Applications of Gel Permeation Chromatography (GPC) to Asphalt Binder Characterization

William H. Daly

Ionela Glover, Ioan Negulescu

Chris Abadie, Rafael Cueto

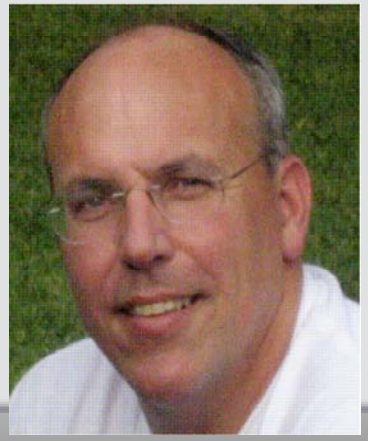
YOUR WORLD DESTINATION… TARGETED!

RAP

The Co-authors

Ioan Negulescu

Ionela Glover



Chris Abadie

Rafael Cueto

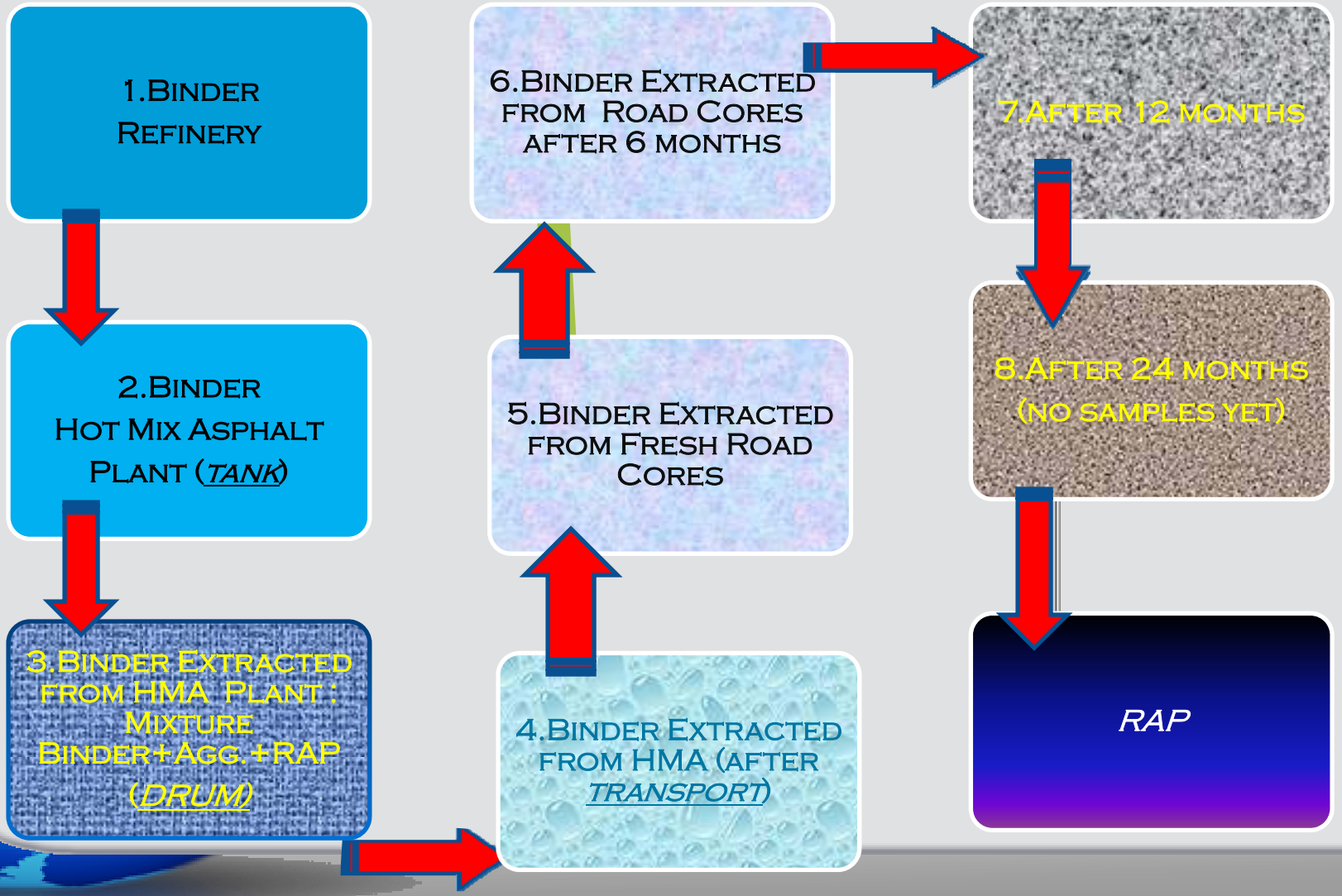
Objectives

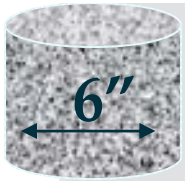
- Develop Experimental Procedures for utilizing Gel Permeation Chromatography (GPC)
- Evaluate binder changes during processing sequence using GPC
- Observe impact of RAP addition during processing
- Follow aging process by coring pavements at annual intervals

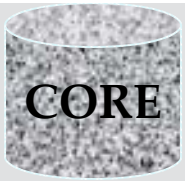
Down the Road, Asphalt Cement Preparation

