Preliminary Alternatives Analysis Report

N(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD)

Specialty Tires of America

Prepared by:

David Auffenberg

Manager, Performance and Special Tire Projects

Specialty Tires of America

Date: March 26, 2024

Table of Contents

Tables 5

Figures 6

Acronyms and Abbreviations 7

Executive Summary 8

1.0 Preparer Information 10

2.0 Responsible Entity and Supply Chain Information 12

3.0 Priority Product Information 13

3.1 Chemical of Concern for Priority Products 14

3.2 Priority Product Function 14

3.3 Priority Product Performance 14

3.4 Priority Product Legal Requirements 15

3.5 Role of the Chemical of Concern 15

3.6 Is the Chemical of Concern or Alternative Replacement Chemical(s) necessary? 15

3.7 Material Safety Data Sheet for 6PPD 15

4.0 Scope of Relevant Comparison Factors 16

4.1 Alternatives Analysis Approach 16

4.2 Life Cycle Segments 17

4.2.1 Raw materials extraction 17

4.2.2 Resource inputs and other resource consumption 17

4.2.3 Intermediate materials processes 17

4.2.4 Manufacture 17

4.2.5 Packaging 17

4.2.6 Transportation 17

4.2.7 Distribution 17

4.2.8 Use 17

4.2.9 Operation and maintenance 17

4.2.10 Waste generation and management 17

4.2.11 Reuse and recycling 17

4.2.12 End-of-life disposal 17

4.3 Relevant Factors 21

4.3.1 Adverse environmental impacts 21

4.3.2 Adverse public health impacts 21

4.3.3 Adverse waste and end-of-life effects 21

4.3.4 Environmental fate 21

4.3.5 Materials and resource consumption impacts 21

4.3.6 Physical chemical hazards 21

4.3.7 Physicochemical properties 21

4.4 Exposure Pathways 34

4.4.1 Chemical Quantity 34

5.0 Scope and Comparison of Alternatives 35

5.1 Alternatives Considered 35

5.1.1 Removal of Chemical of Concern 35

5.1.2 Change of Tire Design/Manufacturing of Priority Products 35

5.1.3 Currently Available Antidegradant Chemicals 36

5.1.4 Development of New Antidegradant Chemicals 37

5.2 Rationale for Alternatives not Selected 38

5.2.1 Removal of Chemical of Concern 38

5.2.2 Change of Tire Design/Manufacturing of Priority Products 38

5.2.3 Currently Available Antidegradant Chemicals 39

5.2.4 Development of New Antidegradant Chemicals 40

5.3 Comparison of Chemical(s) of Concern and Alternative Replacement Chemical(s) 40

5.3.1 Alternative Chemicals Eliminated From Further Evaluation 40

5.3.2 Alternative Chemicals Warranting Further Evaluation 43

5.3.3 New Material Development 43

6.0 Selected Alternative(s) 43

7.0 Work Plan 44

7.1 Discussion of Proposed Tasks for Generating the Final AA Report 44

7.1.1 Lignin/Graphene 44

7.1.2 New Material Development 44

7.2 Alternatives Development Timetable 44

7.2.1 Lab Study Evaluation 44

7.2.2 Plant Mixing Trials 45

7.2.3 Manufacturing Tires for Lab/Field Evaluation 45

7.2.4 Lab Testing of Tires 45

7.2.5 Field Evaluation of Tires 45

7.3 Final AA / Progress Report 45

REFERENCES 46

APPENDICES 48

TABLES

Table 3.1	Priority Products from Specialty Tires of America that contain 6PPD	13
Table 4.1	Life Cycle Relevant Factors Identified in SCP Regulation	18
Table 4.2	Consideration of Potentially Relevant Factors Identified in SCP Regulation	22
Table 5.1	Currently Available Antidegradant Chemicals	36
Table 5.2	Currently Available Antidegradant Chemicals GreenScreen BM Score	39
Table 5.3	GreenScreen Summary of Possible 6PPD Alternatives	41

FIGURES

Figure 4.1 Exposure Model 34

Acronyms and Abbreviations

6PPD - N(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine

6PPD-Q - N(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine quinone

CBI – Confidential business information

ECE – Economic Commission for Europe

EPDM – Ethylene propylene diene monomer

FMVSS – Federal Motor Vehicle Safety Standards

MSDS – Material Safety Data Sheet

NHTSA – National Highway Traffic Safety Administration

STA – Specialty Tires of America

USDA-ARS – United States Department of Agriculture Agricultural Research Service

USGS – United States Geological Survey

USTMA – United States Tire Manufacturers Association

Executive Summary

Specialty Tires of America has been in business for over a century making a wide variety of tires specializing in short manufacturing runs servicing a vast array of niche markets around the world. With our small volume runs and the scope of this regulation focusing on DOT tires in the state of California, our production of tires covered by this regulation has historically been extremely small. For example, in 2023, we manufactured less than 300 tires with 6PPD that were sent directly to dealers in California and estimate that approximately only 35 pounds of 6PPD was introduced into California as tire wear particles. Our position in the tire industry is such that we will be following the lead of the major tire manufacturers regarding the use of rubber antidegradants in tires.

This Preliminary Alternatives Analysis report was prepared to lay out the initial approach for replacement of N(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine (6PPD) which has been deemed a Chemical of Concern by the California Department of Toxic Substances Control (DTSC). 6PPD has been used in the tire industry for decades as an antidegradant material to combat the effects of ozone, oxygen, heat and tire flexing. These four effects can lead to premature age/weather cracking, potential safety issues, and significantly shorter tire life. Research conducted in the last few years has shown 6PPD and one of its by-products, 6PPD quinone (6PPD-Q) to have toxic effects on aquatic life, particularly coho salmon. This research has prompted California to establish this regulation and has started the work on finding a 6PPD replacement. This report was written with a combination of information that is readily available in the public domain, along with the technical experiences of associates of Specialty Tires of America (STA).

Section 1 of this report details those members that were involved in putting this report together. Section 2 lists those distributors that we sell to and ship directly to in the state of California. This information in Section 2 is considered confidential business information. Section 3 lists the specific brands and tire types of priority products that STA manufacturers that contain 6PPD. In addition, this section details the function and performance characteristics of tires and the primary role of 6PPD, which is as an antidegradant material to improve the life and safety of tires.

Section 4 discussed the relevant factors that are deemed to be important during the life cycle of the priority product and why they are relevant. Also, this section laid out the approach to the alternatives analysis and the 4 areas that were considered for this report. Those four areas were 1) Removal of 6PPD with no replacement, 2) Manufacturing/Design changes to eliminate 6PPD, 3) Substitution with a different commercially available material, and 4) Development of a new material. In Section 5, these 4 areas were discussed, and the rationale used to eliminate #1, #2, and several of the commercially available materials in #3. A couple of materials in #3, lignins and graphene, should be further investigated as possible alternatives. The most likely alternatives will

come from #4, development of a new material. These selected alternatives were reviewed in Section 6. Section 7 detailed those steps in the work plan and timing associated with each of those steps.

