

# Utilization of Bio-Oil Fractions as an Asphalt Additive

**R. Christopher Williams  
Justinus Satrio  
Marjorie Rover  
Robert C. Brown  
Ryan Shropshire  
Sheng Teng**

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**IOWA STATE UNIVERSITY**  
Civil, Construction, and Environmental Engineering

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# Presentation Outline

- Background
  - Bio-oil pilot plant production
  - Experimental Plan
  - Results
  - Conclusions and Future Work
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# Asphalt Materials Big Picture

- Derived from the heavy fractions of petroleum crude
  - Refineries have or are in the process of installing coking facilities
  - 5.5 million tons of asphalt pavements paved in Iowa annually (about 280,000 liquid tons of asphalt)
  - Reduction of butadiene from tire manufacturing has created scarcity of polymer in the asphalt industry
  - 88% of all paved roads in the US consist of asphalt materials
  - About 68% of the US Gross Domestic Product relies upon the nation's transportation systems
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# Bio-Energy Components

- Bio-oil
  - Corn Based Ethanol (wet & dry mill)
  - Cellulosic Ethanol
  - Bio-diesel
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# The Developing Bio-Energy Sector

- Crude oil, asphalt & polymer price increases
  - US energy independence
  - Utilizing bio-energy components to replace crude oil sources
  - In the future, the bio-energy sector will become a larger portion of the total energy sector
  - Can part of the bio-energy sector be beneficially used in asphalt materials?
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# Pavement Failure

- Long-term pavement aging occurs due to oxidation of the asphalt binder
- As a pavement oxidizes, the binder stiffens and becomes brittle
- Cracking eventually occurs → pavements can become structurally damaged



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# Asphalt Antioxidants

- Asphalt antioxidants have been previously researched

- Lead diamyldithiocarbamate (LDADC)
- Zinc kailkyldiathiophashate (ZDDP)
- Zinc diabutyl dithiocarbamate (ZDBC)
- Wood lignin



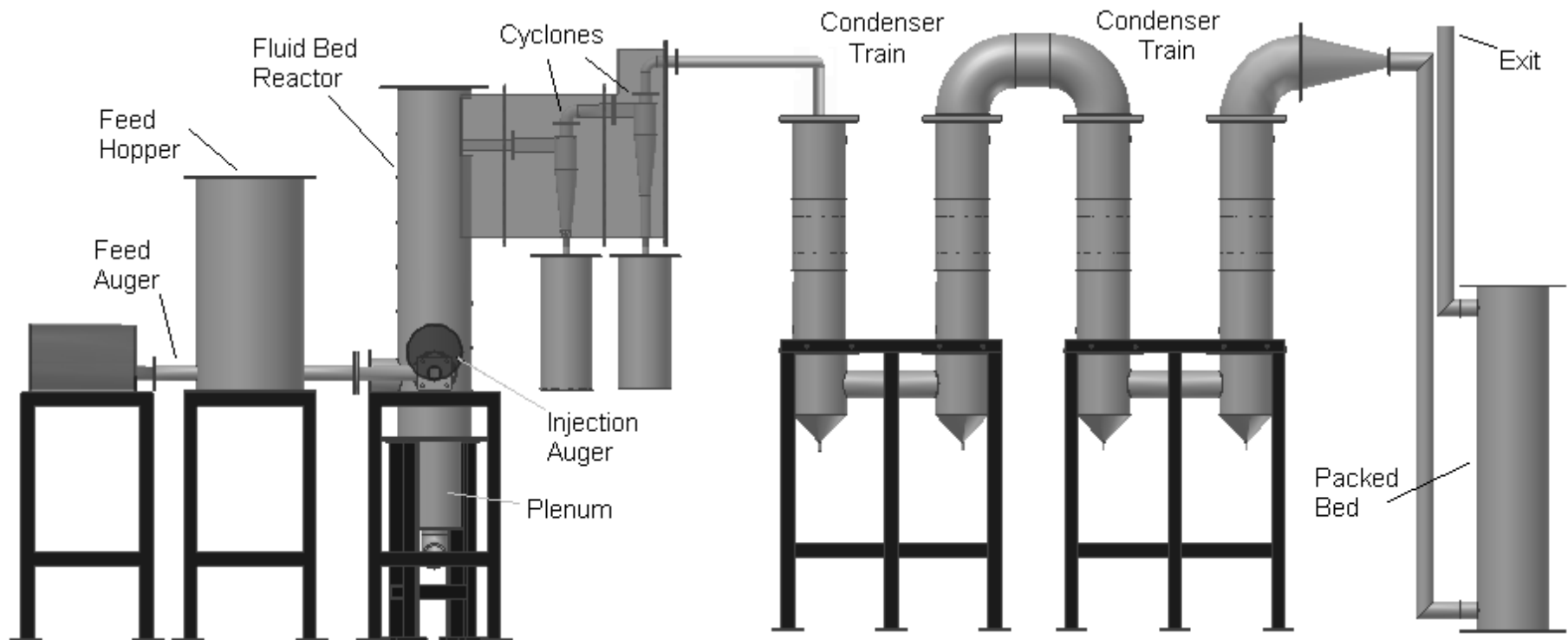
- Many chemicals have proven beneficial, but price and environmental concerns limit use
  - Is there a low cost, environmentally safe antioxidant readily available for use in asphalt pavements?
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# Lignin

- Lignin is a known antioxidant – phenol group
- Abundant supply – 2<sup>nd</sup> most available biological polymer on earth
- Wood derived lignin has been tested as an antioxidant in asphalt binders
- Not much research has been performed, but results showed promise