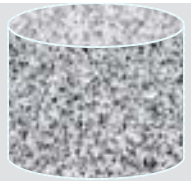
Polymer
-radial
-linear

Sequence of Binder Samples for this Study

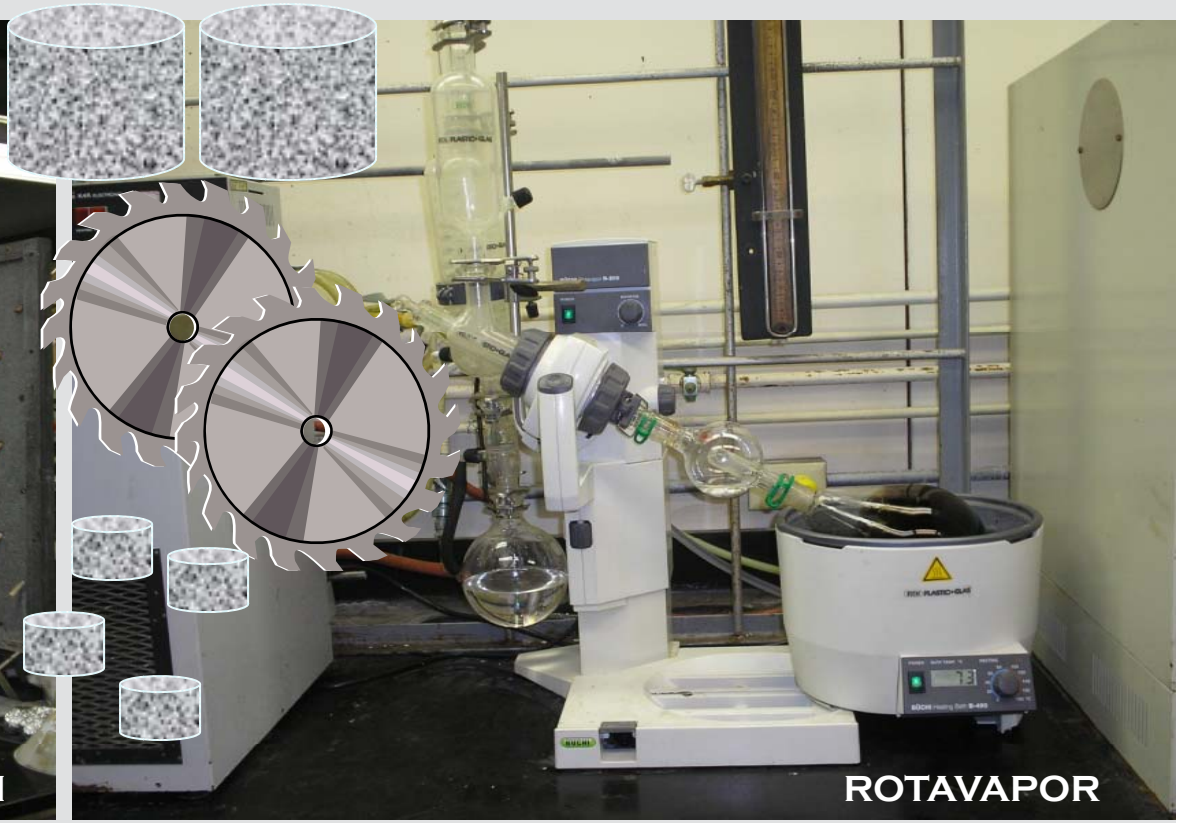


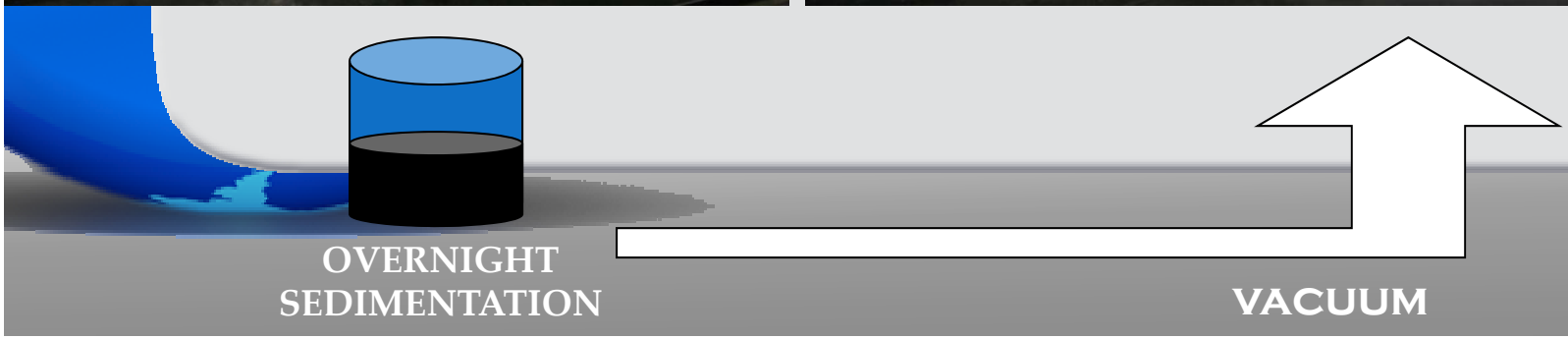




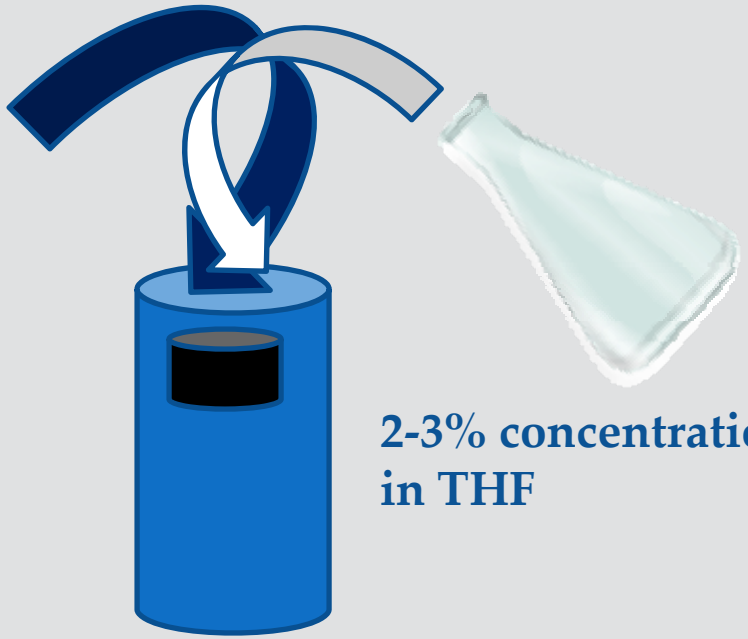


Asphalt Binder Extraction

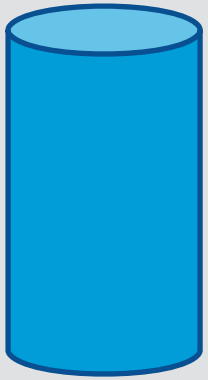