The most likely scenario points to a new material being developed to replace 6PPD. The replacement of 6PPD comes down to two major objectives as alternatives are evaluated. First, a substitute material must eliminate the toxicity issues that 6PPD has shown, without introducing other negative effects. Secondly, the substitute material must have the same level of antidegradant performance as 6PPD. Both objectives are equally important and can be met with the collaborative efforts of all the stakeholders involved with this challenge.

1.0 Preparer Information

Responsible Entities Information:

First Name	**David**
Last Name	**Auffenberg**
Job Title	**Manager, Performance and Special Tire Projects**
Company	**Specialty Tires of America, Inc**
Business Type	**Manufacturer**
Email	**dauffenberg@stausaonline.com**
Phone	**724-349-9010 Ext 3209**
Website	**www.stausaonline.com**
Address	**1600 Washington Street Indiana, PA 15701-2844**

First Name	**Don**
Last Name	**Mateer**
Job Title	**CEO**
Company	**Specialty Tires of America, Inc**
Email	**dmateerIII@polymerenterprises.net**
Phone	**724-349-9010**
Address	**1600 Washington Street Indiana, PA 15701-2844**

First Name	**Thomas**
Last Name	**Schultz**
Job Title	**Legal Counsel**
Company	**Specialty Tires of America, Inc**
Email	**tschultz@polymerenterprises.net**
Phone	**724-349-9010**
Address	**1600 Washington Street Indiana, PA 15701-2844**

CERTIFICATION AND SIGNATURES

"I certify that this document and all attachments were prepared or compiled under my direction or supervision to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person(s) directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that submitting false information or statements is a violation of law."

Responsible Entity Signature  **,CEO** **Date: March 26, 2024**

[Don Mateer]

Responsible Entity Signature  **,VP** **Date: March 26, 2024**

[Thomas Schultz]

2.0 Responsible Entity and Supply Chain Information

Manufacturer(s) and Importer(s):

Please see the information under Responsible Entities in Section 1.

Manufacturer(s), Importer(s), and /or Distributor(s) listed on the Priority Product label:

This data is considered confidential business information (CBI) by Specialty Tires of America. A separate Appendix B will be submitted and marked as CBI, as appropriate.

Purchasers of Priority Product:

This data is considered confidential business information (CBI) by Specialty Tires of America. A separate Appendix B will be submitted and marked as CBI, as appropriate.

Manufacturer(s) and/or Importer(s) Retail Sales Outlets:

Not applicable. Specialty Tires of America does not have its own retail outlets.

3.0 Priority Product Information

Priority Products made by Specialty Tires of America that contain 6PPD are listed in Table 3.1 below:

Table 3.1 - Priority Products from Specialty Tires of America that contain 6PPD

Brand	Tire Types
AMERICAN RACER	Passenger
B.F. GOODRICH	Passenger
BECK	Passenger
BEDFORD	Passenger
CARNEGIE	Light Truck
COKER	Passenger, Light Truck, Heavy Truck
EXXON MOBIL	Passenger
GENERAL	Passenger
GOODYEAR	Passenger, Light Truck
INTERCO	Passenger, Light Truck
KELSEY	Passenger
KEYSER (DEMO DERBY)	Light Truck
M&H	Passenger, Light Truck
MICKEY THOMPSON	Passenger, Light Truck
PRO COMP	Light Truck
PRO TRAC	Passenger
RADIR CHEATER	Passenger
ROYALTON	Passenger
STA	Passenger, Light Truck, Medium Truck, Heavy Truck
STONEBROOK	Light Truck
US ROYAL	Passenger
UNIVERSAL SPORT	Passenger
WOLF PAWS	Light Truck

3.1 Chemical of Concern for Priority Products

The chemical of concern for the priority products is N(1,3-dimethylbutyl)-N'-phenyl-p-phenylenediamine, commonly referred as 6PPD (CAS Number 793-24-8).

3.2 Priority Product Function

The priority products across the different tire brands include several different tire types: Passenger, Light Truck, Medium Truck, and Heavy Truck. Each of these tire types have unique requirements based on the vehicle application. Despite these unique requirements, the product functions across all tire types can be grouped into these categories: [1]

Support the Vehicle Weight

Transmit Acceleration and Braking Forces to the Ground

Change / Maintain Direction

Absorb Shock from the Road Surface

3.3 Priority Product Performance

The performance characteristics of the priority products fall into one or more of the following classifications: [1,2]

Safety	Environmental Impact	Fuel Efficiency
Wear/Longevity	Handling Stability	Ride Comfort
Noise	Dry Grip	Wet Grip

The specific performance characteristics are unique for each individual product (passenger, light truck, medium truck, heavy truck) and are tuned for each specific vehicle. For instance, tires for a sports car need to have maximum performance for dry grip and handling stability, while a semi tractor is more concerned with fuel efficiency and wear/longevity. All these factors are taken into consideration in the design and development of each type of tire.

3.4 Priority Product Legal Requirements

The various tire types that are priority products under this regulation (passenger, light truck, medium truck, heavy truck) are governed in the United States by the National Highway Transportation Safety Administration (NHTSA). NHTSA has established tire test procedures under the Federal Motor Vehicle Safety Standards (FMVSS) to ensure the safety of tires that are run on roads throughout the US. The current test procedures under FMVSS are 109, New pneumatic tires for vehicles manufactured from 1949 to 1975, bias ply tires, and T-type spare tires [3], FMVSS 119, New pneumatic tires for motor vehicles with a GVWR of more than 4,536 kilograms (10,000 pounds), specialty tires, and tires for motorcycles [4], and FMVSS 139, New pneumatic radial tires for light vehicles [5]. All tires that are used on roads in the US must either pass the FMVSS 109, 119, or 139 test procedures as appropriate for the type of tire.

Similarly, there are regulations for tires that are sold in Europe. These are governed by the Economic Commission for Europe (ECE). The regulations that we must meet are ECE-30, Uniform provisions concerning the approval of pneumatic tyres for motor vehicles and their trailers [6], and ECE-54, Uniform provisions concerning the approval of pneumatic tyres for commercial vehicles and their trailers [7].

3.5 Role of the Chemical of Concern

Rubber in tires is subject to degradation due to ozonation, oxidation, heat and flex cracking, which can cause premature aging and potential safety issues. 6PPD is used in tires as an antidegradant to protect the products from all four of these effects. Any alternative must meet or exceed the antidegradation capabilities of 6PPD.

3.6 Is the Chemical of Concern or Alternative Replacement Chemical(s) necessary?

Based on decades of industry experience, tires need effective antidegradant material(s) to meet the safety and performance requirements demanded of the tires today. Thus, 6PPD removal without an effective material replacement presents a threat to tire safety and performance.

3.7 Material Safety Data Sheet for 6PPD

A link to the MSDS for 6PPD is attached in Appendix A.

