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Understanding 6PPD and 6PPD-Quinone

What Is 6PPD? What Is 6PPD-Quinone?

6PPD is a chemical compound that has been used in tire manufacturing for decades. Its primary job is to act as an anti-degradant, protecting tire rubber from breaking down when exposed to ozone, oxygen, and ultraviolet light. This protection is crucial for tire safety and longevity – without 6PPD, tires would crack and deteriorate much more quickly, potentially causing dangerous blowouts on the road.

When 6PPD is exposed to ozone, it undergoes a chemical transformation that creates 6PPD-quinone, often abbreviated as 6PPD-Q. By reacting with 6PPD to form 6PPD-Q the tire rubber is protected from cracking and deterioration. Over time, as the tire surface with 6PPD-Q is worn away by contact with the road, additional 6PPD migrates from the interior of the tire rubber to the surface ensuring the surface remains protected.

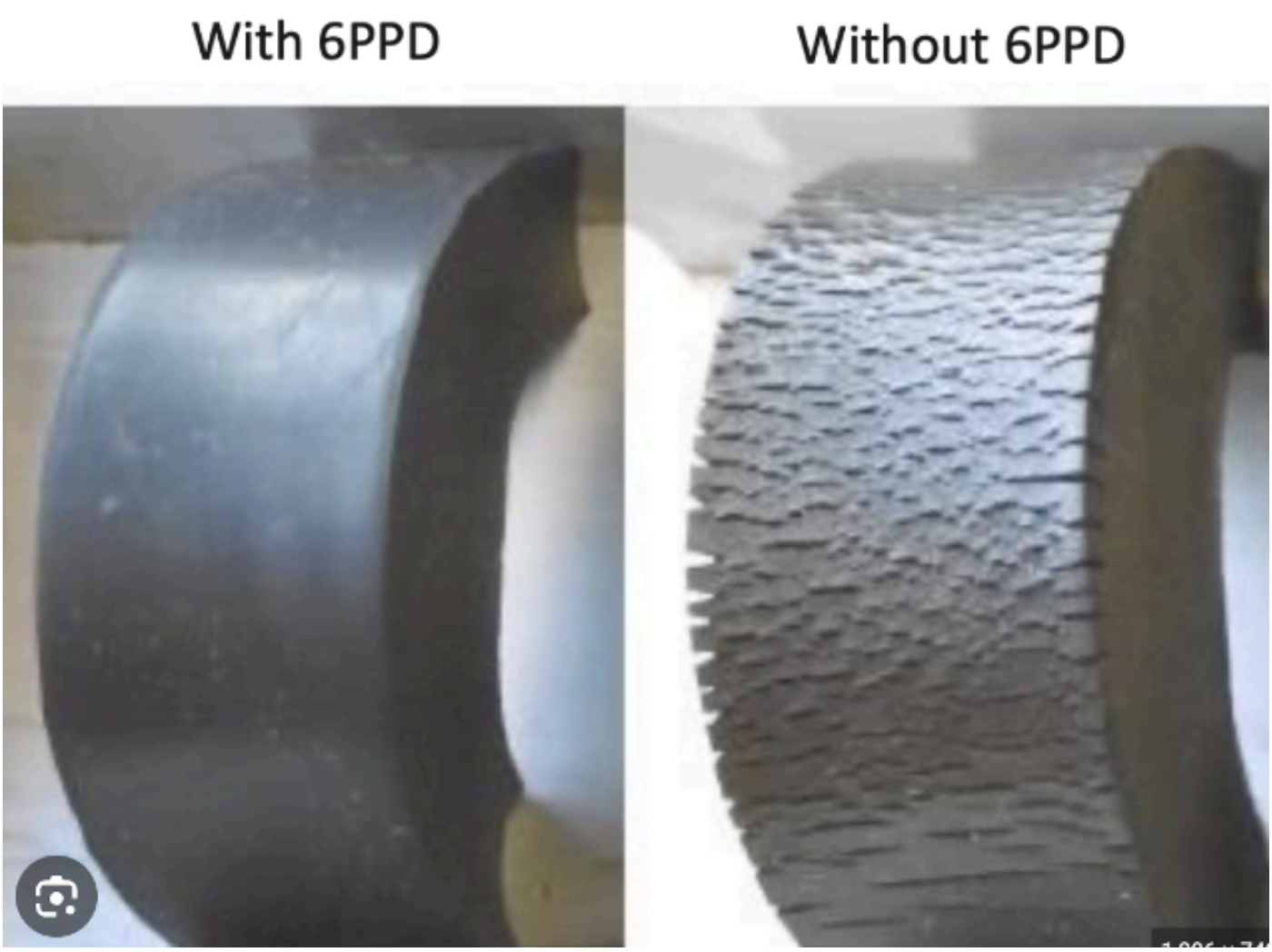

Figure 1: Credit USTMA: https://www.ustires.org/6ppd-tire-manufacturing

The discovery of 6PPD-Q as an environmental concern is relatively recent. In 2020, researchers in Washington State identified 6PPD-Q as the chemical responsible for significant deaths of coho salmon in laboratory studies. Scientists had observed that coho salmon were dying before they could spawn, particularly in streams near busy roads, and recent research suggest that 6PPD-Q could be a contributing factor to this observed mortality, along with other factors such as increased stream temperatures and urban development.