GPC Sample Preparation

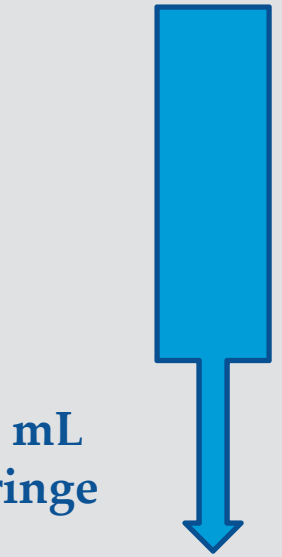


2-3% concentration in THF



1.5 mL vial

3-5 mL syringe



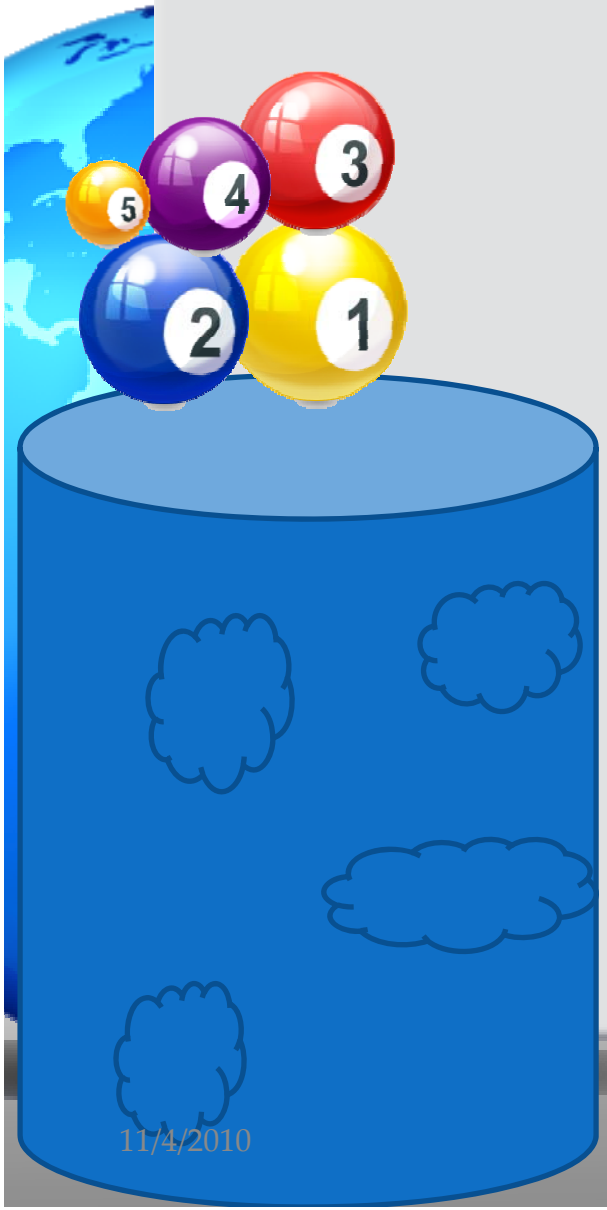
PTFE 45µm filter

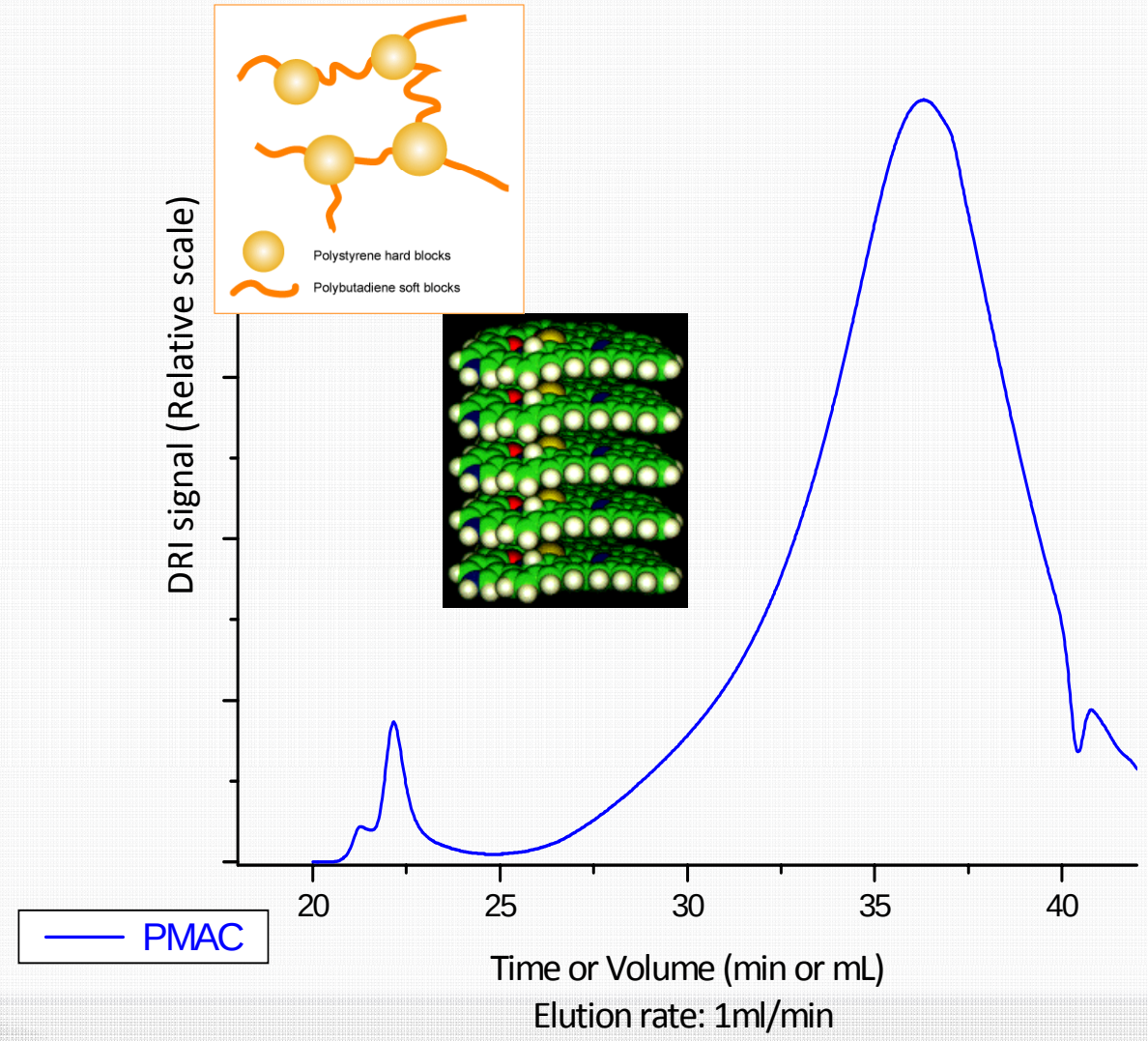
% insoluble by weight

PTFE 45µm THF washed filter

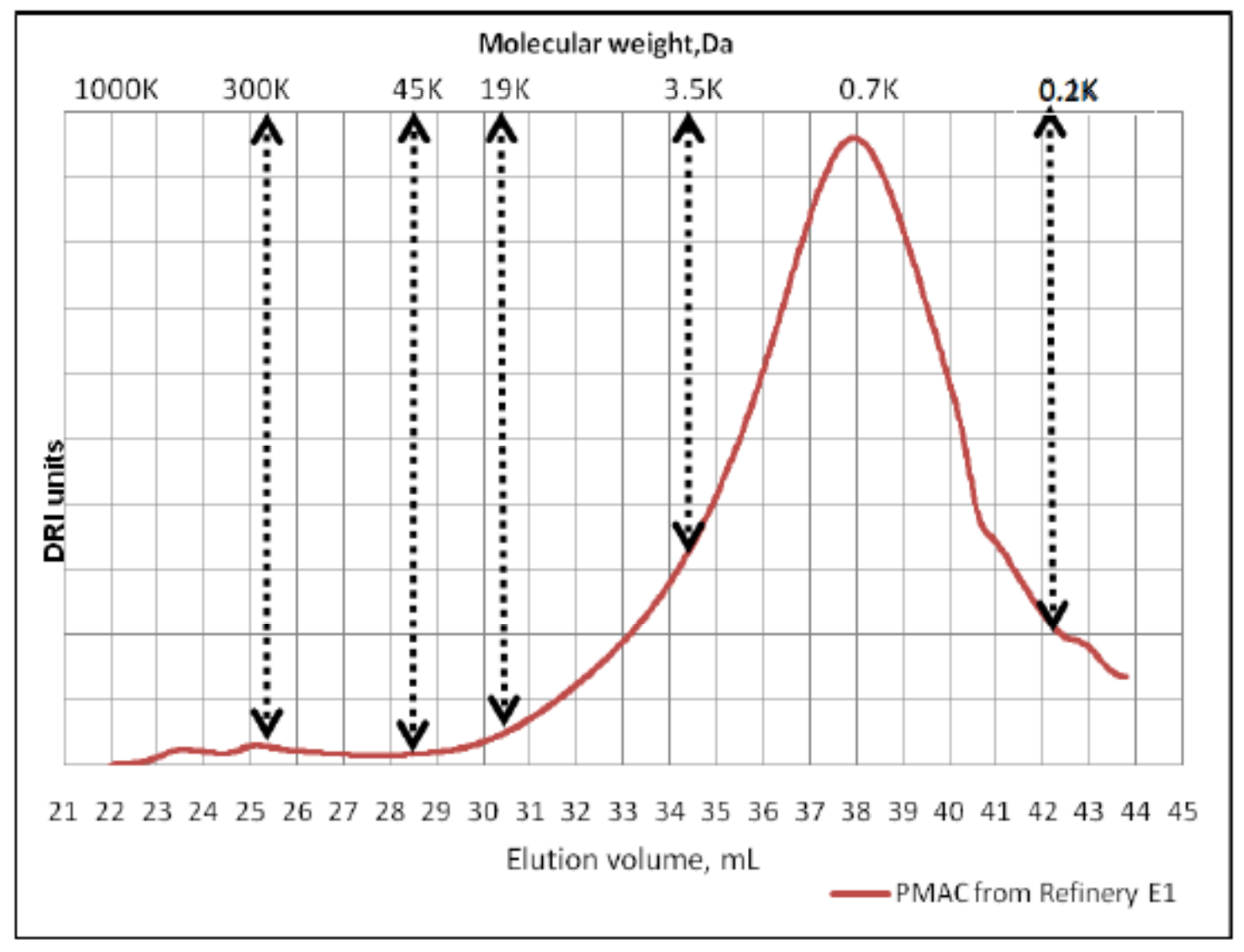