4.0 Scope of Relevant Comparison Factors

4.1 Alternatives Analysis Approach

Tire antidegradants have been in use for decades to provide protection of the exposed rubber components against oxygen, ozone, ambient heat and flex fatigue. Various materials have been barriers, coatings and chemical reactants to prevent premature aging, extend tire life and improve safety of tires on the road. Often, more than one chemical has been used to improve the antidegradation effects on tires. Over the years, 6PPD has become the primary chemical of choice, either alone or in combination with another chemical.

With the recent research that has identified 6PPD and 6PPD-Q as highly toxic to various aquatic life, and in particular to coho salmon, there is now extensive work ongoing to eliminate 6PPD. The focus of this work, and specifically this alternatives analysis is to meet two main objectives: 1) Eliminate the high levels of toxicity that 6PPD introduces into the environment, and 2) Maintain, or improve, the antidegradant performance that 6PPD provides for today's tires.

This alternatives analysis is looking at four main areas to determine what alternatives warrant further investigation as possible replacements for 6PPD.

1. Elimination of 6PPD with current designs
2. Change in design or manufacturing of priority products to eliminate 6PPD
3. Substitution with other commercially available antidegradants
4. Development of new chemical(s)

4.2 Life Cycle Segments

4.2.1 Raw materials extraction

4.2.2 Resource inputs and other resource consumption

4.2.3 Intermediate materials processes

4.2.4 Manufacture

4.2.5 Packaging

4.2.6 Transportation

4.2.7 Distribution

4.2.8 Use

4.2.9 Operation and maintenance

4.2.10 Waste generation and management

4.2.11 Reuse and recycling

4.2.12 End-of-life disposal

The relevant factors for the life cycle segments listed above are discussed in Table 4.1.

Table 4.1 Life Cycle Relevant Factors Identified in SCP Regulation

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
Life cycle segments	Raw material extraction	No	No quantifiable data found on raw material impact. No expected raw material impact as relevant factor.
	Resource inputs and other resource consumption	Unlikely	No significant changes expected in mixing or processing of rubber components with the various alternatives that would impact resource inputs or consumption
	Intermediate materials production processes	No	No data found of any impact of production of intermediate materials of alternatives
	Product manufacture	Possibly	Based on the chemical makeup of the potential alternatives, there could be different handling requirements or exposure concerns during the manufacturing process.
	Packaging	No	The use of any alternatives is based on chemical bonding to provide protection for the rubber components and does not change the physical appearance, size or shape of the end products. Thus, there should be no differences in the packaging, transportation, or distribution of the end products.
	Transportation during and between all segments		
	Distribution		
	Use	Yes	Use of the priority product can definitely be impacted based on what alternative is chosen for 6PPD. 6PPD is typically released into the environment through tire and road wear particles (TRWP) that are microparticles that wear off during use. These particles then get washed into the water system and end up in lakes, rivers, and streams where they impact the aquatic life, particularly coho salmon. The major focus points in replacing the chemical of concern are 1) improving/eliminating the environmental impact of 6PPD and 6PPD-Q while 2) maintaining the antidegradant performance of 6PPD. Any alternatives with reduced antidegradant performance will likely shorten tire life, increase costs, and possibly reduce safety to the consumer. An alternative with improvements in both 1) and 2) is the targeted outcome for the replacement of 6PPD.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Operation and maintenance	Possibly	Operation of the end products should not be impacted as whatever alternative is chosen should be invisible to the end consumer from a day-to-day operations standpoint. Maintenance could be impacted if the safety or longevity of the end product causes the consumer to have to do additional maintenance they are not doing currently doing.
	Waste generation and management	Yes	Waste generation and management would be similar for 6PPD and its alternatives. The major impact of waste surrounds the tire wear particles that get into the water system to ultimately impact the aquatic environment. This aspect is one of the keys and would remain the same regardless of what chemical is used.
	Reuse and recycling	Yes	Nearly all passenger and light truck tires are single use, there is no reuse/recycle of these products. On the other hand, medium and heavy duty truck tires, which are typically used on commercial trucks, can be retreaded, which allows for additional reuse of the carcasses for these products. For those tires that are retreaded, the performance of the alternatives can impact the safety/longevity of the carcass which could impact how many times a carcass can be retreaded and still provide a safe product for the commercial trucking industry.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	End-of-life disposal	Yes	After a tire has completed its useful life under its intended purpose, there are dozens of potential places for tires to be disposed. Major areas of used tire disposal are: 1) Burned for fuel, 2) Disposed of in landfills, and 3) Ground for rubber crumb to be used in paving, playgrounds, synthetic turf, and landscaping. Nearly all of these options pose the risk of 6PPD being released into the environment and the potential for further environmental impact. While alternatives would eliminate this additional exposure of 6PPD, these alternatives need to be evaluated for these same potential issues of environmental impact due to their levels of toxicity for the chemical or its byproducts.

4.3 Relevant Factors

4.3.1 Adverse environmental impacts

4.3.2 Adverse public health impacts

4.3.3 Adverse waste and end-of-life effects

4.3.4 Environmental fate

4.3.5 Materials and resource consumption impacts

4.3.6 Physical chemical hazards

4.3.7 Physicochemical properties

The factors that have been evaluated for each of the sections above are discussed in Table 4.2.

Table 4.2 Consideration of Potentially Relevant Factors Identified in SCP Regulation

Category	Factor That is Relevant if MateriallyDifferent Among Possible Alternatives	Relevant?	Basis
Adverse air quality impacts	Would it bring any changes to emissions of California Toxic Air Contaminants (*e.g.*, Benzene, Cr (VI))?	No	We have not found data that the chemical of concern or any potential alternatives would impact the emissions of the California Toxic Air Contaminants.
	CO2 emissions	No	We have not found data that the chemical of concern or any potential alternatives would have an impact on CO2 emissions.
	Other global warming gas emissions	No	We have not found data that the chemical of concern or any potential alternatives would have an impact on global warming gas emissions.
	Nitrogen oxide emissions	No	We have not found data that the chemical of concern or any potential alternatives would have an impact on nitrogen oxide emissions.
	Particulate matter emissions	No	We have not found data that the chemical of concern or any potential alternatives would have an impact on particle matter emissions.
	Ozone depleting substances	No	The use of antidegradants like the chemical of concern are effective by reacting with ozone to neutralize the degradation effects of the rubber in tires. We have found no data to indicate that this reaction has a substantial impact on depleting ozone in the atmosphere.
	Sulfur dioxide emissions	No	We have not found data that the chemical of concern or any potential alternatives would have an impact on sulfur dioxide emissions.
	Would it bring any changes to emissions of compounds that might lead to tropospheric ozone production?	No	We have not found data that the chemical of concern or any potential alternatives would have an impact on tropospheric ozone production.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
Adverse ecological impacts	Would the product, its constituents, or its likely breakdown products have any acute or chronic toxicity to impact aquatic, avian, or terrestrial animal or plant organisms or microbes?	Yes	6PPD and one of its byproducts, 6PPD-Q have been shown to have acute toxicity to aquatic life. The Greenscreen analysis of 6PPD has given an Acute Aquatic Toxicity score of very high and a Chronic Aquatic Toxicity score of very high for its toxic impact on aquatic life [1]. In addition, research conducted by Tian et al 2021 [2] has shown 6PPD-Q to be as toxic as 6PPD.
	Would it bring changes in population size, reduction in biodiversity, or changes in ecological communities?	Yes	From research in the Pacific Northwest, there has been observed changes to aquatic life, particularly coho salmon, due to the impact of 6PPD and 6PPD-Q. Any alternatives need to eliminate/minimize this effect in future products.
	Would it bring changes to abilities of an endangered or threatened species to survive or reproduce?	Yes	Lack of reproduction of coho salmon has been observed and linked to 6PPD/6PPD-Q. Any alternatives need to eliminate/minimize this effect in future products.
	Would it bring changes to deterioration or loss of environmentally sensitive habitats?	Yes	Environmental changes have been observed due to the presence of 6PPD/6PPD-Q. Any alternatives need to eliminate/minimize this effect in future products.
	Would it bring changes that contribute to or cause vegetation contamination or damage?	No	No data has been found that 6PPD impacts vegetation contamination or damage.

