Silica for high performance tires

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Why sustainable mobility?

- Global trend to double the number of vehicles in the next 30 years

To meet the sustainability challenge:
- Limit the greenhouse gas emissions to sustainable levels
- Reduce conventional emissions: carbon monoxide, nitrogen oxide, VOC, particulates, plumb
- Reduce the reliance on fossil fuels, which have limited capacity

Source: “Mobility 2030” Report – Overview 2004
Interesting trends...

- Increase of around 30% in passenger cars weight in the last 20 years
- Strong growth de large vehicles in Europe
  - SUV demand doubled in 5 years
  - Small and medium-sized vehicles still have the main market share
- Dominance of large vehicles in North America
  - Strong market participation of SUV’s and pickups
  - Reduction of small and medium SUV’s

<table>
<thead>
<tr>
<th>Year</th>
<th>Golf I</th>
<th>Golf II</th>
<th>Golf III</th>
<th>Golf IV</th>
<th>Golf V</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974-1983</td>
<td>750 kg</td>
<td>900 kg</td>
<td>1,000 kg</td>
<td>1,080 kg</td>
<td>1,150 kg</td>
</tr>
<tr>
<td>1983-1990</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991-1996</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1997-2002</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2003-…</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Tires rolling resistance is a vital factor in the reduction of fuel consumption and emissions.

Rolling resistance: > 20% of the resistance forces of a tire.

Fuel

CO2 emissions (+ CO, NO\textsubscript{x}, …)

• To move a vehicle, four resistance forces have to be overcome:
  • Vehicle inertia
  • Aerodynamics project
  • Vehicle inner losses
  • Tire rolling resistance

Source: Factbook Michelin; Pre-Consultant BV, Method Eco-Indicator 99
Regarding the tire lifecycle, the silica environmental impact is lower than carbon black

Analysis of the standard European car tire lifecycle

- The utilization phase has the higher contribution for the environmental load in a car tire lifecycle.
- The most important aspect is the fuel consumption that can be attributed to rolling resistance, approximately 20%.

➔ For 1 metric ton of CO2 emitted during the production of high-performance silica, the Rhodia technology contributes to save 40 metric tons of CO2 for the community.

Source: Factbook Michelin; Pre-Consultant BV, Method Eco-Indicator 99
Two kinds of precipitated silica applications in tires

Silica for “Green Tires”
• reinforcement load for running tread
• passenger car tires
• high silica content (> 40 phr or >50% of total reinforcement load)
• needs aligned with the use of high performance silica

Silica for traditional applications
• running band, body, belts
• passenger car tires & truck tires (tear resistance and stone chip resistance, grip)
• low silica content
• these properties can be achieved through the application of conventional silica
Silica dispersibility in rubber: a feature needed for reinforcement

- Limitation of silica use due to a reinforcement issue caused by the low dispersion level of the load itself, and also the good interaction between the rubber hydrocarbon chains (SBR, NR, or BR) and the silica hydrophilic surface
- The “highly dispersible silica” became a worldwide reference of low tire rolling resistance with no damage to reinforcement (abrasion resistance)

Dispersibility characterization

Dispersibility characterization

Granulometry in water after US treatment
Silica aggregate
The “Green Tire” Concept: reduces the tire rolling resistance without performance loss

• Combining a specific synthetic rubber and a coupling agent like silane, in early 1990’s, Rhodia launched a new silica for “Green Tires” technology

• Increase of silica use based on the search for a better performance of tires and automobiles, causing a significant development of know how of the silica compounds processing
Safety is compatible with low energy consumption tires

• The tires that have high wet braking can also have high rolling resistance
• Performance increased by technology (project, materials)

• Consequences on the separate features of ABS
  • Viscoelastic behavior controls the grip level
  • Silica reinforced running treads are more flexible dynamically and achieve a larger contact area

Source: DIK - Deutsches Institut für Kautschuktechnologie e.V
Nearly 20 years of sustained cutting-edge silica technology for tires

On the 5 year horizon, our innovation resources should be prioritized on product extensions and key breakthrough projects such as Truck tire

Rhodia invests in highly dispersible silica

1992

High surface
Improved sport handling

Low surface
Better processing & improved wet grip

2008

Improved wear & rolling resistance

2015

New generation products
• Ultra low rolling resistance
• Easy mixing

Solution for truck tires

Breakthrough process innovation
• Improvement in capital efficiency

Source: Rhodia Silica, IRC Brazil, June 2011
Meeting customers needs: 2 major site expansion in 2011 bringing our total worldwide capacities to 420 kT

**Additional capacity**
38 kT

**Precipitated silica**

**Highly dispersible silica (HDS)**

**Global research**
8 factories and 4 R&D centers

**Market positioning**

 nº 1 Tire silica

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**Reserve markets**

% WW Capacity

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**Source:** Rhodia Silica, IRC Brazil, June 2011
# Rhodia HDS portfolio

## Highly dispersible silica

<table>
<thead>
<tr>
<th>Name</th>
<th>Zeosil®1085Gr</th>
<th>Zeosil®1115MP</th>
<th>Zeosil®1165MP</th>
<th>Zeosil®Premium200MP</th>
<th>ZHRS®1200MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspect</td>
<td>White micro-granulate</td>
<td></td>
<td>White micropearl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>France</td>
<td>South Korea</td>
<td>EU: FR, I/USA/Asia: SK CN</td>
<td>France</td>
<td>Italy</td>
</tr>
</tbody>
</table>

### Typical analysis

<table>
<thead>
<tr>
<th>CTAB (m²/g)</th>
<th>80</th>
<th>110</th>
<th>160</th>
<th>200</th>
<th>195</th>
</tr>
</thead>
<tbody>
<tr>
<td>BET (m²/g)</td>
<td>90</td>
<td>115</td>
<td>165</td>
<td>215</td>
<td>200</td>
</tr>
</tbody>
</table>

| Processing | 5 | 4 | 3 | 2 | 1 |
| RR         | 5 | 4 | 3 | 4 | 2 |
| Handling   | 1 | 2 | 3 | 4 | 5 |
| Wear       | 1 | 2 | 3 | 5 | 4 |
| Dry Grip   | 1 | 2 | 3 | 3 | 3 |
| Wet Grip   | 5 | 4 | 3 | 2 | 2 |
| Ice/Snow   | 5 | 4 | 3 | 1 | 2 |

### Example of associated tire range

- Tires with high wet/snow/ice grip (winter tire)
- Fuel efficient tires, Asia standards OE+ (RT)
- Fuel efficient tires West EU & USA standards OE+ (RT)
- New generation fuel efficient tires (EU/labelling)
- UHP tires

* Source: Rhodia Silica, IRC Brazil, June 2011

* High aggregate size
Rhodia is committed to reducing fuel consumption & greenhouse gas emission

• Since the start of silica use in “Green Tires”, in the early 1990’s, Rhodia facilities produced more than 800,000 metric tons of silica for the tire industry

• Rhodia technology contributed to:
  • The reduction of fuel consumption equivalent to 50 billion liters
  • The reduction of 50 mm tons of CO2 emissions – the equivalent to the carbon absorbed by 1.25 billion trees in a year
  • (Based on the global model according to which 20% lower rolling resistance reduces 5% of CO2 emissions)

Source: Rhodia Silica, IRC Brazil, June 2011
« Let’s innovate for sustainable performance »