Agilent 1100 GPC System

Typical PMAC GPC Chromatogram

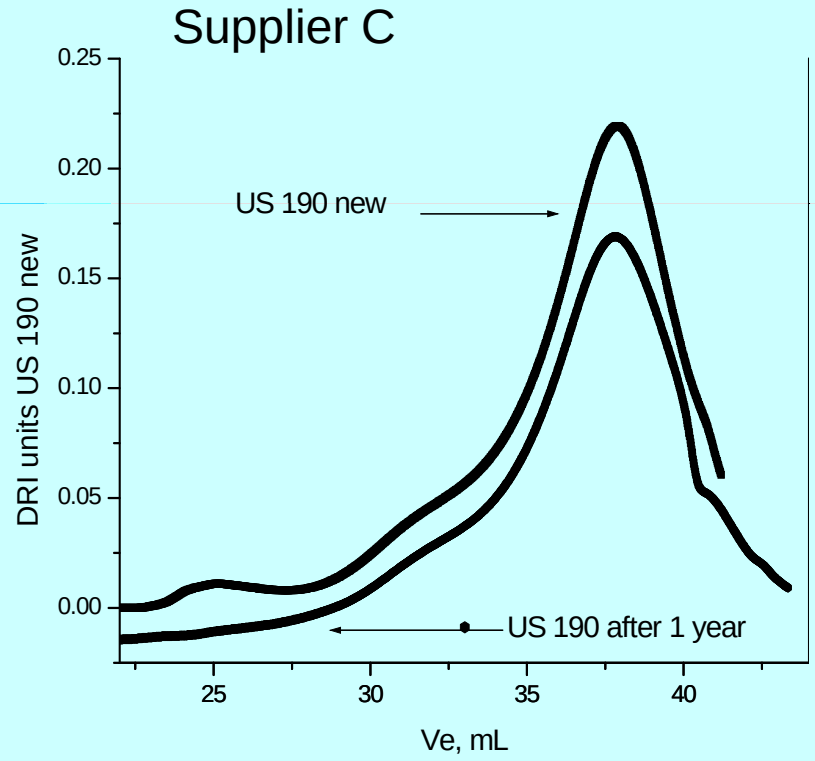


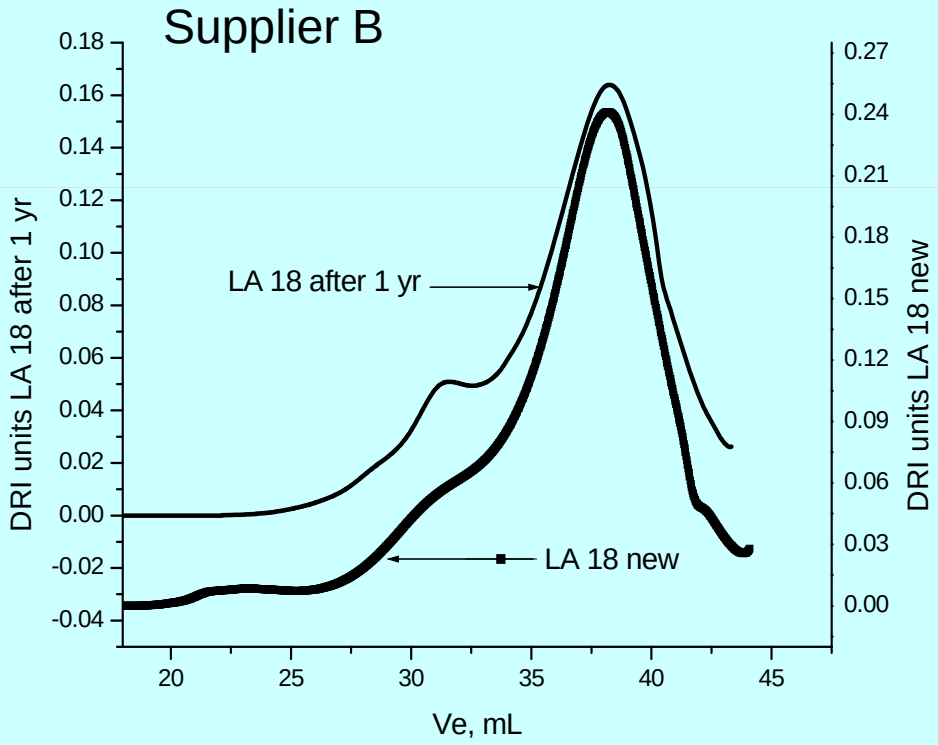


Regions of a PMAC GPC chromatogram, showing the relationship between elution volume and molecular weights values, based on calibration curve.



