

A tire industry perspective on 6PPD replacement: the challenge

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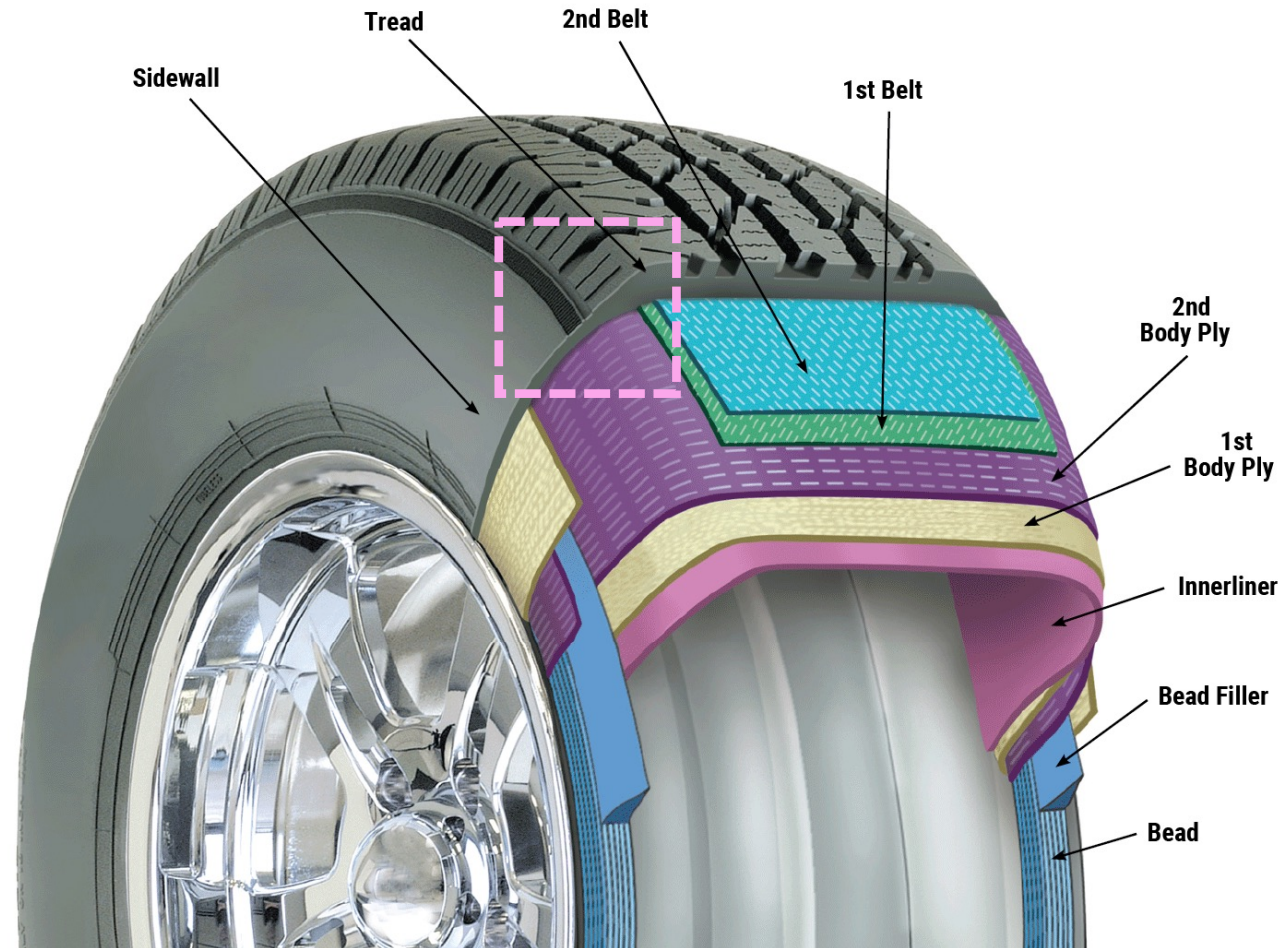
*Collaborative Innovation Forum:
Functional Substitutes to 6PPD in Tires*
Highline College, Des Moines, WA
December 14, 2022