Category	Factor That is Relevant if MateriallyDifferent Among Possible Alternatives	Relevant?	Basis
	Would it bring adverse effects on environments that have been designated as impaired by a California State of federal regulatory agency?	Yes	The research that has led the California DTSC to designate 6PPD as a chemical of concern has documented the adverse effects of 6PPD on coho salmon and other aquatic life.
	Would it result in biological or chemical contamination of soils?	Possibly	Research has shown the pathway of 6PPD introduction into waterways through the stormwater run-off of tire wear particles into the various bodies of water. This stormwater run-off also introduces 6PPD into the soils. Data gaps exist about soil contamination of the stormwater run-off that would need further research to determine potential impact.
Adverse soil quality impacts	Would it impact soil compaction or other soil structure changes?	No	6PPD and any of its alternatives are not expected to impact soil structure in any of the ways listed here.
	Would it impact soil erosion?		
	Would it cause loss of organic matter in soil?		
	Would it cause soil sealing?		
Adverse water quality impacts	Would the product be expected to directly enter the municipal storm sewer systems (*e.g.*, car wash detergents)?	Yes	Based on the pathway that has been studied, 6PPD has been shown to directly enter the storm sewer systems from tire wear particles being washed into the sewers from stormwater run-off.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Would it bring any increase in biological oxygen demand within the water system?	No	No data has been found that 6PPD or any alternatives would impact the biological oxygen demand.
	Would it bring any increase in chemical oxygen demand within the water system?	No	No data has been found that 6PPD or any alternatives would impact the chemical oxygen demand.
	Would it bring any increase in temperature of water systems?	No	No data has been found that 6PPD or any alternatives would impact the water temperature.
	Would it bring any increase in total dissolved solids in water systems?	No	6PPD has a low solubility in water and would likely not have much impact on dissolved solids in water systems.
Public health impacts	Carcinogenicity	Possibly	Per the GreenScreen assessment from ToxServices, 6PPD is rated low. Most other chemicals tested as possible alternatives are also low. TMQ (M) and NBC (H) are exceptions that could make this an important factor.
	Developmental toxicity	Possibly	Per the GreenScreen assessment from ToxServices, 6PPD is rated moderate. Alternatives with a similar chemical structure to 6PPD also scored moderate, while several others were classified as low. Depending on what final alternatives are pursued, this may or may not be a relevant factor.
	Reproductive toxicity	Yes	Per the GreenScreen assessment from ToxServices, 6PPD is rated high. Alternatives cover the entire range from low to high so this may or may not be relevant in the long run, but with 6PPD being high, this factor needs to be considered.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Cardiovascular toxicity	Possibly	Research has shown potential cardiovascular toxicity of 6PPD in zebrafish [3]. Further study would be needed to see the impact on human cardiovascular toxicity of any of the alternatives.
	Dermatotoxicity	Possibly	Per the GreenScreen assessment from ToxServices, several of the chemicals have high levels of skin sensitization, most have low levels of skin irritation, so this factor needs to be evaluated for the final alternatives as well.
	Endocrine toxicity	Yes	Per the GreenScreen assessment from ToxServices, 6PPD is listed as moderate. The other alternatives that have been tested are also moderate, but there a several data gaps of some of the chemicals so this needs to be investigated further.
	Epigenetic toxicity	No	No data has been found indicating 6PPD or its alternatives impact this factor.
	Genotoxicity	No	Per the GreenScreen assessment from ToxServices, 6PPD and any alternatives are determined to be low with respect to genotoxicity. Final alternatives would need to have further work done to determine the impact.
	Hematotoxicity	Yes	Per the GreenScreen assessment from ToxServices, 6PPD and several alternatives have been rated moderate to high for Systemic Toxicity. This would need to be studied further for the final alternatives.
	Hepatotoxicity and digestive system toxicity	Yes	Per the GreenScreen assessment from ToxServices, 6PPD and several alternatives have been rated moderate to high for Systemic Toxicity. This would need to be studied further for the final alternatives.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Immunotoxicity	Yes	Per the GreenScreen assessment from ToxServices, 6PPD and its alternatives cover the entire range from low to high depending on the particular chemical. In addition, there are some data gaps in some of this analysis. Due to some potential alternatives having high levels of immunotoxicity, data needs to be determined for the final alternatives before they are implemented.
	Musculoskeletal toxicity	No	No data has been found indicating 6PPD or its alternatives impact this factor.
	Nephrotoxicity	Possibly	No specific data was found regarding 6PPD or alternatives impact on kidneys. However, since there is some connection with hemoto and hepatotoxicities, there could be a connection here. Further work needs to be done.
	Neurodevelopmental toxicity	Possibly	Per the GreenScreen assessment from ToxServices, there are some instances of 6PPD or alternatives having moderate impact. However, there are a lot of data gaps that need to be further investigated to determine if this factor is relevant.
	Neurotoxicity	Possibly	Per the GreenScreen assessment from ToxServices, determination of neurotoxicity was moderate for 6PPD and low to moderate for those alternatives that were tested. Significant data gaps exist around this factor that further testing needs done to be more conclusive of the effects.
	Ocular toxicity	Possibly	Per the GreenScreen assessment from ToxServices, 6PPD and several alternatives have moderate to high levels of eye irritation. Further study is needed to determine if toxicity exists.
	Ototoxicity	No	No data has been found indicating 6PPD or its alternatives impact this factor.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Reactivity in biological systems	No	No data has been found to expect 6PPD or any of its alternatives to be reactive in this manner.
	Respiratory toxicity	Possibly	Per the GreenScreen assessment from ToxServices, the level of respiratory irritation is low to moderate for those chemicals that have been tested. There are data gaps that need to be filled, so this factor would need to be studied further to determine its relevance.
	Exceedance of an enforceable California or federal standard related to public health	No	No data was found with an exceedance to public health standards.
Waste and end-of-life effects	Would it bring any change to the volume or mass of the waste materials and byproducts generated during the life cycle?	No	Since the 6PPD and alternatives are expected to be used at roughly the same amounts, waste materials generated would not be expected to be significantly different.
	Would it need any special handling to mitigate adverse impacts resulted from the waste materials generated during the life cycle?	No	No additional adverse impacts of waste materials would be expected to be different between 6PPD and its alternatives.
	Effects on solid waste or wastewater disposal or treatment	No	Nothing is expected to be significantly different between 6PPD and its alternatives.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Effects on discharge(s) or disposal(s) to storm drains or sewers adversely affecting wastewater or stormwater treatment facilities?	No	Nothing is expected to be significantly different between 6PPD and its alternatives.
	Release to the environment	No	The life cycle of 6PPD and its alternatives is expected to be the same. Therefore, the introduction of all these types of materials into the environment should be the same and this factor is not significantly different for any of the materials being considered.
	Aerobic and anaerobic half-lives of the product, its constituents, or its likely breakdown products?	Possibly	6PPD can break down rather quickly, which indicates the presence of the by-products are a factor in the environment. Final alternatives would need further evaluation to determine their own impact on the environment.
	Aqueous hydrolysis half-life of the product, its constituents, or its likely breakdown products?	Possibly	6PPD can break down rather quickly, which indicates the presence of the by-products are a factor in the environment. Final alternatives would need further evaluation to determine their own impact on the environment.
Environmental fate	Bioaccumulation of the product, its constituents, or its likely breakdown products?	Yes	Per the GreenScreen analysis from Tox Services, 6PPD has a high level of bioaccumulation. The alternatives cover the range from low to high, so this may not be a factor depending on the final chemical chosen, but based on the issue with 6PPD it needs to be considered.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Mobility in environmental media	Yes	The mobility of 6PPD in water entering the lakes and streams and impacting the aquatic life must be considered for any alternative chosen.
	Persistence	Yes	Per the GreenScreen analysis from Tox Services nearly all chemicals being considered have high or very high persistence, so this is a relevant factor for a replacement.
	Photodegradation	Yes	Research published on the photodegradation of 6PPD shows higher incidence of the more toxic 6PPD-Q due to photodegradation. This would need further study in the alternatives to determine overall impact. [4]
Materials and resource consumption	Impacts on consumption of renewable resources, including energy and raw materials, throughout the life cycle?	No	The life cycle should not be significantly different for 6PPD or its alternatives. Therefore, there should not be an appreciable impact on consumption of renewable resources.
	Impacts on consumption of nonrenewable resources, including petroleum, coal, metals, minerals, and other finite resources, throughout the life cycle?	No	The life cycle should not be significantly different for 6PPD or its alternatives. Therefore, there should not be an appreciable impact on consumption of nonrenewable resources.
Physical chemical hazards	Do the product or the alternatives exhibit oxidizing properties that facilitate combustion?	No	No data was found to indicate this is an area of concern.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Do the product or the alternatives exhibit explosivity?	No	No data was found to indicate any issues with explosivity of any of the chemicals under consideration.
	Do the product or the alternatives exhibit flammability?	No	Per the GreenScreen assessment from Tox Services, neither 6PPD or any of its alternatives have concerns for flammability.
Physico-chemical properties	Do the product and alternatives have different physical states?	No	Some chemicals are solids, and some are liquids but not a relevant factor.
	Molecular weight	Yes	Molecular weights are different and can have an impact on absorption rates.
	Density	No	This property does not appear to differ significantly among the alternatives.
	Vapor pressure	Possibly	Different vapor pressures could impact levels of exposure.
	Melting point	No	Melting point may slightly impact handling/manufacturing, but not likely to have a significant impact.
	Boiling point	No	Boiling point may slightly impact handling/manufacturing, but not likely to have a significant impact.
	Water solubility	Possibly	The impact of 6PPD on aquatic life makes this a relevant factor depending on which alternative is chosen and its impact on aquatic life.
	Lipid solubility	Possibly	Lipid solubility could be important in terms of dermal exposure and mobility between soil and water.