GPC chromatogram of binders Before and after 1 year in the field





Distribution of components in original asphalt binders

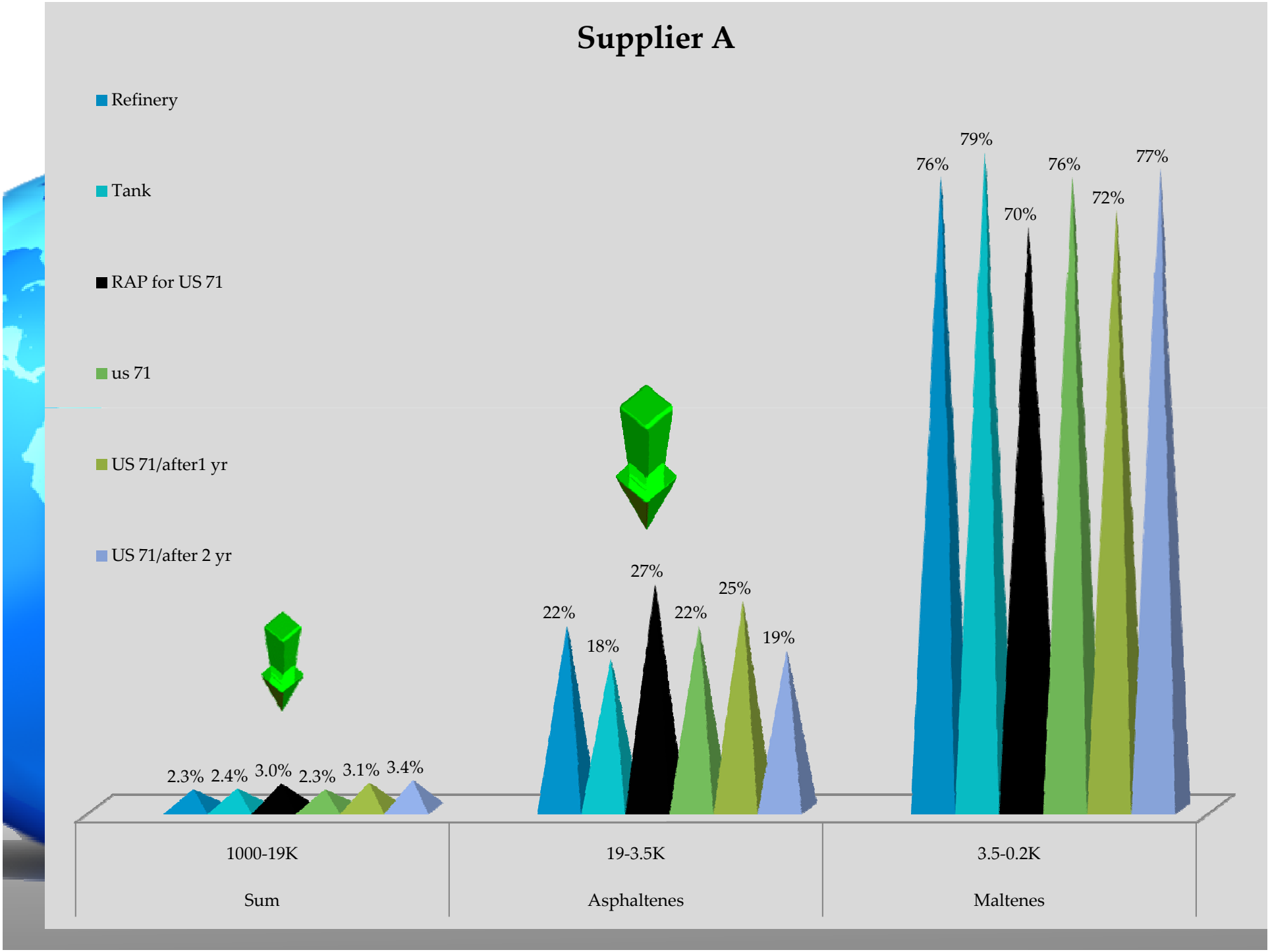
		VHMw	HMw	MMw	Sum	Asphaltenes	Maltenes
	PG	1000-300K	300-45K	45-19K	1000-19K	19-3K	3-0.2K
A	64-22	0.0%	0.0%	0.0%	0.0%	15%	85%
A	70-22M	0.2%	0.6%	0.5%	1.3%	15%	84%
A	76-22M	0.6%	3.0%	0.7%	4.3%	14%	82%
B	64-22	0.0%	0.0%	0.0%	0.0%	19%	81%
B	70-22M	0.1%	1.2%	0.6%	1.9%	17%	81%
B	76-22M	0.3%	1.0%	0.8%	2.1%	16%	82%
C	64-22	0.0%	0.0%	0.0%	0.0%	16%	84%
C	70-22M	0.0%	0.5%	0.8%	1.3%	17%	82%
C	76-22 M	0.1%	1.3%	1.2%	2.7%	17%	81%

Distribution of components

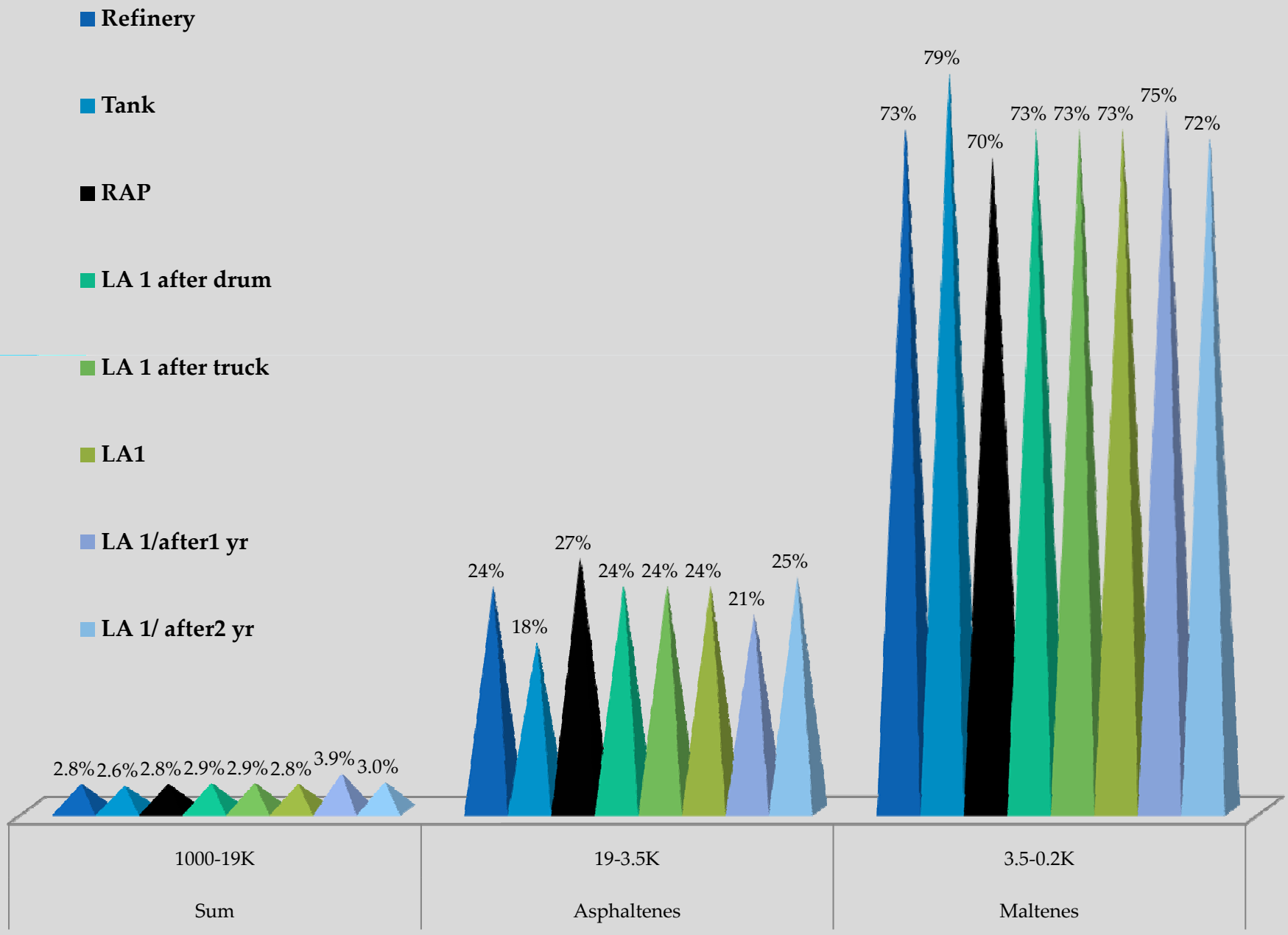
	VHMw	HMw	MMw	Sum	Asphaltenes	Maltenes
	1000-300K	300-45K	45-19K	1000-19K	19-3.5K	3.5-0.2K
Supplier A2						
Refinery	0.0%	0.4%	1.9%	2.3%	22%	76%
Tank	0.2%	1.2%	1.0%	2.4%	18%	79%
RAP for US 71	0.0%	0.7%	2.2%	3.0%	27%	70%
us 71	0.0%	0.4%	1.9%	2.3%	22%	76%
US 71/after1 yr	0.0%	1.3%	1.8%	3.1%	25%	72%
US 71/after 2 yr	0.1%	1.5%	1.7%	3.4%	19%	77%
Supplier B2						
Refinery	0.1%	1.0%	1.8%	2.8%	24%	73%
Tank	0.3%	1.1%	1.2%	2.6%	18%	79%
RAP	0.0%	0.5%	2.3%	2.8%	27%	70%
LA 1 after drum	0.1%	1.0%	1.9%	2.9%	24%	73%
LA 1 after truck	0.1%	1.0%	1.9%	2.9%	24%	73%
LA1	0.1%	1.0%	1.8%	2.8%	24%	73%
LA 1/after1 yr	0.1%	1.3%	2.5%	3.9%	21%	75%
LA 1/ after2 yr	0.0%	1.0%	2.0%	3.0%	25%	72%
Supplier C1						
Refinery	0.1%	2.0%	1.5%	3.6%	21%	75%
Tank	0.1%	2.1%	0.8%	3.1%	18%	79%
NO RAP						
US 190	0.1%	2.0%	1.5%	3.6%	21%	75%
US 190/after 1yr	0.3%	1.6%	1.6%	3.5%	13%	84%
Us 190/after 2 yr	0.1%	1.6%	1.8%	3.5%	19%	78%

