

We will start momentarily at 2pm ET



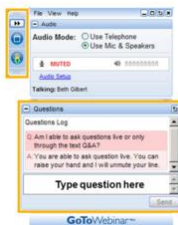
Slides available now! Presentation available ONE WEEK after the webinar:  
<http://acswebinars.org/motorcycles-and-cars>

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

1

## Have Questions?

Type Questions Box!



**“Why am I muted?”**  
Don't worry. Everyone is muted except the presenter and host. Thank you and enjoy the show.

Or tweet using #acswebinars



Slides available now! Presentation available ONE WEEK after the webinar:  
<http://acswebinars.org/motorcycles-and-cars>

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

2

Do you like Motorcycles?



Cars?



& Chemistry?!

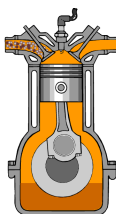


Join the *Trenton Local ACS* for an exciting event where we get together to explore the chemistries found in motorcycles and cars!

## The Chemistry of Motorcycles and Cars: Lighting the Fires that Move your Tires

<http://acswebinars.org/motorcycles-and-cars>

October 24<sup>th</sup> 2-3 pm



**Lubrizol**

Trenton



The College of New Jersey



**BRIDGESTONE**  
Your Journey, Our Passion

**ACS Webinars**<sup>®</sup>  
CLICK • WATCH • LEARN • DISCUSS



If you enjoy ACS Webinars<sup>®</sup> every Thursday...  
please support the program!



[www.join.acs.org](http://www.join.acs.org)

**ACS Network**  
Where Chemists Connect

ACS Network (search for group acswebinars)  
[www.communities.acs.org](http://www.communities.acs.org)

Find the many benefits of ACS membership!



Like us on  
Facebook!



[www.facebook.com/acswwebinars](http://www.facebook.com/acswwebinars)

5

## Fan of the Week

How has ACS Webinars<sup>®</sup> benefited you?



“Topics I wish I had more time to read on are encapsulated into a sixty minute time period for professional education.”

Ann M. Heos  
Quality Assurance Assistant  
Environmental Testing Services  
Geolabs Inc.  
Braintree, MA



Be a featured fan on an upcoming webinar! Write to us @ [acswwebinars@acs.org](mailto:acswwebinars@acs.org)

6



**Q: “Hungry for a brain snack?”**

**A: ACS WEBINETS™ on YouTube**

“ACS Webinets™ are 2 minute segments that bring you valuable snippets from some of our most popular full length ACS Webinars® ”

See all of our ACS Webinets™ on YouTube at  
<http://bit.ly/acswebinets>

7

**ACS Webinars®**  
CLICK \* WATCH \* LEARN \* DISCUSS



**Enjoy our most popular ACS Webinars® !**



[www.acswebinars.org/most-popular](http://www.acswebinars.org/most-popular)

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

8



## The ACS International Center™ presents: Study Abroad in Japan



Featuring speakers from the **Japan Society for the Promotion of Science (JSPS)** and the **Japan Science and Technology Agency (JST)** on postdoc and professional exchange opportunities in Japan, and opportunities for you to get involved.

**Wednesday, October 30, 2013**  
**2:00-3:00PM (EDT)**

**Register now at [www.acs.org/ic\\_japan](http://www.acs.org/ic_japan)**

9

## Upcoming ACS Webinars® [www.acswebinars.org](http://www.acswebinars.org)



Thursday, October 31, 2013

### “Hollywood Chemistry: Science on the Big Screen”

**Dr. Jovana J. Grbić**, Biological Chemist and Founder of ScriptPhD.com

**Dr. Bill Courtney**, Chemist and Owner, Cheese-ology Macaroni & Cheese



Thursday, November 7, 2013

### “Getting the Most out of Your Mentoring Relationships”

**Dr. Donna Dean**, Director, National Institute of Biomedical Imaging and Bioengineering

**Dr. David Harwell**, Assistant Director, ACS Careers

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

10

ACS Webinars®  
CLICK • WATCH • LEARN • DISCUSS



## The Chemistry of Motorcycles and Cars: Lighting Fires that Move Tires



**Dr. John Manka**  
Global Department Manager,  
Lubrizol Additives



**Dr. Terry Hogan**  
Senior Research Associate,  
Bridgestone



**Dr. Matt Crowe**  
Analytical Chemist, Dow  
Chemical

Slides available now! Presentation available **ONE WEEK** after the webinar:

<http://acswebinars.org/motorcycles-and-cars>

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

Do you like Motorcycles?