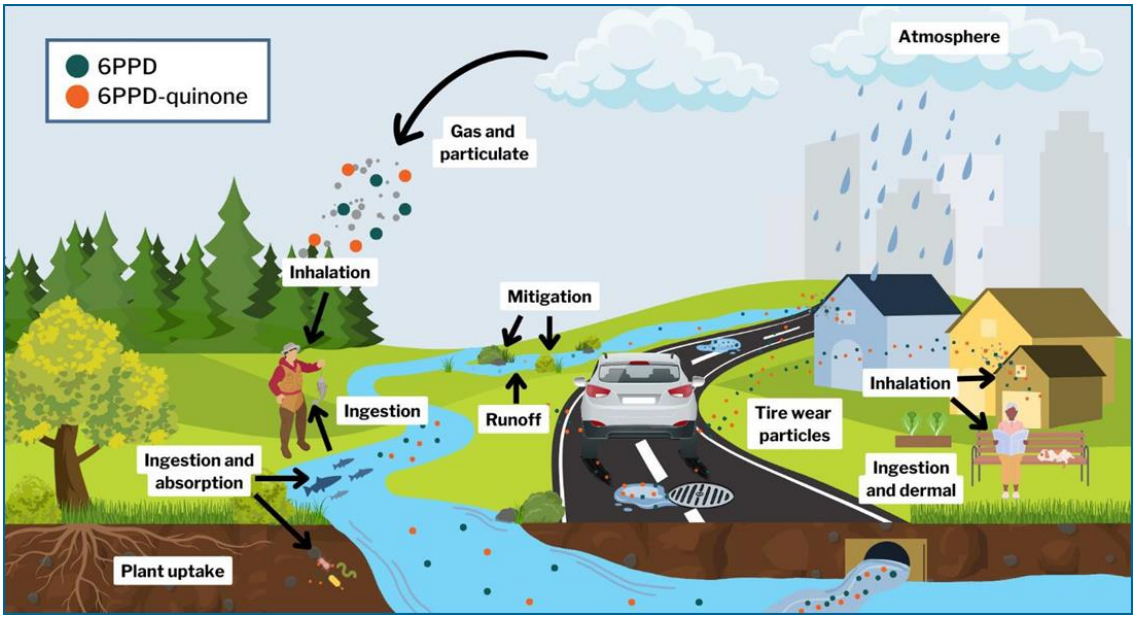
Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
	Octanol-water partition coefficient (Kow)	Possibly	Depending on the level of toxicity of the alternatives.
	Octanol-air partition coefficient		
	Organic carbon partition coefficient		
Product function and performance	Are there material differences in terms of the useful life of the product?	Possibly	Depending on which alternative is chosen, there could be material differences between it and 6PPD.
	Are there material differences in terms of the function and performance of the product?	Possibly	The only alternatives that should be considered should have the function of being better for the environment while having the same antidegradant performance of 6PPD.
	Are there material differences in terms of the functional acceptability of the product?	Possibly	The only alternatives that should be considered should be functional acceptable in terms of eliminating/reducing the toxic impact on aquatic life.
	Are there material differences in terms of the technical feasibility of the product?	Possibly	The only alternatives that should be considered moving forward should operate at the same technical level as 6PPD.
Chemical quantities	Quantities needed to manufacture product	No	Since the 6PPD and alternatives are expected to be used at roughly the same amounts, the quantities needed to manufacture products would not be expected to be significantly different.
	Quantities placed into the stream of commerce in California	No	Since the 6PPD and alternatives are expected to be used at roughly the same amounts, the amounts introduced into California would not be expected to be significantly different.