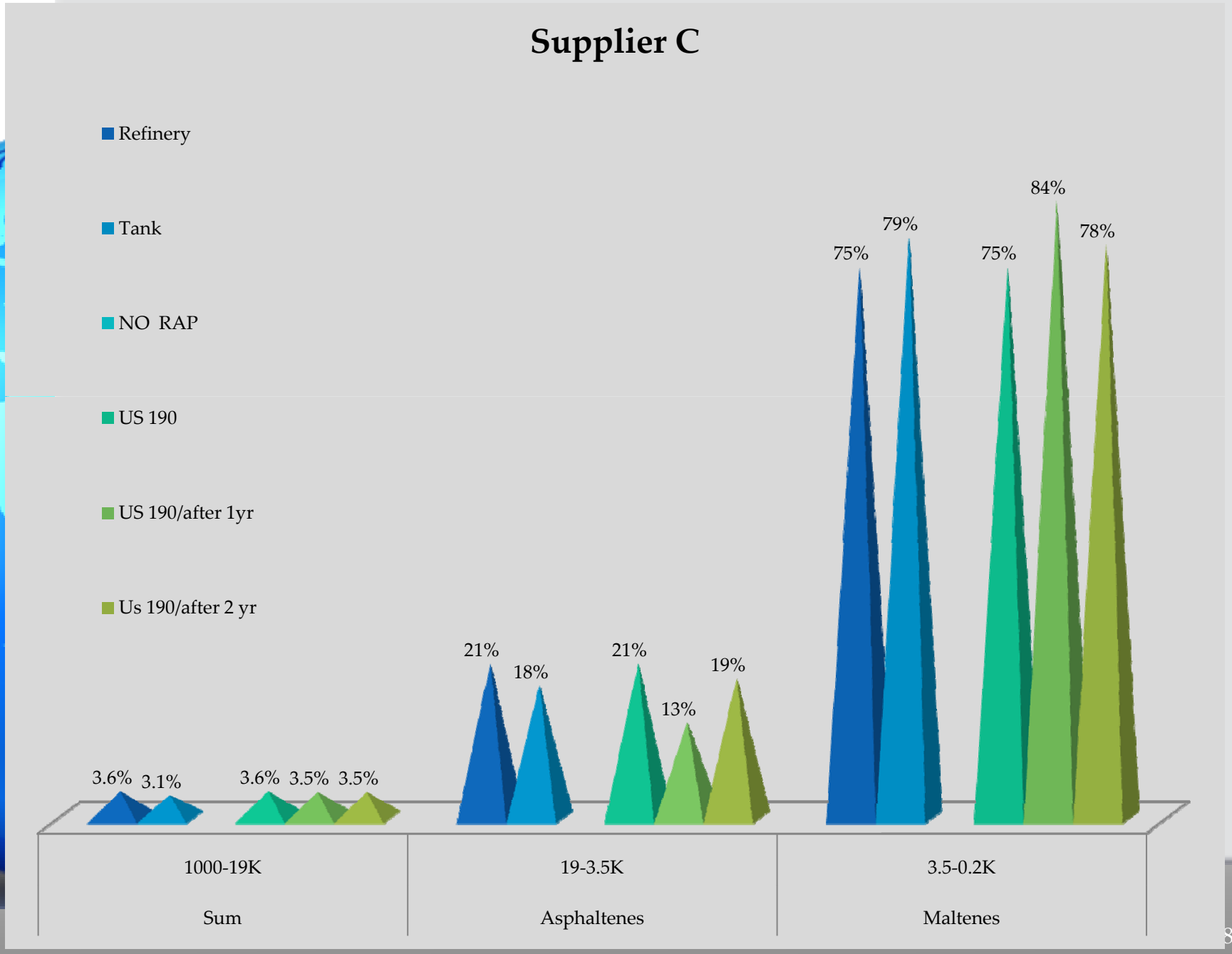
Typical Binder THF Insolubles

PG Grade or RAP sample	Typical % insoluble THF on 0.45 mμ filter
64-22, original	4%-5%
76-22 original	6-7%
76-22, core new route	10-11%
RAP	7-10%
Source	Atypical
B1 refinery	18%
LA 18 new	23%