# Bio-oil Pilot Plant



# Characteristics of Fractionated Bio-Oil

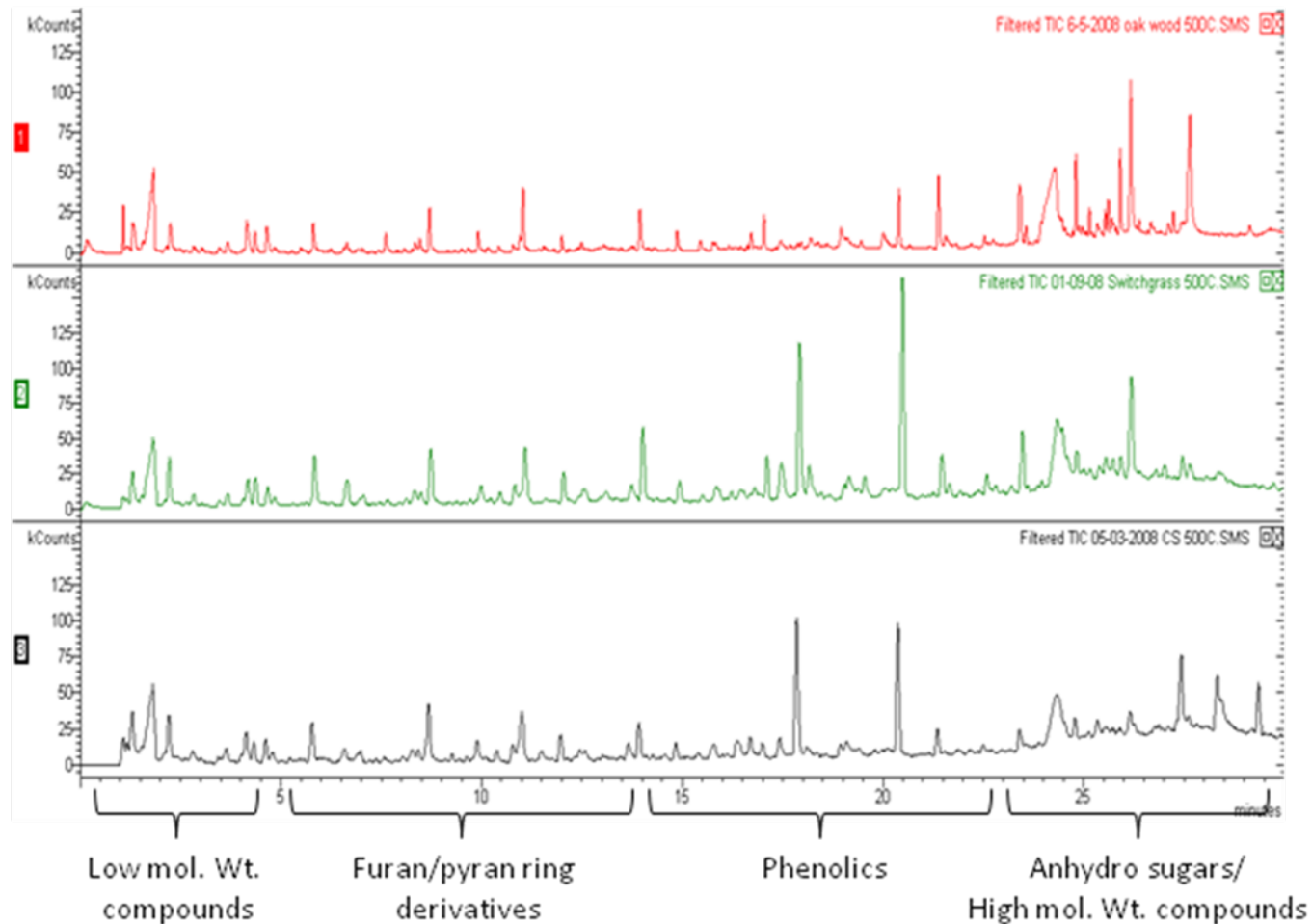
Property	Cond. 1	Cond. 2	Cond. 3	Cond. 4	ESP
Fraction of total oil (wt%)	6	22	37	15	20
pH	-	3.5	2.7	2.5	3.3
Viscosity @40oC (cSt)	Solid	149	2.2	2.6	543
Lignin Content (wt%)	High	32	5.0	2.6	50
Water Content (wt%)	Low	9.3	46	46	3.3
C/H/O Molar Ratio	1/1.2/ 0.5	1/ 1.6/ 0.6	1/ 2.5 / 2	1/ 2.5 /1.5	1/1.5/ 0.5



	<b>Corn Stover</b>	<b>Oak Wood</b>	<b>Switch Grass</b>
<b>Lignin</b>	<b>82.3</b>	<b>83.9</b>	<b>81.0</b>
<b>Moisture</b>	<b>16.8</b>	<b>15.4</b>	<b>17.8</b>
<b>Solids</b>	<b>0.6</b>	<b>0.6</b>	<b>1.1</b>
<b>Ash</b>	<b>0.3</b>	<b>0.1</b>	<b>0.2</b>