consultingforpolymers.com

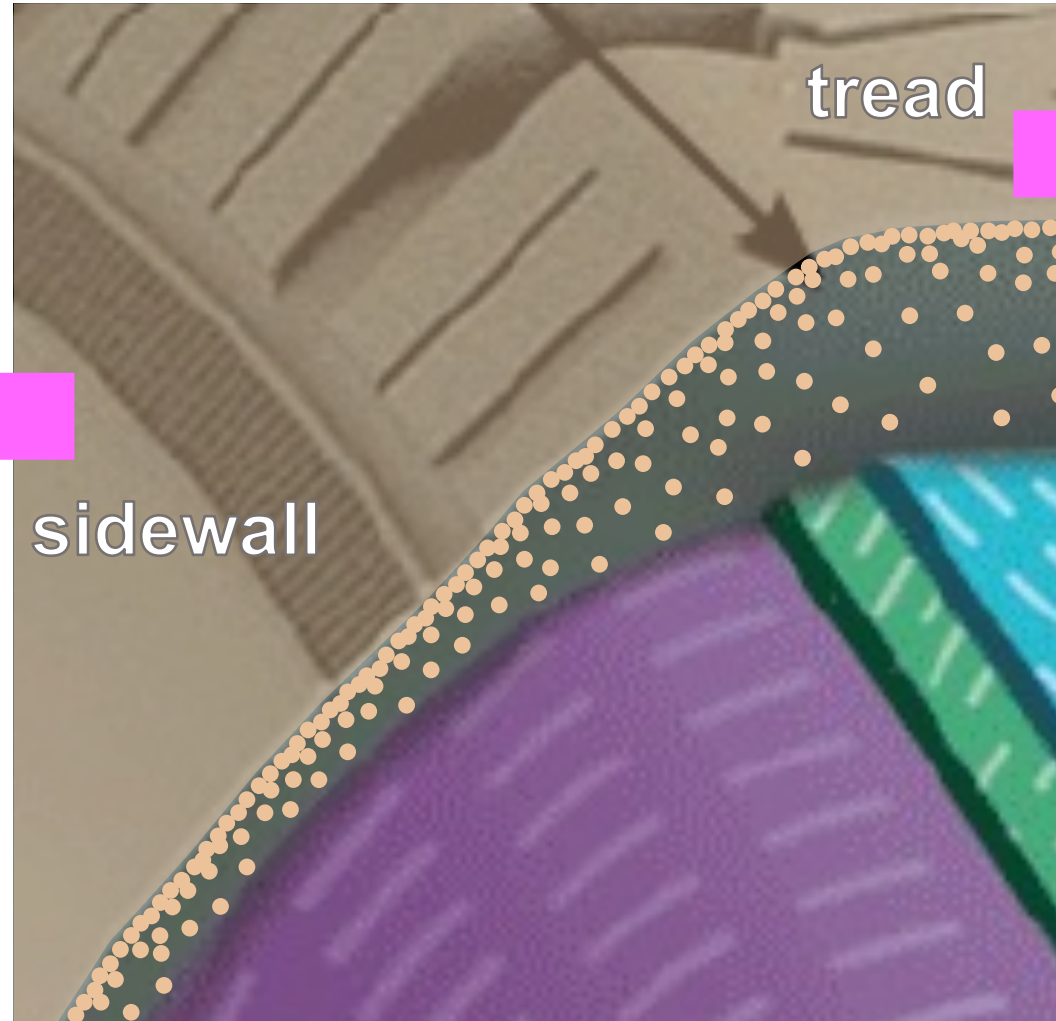
Tires are complex composite structures that rely on chemistry, physics, and engineering for durability, road safety, fuel economy, etc.

- Rubber compounds for tires have 10 to 15 ingredients
 - » Raw material substitution can lead to unintended interactions
- With exception of inner liner, all rubber compounds in tires have 0.5 to 1.5 wt.% 6PPD