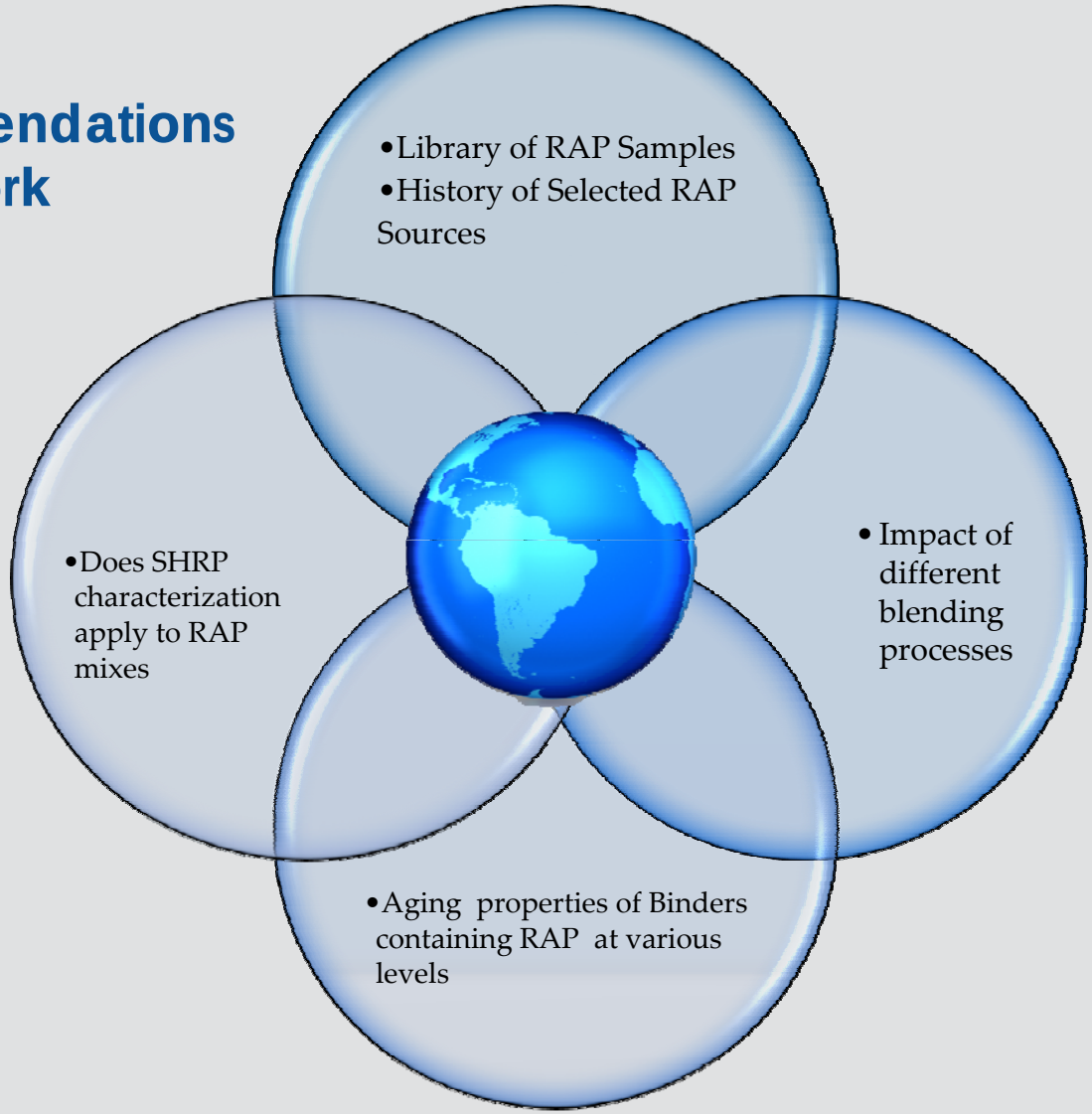

Supplier A
Refinery
Tank
RAP for US 71
us 71
US 71/after1 yr
US 71/after 2 yr
2.3%
2.4%
3.0%
2.3%
3.1%
3.4%
22%
18%
27%
22%
25%
19%
76%
79%
70%
76%
72%
77%
1000-19K
Sum
19-3.5K
Asphaltenes
3.5-0.2K
Maltenes