# Micropyrolyzer GC/MS Analysis of Feedstock Materials

Oak Wood

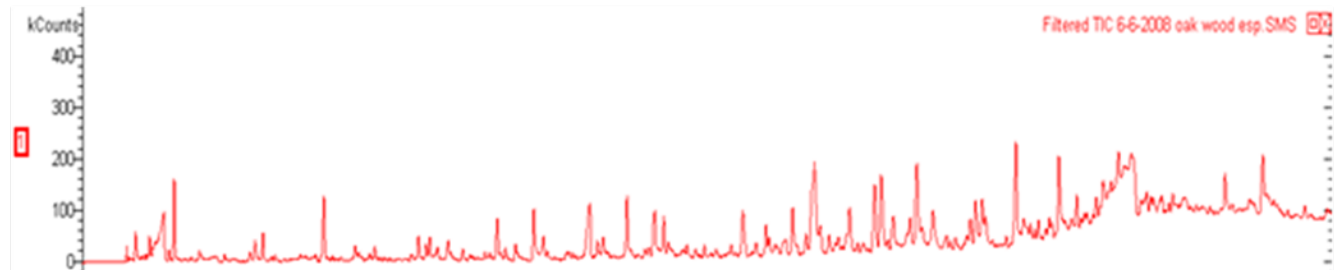


Switch Grass

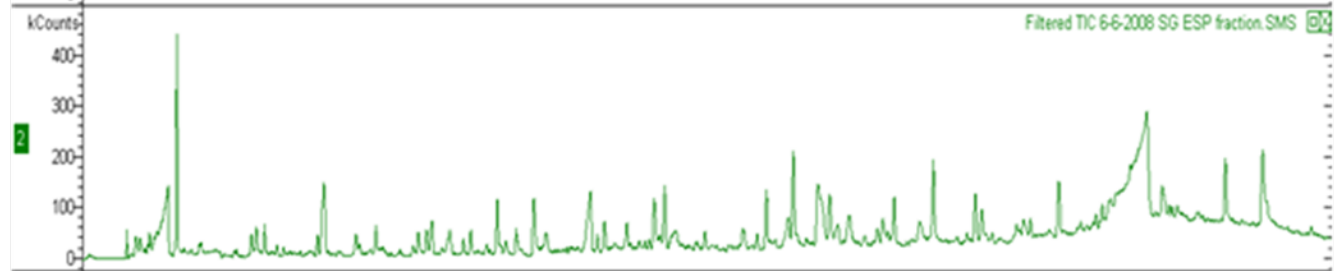
Corn Stover

# GC/MS Analysis of ESP Fractions

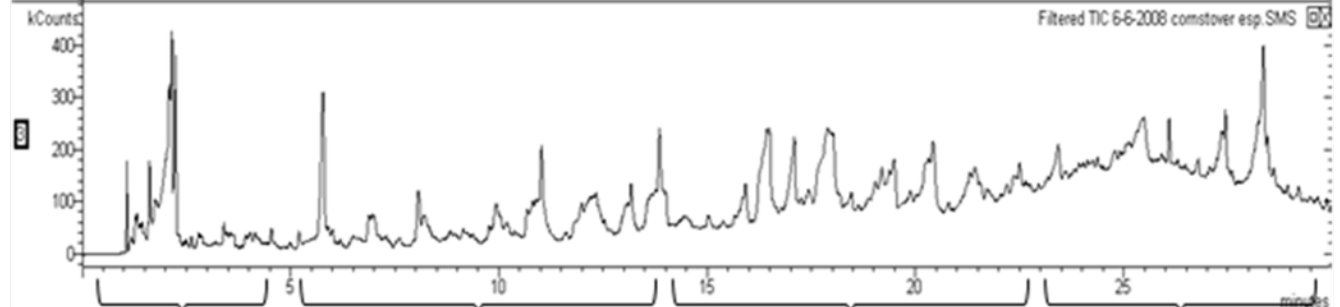
Oak Wood



Switch Grass



Corn Stover



Low mol. Wt.  