Cars?



& Chemistry?!

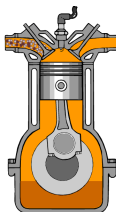
Join the *Trenton Local ACS* for an exciting event where we get together to explore the chemistries found in motorcycles and cars!



## The Chemistry of Motorcycles and Cars: Lighting the Fires that Move your Tires

<http://acswebinars.org/motorcycles-and-cars>

October 24<sup>th</sup> 2-3 pm



**Lubrizol**

Trenton



The College of New Jersey



**BRIDGESTONE**  
Your Journey, Our Passion



The slide features a central graphic with a blue and green molecular structure on the left and a collage of images on the right, including a hand holding a smartphone, a car, and a person working at a computer. Below the graphic, the text reads: ACS Webinar, Engines and Engine Oils, John S. Manka PhD, Global Department Manager, R&D Chemical Synthesis. The Lubrizol logo is in the bottom right corner, and a small copyright notice is in the bottom left.

ACS Webinar  
**Engines and Engine Oils**

John S. Manka PhD  
Global Department Manager  
R&D Chemical Synthesis

© 2013 The Lubrizol Corporation, all rights reserved.

**Lubrizol**

## Engine Oil Poll Question



- What are the four strokes of the combustion cycle?
  - A. Inhalation, Squeezing, Burning, Exhalation
  - B. Intake, Compression, Power, Exhaust
  - C. Uptake, Pressurization, Combustion, Outtake
  - D. Suck, Squeeze, Bang, Blow
  - E. #1, #2, #3 and #4

## Engine Oil Poll Question



- Do you regularly check your vehicle's engine oil level?
  - A. Yes I do
  - B. No I do not
  - C. I check my oil when the check engine light comes on
  - D. I do not even know where the engine oil dipstick is
  - E. What is a dipstick?

15 © 2013 The Lubrizol Corporation, all rights reserved.



## Outline



- **Internal Combustion Engines**
  - Combustion Cycle
  - Major Parts of the Engine
- **Passenger Car vs. Motorcycle Engines**
- **Function of Engine Oil**
- **Engine Oil Formulation**
  - Base oils
  - Viscosity Modifiers
  - Additives
- **Engine Oil Trends**

16 © 2013 The Lubrizol Corporation, all rights reserved.





## Internal Combustion Engines



- **Engines Convert Chemical Energy to Kinetic Energy**
- **Can be Compression Ignition or Spark Ignition**
  - Diesel engines are compression ignition and use the heat from compressing the intake charge to ignite the fuel
  - Gasoline engines are spark ignition and use spark plugs to ignite the fuel
- **Can be 2 Stroke or 4 Stroke**
  - Stroke refers to how many piston strokes are in the combustion cycle
  - 2 Stroke engines are not produced anymore for motorcycles
    - Inexpensive, high power density, very poor emissions

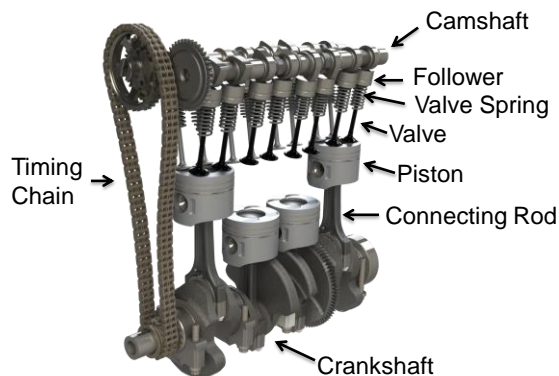
17 © 2013 The Lubrizol Corporation, all rights reserved.

