, providing an expansive and specialized product base which is able to address challenging customer requirements.

Servicing the rubber, thermoplastics and other polymer related industries for more than 90 years, Harwick Standard is a management owned and operated sales, marketing and technical support organization headquartered in Akron, OH. Harwick Standard is ISO 9001:2015 registered and operates a nationwide distribution network supplying world class quality products.

Classifieds

AGC
Your Dreams, Our Challenge

AFLAS® FLUOROELASTOMERS

AFLAS Fluoroelastomers

FEPM: 100 and 150 Series high strength, general purpose use; **NEW Grades** 600X and 400E with rapid cure and multi-layering capability. **Specialty FKM**: 200P BRE for improved performance over Type VI FKMs. **FFKM:** PM-1100, PM-3000 and CP-4000 for critical applications at ultra-hot temperatures.

Contact us to learn about our FDA compliant AFLAS Fluoroelastomer grades!

www.agcchem.com

Technical Consultant

- International experience in rubber molding, rubber extrusion, rubber-to-metal bonding
- In-house training, Problem solving, Product & Process Development
- Value Engineering
- Cost Reduction
- Increased Productivity

Email: 131wanderer@gmail.com

Release Coatings of New York, Inc.

Formed Hose Release

Injection, Compression & Transfer Molded Parts Release

(800) 457-7817 • Fax: (585) 593-4912
Website: www.rcony.com • Email: rnaples@rcony.com
ISO 9001:2015 Company

Experienced Sales and Customer Solutions for Suppliers to the Rubber Industry →

Open More Doors ×
Increase Sales
Generate and Track New Leads
Identify New Market Opportunities

Contact for more Information:
garyjhorning@gmail.com

DUROMETERS
Rubber Hardness Testers

Shore A Normal rubber
Asker C Soft rubber & sponge
Shore D Hard rubber & plastics
Shore E Soft rubber & sponge
And More Scales Available

- ASTM D2240 compliant (Shore scales only)
- NIST Certificate included
- Optional ISO 17025 Certificate

BEST Value Pricing!

866-527-4666
www.hoto-instruments.com

Ken-React®
Titanates & Zirconates

Better than silanes – We offer Solutions: www.4kenrich.com

APV® ENGINEERED COATINGS

THE LEADER IN **MARKING INKS & CUSTOM APPLICATION** EQUIPMENT SINCE 1878

APVCOATINGS.COM

Pulverizing - Fine Grinding Services

- Pulverizing - Fine Grinding
- Blending – Mixing
- Laboratory Processing – Lab Grinding, Pulverizing, Sifting

Allgrind Plastics, Inc.
908-479-4400
I-78 Bloomsbury, NJ
www. allgrind.com ▪ services@allgrind.com

Classifieds

RubberWorld

Coming in July!
Annual Machinery & Equipment Directory

Index To Advertisers

Rubber World
SALES STAFF

DENNIS J. KENNELLY
Senior VP-Associate Publisher
1741 Akron-Peninsula Rd.
Akron, OH 44313-5157
Ph: 330-864-2122
Fx: 330-864-5298
Email: dennis@rubberworld.com

MIKE DIES
Marketing Representative
1741 Akron-Peninsula Rd.
Akron, OH 44313-5157
Ph: 330-864-2122
Fx: 330-864-5298
Email: mike@rubberworld.com

PETE MCNEIL
Sales Consultant
1741 Akron-Peninsula Rd.
Akron, OH 44313-5157
Ph: 330-864-2122
Fx: 330-864-5298
Email: pete@rubberworld.com

RINGIER TRADE PUBLISHING
East China - **VIVIAN SHANG**
Phone: +86-21 6289-5533 EXT 169
vivian@ringiertrade.com
North China and South China

MAGGIE LIU
Phone: +86-20 8732-3316
EXT 9332
Email: maggieliu@ringiertrade.com

Hong Kong
MIKE HAY
Phone: +852 2369 8788 ext 11
Email: mchhay@ringier.com.hk

Taiwan
SYDNEY LAI
886 4 2329 7318
Email: sydneylai@ringier.com.hk