compounds

Furan/pyran ring  
derivatives

Phenolics

Anhydro sugars/  
High mol. Wt. compounds

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# Experimental Plan

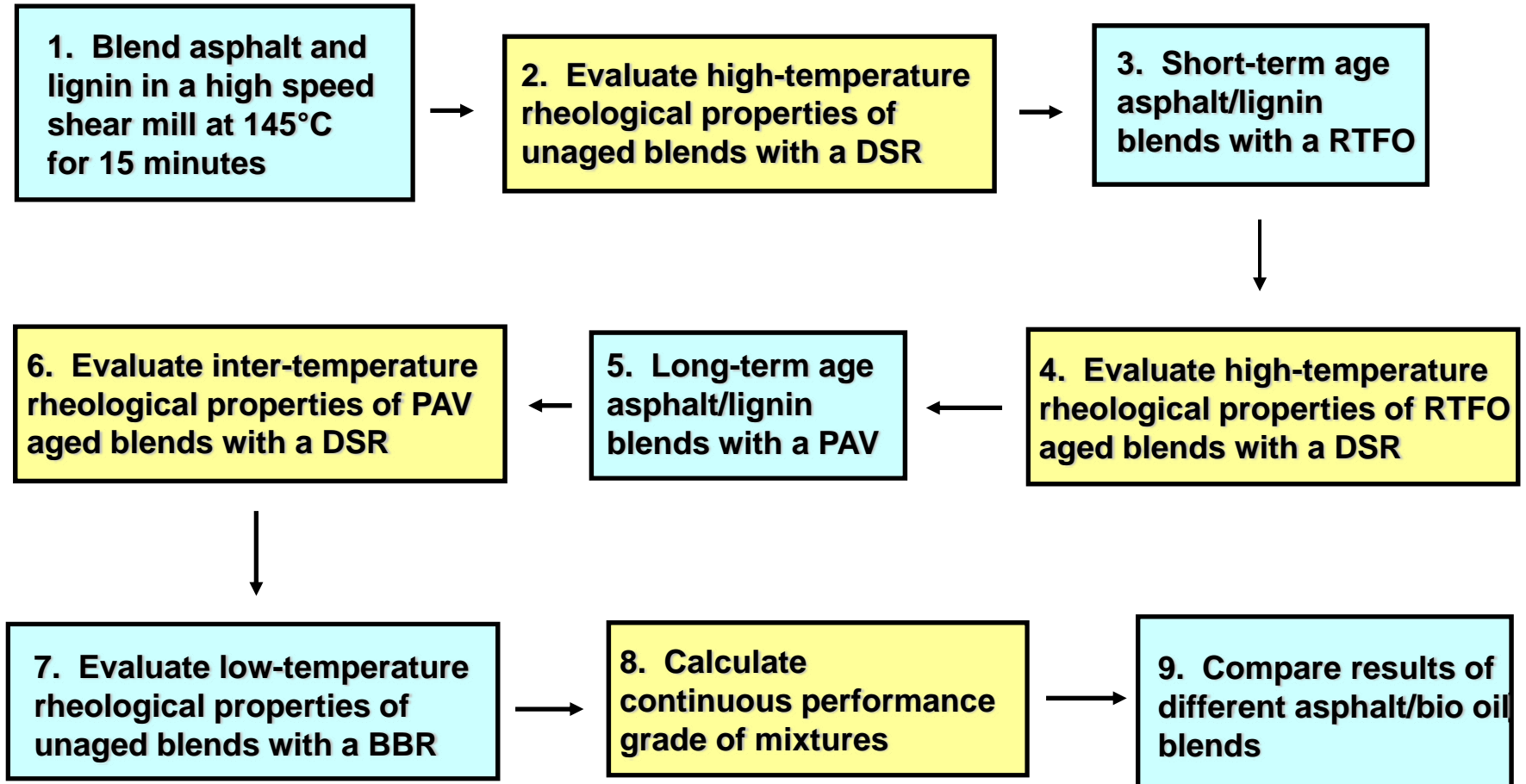
- Three asphalt binders
    - 1 local binder (1 polymer-modified, 1 neat binder)
    - 2 well known binders (AAD-1 & AAM-1)