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particles generated during driving."

What makes this discovery particularly significant is how much we still don't know about 6PPD and 6PPD-Q. While we understand from laboratory studies that 6PPD-quinone is toxic to coho salmon—the exact mechanism of this toxicity remains unclear. Surprisingly, some other types of salmon, such as chinook and sockeye salmon, aren't affected by 6PPD-Q in laboratory studies. Researchers are still investigating factors that influence how 6PPD transforms in the environment, how quickly it breaks down, and whether it accumulates in living organisms over time.

6PPD is present in virtually all motor vehicle tires manufactured today. However, the primary way this chemical enters the environment is through tire wear particles generated during driving. Tires are designed to grip the road surface. Every time a vehicle accelerates, brakes, or turns, tiny particles of tire rubber are abraded off and released into the environment.

What Does It Have To Do With Recycled Rubber?

The connection between 6PPD and recycled rubber products is important to understand because many recycled rubber applications are made from tire rubber. The tire recycling industry has created a valuable environmental success story, diverting hundreds of millions of tires from landfills each year. Instead of taking up space in landfills or illegally dumped in the environment, these tires are processed into products like fuel, aggregate, athletic and playground surfaces, and manufactured goods.

This recycling effort represents a significant environmental achievement. Tire recycling and reuse diverts more than 200 million tires from landfills annually in the United States alone. This has reduced the tire dumps and stockpiles that once plagued communities —from 1 billion tires stockpiled in the United States, that number has been reduced to less than 50 million today. Tires not properly managed are a fire risk to local communities, take up valuable landfill space, and serve as a breeding ground for mosquitos and other pests.

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While recycled rubber products do contain 6PPD, recycled rubber typically contains many times less 6PPD than new tires. According to research, and the states of California and Washington, an end-of-life tire has 10 to 20 times less 6PPD than a new tire. This reduction occurs because as tires age, the 6PPD added during manufacturing migrates to the tire surface and reacts with ozone, depleting the original chemical content. That means by the time a typical end-of-life tire arrives for recycling, much of the 6PPD has been expended.

Perhaps more importantly, recycled rubber products are fundamentally different from tire wear particles, which are the primary source of 6PPD and 6PPD-Q in the environment. The size, use, and location of recycled rubber applications create fewer potential pathways for any entry into the environment. Unlike tire wear particles that are continuously generated and enter surface water bodies through stormwater runoff, recycled rubber does not experience the same type of wear and does not release the same types or amounts of chemicals. Additionally, research indicates that 6PPD-Q binds with soil, further limiting its mobility to enter waterways at all.

Additionally, some recycled rubber applications actually help solve the 6PPD problem. Rubberized asphalt, for example, has been shown to act as an environmental sink for 6PPD compounds—meaning it absorbs more of the chemical than typical asphalt roads. Research has demonstrated that rubber-modified asphalt can absorb and retain 6PPD-Q released by tires on roadways, according to a report by the University of Nevada Reno.

What's The Solution?

The long-term solution to 6PPD concerns lies in the alternatives analysis being led by tire manufacturers in collaboration with California and other states. A global consortium of 30 tire manufacturers has been working to identify safer alternatives to 6PPD that

perform as well or better in terms of tire safety. Their preliminary assessment evaluated over 60 potential alternatives and identified seven that warrant further evaluation. This represents the largest collaborative effort in the tire industry's history to find safer alternatives to an essential tire component.

The recycled rubber industry fully supports these alternatives analysis efforts. As safer alternatives to 6PPD are developed and implemented in new tire manufacturing, the recycled rubber products made from future end-of-life tires will contain even lower levels of compounds. This creates a positive cycle where improvements in tire manufacturing benefit both new tires and the recycled products made from them years later.

While tire manufacturers and states like California and Washington focus on chemical alternatives, we should remember that end-of-life tires contain much lower concentrations of the compounds that create environmental problems. By the time tires reach the end of their useful life, much of the original 6PPD has already been consumed in its protective role or has migrated out of the tire structure.

> “Recycled rubber applications are not exposed to the same dynamic conditions that create tire wear particles during vehicle operation. ”

The potential creation of 6PPD-quinone and its entry into the environment through recycled rubber products follows very different pathways than tire wear particles. Recycled rubber applications are not exposed to the same dynamic conditions that create tire wear particles during vehicle operation. They don't experience the continuous abrasion, heat, and ozone exposure that occurs when tires roll on roads. This means they likely don't generate the same types of particles or release chemicals in the same way.

The recycled rubber industry continues to provide crucial environmental benefits by keeping tires from being dumped illegally or placed in landfills.

While we continue to learn more about 6PPD and its environmental impacts, the evidence clearly shows that recycled rubber products are part of the solution. They contain lower concentrations of 6PPD compounds and in some cases actually help capture and contain 6PPD compounds that would otherwise enter the environment. Most importantly, they represent a successful model of circular economy thinking that keeps valuable materials in use while reducing environmental burdens.

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Containing Crumb Rubber

The Recycled Rubber Coalition