**Lubrizol**

## Major Parts of a 4 Stroke Engine



- **Parts Groups**
  - Valve Train
  - Piston Group
  - There are many other parts as well



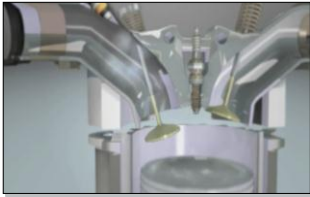
18 © 2013 The Lubrizol Corporation, all rights reserved.

**Lubrizol**

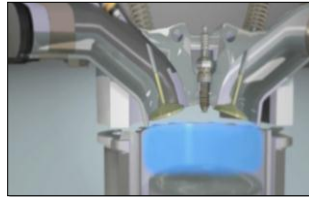
## The Four Stroke Combustion Cycle



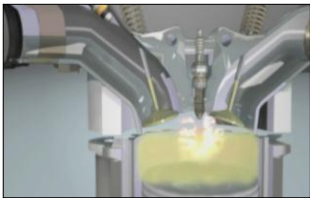
1. Intake



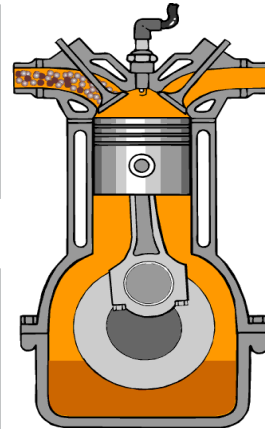
2. Compression



3. Power



4. Exhaust



**Lubrizol**

19 © 2013 The Lubrizol Corporation, all rights reserved.

## Passenger Car vs. Motorcycle Engine Oil



- **Motorcycles are often air cooled with a small oil sump**
  - Run hotter
- **Motorcycles usually have a high power density**
  - Power density is HP/ cubic inch
  - Run hotter
  - Higher RPM
- **Motorcycles often have transmission and clutches in the engine crankcase**
  - Friction modifier choice is critical
  - Need more gear protection
- It is important to use the proper motorcycle engine oil as recommended by the OEM

20 © 2013 The Lubrizol Corporation, all rights reserved.

**Lubrizol**

## Engine Oil Poll Question



- How often do you change your engine oil?
  - A. 3000 miles
  - B. 5000 miles
  - C. 7500 miles
  - D. Longer than 7500 miles
  - E. When my car's engine oil life monitor tells me to
  - F. Oh... Are you supposed to change it?

21 © 2013 The Lubrizol Corporation, all rights reserved.



## Functions of a Lubricant

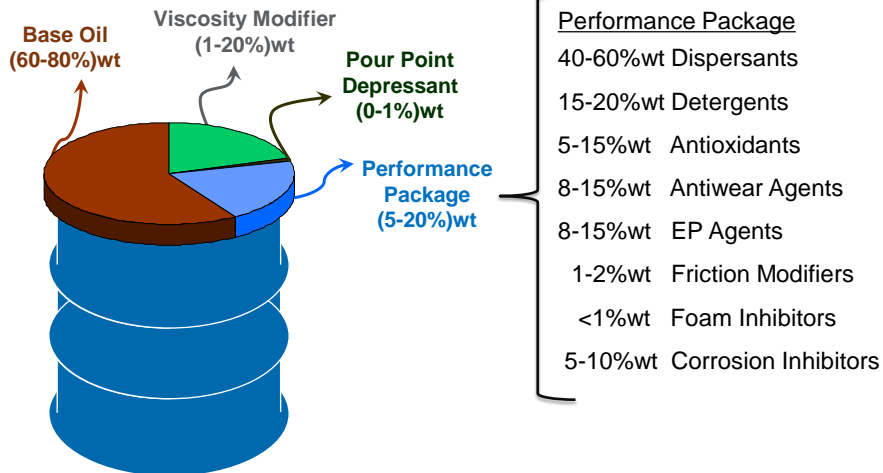


- Lubrication
  - Reduces friction and wear by introducing a film between moving parts
- Cooling
  - Helps dissipate heat away from the critical parts of the equipment
- Cleaning and Suspending
  - Facilitates smooth operation of equipment by removing and suspending products, such as carbon or soot, sludge, and varnish
- Protection
  - Prevents metal damage due to oxidation and corrosion

22 © 2013 The Lubrizol Corporation, all rights reserved.