  - Three experimental bio-oil fractions
    - Corn Stover
    - Oak Wood
    - Switch Grass
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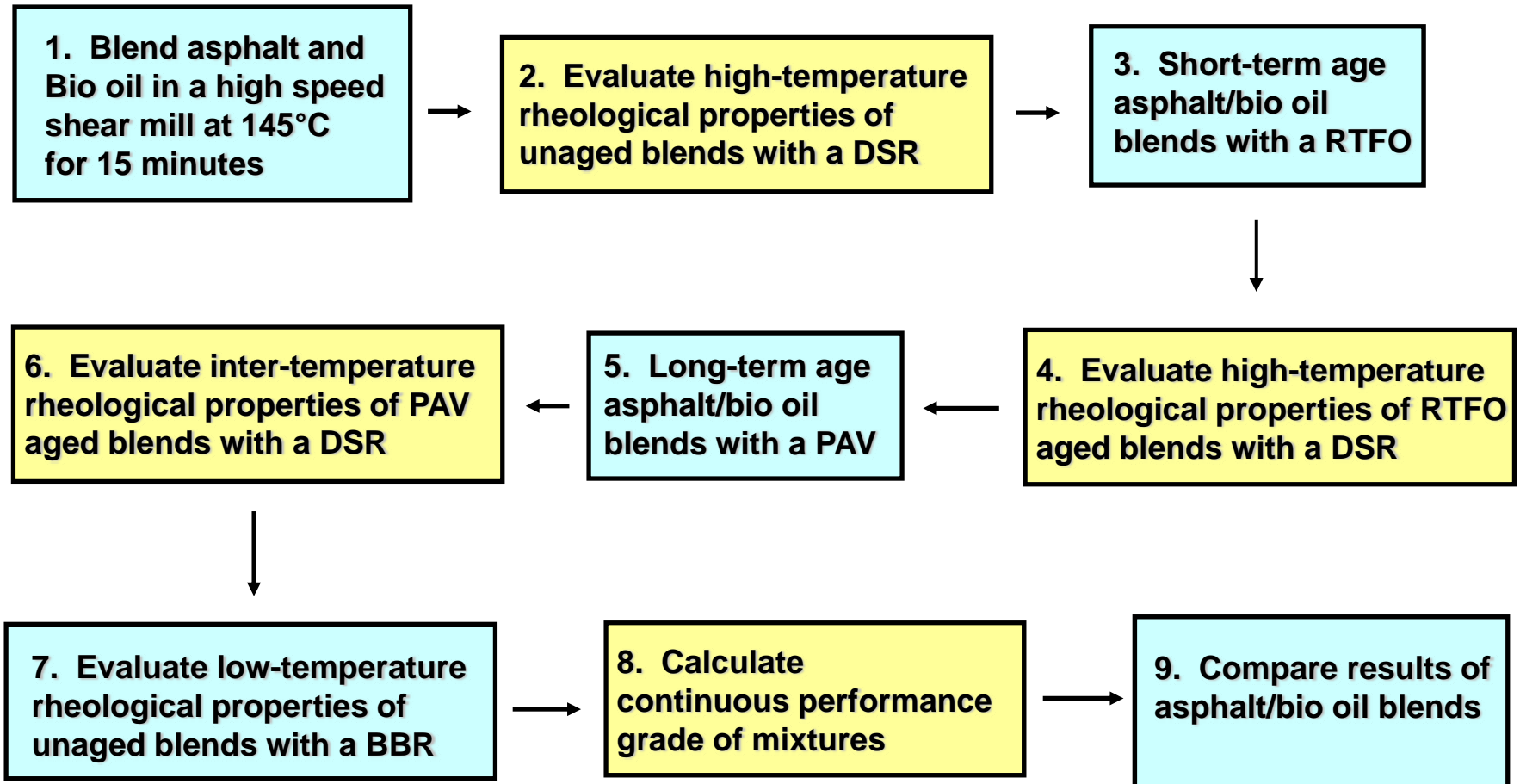
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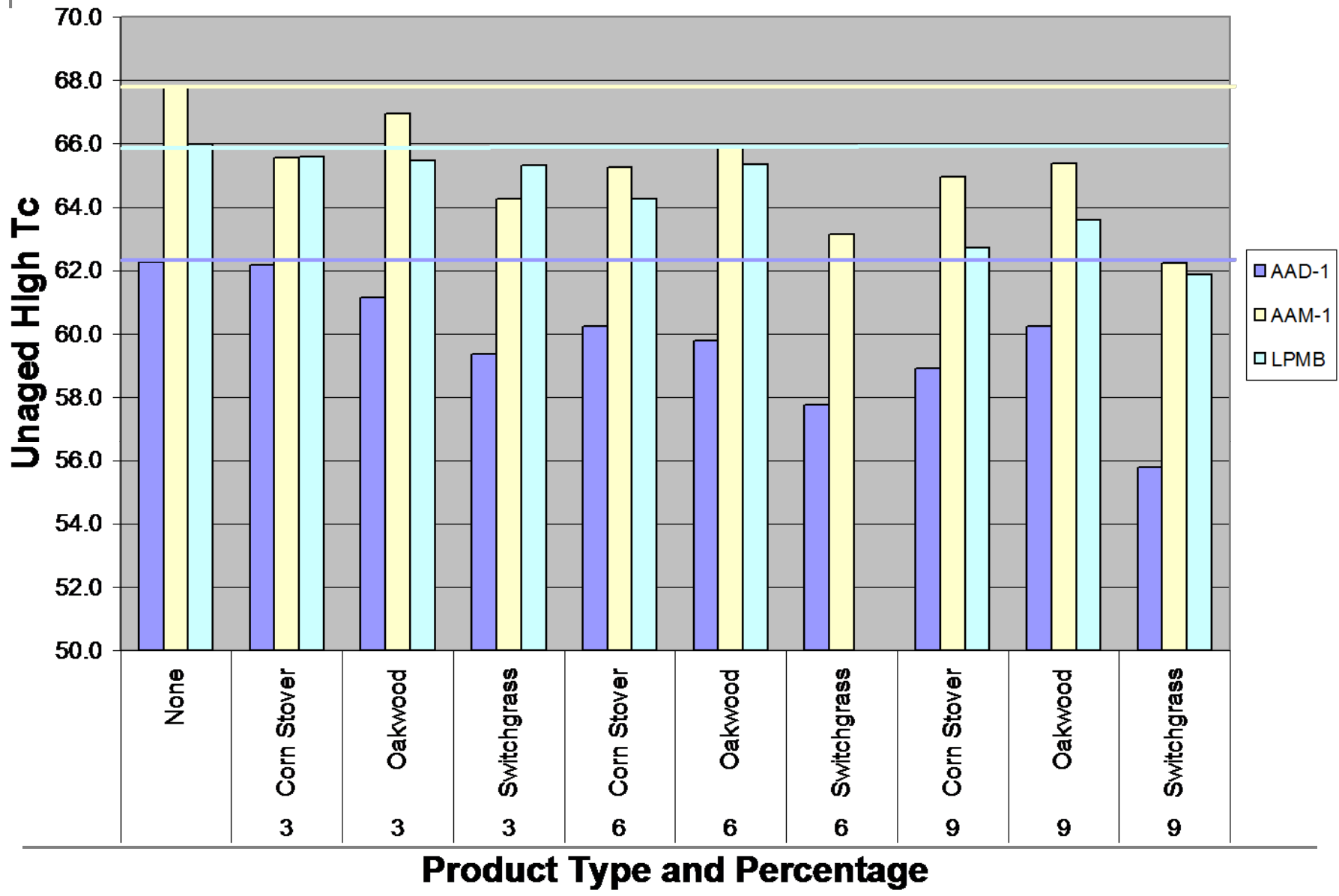
# Experimental Plan