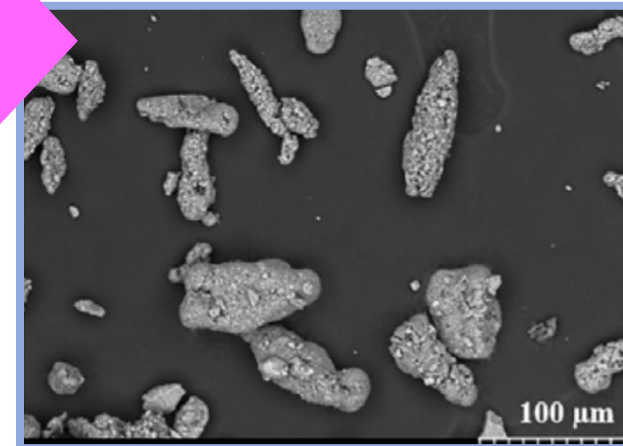


Main potential routes to the environment

**Sidewall Bloom:
wax + 6PPD**



**Tire & Road
Wear Particles
(TRWPs)**

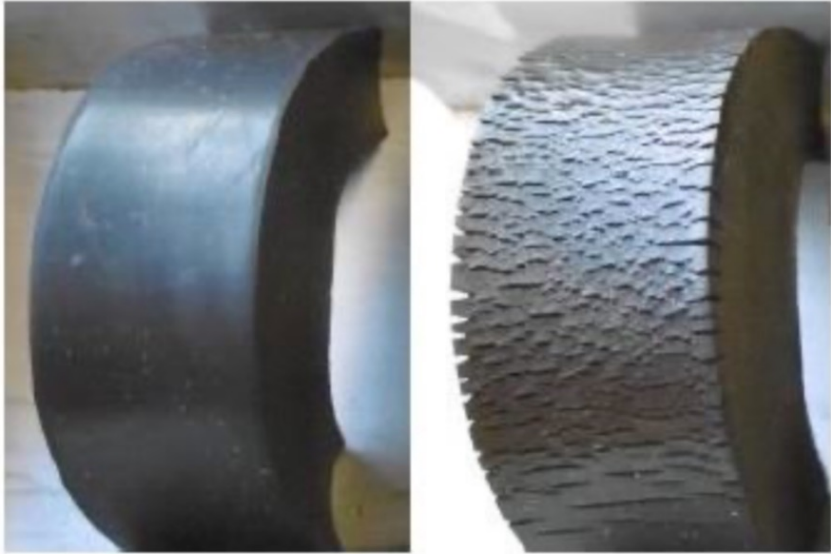


M. Kovoichich et al.,
Sci. Total Environ. **2021**,
757, 144085
[funded by the Tire
Industry Project]

6PPD in tires

with 6PPD

without 6PPD



<https://www.rubbernews.com/news/ustma-california-epa-look-alternative-6ppd-tire-additive>

To act like 6PPD, a drop-in substitute must:

- Function as antiozonant and antioxidant to help prevent the degradation and cracking of rubber compounds (unsaturated elastomers) by protecting against ozone attack, oxidation, and heat aging
 - » Including internal rubber compounds which experience diffusion-limited oxidation (from tire air pressure) and thermal-mechanical degradation
- Protect the tire in static and dynamic loading conditions
- Undergo controlled blooming/diffusion to surfaces of sidewall and tread

- Not interfere with crosslinking chemistry (accelerated sulfur vulcanization)
- Not interfere with important bonding between rubber and tire reinforcement cords