Category	Factor That is Relevant if Materially Different Among Possible Alternatives	Relevant?	Basis
Potential Exposure	Human exposure during life cycle of product	Possibly	The exposure to the population would expected to be the same with 6PPD or any alternative. However, depending on the potential toxicity to humans of an alternative, it could be more of a factor than it is currently.
	Exposure to sensitive subpopulations	Possibly	The exposure to the population would expected to be the same with 6PPD or any alternative. However, depending on the potential toxicity to humans of an alternative, it could be more of a factor than it is currently.
Economic impacts	Will the product and its alternatives have a different cost to consumers or other users?	Possibly	Depending on which alternatives are chosen for final analysis and the level of research/scale-up/manufacturing costs that each have, there could be a different cost to the consumer when the final replacement is determined.

4.4 Exposure Pathways

A model that illustrates the exposure pathways of 6PPD being introduced into the environment is shown in Figure 4.1. Tire road wear particles are released from the tire in use into the air and deposited along roadways. TWRP in the air can be inhaled as a source of exposure. Rain can wash these airborne particles into the soil and bodies of water. Also, storm water runoff can wash these particles into various waterways where the 6PPD can be ingested by fish and other aquatic life.

Figure 4.1 Exposure Model [8]



4.4.1 Chemical Quantity

Based on full year 2023 direct sales to dealers listed in Section 2, approximately 69 lbs. of 6PPD had potential impact estimated at 35 lbs. or 50% of 6PPD/6PPD-Q discharged as tire particles.

The expectation is that any alternative chemical will be used in approximately the same amounts as 6PPD. So, the expected introduction of any alternative into California should be about the same quantities as described above for 6PPD.

5.0 Scope and Comparison of Alternatives

5.1 Alternatives Considered

5.1.1 Removal of Chemical of Concern

The first alternative considered is to remove the 6PPD and not replace it with another chemical.

5.1.2 Change of Tire Design/Manufacturing of Priority Products

The second alternative considered is to modify the design and/or manufacturing process with the elimination of the 6PPD. From the design/manufacturing aspect, ways were explored to establish a "barrier" between the unprotected tread and sidewall rubber components and the attacking ozone from the atmosphere. Waxes are currently a chemical ingredient that is used in rubber components to help with oxygen and ozone attack. Consideration of types and amounts of various waxes was explored. In addition, adding components to the outside of the tires was investigated. The best example found was a material like EPDM, since this material is fully saturated, it is not prone to ozone attack like most unsaturated compounds used in tires.

5.1.3 Currently Available Antidegradant Chemicals

The third alternative considered is the evaluation of those materials that are currently commercially available as antidegradants. Some of these are based on a similar chemical structure as 6PPD, while others are totally unrelated in structure, but all have shown some success as an antidegradant. The commercially available materials that were considered are:

Table 5.1 Currently Available Antidegradant Chemicals	
Chemical	**CASRN**
6QDI [N~1~-(4-Methylpentan-2-yl)- N~4~-phenylcyclohexa-2,5-diene- 1,4-diimine]	52870-46-9
IPPD [N-Isopropyl-N'-phenyl-p- phenylenediamine]	101-72-4
77PD [N,N'-Bis(1,4-dimethylpentyl)-4- phenylenediamine]	3081-14-9
CCPD [N,N'-Dicyclohexyl-4- phenylenediamine]	4175-38-6
7PPD [N-(5-Methyl-2-hexyl)-N'- phenyl-p-phenylenediamine]	3081-01-4
TMQ [1,2-Dihydro-2,2,4-trimethylquinoline]	147-47-7
NBC [Nickel dibutyldithiocarbamate]	13927-77-0
Ethoxyquin [6-Ethoxy-2,2,4- trimethyl-1,2-dihydroquinoline]	91-53-2
Dilauryl thiodipropionate	123-28-4
DADP [diaryl-p-phenylene diamine]	68953-84-4
Graphene	Various
Lignin	Various

5.1.4 Development of New Antidegradant Chemicals

The research work identifying 6PPD and 6PPD-Q as toxic substances to coho salmon and other aquatic species has prompted a significant amount of additional research among the stakeholders in the tire and chemical industries to find a replacement for 6PPD that eliminates the toxic effects while maintaining the antidegradant performance. A recent alliance that will be driving this research is a collaboration between the United States Tire Manufacturers Association (USTMA) and the U.S. Geological Survey (USGS) [9]. Another alliance between Flexsys and the US Department of Agriculture Agricultural Research Service (USDA-ARS) is dedicated to finding a sustainable 6PPD alternative [10]. Alliances such as these between various stakeholders are key to finding such an alternative.

Recent research evaluating various derivatives of 6PPD through modeling has yielded some interesting possibilities for alternatives to improve the toxicity of a 6PPD-like chemical. [11]. Research projects like this are critical to filling the data gaps of current 6PPD knowledge and advancing an alternative to replace 6PPD as quickly as possible.

Since nearly all existing materials identified to date have short comings or data gaps with respect to improved toxicity compared to 6PPD, or antidegradant performance compared to 6PPD, the likelihood at this point is for a new alternative to come from the new alliances and research that will be ongoing. Our focus is to monitor the research going on in the industry and evaluate new alternatives as they become available.

5.2 Rationale for Alternatives not Selected

5.2.1 Removal of Chemical of Concern

While the option of removing the 6PPD and not replacing it with another chemical would address the adverse impacts that the 6PPD and 6PPD-Q have on the environment, this change would leave the rubber in the tires vulnerable to ozone attack. From personal experience, industry knowledge and comments from the USTMA, tires without any type of antidegradant would compromise the safety of the products and have significant age cracking and severely reduced safety performance. This is not a viable option moving forward [12].

5.2.2 Change of Tire Design/Manufacturing of Priority Products

For all of our rubber compounds used in the various tire applications, waxes have been used as a supplement to other antidegradant materials. The waxes act as a “mechanical” barrier to keep the ozone away from the rubber, while those antidegradants like 6PPD act as a “chemical” barrier by reacting with the ozone to keep it away from the rubber. From our experience with different types and levels of waxes, the “mechanical” barrier effect of just wax is not as effective as what the “chemical” barrier effect of what materials like 6PPD provides or a combination of the two materials. In addition, there is a limited amount of wax that can be added before wax starts to bloom to the surface which causes other issues.