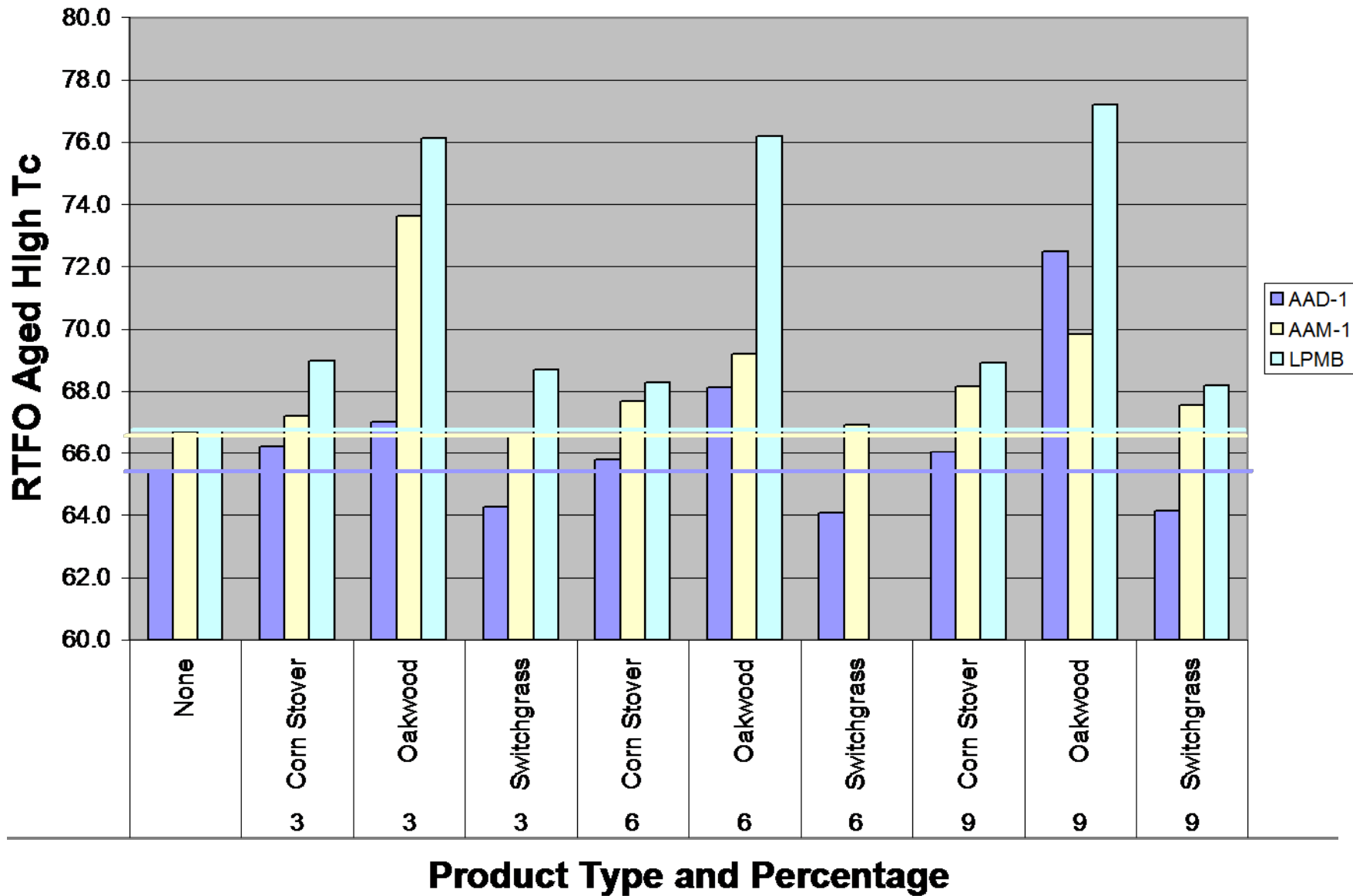
- Each asphalt mixed with each lignin sample at 3, 6, and 9 percent by weight
  - Evaluate rheological properties and determine  $T_c$  and performance grade of each blend
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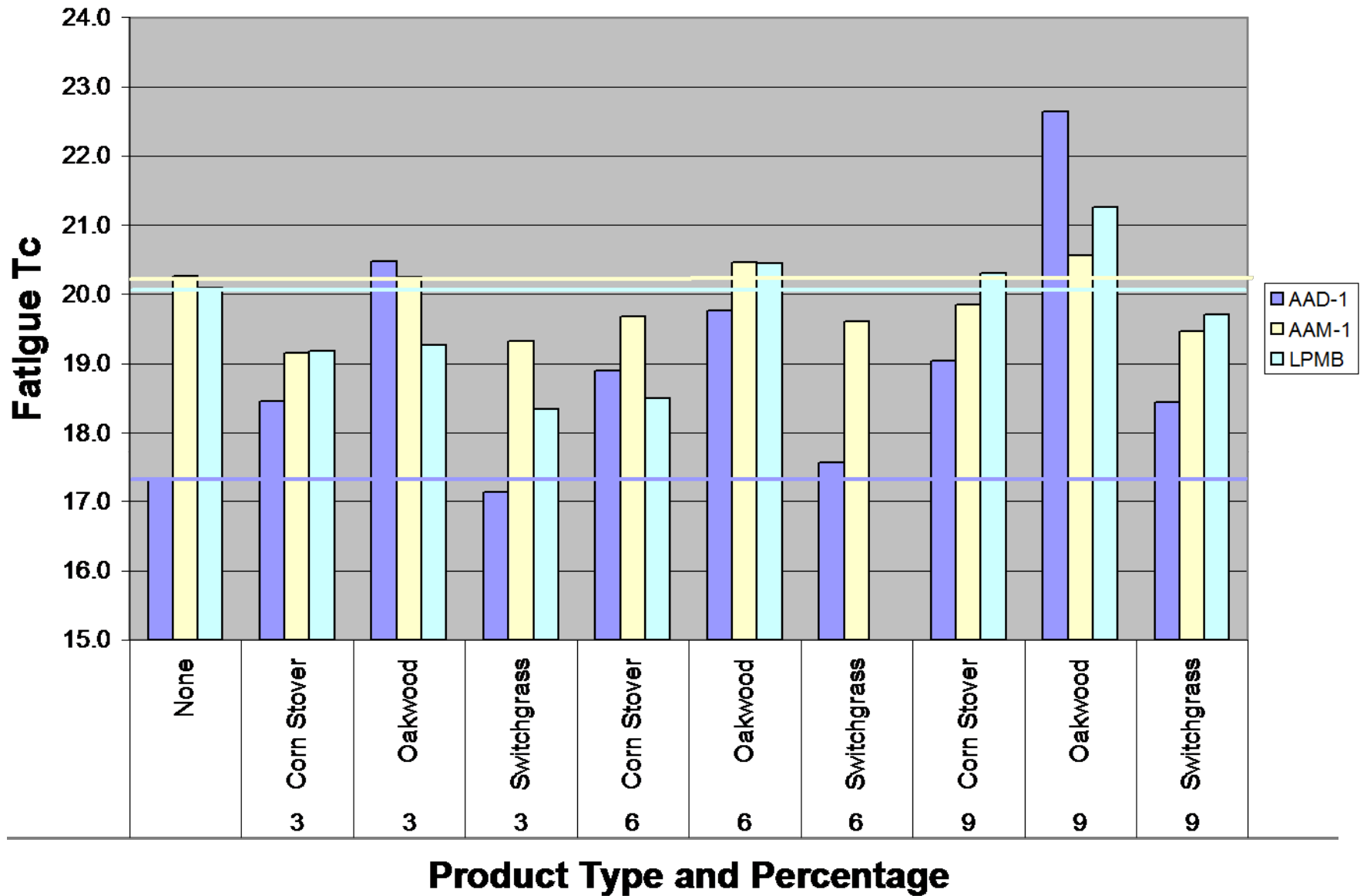
# Performance Testing



