



PPG Industries
Bringing innovation to the surface.™

A Materials Approach to Fuel-Efficient Tires

Timothy Okel
Peter L. Votruba-Drzal, Ph.D.
Mark Bowman, Ph.D.
PPG Industries

5/18/2012

Project ID # VS0884

This presentation does not contain any proprietary, confidential, or otherwise restricted information



Overview

Timeline

- Start: 10/01/2011
- End: 09/30/2014
- % complete: 17%*

* May 2012

Budget

- Total project funding
 - \$2,046,503 (Total)
 - \$1,485,851 (DOE)
- Funding Obligated
 - \$418,448 (DOE)

Barriers

- Barriers addressed
 - ▶ Technical Target
 - Tires for improved fuel efficiency to reduce fuel consumption by legacy vehicles
 - ▶ Technical Barriers
 - Cost and consumer adoption

Partners

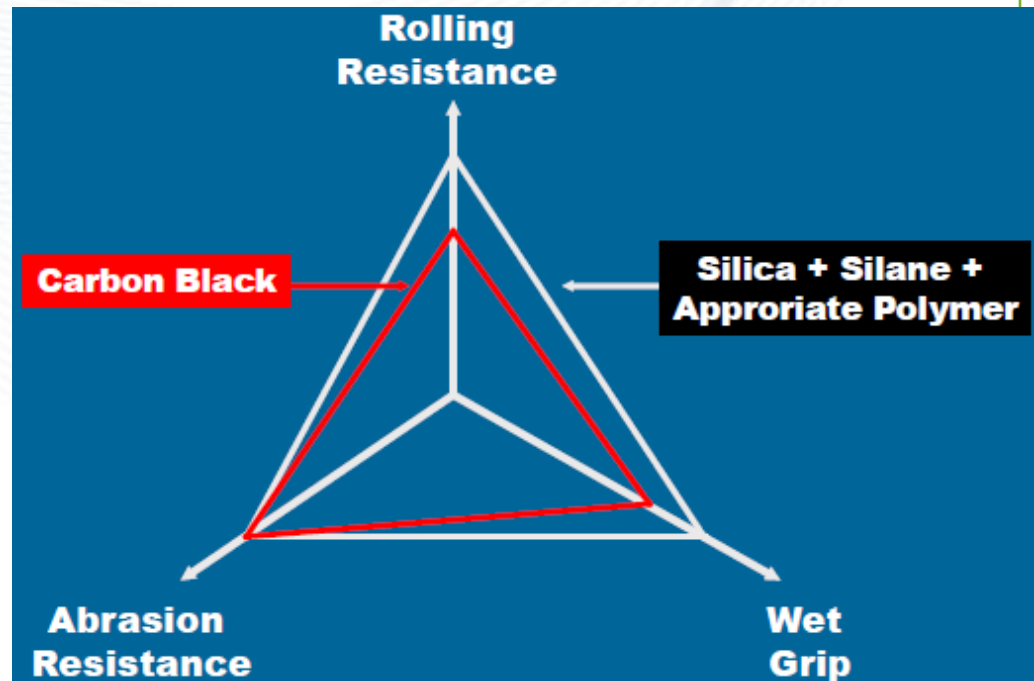
- Goodyear® Tire & Rubber Company



Relevance

■ Objectives:

