THE 2ND ASIA-PACIFIC
BASE OIL CONFERENCE
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Higher VI Group III Base Oils from Fuels Hydrocracker Residues

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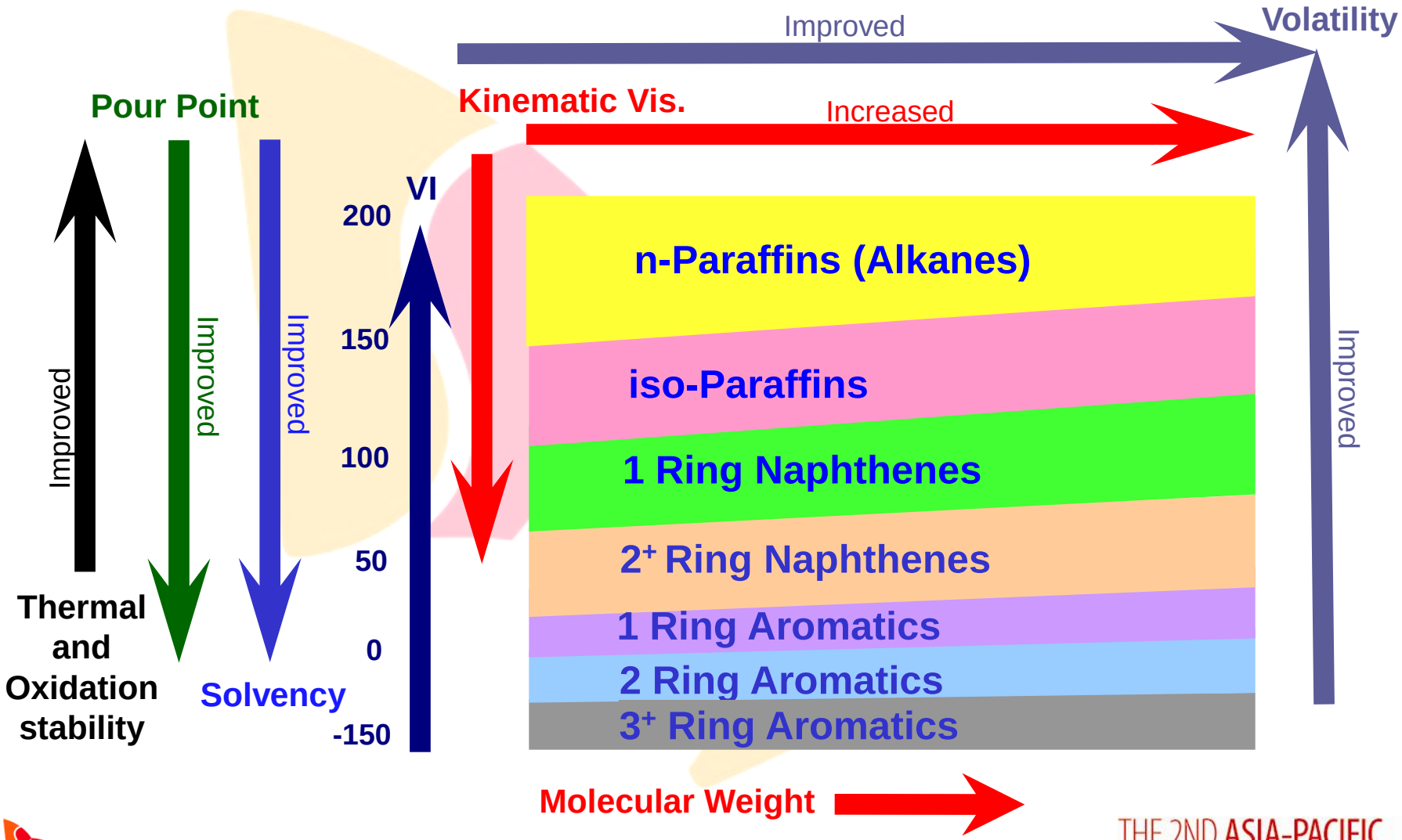
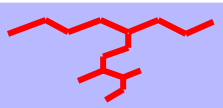
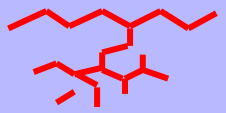
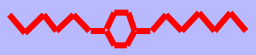
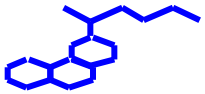
Presentation Overview

- Technical issues in base oil manufacture
- Review of VHVI base oil manufacture
- Next generation Group III base oil, New YUBASE
- Physical-chemical properties of New YUBASE
- Blending study results with New YUBASE
- Bench test results
- Summary and Discussion