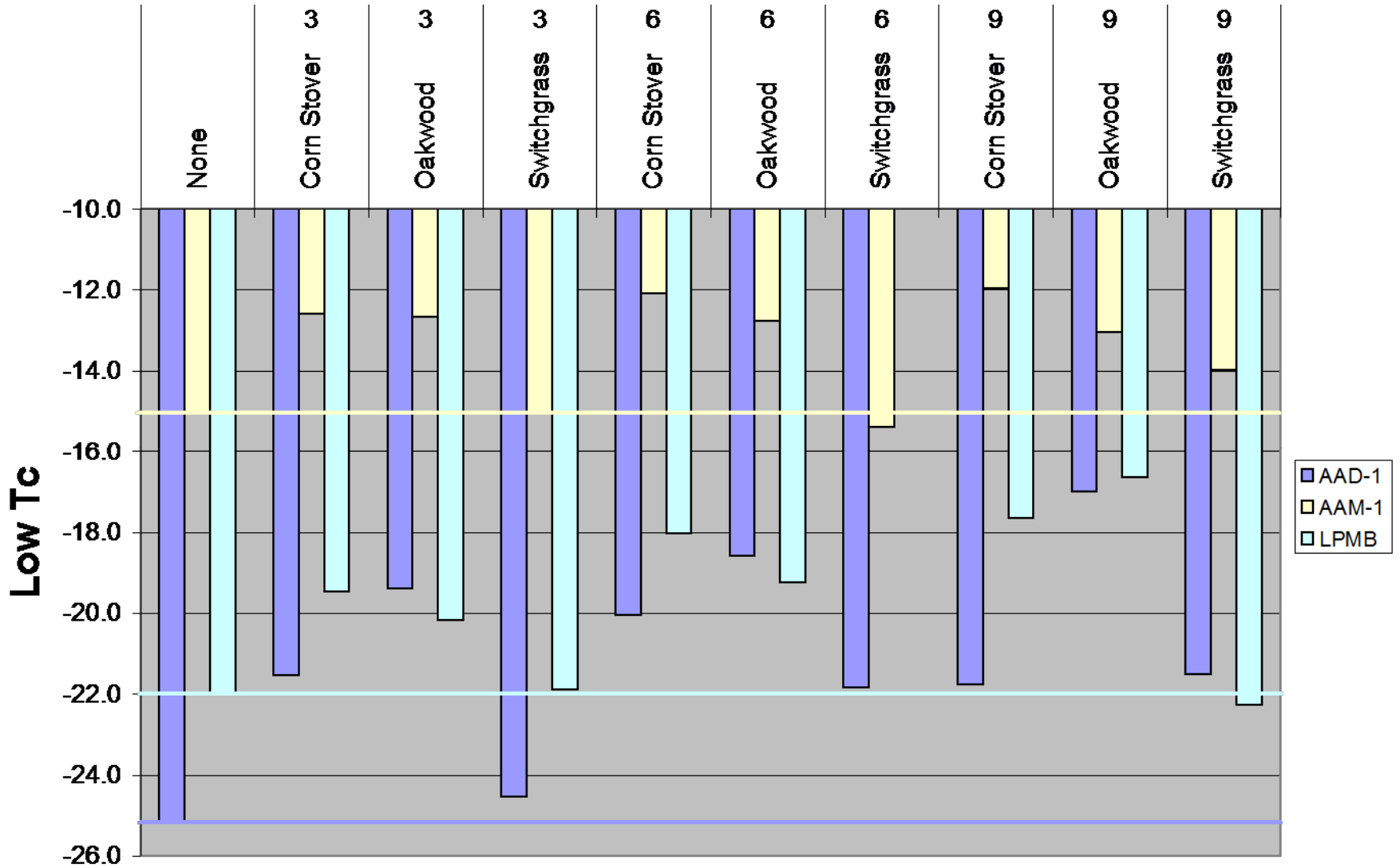


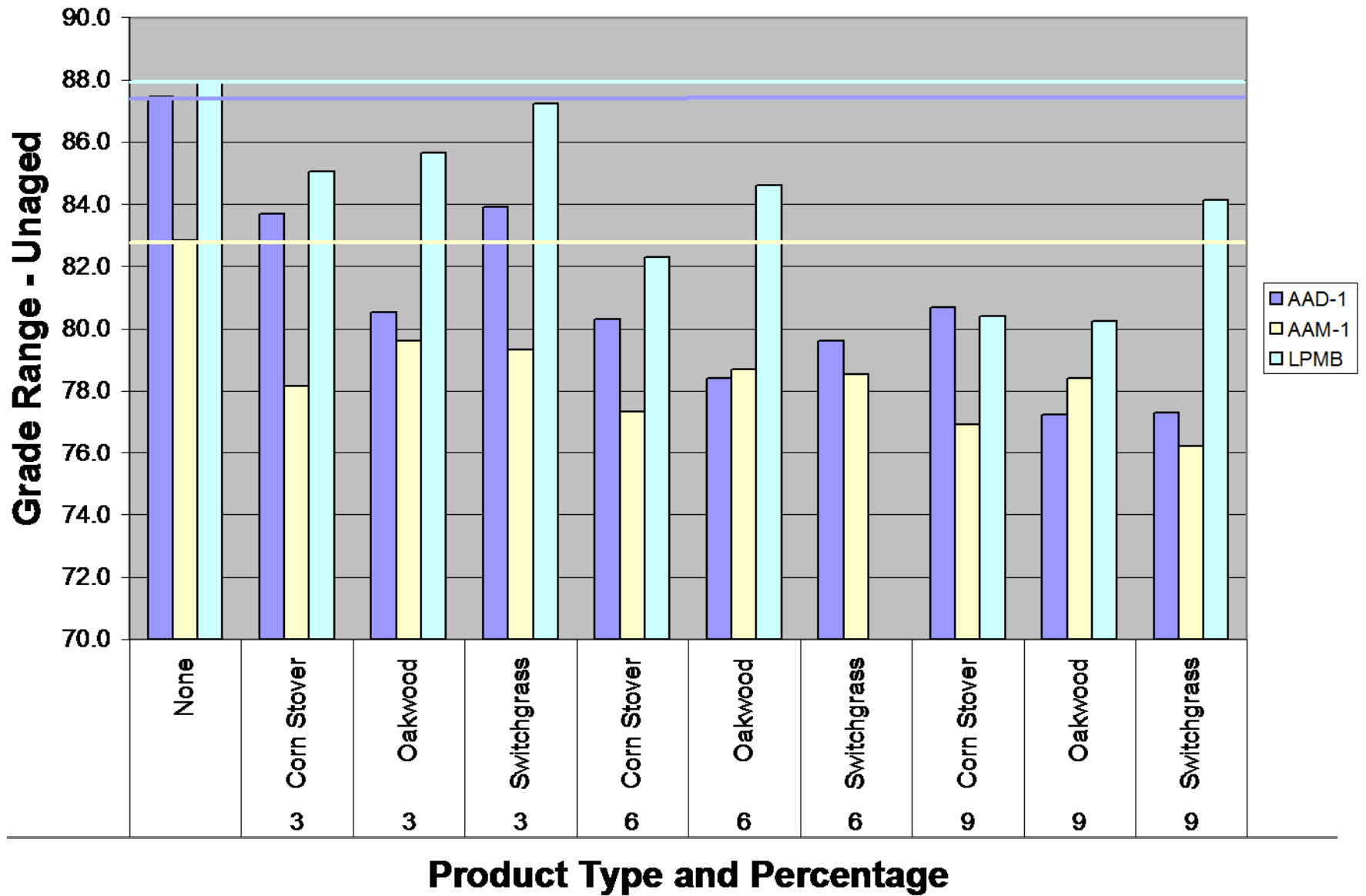


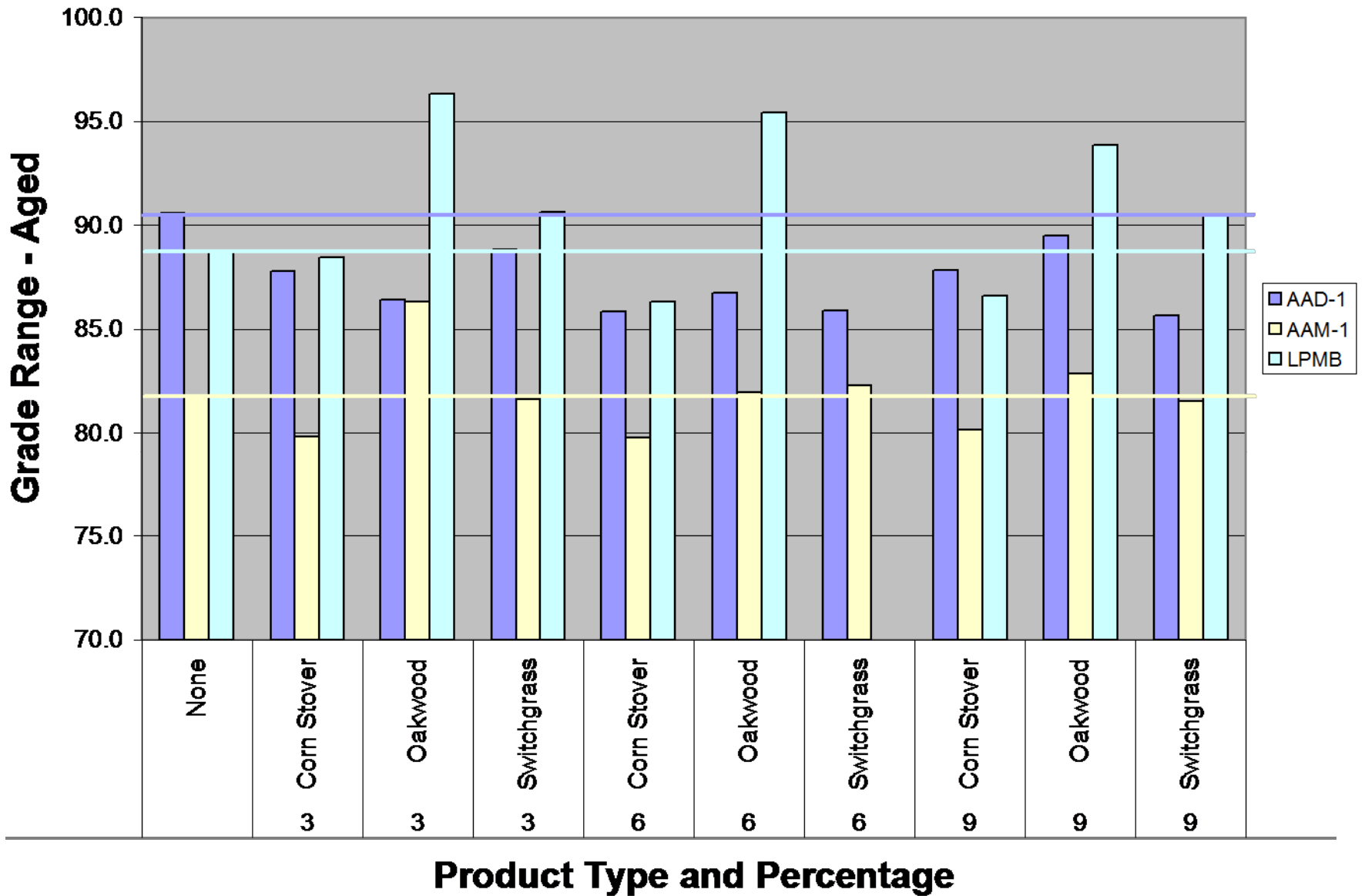




# Product Type and Percentage







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# Conclusions

- The addition of lignin containing co-products to asphalt binders causes a stiffening effect
    - Binder effects
    - Biomass Source of Lignin
    - Amount of Lignin
  - The stiffening effect increases the high, int., and low critical temperatures of the asphalt/lignin blends
  - The high temperatures are increased more than the low temperatures
  - Grade ranges in some combinations are increased by one grade (6°C) and in other combinations no effects
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# Future Research

- Examination of chemistry & its relationships to rheology
  - Examination of reduced production temperatures
  - Developing non-petroleum based binder
  - Mix performance testing
    - Permanent deformation
    - Fatigue cracking
    - Thermal cracking
    - Moisture susceptibility
  - Construction of 5 ton/day pilot plant is underway
  - Construction of 50 ton/day pilot plant is planned for Fall 2008
  - Field trials
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# Big Picture

- Economic opportunity
  - Integration of green technologies into asphalt industry that is sustainable
  - Bio-energy co-products will be regionally produced and “married” with regionally supplied asphalt binders
  - The US economy is highly dependant upon transportation infrastructure
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# Acknowledgements

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**Thank You!**  
**Questions?**

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