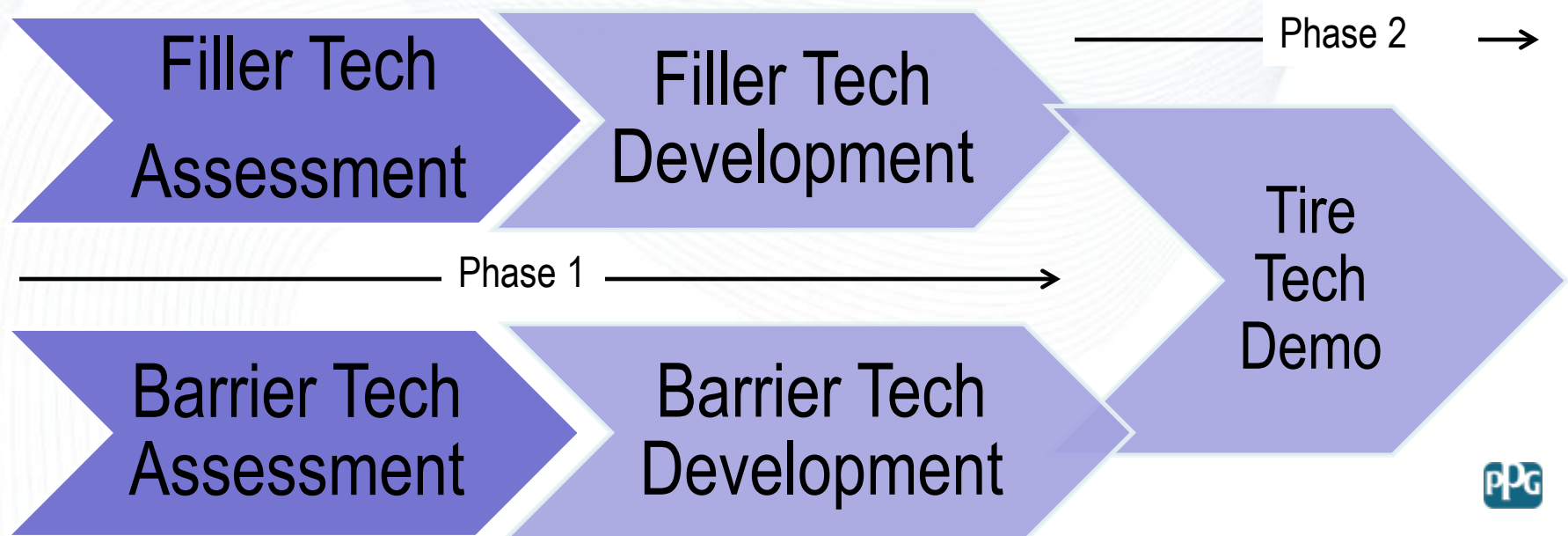
- ▶ The objective of this project is to design, develop, and demonstrate fuel efficient and safety regulation compliant tire filler and barrier coating technologies that will improve overall fuel efficiency by at least 2%.
- ▶ From the 2006 Transportation Research Board Report *
 - A 10 percent reduction in rolling resistance can reduce consumer fuel expenditures by 1 to 2 percent for typical vehicles. This savings is equivalent to 6 to 12 gallons per year.
 - A 1 psi drop in inflation pressure increases the tire's rolling resistance by about 1.4 percent
- ▶ The technologies to be researched, developed, and demonstrated under this project include:
 - Tire Filler Technology (Modified Silica-based)
 - Tire Barrier Coating Technology (Reduced Oxygen Transmission Rate) technologies.



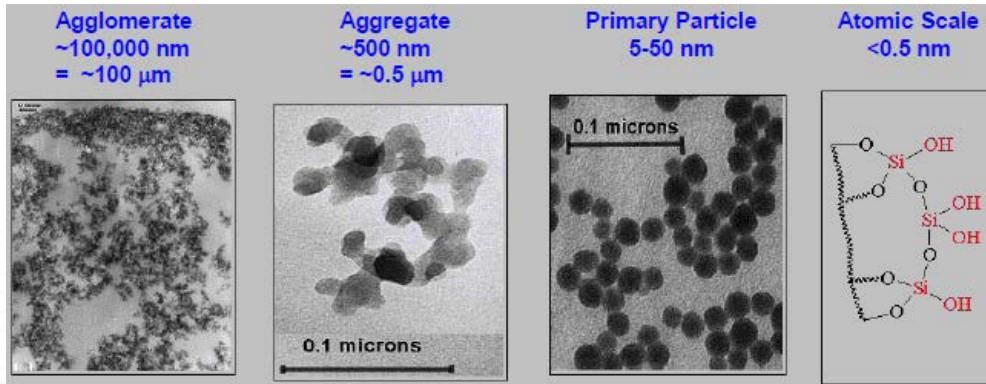
*Transportation Research Board Special Report 286, "Tires and Passenger Vehicle Fuel Economy Informing Consumers, Improving Performance", NATIONAL RESEARCH COUNCIL OF THE NATIONAL ACADEMIES, 2006

Relevance: Program Flow

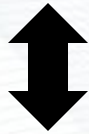
- **Phase I:** This phase will systematically evaluate the feasibility of the two technology approaches and down select candidates for Phase II development.
- **Phase II:** This phase will combine the prototypes down selected from Phase I and includes a tire build and testing scheme to validate the developed technologies.