## Engine Oil Formulation



23 © 2013 The Lubrizol Corporation, all rights reserved.

**Lubrizol**

## Engine Oil Poll Question



- Do you know which engine oil viscosity grade your vehicle uses?
  - A. Yes, I do
  - B. No, I do not
  - C. I use whatever the mechanic puts in
  - D. I use whatever is on sale
  - E. What is a viscosity grade?

24 © 2013 The Lubrizol Corporation, all rights reserved.

**Lubrizol**

# Base Oils



| API              | Production Process                                    | Performance Characteristics                                                      | % S   | % Saturates | Viscosity Index |
|------------------|-------------------------------------------------------|----------------------------------------------------------------------------------|-------|-------------|-----------------|
| <b>Group I</b>   | Solvent refined.                                      | Good solvency. Vulnerable to oxidation and thermal degradation.                  | >0.03 | <90         | 80 to 120       |
| <b>Group II</b>  | Mild hydrocracking and catalytic dewaxing.            | High saturate levels good oxidation and thermal stability.                       | ≤0.03 | ≥90         | 80 to 120       |
| <b>Group III</b> | Severe hydrocracking and advanced catalytic dewaxing. | High viscosity indexes and very good thermal and oxidation stability.            | ≤0.03 | ≥90         | ≥ 120           |
| <b>Group IV</b>  | Chemically engineered synthetic base stock. PAOs      | Low pour point, high viscosity index, excellent thermal and oxidation stability. |       |             |                 |
| <b>Group V</b>   | Base oils not included in any of the other categories | Can have poor low temperature or oxidation performance                           |       |             |                 |

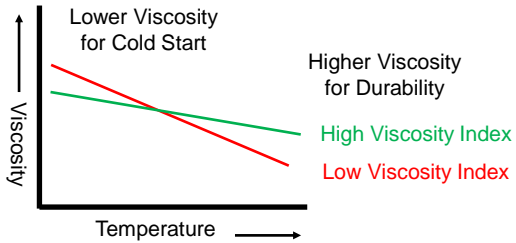
25 © 2013 The Lubrizol Corporation, all rights reserved.



# Viscosity Modifiers



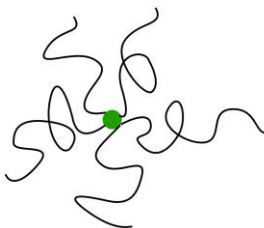
- Polymers that maintain oil viscosity over changes in temperature
- Enables the “winter” grade lubricants
  - 10W30



Linear Polymer



Star-Shaped Polymer



Branched Polymer



26 © 2013 The Lu



## Additives



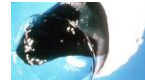
Additives impart or reinforce a desirable property of the lubricant



Detergent



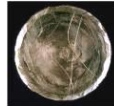
Dispersant



Oxidation Inhibitor



Friction Modifier



Antiwear



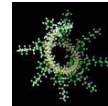
Extreme Pressure Agent



Foam Inhibitor



Corrosion Inhibitor



Viscosity Modifier/PPD

**Lubrizol**

27 © 2013 The Lubrizol Corporation, all rights reserved.

## Lubricant Additives



- **Dispersant**
  - Suspends by-products of oxidation and lubricant decomposition in oil.
- **Detergent**
  - Neutralizes acids that result from oxidation/combustion of fuel and lubricant.
- **EP/Antiwear Agent**
  - Minimizes wear by making sacrificial chemical film on metal surfaces
- **Friction Modifier**
  - Increases the durability of lubricant film, lowers friction, and increases fuel economy.
- **Oxidation Inhibitor**
  - Slows down the rate of oxidation of the oil, hence controlling oil viscosity.
- **Pour Point Depressant**
  - Lowers the temperature at which the lubricant flows
- **Rust and Corrosion Inhibitors**
  - Form a barrier between chemically corrosive species and the metal surface.

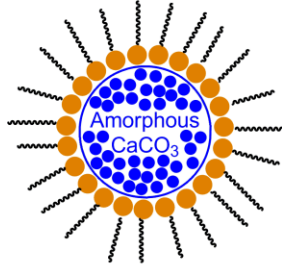
**Lubrizol**

28 © 2013 The Lubrizol Corporation, all rights reserved.

