Tire release agents

Bluestar Silicones’ release agents can be used to improve productivity in tire curing

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Green tire curing is performed in heating presses, usually equipped with metal molds to shape the tires’ outsides during vulcanization, and inflatable rubber bladders to shape the inside of the green tires and press the tires against the metal mold.

At the interface of the metal mold/cured tire, the use of release agents is limited to certain cases – for example, with winter tires made of specific, sticky compounds, tires that have 3D tread designs, or tires with soft sidewall rubber. In most cases, modern tire tread formulations do not require the use of release agents.

At the interface of the tire/inflatable rubber bladder, the release is much more critical: without the use of a release agent, tire rubber and bladder rubber would certainly stick together after curing.

Depending on the tire plant organization, inside tire release agents are applied either on the inside of the green tire or on the inflatable bladder. Some plants use release agents that are efficient only for a single release; others prefer agents that allow for several successive releases.

Bluestar Silicones has developed a range of products that provide the best solutions for its customers’ needs.

The design of Bluestar Silicone’s new generation of multi-release inside paints has enabled its customers (tire producers) to improve productivity through defect rate reduction and reduced bladder release treatment frequency.

Bladder release agents

There are three types of bladder release agents: single-release, multi-release and semi-permanent.

Standard single releases may be classified as non-reactive systems. These are sprayed on every green tire. They do not provide any special bladder protection.

Reactive single releases contain reactive functions that allow the release agent film to stick to the bladder surface, thereby helping to protect the bladder surface from chemical and mechanical aggressions.

Multi-release agents allow for 2-12 releases per application. When sprayed on the inner liner of the tire, they transfer during curing to the bladder surface and remain there to insure the subsequent tire curing cycles without need for reapplication of release agent. The release film then has to be refreshed after the optimized number of release cycles by means of curing another treated tire. The advantage is that the release agent is applied outside the tire press area, keeping the production area free of unwanted release agent deposits.

Semi-permanent, multi-release agents are mainly applied directly to the bladder surface and include reactive functions that allow for a prolonged presence of the release agent on the bladder surface. This may allow up to 24 releases, so they have to be applied twice-per-shift in a typical passenger car tire production. The risk here is that the release agent drips into, or settles in, the mold during application. The mold should therefore be protected during this step.

How does the multi-release agent work?

Tire production is a several-step process. The last transformation is the curing of the green tire. A lot of value would be lost if this step malfunctions. An efficient release agent helps to provide the best-possible curing conditions.

A multi-release agent is applied on the inside of the green (uncured) tire. This side is going to be in contact with the inflatable bladder. The green tire (uncured) is then placed in the cavity of the heating press. The mold closes and the bladder starts to inflate.

During bladder inflation, the release agent film to stick to the bladder surface, thereby helping to protect the bladder surface from chemical and mechanical aggressions.

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During bladder inflation, the release agent has to promote lubrication and air bleed. The lubrication or slip effect of the release agent allows for perfect bladder centering inside the tire. This is necessary to achieve perfectly symmetrical tires. This function also
helps to avoid buckled and pinched bladder defects. This is particularly important when the bladder/tire size fit is not perfect. It also helps with optimum bladder positioning when the bladder size naturally increases in operation due to aging at elevated numbers of release cycles.

An efficient slip/lubrication effect is obtained with release agent films providing low coefficients of friction.

The air bleed is an important performance parameter. A release agent should promote air evacuation. When the bladder inflates inside the tire, it replaces the present air volume. This air volume has to be evacuated completely; remaining air bubbles would cause ‘trapped air defects’. These are depressions (‘blister’) in the tire inner-liner layer. In these areas, the inner-liner rubber layer becomes very thin or even non-existent. So tire inflation gas (air or nitrogen) will leak in these areas. Diffusion into the upper tire rubber layers will occur and may lead to delamination effects.

To avoid this, tire manufacturers create bladder surfaces presenting drain channels starting in the middle of the bladder and going to the toe. Between the channels, the bladders are often given an ‘orange peel’ structure that allows air to drain sideways into the evacuation channels. To further improve the air evacuation performance, the release agent should bring about a rough surface micro-structure. This allows for additional evacuation channels for otherwise remaining trapped air volumes.

When the metallic mold is closed and the bladder is fully deployed, the temperature is raised to up to 200°C. During this phase, the release agent must be resistant to the temperature and must transfer, from the inner liner of the tire, onto the bladder. Thermal resistance is required in the formulation of a bladder release agent, which must be able to withstand high temperatures. Occurrence of ash and gaseous degradation products at the bladder/inner-liner interface must be avoided.

Transfer is important, too, when the release agent is applied on the tire’s inside. In this case, the release agent has to transfer from the tire to the bladder during curing. Such transfer is mandatory for multi-releases. It ensures the release of the following tires, which are not treated with fresh release agent. In the latest generation of release agents, the transferred film also helps protect the bladder surface against erosion.

The tire cures in the closed press, with the bladder fully deployed and under pressure by water vapor at about 200°C. During this step the tire must not stick to the bladder. The release agent film forms the necessary barrier between both.

The anti-stick effect of the release agent is ensured by the creation of a continuous separation layer between bladder and inner liner of the tire. This is a major function.

### Table 1: Bluestar Silicones – Lyndcoat tire release product range

<table>
<thead>
<tr>
<th>Lyndcoat</th>
<th>Transparent</th>
<th>Filled</th>
<th>Single release</th>
<th>Multi-release</th>
<th>Viscosity [mPas]</th>
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<tr>
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<td>X</td>
<td></td>
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<td></td>
<td>X</td>
<td>(X)</td>
<td>1600</td>
</tr>
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<td>(X)</td>
<td>1600</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
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<td>X</td>
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<td></td>
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</table>

Notes: Bluestar Silicones tire release product range (Lyndcoat trademark) is exclusively composed of water-based low VOC formulations. Bluestar offers non-filled and filled single releases and multi-releases, bladder coating and mold releases. The filled multi-release range is a proprietary technology of Bluestar Silicones.
of a bladder release. If the layer has defects, the tire will cure onto the bladder rubber, rendering the separation of the two impossible without destructive rupture.