The use of saturated polymers like EPDM can provide better ozone resistance compared to the unsaturated polymers that are commonly in use in tire compounds. The main issue arises regarding the compatibility of EPDM with unsaturated polymers. There are two approaches that have been considered. First, if EPDM is mixed into the existing tread and sidewall compounds, the polymer incompatibility would impact the physical properties of these compounds to the point that the safety of the end product could be compromised. Secondly, if a separate rubber component that is comprised of only EPDM polymer is added on top of the sidewall, for instance, to provide the “mechanical” barrier, the incompatibility of the polymers between the sidewall and EPDM-barrier component could lead to potential adhesion issues between components that could compromise safety. In addition, adding this type of component on top of the tread compound is not practical, as it would change the performance of the tire and as this barrier component wears away, the tread compound would be exposed to ozone degradation.

Overall, the use of only “mechanical” barriers in place of “chemical” barriers will not provide as effective protection while causing compromises in safety.

5.2.3 Currently Available Antidegradant Chemicals

Several of the chemicals that are commercially available were analyzed by the Washington State Department of Ecology as potential replacements for 6PPD to determine their levels of toxicity in comparison to 6PPD. The GreenScreen for Safer Chemicals method was used and an overall benchmark score (BM score) was given [13]. BM values for 6PPD and several alternatives are listed in Table 5.2.

Table 5.2 Currently Available Antidegradant Chemicals GreenScreen BM Score	
Chemical	**BM Score**
6PPD [N-(1,3-Dimethylbutyl)-N'- phenyl-p-phenylenediamine]	BM-1
6QDI [N~1~-(4-Methylpentan-2-yl)- N~4~-phenylcyclohexa-2,5-diene- 1,4-diimine]	BM-1
IPPD [N-Isopropyl-N'-phenyl-p- phenylenediamine]	BM-1
77PD [N,N'-Bis(1,4-dimethylpentyl)-4- phenylenediamine]	BM-2
CCPD [N,N'-Dicyclohexyl-4- phenylenediamine]	BM-1
7PPD [N-(5-Methyl-2-hexyl)-N'- phenyl-p-phenylenediamine]	BM-1
TMQ [1,2-Dihydro-2,2,4-trimethylquinoline]	BM-2
NBC [Nickel dibutyldithiocarbamate]	BM-1
Ethoxyquin [6-Ethoxy-2,2,4- trimethyl-1,2-dihydroquinoline]	BM-2

Classification for the benchmark scores are

BM-1 Avoid Chemical of High Concern

BM-2 Use but Search for Safer Substitutes

Since all the chemicals listed in Table 5.2 have moderate or significant levels of various toxicities to warrant their BM scores, all those chemicals listed in Table 5.2 are eliminated from consideration as potential replacements for 6PPD.

Dilauryl thiodipropionate

Dilauryl thiodipropionate was evaluated as part of the State of Washington study and had a GreenScreen BM score of BM-3, Use but Still Opportunity for Improvement [13]. This was the best alternative from a toxicity standpoint from the GreenScreen study. However, this material is generally used to protect synthetic polymers during manufacture and has no antiozonant activity [12]. This material is also eliminated from further study.

DADP [diaryl-p-phenylene diamine]

DADP [diaryl-p-phenylene diamine] has been used as a secondary antidegradant, typically with 6PPD as the primary. Experience using this material as the primary or only antidegradant material has not been successful in providing appropriate levels of protection. Based on this previous experience, this material is not being considered further as a replacement for 6PPD.

5.2.4 Development of New Antidegradant Chemicals

Based on the research that we have been following to date, there are no new alternatives that have been ruled out at this point.

5.3 Comparison of Chemical(s) of Concern and Alternative Replacement Chemical(s)

5.3.1 Alternative Chemicals Eliminated From Further Evaluation

The GreenScreen summary of those chemicals that are commercially available but are not being considered for future evaluation is listed in Table 5.3.

Table 5.3 GreenScreen Summary of Possible 6PPD Alternatives

Chemical (CASRN)	Carcinogenicity	Genotoxicity/Mutagenicity	Reproductive Toxicity	Developmental Toxicity	Endocrine Activity	Acute Toxicity	Systemic Toxicity (single)	Systemic Toxicity (repeat)	Neurotoxicity (single)	Neurotoxicity (repeat)	Skin Sensitization
6PPD 793-24-8	**L**	**L**	**H**	**M**	**M**	**M**	DG	**M**	*M*	DG	**H**
6QDI 52870-46-9	**L**	**L**	**H**	**M**	**M**	**M**	*M*	**M**	*M*	DG	**H**
IPPD 101-72-4	*L*	**L**	*H*	**M**	*M*	**M**	DG	**M**	*M*	DG	**H**
77PD 3081-14-9	*L*	**L**	**L**	*M*	DG	**M**	**L**	**M**	*L*	DG	*H*
CCPD 4175-38-6	*L*	*L*	*L*	*M*	DG	*H*	DG	*H*	*L*	DG	*H*
7PPD 3081-01-4	**L**	**L**	**H**	**M**	**M**	**L**	**L**	**M**	*L*	DG	**H**
TMQ 147-47-7	**M**	**L**	*M*	*M*	DG	**M**	**vH**	**H**	DG	DG	*L*
NBC 13927-77-0	*H*	**L**	*M*	*L*	DG	**L**	**L**	**H**	*M*	*L*	**L**
Ethoxyquin 91-53-2	*L*	**L**	*M*	*M*	**M**	**M**	**vH**	**H**	DG	DG	**M**
Dilauryl Thiodipropionate 123-28-4	*L*	**L**	*L*	**L**	DG	**L**	**L**	**L**	*L*	DG	**L**

Chemical (CASRN)	Respiratory Sensitization	Skin Irritation	Eye Irritation	Acute Aquatic Toxicity	Chronic Aquatic Toxicity	Persistence	Bioaccumulation	Reactivity	Flammability	Benchmark Score
6PPD 793-24-8	*M*	**L**	**M**	**vH**	**vH**	*H*	**H**	**L**	**L**	**BM-1**
6QDI 52870-46-9	DG	**L**	**H**	**vH**	**vH**	*vH*	**H**	**L**	*L*	**BM-1**
IPPD 101-72-4	*M*	**L**	*M*	**vH**	*vH*	*H*	**vL**	*L*	**L**	**BM-1**
77PD 3081-14-9	*M*	**L**	**L**	**vH**	**vH**	*H*	*M*	*L*	**L**	**BM-2**
CCPD 4175-38-6	*M*	*vH*	*H*	*vH*	*vH*	*H*	*H*	*L*	*L*	**BM-1**
7PPD 3081-01-4	*M*	**L**	*M*	**vH**	**vH**	*H*	*L*	*L*	**L**	**BM-1**
TMQ 147-47-7	*L*	*L*	*L*	*H*	*H*	*H*	**vL**	*L*	**L**	**BM-2**
NBC 13927-77-0	*M*	**L**	*H*	**L**	*L*	*vH*	*L*	*L*	**L**	**BM-1**
Ethoxyquin 91-53-2	DG	**L**	**L**	**H**	*H*	*H*	**vL**	**L**	**L**	**BM-2**
Dilauryl Thiodipropionate 123-28-4	*L*	**L**	**L**	**L**	*L*	**L**	*vL*	*L*	**L**	**BM-3**

As stated above, due to the BM scores, all chemicals above have been eliminated from further consideration.