# Function of a Detergent



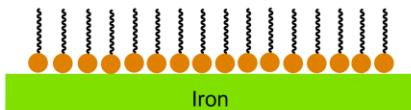
Neutralize Acids



High Temp Cleanliness



Corrosion and Friction

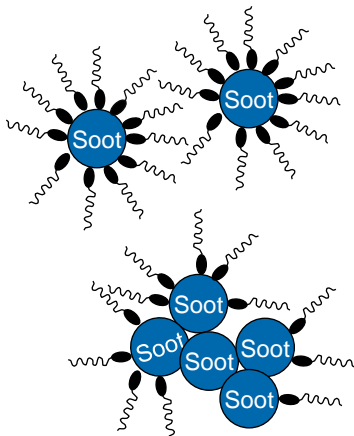


29

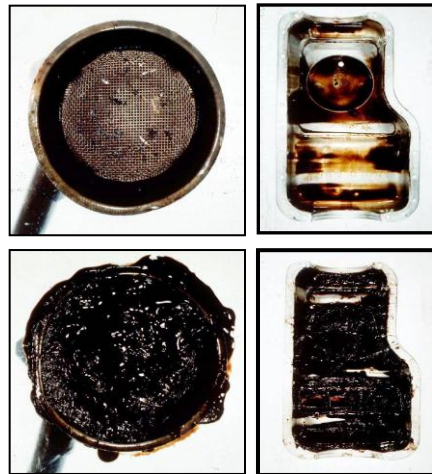
# Function of a Dispersant



Dispersants Prevent Soot Agglomeration



Low Temp Cleanliness

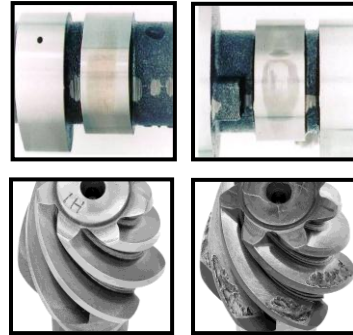
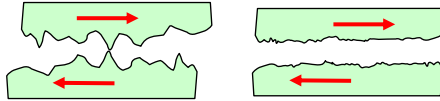
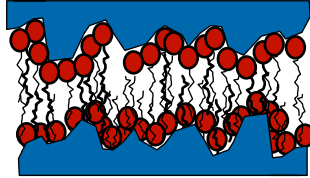


30 © 2013 The Lubrizol Corporation, all rights reserved.

## Function of Antiwear, EP and FMs



### Control Wear and Impact Friction



31 © 2013 The Lubrizol Corporation, all rights reserved.

**Lubrizol**

## Engine Oil Trends



- **Longer Drain Intervals**
  - Shear stable viscosity modifiers, antioxidancy, TBN
- **Fuel Economy**
  - Friction Modifiers and lower viscosity oils
- **Emissions**
  - Reduced amount of sulfur, phosphorus and metals in Engine Oils
  - Compatibility with biofuels
- **Higher Power Densities**
  - Smaller engines but more horsepower
    - Turbochargers
  - Higher Operating Temperatures
    - Antioxidants

32 © 2013 The Lubrizol Corporation, all rights reserved.

**Lubrizol**



# Lubrizol Additives Websites



- [hddeo.com](http://hddeo.com)
- [pceo.com](http://pceo.com)
- [mceo.com](http://mceo.com)
- [gf-5.com](http://gf-5.com)
- [drivelinenews.com](http://drivelinenews.com)
- [tractorlife.com](http://tractorlife.com)
- [fluidlineflash.com](http://fluidlineflash.com)
- [lubrizolK2M.net](http://lubrizolK2M.net)
- [lubrizol.com/lubricant and fuel additives/](http://lubrizol.com/lubricant-and-fuel-additives/)
- [lubrizol.com/success together](http://lubrizol.com/success-together)



33 © 2013 The Lubrizol Corporation, all rights reserved.