Supplier B

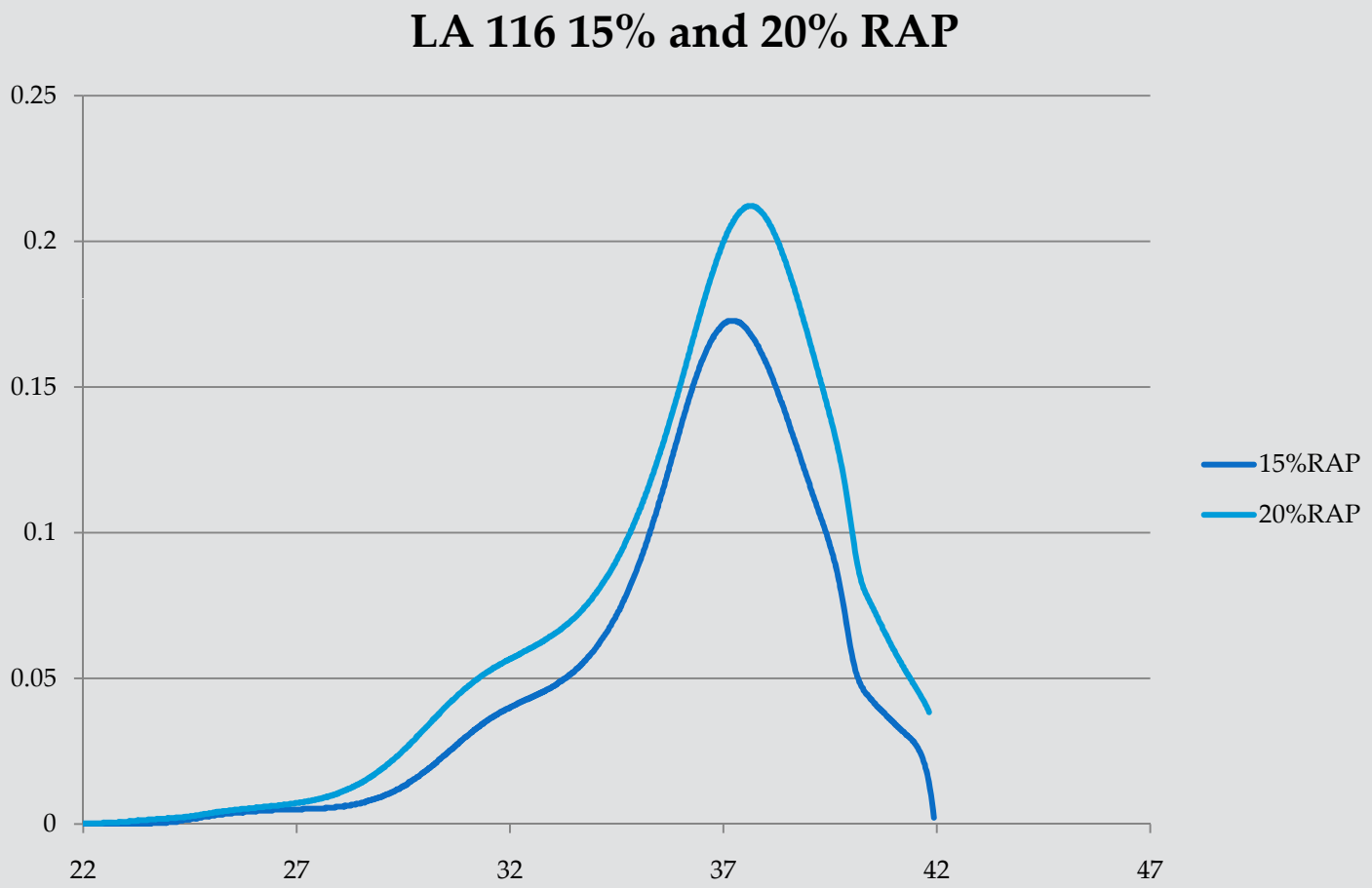

Refinery
Tank
RAP
LA 1 after drum
LA 1 after truck
LA1
LA 1/after1 yr
LA 1/ after2 yr
2.8% 2.6% 2.8% 2.9% 2.9% 2.8% 3.9% 3.0%
24% 18% 27% 24% 24% 24% 21% 25%
73% 79% 70% 73% 73% 73% 75% 72%
1000-19K
Sum
19-3.5K
Asphaltenes
3.5-0.2K
Maltenes


Supplier C
Refinery
Tank
NO RAP
US 190
US 190/after 1yr
Us 190/after 2 yr
3.6%
3.1%
3.6%
3.5%
3.5%
21%
18%
21%
13%
19%
75%
79%
75%
84%
78%
1000-19K
Sum
19-3.5K
Asphaltenes
3.5-0.2K
Maltenes

Recommendations Future Work

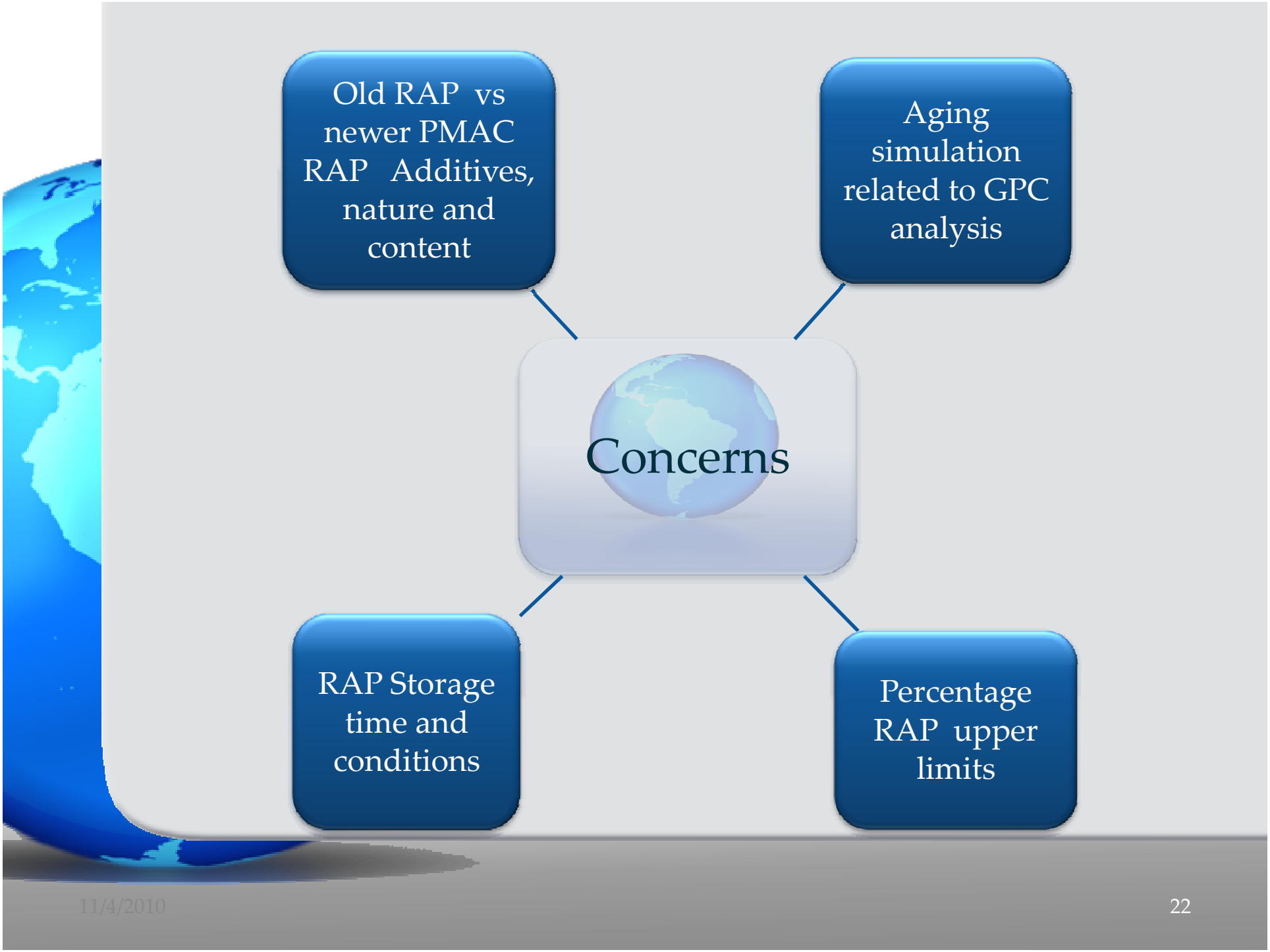


Not ready


LA 116 15% and 20% RAP
0.25
0.2
0.15
0.1
0.05
0
22
27
32
37
42
47
15%RAP
20%RAP

RTFO vs. Core Road

	VHMw	HMw	MMw	Sum	Asphaltenes	Maltenes
	1000-300K	300-45K	45-19K	1000-19K	19-3.5K	3.5-0.2K
Refinary A/ RTFO	0.2%	1.3%	0.9%	2.4%	20%	78%
LA 26 core road	0.2%	1.5%	1.4%	3.1%	25%	72%
Refinery B/ RTFO	0.3%	1.2%	1.3%	2.9%	19%	79%
LA18 core road	0.0%	1.2%	2.3%	3.5%	26%	70%
Refinery D/ RTFO	0.5%	0.8%	0.7%	2.0%	16%	82%
LA 15 core road	0.2%	1.2%	0.9%	2.3%	20%	77%


Old RAP vs newer PMAC RAP Additives, nature and content
Aging simulation related to GPC analysis
Concerns
RAP Storage time and conditions
Percentage RAP upper limits

Conclusions

Addition of RAP during the mixing process increases the asphaltene content with a corresponding decrease in the maltenes content.

Field samples containing RAP show slower oxidation than that predicted by RTFO laboratory aging suggesting that addition of 20 wt% RAP is beneficial to oxidative stabilization.

Experimental data limited by number of RAP samples available. Please send us more samples.

Thank You , any Questions ?