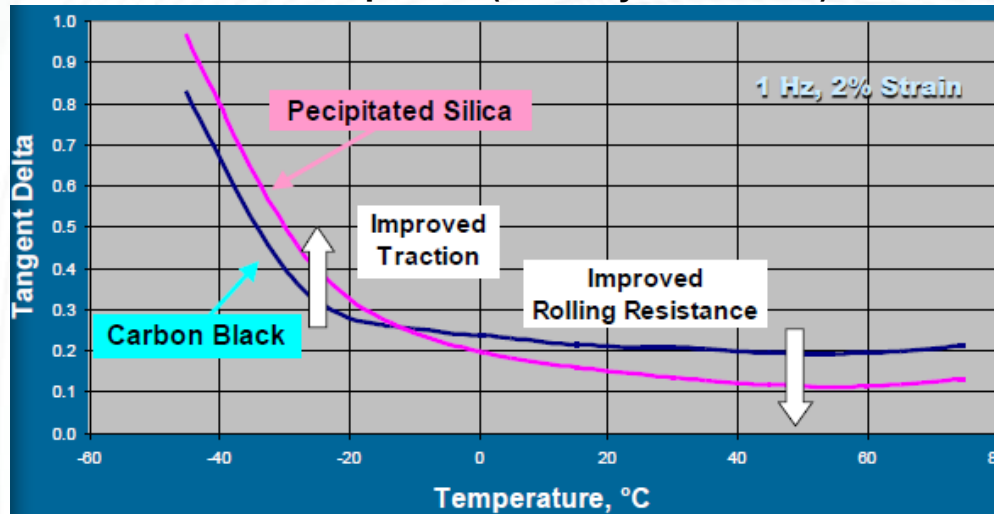
Approach/Strategy: Fillers



Silica Structure, Morphology, and Surface Functionality



Material Properties (Industry Standards)



Selection of up to five combinations of surface modifiers and underlying silica morphology that show the greatest potential for producing a novel silica-based filler enabling a 10% improvement in tread wear while maintaining the fuel efficiency improvements already demonstrated by an Agilon™ 400 reinforced passenger tread compound.



Technical Accomplishments and Progress: Fillers

Lab scale functionalization

- We have accomplished a process that enables us to functionalize a model grade of silica in a small scale reactor with compatibilizers and coupling agents.
- Experiments are underway to investigate how specific combinations of compatibilizers with a predefined specific coupling agent affect the physical properties of silica.
- Silicas are characterized by
 - ▶ Particle shape, size, and surface area
 - ▶ Microstructure (porosity)
 - ▶ Surface Functionality

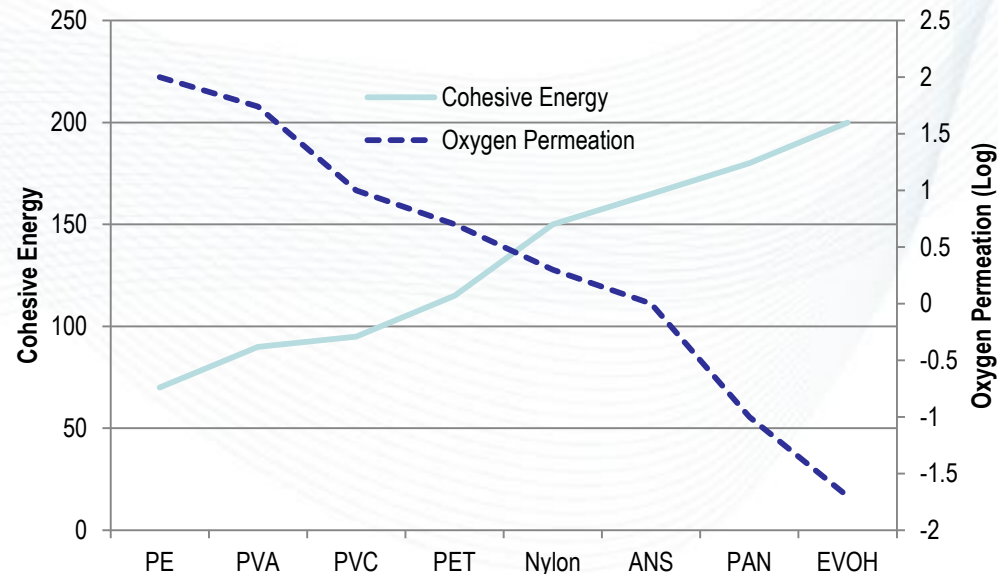
Mixing of functionalized silica within model rubber formulations