After curing, the bladder deflates. The release agent has to ensure the anti-stick function, allowing the bladder to part from the tire.

The mold is then opened and the bladder fully retreats to allow the tire to be retrieved. Here, the release agent has to ensure a slip function again – between tire and retreating bladder.

Multi-release agents are not applied on every tire. The full process, as already described, must be efficient throughout the following curing cycles without fresh release agent treatment – i.e. the release agent treatment must have high durability.

The durability of the release agent layer is what makes the product a multi-release, meaning there is no need to treat every tire. The release agent that has been painted on the tire’s inner liner transfers to the bladder and refreshes the release layer remaining on the bladder surface. The freshly transferred release agent cures during tire curing. This allows for replenishment of the release layer on the bladder. This then allows for a number of non-treated tires to be cured. The more durable these release agents are, the lower the number of tires that have to be treated. This allows for reduced occupation of the spray application system. In many cases, the use of multi-releases avoids costly investment in additional spray systems.

**Increased productivity**

Very often, the release agent application step limits the tire production cycle and requires important investment to increase capacity. In order to overcome this or to avoid investment, Bluestar Silicones’ latest generation Multi-release Inside Paint Lyndcoat BR2512 has been developed.

It helps customers to improve their productivity without the need for investment.

During the development of Lyndcoat BR2512, Bluestar concentrated on combining improved durability with high air bleed and excellent slip, giving access to reduced defect rates and improved bladder life.

In addition to these productivity improvements, Bluestar Silicones has also focused on the cost of the release agent treatment with a reduction in the weight of the coat, while still offering high performance.

This insures a direct benefit for customers due to reduced release agent consumption and significant savings in occupied warehouse space and internal transport.

**Durability versus air bleed**

Most available multi-release agents are materials that do not contain any filler. This is to get maximum durability from the bladder release. Fillers that are large render the coating less resistant mechanically and therefore reduce the number of tires that can be molded per release agent application.

However, this also has a downside. Without fillers, it is hard to achieve a high surface roughness of the coating. But this roughness is needed to ensure efficient air bleed promotion. This is why, in many cases, multi-release or semi-permanent bladder coatings do not perform well on high-performance tires that have a low sidewall and a square design, making air evacuation difficult in the shoulder region.

In these cases, tire manufacturers most often prefer filled single releases that give them the necessary additional bladder surface roughness to ensure air bleed.
According to test results shown in Figures 4 and 5, Lyndcoat BR2512 gives the best compromise between durability and air bleed. This technology is illustrated in Figure 6, which compares the untreated bladder surface with the Lyndcoat BR2512 coated part of the bladder surface (excessive thickness for visual effect).

A confocal laser scanning microscope scan determined the peak surface roughness to be approximately 6µm (Figure 7).

**Reduction of defect rate**
If performance evaluation in the laboratory showed excellent results for Lyndcoat BR2512 in terms of possible release cycles, slip effect, air evacuation promotion, film elasticity and ease of application, then nothing could better document product performance than a production trial.

Figure 8 sums up the essential data of a factory trial comparing Lyndcoat BR2512 bladder release with a non-filled, multi-release material.

Due to excellent filler bonding in the Lyndcoat BR2512 layer, the 'foreign object' defect is no higher than with a non-filled bladder release.

The reduction in trapped-air defects is impressive. The filler clearly helps increase the surface roughness of the bladder surface, which is responsible for efficient air evacuation.

The low level of 'off center' defects shows the excellent slip effect that Lyndcoat BR2512 provides.

**Bladder life extension**
Multi-release agents are, in most cases, emulsions of reactive silicones that graft onto the bladder surface and create a thin protective coating. This coating protects the bladder surface against abrasion, oxidation and compounds migrating from the tire rubber. The bladder release thereby increases the bladder life, when compared with a non-reactive single release.

It is important to ensure this protective effect right from the start-up of a fresh bladder in a press. It is therefore recommended to treat the fresh bladder with a bladder coating, or simply with a first layer of the bladder release agent, which will then be employed as an inside paint.

It is possible to obtain a 20% bladder life increase using this method. This means reduced costs for bladders, but most of all reduced downtime of the tire curing presses.

As shown in Figure 8, a reduced amount of bladder-leak-related defects demonstrates the high level of bladder protection conferred by the Lyndcoat BR2512 release layer.

**Coat weight**
Green tires are typically treated with comparable amounts of performing multi-release agents, as would be the case with single release inside tire release agents.

For a passenger car tire, treated in a standard air spray cabin, this amount is typically 8-15g wet weight emulsion.

Figure 9 compares the typical thickness for several multi-release inside paints. Lyndcoat BR2512 is very efficient, even at very low coat weight, and is easy to apply by spray. The operators can optically verify the homogeneity of the coating after spray application as the wet film has a whitish color. The correctly applied film then becomes translucent when dry.

Excessive product application, as seen in Figure 10, is easy to determine because of the white layer it forms. A dried film of excessive thickness, also shown, is grey, as opposed to a thin film being translucent.

**Conclusion**
An analysis of market needs has shown a strong demand for productivity improvement within customer sites. The challenge for Bluestar Silicones was to propose a new multi-release agent, with improved properties, that allows customers to decrease their costs, and gives the best possible compromise between durability, slip and air bleed, resulting in very low defect rates and high bladder life extension.