5.3.2 Alternative Chemicals Warranting Further Evaluation

Research done to date has shown that Lignin and Graphene have some potential as a 6PPD replacement. There are data gaps that exist as to potential toxicity issues and the antidegradant performance needs some additional study, but these two items should be evaluated further.

5.3.3 New Material Development

Since there is no direct replacement that exists at the present time that eliminates the toxicity issues of 6PPD, while maintaining the antidegradant performance, ongoing research is underway to find a new material that meets both of these criteria without creating other issues. One recent research report evaluated 129 different derivatives of 6PPD, looking at the toxicity levels [11]. This type of research is expected to lead to new alternatives for 6PPD. The USTMA, along with key chemical companies such as Lanxess and Flexsys, has been spearheading this research. Our approach is to continue to monitor this research for breakthroughs and evaluate these new materials in our products when they become available.

6.0 Selected Alternative(s)

Two types of materials that are currently commercially available, lignins and graphene, will continue to be evaluated as potential alternatives for 6PPD. This is based on research and development that has already been done that indicates these might be suitable to replace 6PPD.

From the direction of some of the major stakeholders in the tire industry and current chemical manufacturers of 6PPD, development of new materials to eliminate the toxicity of 6PPD while maintaining the antidegradant performance is expected to yield the most likely alternatives that meet both of these criteria. We will continue to monitor this ongoing research and work closely with our other partners in the industry to implement the best alternatives to 6PPD.

7.0 Work Plan

7.1 Discussion of Proposed Tasks for Generating the Final AA Report

7.1.1 Lignin/Graphene

Additional research and evaluation of both of these alternatives needs to be completed outside of STA to ensure that these materials have acceptable toxicity performance from the relevant stakeholders and regulatory agencies. Once this is determined, our development process will proceed as outlined in section 7.2 below. Specific dates will be determined when we get the material in house for evaluation.

7.1.2 New Material Development

With new material research and development ongoing but no new materials being available for lab or product evaluation at this point, it is not possible to put specific dates to the development timeline. However, the layout below provides details for the approximate length of time for each step in the development process. There are several high-level steps that are outside of our control in the development timeline in the early parts of this process that need to be completed to have material for our evaluation. The steps in section 7.2 below will start once lab quantities of an alternative material that have been deemed acceptable from the toxicity viewpoint by the relevant stakeholders and regulatory agencies.

7.2 Alternatives Development Timetable

7.2.1 Lab Study Evaluation

Viable alternatives will be mixed in lab scale quantities for evaluation of relevant physical properties. Key testing of antidegradant properties will be compared with the 6PPD control to determine equivalent or better performance of the new alternatives. This step is generally 2 months/iteration and 1-2 iterations are expected to be needed for this step. Total time is 4 months.

7.2.2 Plant Mixing Trials

The start of the plant mixing trials is dependent on sufficient quantity of material being available to run larger-scale trials. If quantities are available at the completion of the lab study work, then plant mixing trials can begin immediately. If not, there will be a delay in the start of this step.

Plant mixing trials will determine if there are any changes needed to the formulation or mixing process to make the compound on a large scale. Mixing trials completed in approximately 2 weeks.

7.2.3 Manufacturing Tires for Lab/Field Evaluation

Following successful mixing trials, tires will be manufactured for lab/field evaluation. Typical time is 2 months.

7.2.4 Lab Testing of Tires

Lab testing of full tires and tire sections to ensure quality is equivalent to control, which includes safety and antidegradant performance. Lab testing time is about 2 months.

7.2.5 Field Evaluation of Tires

Field evaluation to determine antidegradant performance of alternatives vs control. This testing will be held concurrently with the lab testing of tires in 7.2.4 above. Field testing time can be 1-2 years or longer.

7.3 Final AA / Progress Report

From the timetable outline above, it is very likely that this process will take longer than the 12-month regulation for having the final AA completed. At the 12-month mark following approval of this preliminary AA, a progress report will be completed to give a status update on our replacement of 6PPD.

REFERENCES

References for report

1. Bridgestone web page – www.bridgestone.com/products/basic_knowledge/function_and_performance
2. Michelin web page – https://thetiredigest.michelin.com/performance
3. NHTSA FMVSS 109 regulation - https://www.govinfo.gov/content/pkg/CFR-2012-title49-vol6/pdf/CFR-2012-title49-vol6-sec571-109.pdf
4. NHTSA FMVSS 119 regulation - https://www.govinfo.gov/content/pkg/CFR-2011-title49-vol6/pdf/CFR-2011-title49-vol6-sec571-119.pdf
5. NHTSA FMVSS 139 regulation - https://www.govinfo.gov/content/pkg/CFR-2022-title49-vol6/pdf/CFR-2022-title49-vol6-sec571-139.pdf
6. ECE-30 regulation - https://op.europa.eu/en/publication-detail/-/publication/fbec46cd-c715-44ef-a865-50084b8f2a95
7. ECE-54 regulation - https://op.europa.eu/en/publication-detail/-/publication/018ac3d5-ac64-4d65-89f6-47ca8fa1b4ae
8. https://6ppd.itrcweb.org/wp-content/uploads/2023/09/6PPD-Focus-Sheet-Web-Layout-9.pdf
9. https://www.ustires.org/us-tire-manufacturers-association-and-us-geological-survey-partner-joint-research-6ppd-alternatives
10. https://flexsys.com/2023/flexsys-announces-6ppd-alternatives-cooperative-research-development-agreement-with-usda-ars/
11. Tire additives: Evaluation of joint toxicity, design of new derivatives and mechanism analysis of free radical oxidation,
    Xixi Li, Xinyi Chen, Bing Chen, Wenhui Zhang, Zhiwen Zhu, Baiyu Zhang;
    https://doi.org/10.1016/j.jhazmat.2023.133220
12. https://www.ustires.org/sites/default/files/2022-02/USTMA%20feedback%20on%20the%20Dept%20of%20Ecology%20antioxidants%20and%20antiozonants%20assessment.pdf
13. https://www.ezview.wa.gov/site/alias__1962/37732/research_and_proposed_alternatives_to_6ppd.aspx
14. https://dtsc.ca.gov/wp-content/uploads/sites/31/2021/08/USTMA-DTSC-6PPD-Workshop_ADA-Compliant-7.26.2021.pdf

References for Table 4.2

1. https://www.ezview.wa.gov/Portals/_1962/Documents/6ppd/GreenScreenExecutiveSummaryFor6PPD.pdf
2. https://pubmed.ncbi.nlm.nih.gov/33273063/
3. https://pubmed.ncbi.nlm.nih.gov/37094682/
4. https://www.sciencedirect.com/science/article/abs/pii/S0304389423014103

APPENDICES

Appendix A – Material Safety Data Sheet for 6PPD

The MSDS sheet from Sovereign Chemical for 6PPD is in the link below.

https://www.sovchem.net/wp-content/uploads/2021/11/Dusantox-6PPD-SDS.pdf

Appendix B – Distributors/Purchasers of Priority Product in California

This information is considered Confidential Business Information and is being submitted in a separate, redacted document.