- Experiments are underway to measure effects of experimental functionalized silicas on the uncured and cured physical properties of model rubber formulations.
- Key experimental characterization includes
 - ▶ Dispersion
 - ▶ Uncured Rubber Properties (Processing)
 - ▶ Cured Rubber Properties

Approach/Strategy: Tire Innerlayer

■ Tire Innerlayer:

- ▶ Currently tire innerlayers are usually halobutyl rubber (0.75-1.5 mm thick)
- ▶ Tire innerlayer also contributes to passenger comfort (reduced noise and vibration) and tire handling characteristics
- ▶ Use PPG waterborne polyurethane dispersions (lower O_2 and N_2 solubility than halobutyl rubber)



- ▶ Incorporation of platy fillers (reduced gas permeation due to longer, tortuous path)

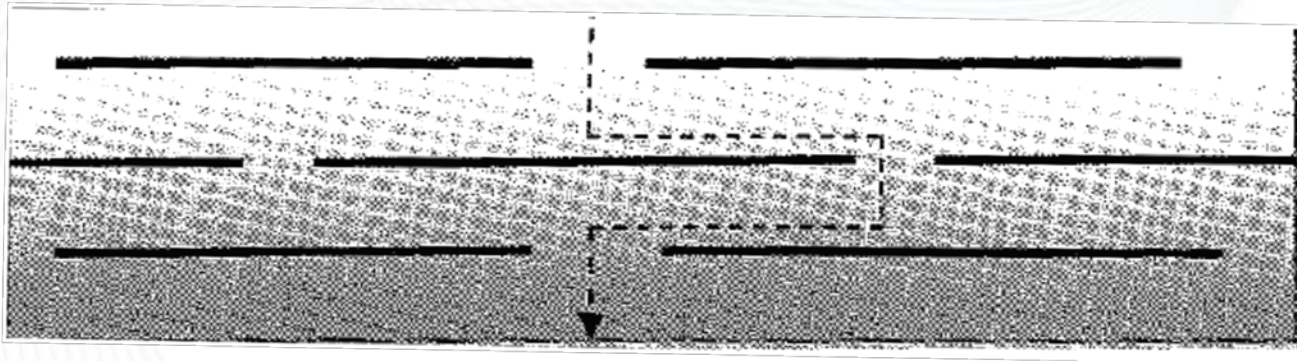


Technical Accomplishments to Date

■ Benchmarking of innerlayer films

► January 2012 – March 2012

- PPG waterborne polyurethane dispersions synthesized with zero volatile organic compounds (VOCs)
- Polymer blends of PPG's water based polyurethane dispersion and commercial elastomers successfully blended together (hydrophilic and hydrophobic elastomers usually are not compatible)
- Elasticity and oxygen permeation rates are being measured
- Successful incorporation of platy fillers with aspect ratios as high as 10,000:1



Proposed Future Work

■ Fillers

- ▶ Determine five combinations of surface modifiers and underlying silica morphology for optimum manufacturability, processing and performance.
 - Key metrics: processing, cure, dispersion, stress-strain, abrasion, and dynamic properties,
 - Milestones: Down selection of filler materials (12/31/13)

■ Coatings

- ▶ Determine design principles for oxygen barrier properties and polymer coating formulations
 - Key metrics: oxygen permeation, elasticity
 - Milestones: Down selection of coating materials (12/31/13)

■ Risk Management

- ▶ Negative impact on manufacturability
- ▶ Elasticity and oxygen barrier are mutually exclusive



Collaboration and Coordination with Other Institutions

■ Subcontractors

► The Goodyear Tire & Rubber Company

- Within the VT Program
- Goodyear will build tires for testing and evaluation of both fillers and coatings developed during this program
 - Tire Fabrication and Testing
 - Barrier Coating Testing
- Goodyear will also provide an advisory role during the program

Summary Slide

■ In the first six months of the project

■ Objective

- ▶ Design, develop, and demonstrate fuel efficient and safety regulation compliant tire filler and barrier coating technologies

■ Expected Outcome

- ▶ A tire with improved overall fuel efficiency by at least 2%
 - 15% reduction in manufacturing cost, or
 - 10% improvement in tread wear, while
 - Maintaining the fuel efficiency improvements

Technical Back-Up Slides

Key Reference

- Transportation Research Board Special Report 286,
“Tires and Passenger Vehicle Fuel Economy
Informing Consumers, Improving Performance”,
NATIONAL RESEARCH COUNCIL OF THE NATIONAL
ACADEMIES, The National Academies Press,
Washington, D.C., 2006