## Working together, achieving great things

When your company and ours combine energies, great things can happen. You bring ideas, challenges and opportunities. We'll bring powerful additive and market expertise, unmatched testing capabilities, integrated global supply and an independent approach to help you differentiate and succeed.

© 2013 The Lubrizol Corporation, all rights reserved.





## Chemistry of Motorcycles and Cars: Lighting the Fires that Move Your Tires...

Terry Hogan  
October 24, 2013



35

### What is inside your tire?

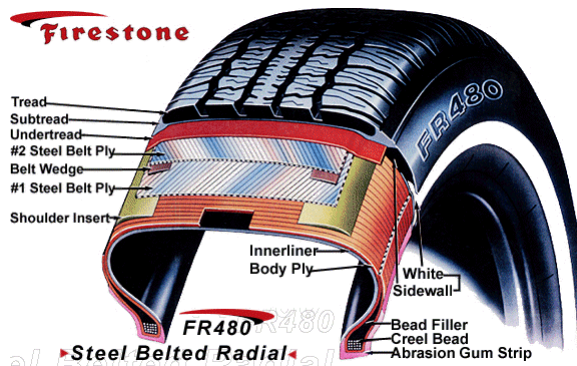


*There is more to a tire than what appears on the surface.*


Over a dozen different tire components each with a specific formulation!

**Focus for Today's Talk:**

- Tread Polymers
- Sidewall Polymers



## Tread Compounds



**Tread Requirements**

- Rolling Resistance (Fuel Economy)
- Wet Traction
- Dry Traction
- Snow Traction
- Wear

**Typical Tread Polymers**

- Natural Rubber (*cis*-polyisoprene)
- SBR (poly(styrene-*co*-butadiene))
- BR (*cis*-polybutadiene)

High molecular weight  
Contain unsaturation

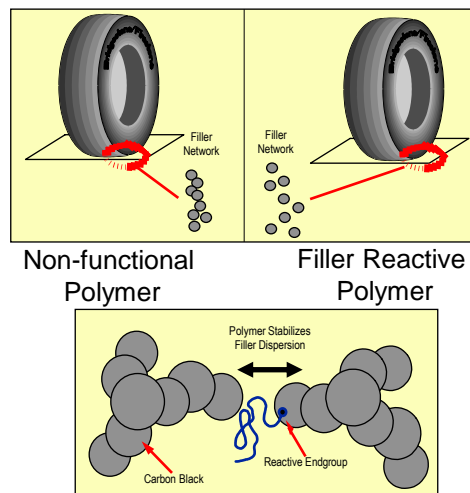
Rolling Resistance  
Wet Traction  
Wear

**“Magic Triangle”**

How do we improve the trade off of the magic triangle?  
**Chemistry!**

## Payne Effect

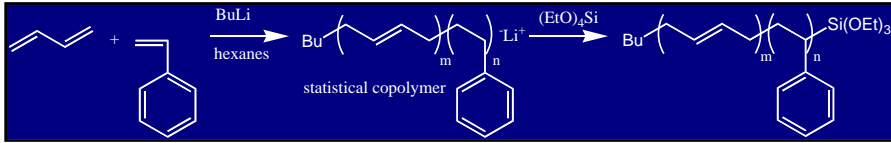
As rubber passes through the footprint of the tire, filler-filler contacts cause energy loss.



A functional polymer stabilized a more disperse filler network.

## Influence of Functional Polymers

### Synthesis of functional SBR:



### Tire Properties:

|                                                   | Non Functional | TEOS Terminated |
|---------------------------------------------------|----------------|-----------------|
| Tire Rolling Resistance Index <sup>a</sup>        | 100            | 93              |
| Wet Skid Peak Force Index <sup>b</sup>            | 100            | 99              |
| Dry Skid Peak Force Index <sup>c</sup>            | 100            | 102             |
| Wear Index (Average of Main Grooves) <sup>d</sup> | 100            | 123             |

Hogan, et. al. Rubber World, September 2010.