Some tire wear and lifetime considerations

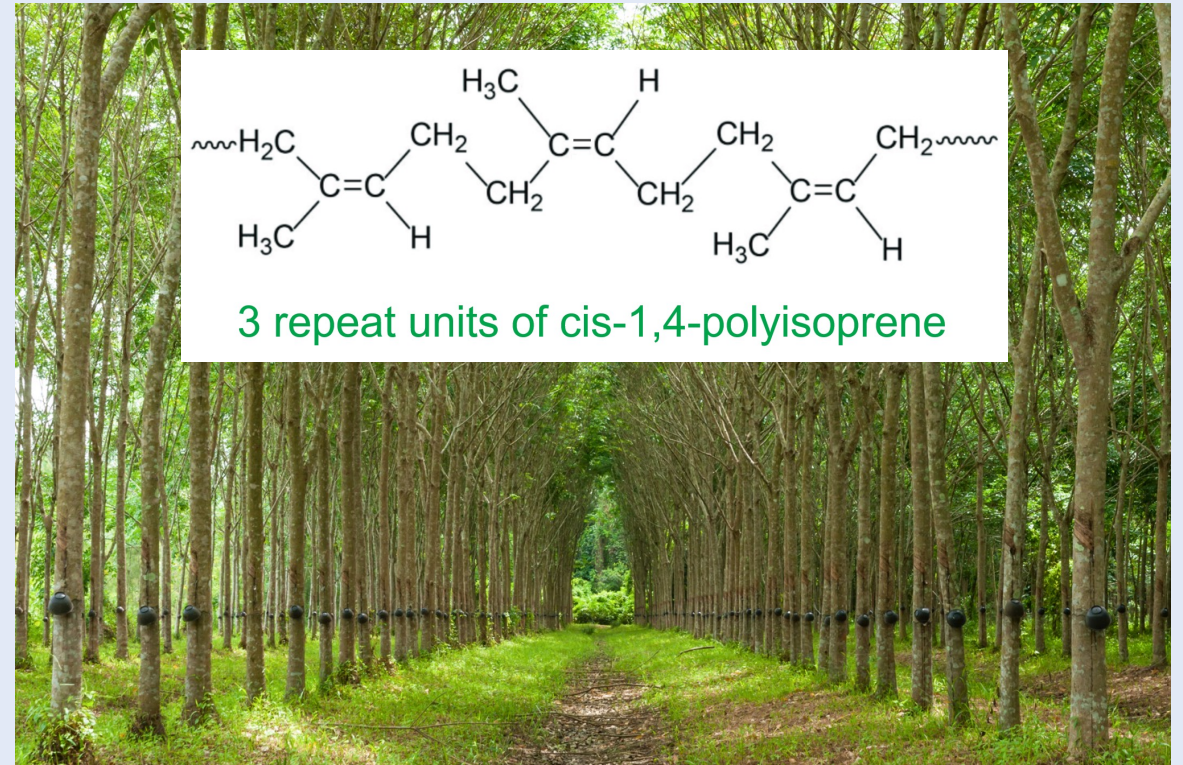
- Part of tread wear is thermal-mechanical-oxidative degradation of the tread compound
 - » Less effective substitute will lead to more tire & road wear particles

- If tire lifetime is reduced 15% from less effective substitute, that would mean 15% more environmental impact from raw materials and energy needed to produce more tires

- A possible longer-term solution is to use elastomers that are mostly saturated
 - » Already studied extensively through the decades at tire companies and raw materials suppliers
 - » Current saturated elastomer options are contrary to the sustainability megatrend

Natural rubber's superpowers:

- Premier durability due to strain-induced crystallization
- Sustainable material