*a* Lower values in Tire Rolling Resistance Index indicate improved fuel economy. (SAE J2452)

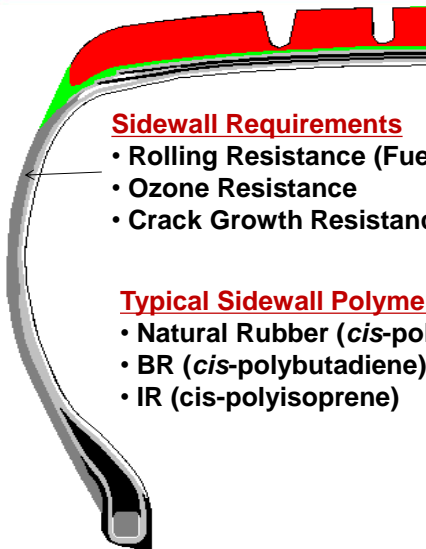
*b* Higher values in Wet Skid Peak Force Index indicate better wet traction. Value was taken at 20 mph.

*c* Higher values in Dry Skid Peak Force Index indicate better dry traction. Value was taken at 40 mph.

*d* Higher values in Wear Index indicate better wear. Tread depth measured after 30,000 miles.

**Application of chemistry improved rolling resistance and wear without affecting traction.**

## Sidewall Compounds



### Sidewall Requirements

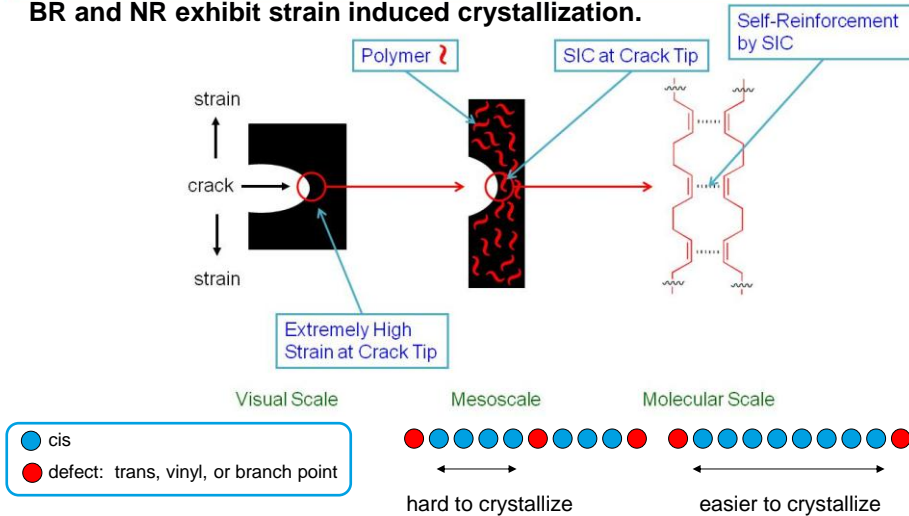
- Rolling Resistance (Fuel Economy)
- Ozone Resistance
- Crack Growth Resistance

### Typical Sidewall Polymers

- Natural Rubber (*cis*-polyisoprene)
- BR (*cis*-polybutadiene)
- IR (*cis*-polyisoprene)

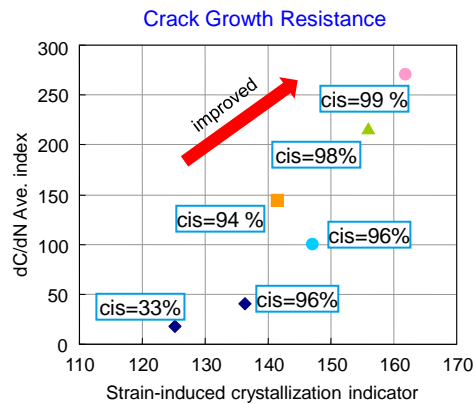
## Strain Induced Crystallization

BR and NR exhibit strain induced crystallization.



- Repeating cis microstructure increases the ability of the polymer to undergo SIC.
- Defects (trans, vinyl, branching) hinder the ability of the polymer to undergo SIC.

## Influence of Cis Content on Crack Growth



Application of catalyst technology to increase *cis* content improved sidewall crack growth resistance.

## Other Chemistry in Tires

- Silanes
- Vulcanization (cure accelerators)
- Rubber-metal adhesion
- Specialty fillers
- Sustainable raw materials
- Antiozonants and antioxidants

Chemistry is driving tire development.