Previous raw material substitution in the tire industry

Rubber News

NEWS AIRLESS TIRES CUSTOM RESOURCES DATA EVENTS ADVERTISE DIGITAL EDITION

October 03, 2005 02:00 AM

← Oct. 3, 2005

Michelin to phase out aromatic oils by 2010

BRUCE DAVIS



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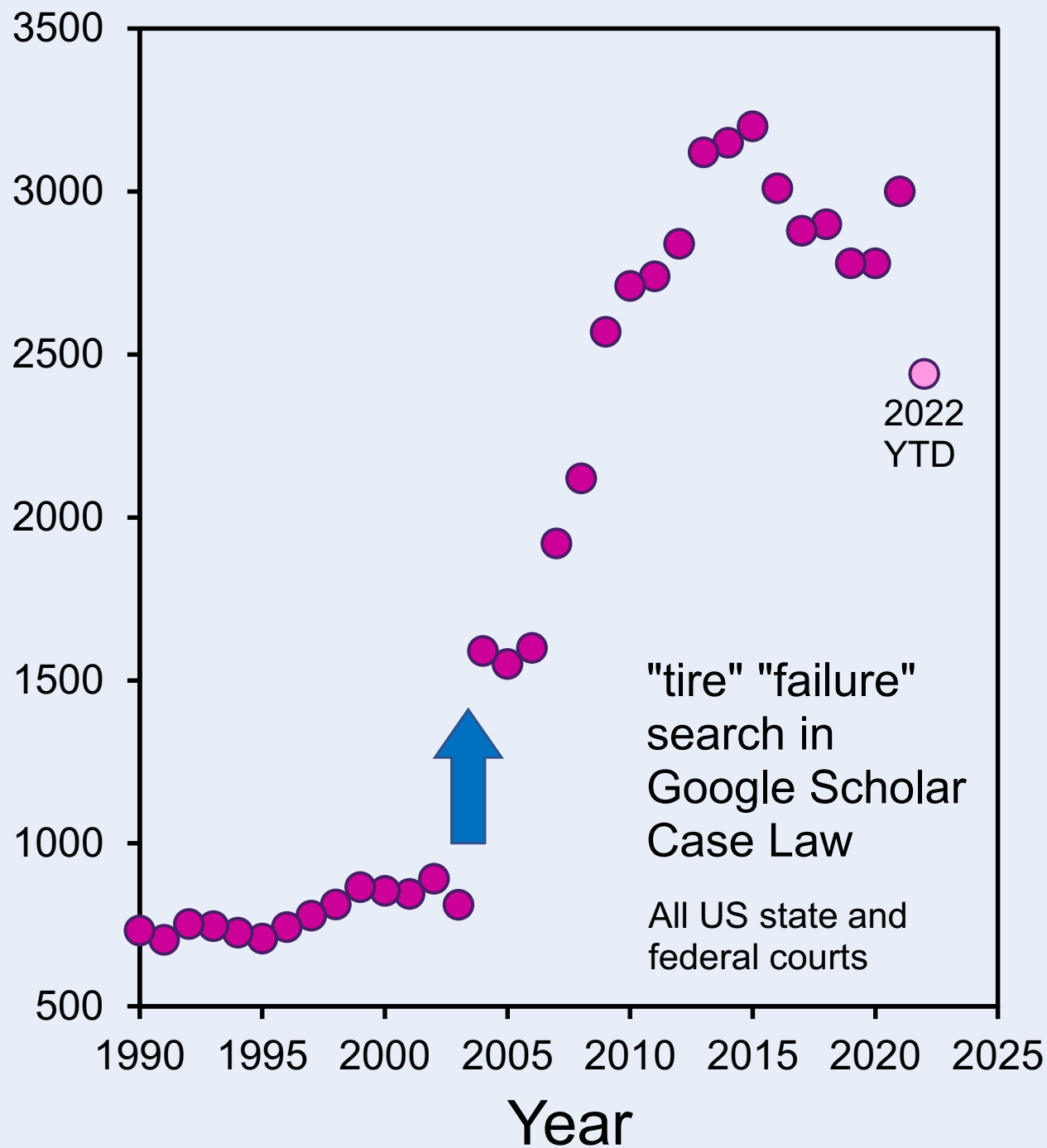
AKRON—Groupe Michelin, responding to regulatory restrictions on suspected carcinogenic or toxic materials, will phase out the use of aromatic processing oils at its plants worldwide by the end of 2010 and is looking for alternatives for zinc oxide.

Michelin's volunteer action goes beyond regulations in Europe that mandate tires sold in the European Union after 2009 be free of aromatic oils, according to Terry Gettys, president of Michelin Americas Research and Development Center in Greenville, S.C. He spoke on the subject while giving the keynote address at the recent Tire Society meeting in Akron.


<https://www.rubbernews.com/article/20051003/NEWS/310039962/michelin-to-phase-out-aromatic-oils-by-2010>

- EU ban on aromatic oils in tires was effective on Jan. 1, 2010, following a directive in 2005 about the ban
- Most major tire companies elected to apply the oil replacement globally versus only in EU
 - Based on my personal experience, this took about 4-5 years at one tire company and 3-4 years at another tire company
- Differences compared to 6PPD situation:
 - » Not a durability-critical ingredient
 - » Not a reactive chemical
 - » At the start of this replacement, oil substitutes were already available from multiple suppliers

Number of Documents



- Today's tires are more durable and safer on the road than ever before
- Tire companies are in constant defense of lawsuits

- 
- The background image shows a scenic view of a road and a stream in autumn. On the left, the rear of an orange SUV is visible, parked on a paved road. To the right of the road is a stone retaining wall, and beyond that, a shallow stream flows over rocks. The surrounding trees have vibrant autumn foliage in shades of yellow, orange, and red. The entire image is overlaid with a semi-transparent blue filter.
- **Today is a unique opportunity to learn different perspectives and share ideas toward effective substitutes for 6PPD in tires.**
 - **Let's build relationships and work together to find a solution that is safer for coho salmon while keeping tires safe for you and your family.**