Thank You!

Check your tire pressure!



ACS Webinars®  
CLICK • WATCH • LEARN • DISCUSS



## The Chemistry of Motorcycles and Cars: Lighting Fires that Move Tires



**Dr. John Manka**  
Global Department Manager,  
Lubrizol Additives



**Dr. Terry Hogan**  
Senior Research Associate,  
Bridgestone



**Dr. Matt Crowe**  
Analytical Chemist, Dow  
Chemical

Slides available now! Presentation available **ONE WEEK** after the webinar:

<http://acswebinars.org/motorcycles-and-cars>

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

Upcoming ACS Webinars®  
[www.acswebinars.org](http://www.acswebinars.org)



Thursday, October 31, 2013

### “Hollywood Chemistry: Science on the Big Screen”

**Dr. Jovana J. Grbić**, Biological Chemist and Founder of  
ScriptPhD.com

**Dr. Bill Courtney**, Chemist and Owner, Cheese-ology Macaroni  
& Cheese



Thursday, November 7, 2013

### “Getting the Most out of Your Mentoring Relationships”

**Dr. Donna Dean**, Director, National Institute of Biomedical  
Imaging and Bioengineering

**Dr. David Harwell**, Assistant Director, ACS Careers

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

46

## Stay Connected...

facebook

[www.facebook.com/acswebinars](http://www.facebook.com/acswebinars)



[www.twitter.com/acswebinars](http://www.twitter.com/acswebinars)

LinkedIn

LinkedIn (search group for acswebinars)

Email ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

47

## The Chemistry of Motorcycles and Cars: Lighting Fires that Move Tires



**Dr. John Manka**  
Global Department Manager,  
Lubrizol Additives



**Dr. Terry Hogan**  
Senior Research Associate,  
Bridgestone



**Dr. Matt Crowe**  
Analytical Chemist, Dow  
Chemical

Slides available now! Presentation available **ONE WEEK** after the webinar:

<http://acswebinars.org/motorcycles-and-cars>

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)



# Fan of the Week

How has ACS Webinars<sup>®</sup> benefited you?



“Topics I wish I had more time to read on are encapsulated into a sixty minute time period for professional education.”

Ann M. Heos  
Quality Assurance Assistant  
Environmental Testing Services  
Geolabs Inc.  
Braintree, MA



Be a featured fan on an upcoming webinar! Write to us @ [acswebinars@acs.org](mailto:acswebinars@acs.org)

49



## The ACS International Center™ presents: Study Abroad in Japan



Featuring speakers from the **Japan Society for the Promotion of Science (JSPS)** and the **Japan Science and Technology Agency (JST)** on postdoc and professional exchange opportunities in Japan, and opportunities for you to get involved.

Wednesday, October 30, 2013  
2:00-3:00PM (EDT)

Register now at [www.acs.org/ic\\_japan](http://www.acs.org/ic_japan)

50

If you enjoyed this ACS Webinar today...  
please support the program!



[www.join.acs.org](http://www.join.acs.org)

ACS Network  
Where Chemists Connect

ACS Network (search for group acswebinars)  
[www.communities.acs.org](http://www.communities.acs.org)

Find the many benefits of ACS membership!

51

ACS Webinars® does not endorse any products or services. The views expressed in this presentation are those of the presenter and do not necessarily reflect the views or policies of the American Chemical Society.

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

52

## Upcoming ACS Webinars®

[www.acswebinars.org](http://www.acswebinars.org)



Thursday, October 31, 2013

### “Hollywood Chemistry: Science on the Big Screen”

**Dr. Jovana J. Grbić**, Biological Chemist and Founder of ScriptPhD.com

**Dr. Bill Courtney**, Chemist and Owner, Cheese-ology Macaroni & Cheese



Thursday, November 7, 2013

### “Getting the Most out of Your Mentoring Relationships”

**Dr. Donna Dean**, Director, National Institute of Biomedical Imaging and Bioengineering

**Dr. David Harwell**, Assistant Director, ACS Careers

Contact ACS Webinars® at [acswebinars@acs.org](mailto:acswebinars@acs.org)

53