Relations of base stock composition & physical property



Refining trends in base stock composition

Chemical Type	Structure	VI	Pour	Oxidation	Toxicity
n-Paraffin (Wax)		Very High ~175	Solid @50°C	Excellent	Low
iso-Paraffins with Branched chains		High ~150	Good	Excellent	Low
iso-Paraffins with highly branched chains (PAO's)		Good ~130	Good	Excellent	Low
cyclo-Paraffin-single ring with long chains		Good ~130	Good	Good	Low
Naphthenes, polycondensed		Poor ~60	Good	Medium	Low
Monoaromatics, long chains		Poor ~60	Good	Medium	Medium
Polyaromatics		Very Poor <0	Good	Very Poor	Very High

Technical issues in base oil manufacture

- SAE 0W-20 and 0W-30 full Group III oils tend to be borderline or needed PAO partially on both low temperature viscometrics and volatility
- Base oil properties controlled through feedstock selection and manufacturing process
- Refiners continue to search for innovative ways to maximize iso-paraffins and small-ring paraffins
  - Increasing hydrocracker severity
  - Waxy feeds

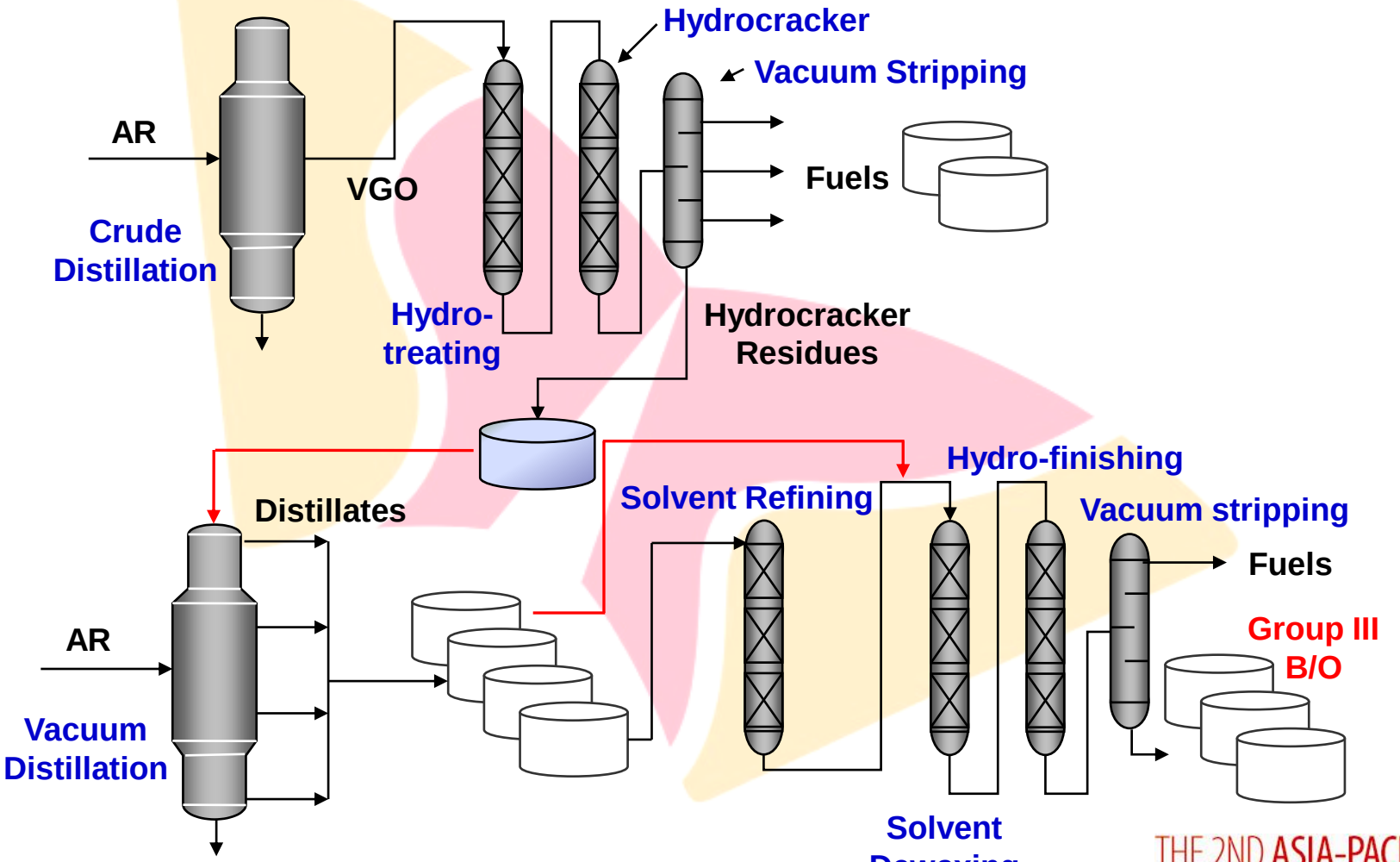
Review of VHVI base oil manufacture

Brief history of hydro-processing

- Gulf(now Chevron) introduced lube oil hydro-treating technology (Idemitsu Kosan, Chiba, 1965)
- Shell introduced severe hydro-treating for HVI base oil (1972), and VHVI base oil from slack wax (1978)
- BP was the first VHVI base oil manufacturer from fuels hydrocracker residues (1984)
- Chevron designed lube oil complex for HVI base oils (1983-1984), Iso-dewaxing (1991) and VHVI base oils (1996)
- SK Energy integrated fuels hydrocracker and lube catalytic dewaxing (1995)

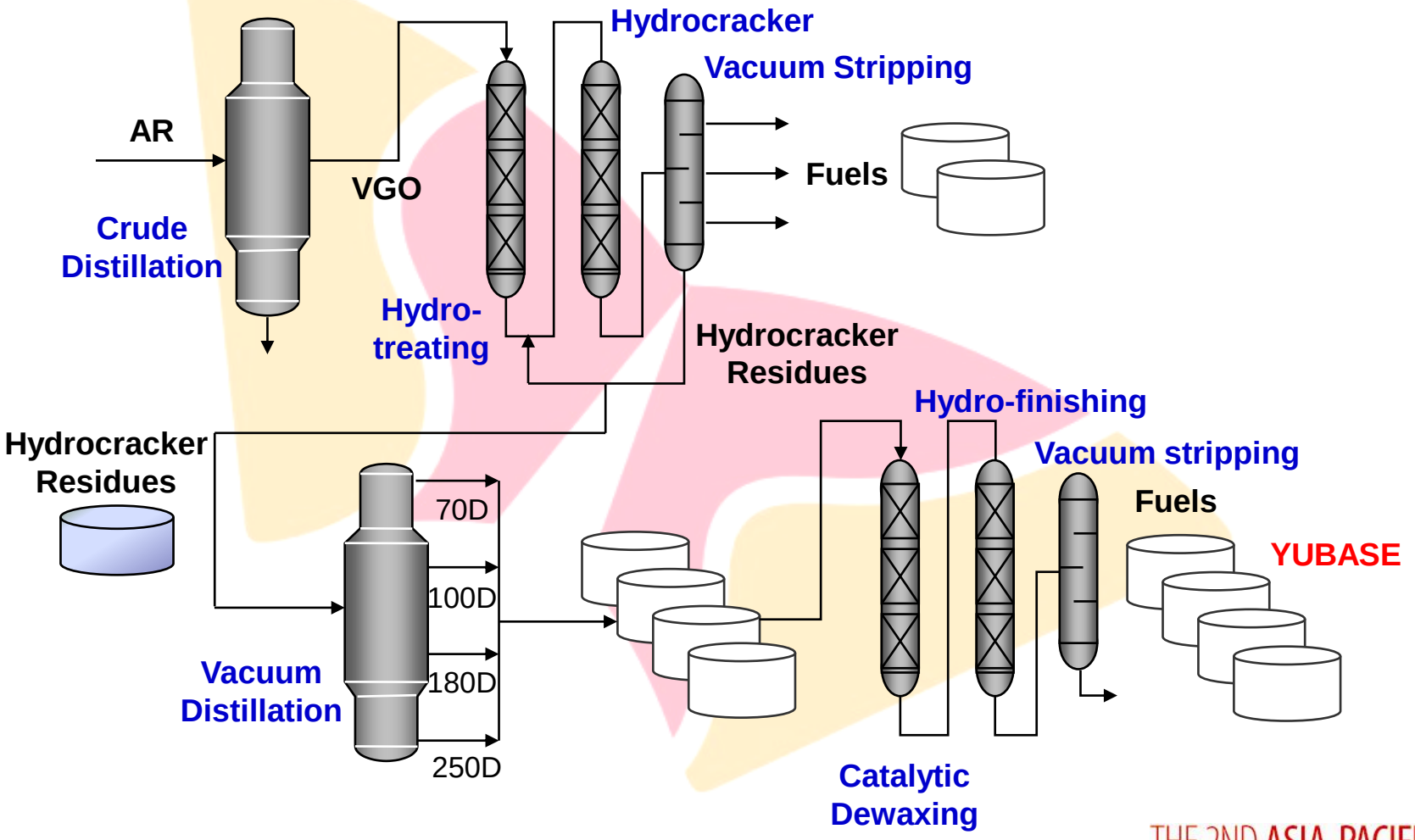
Review of VHVI base oil manufacture

from Fuels hydrocracker residues (I)



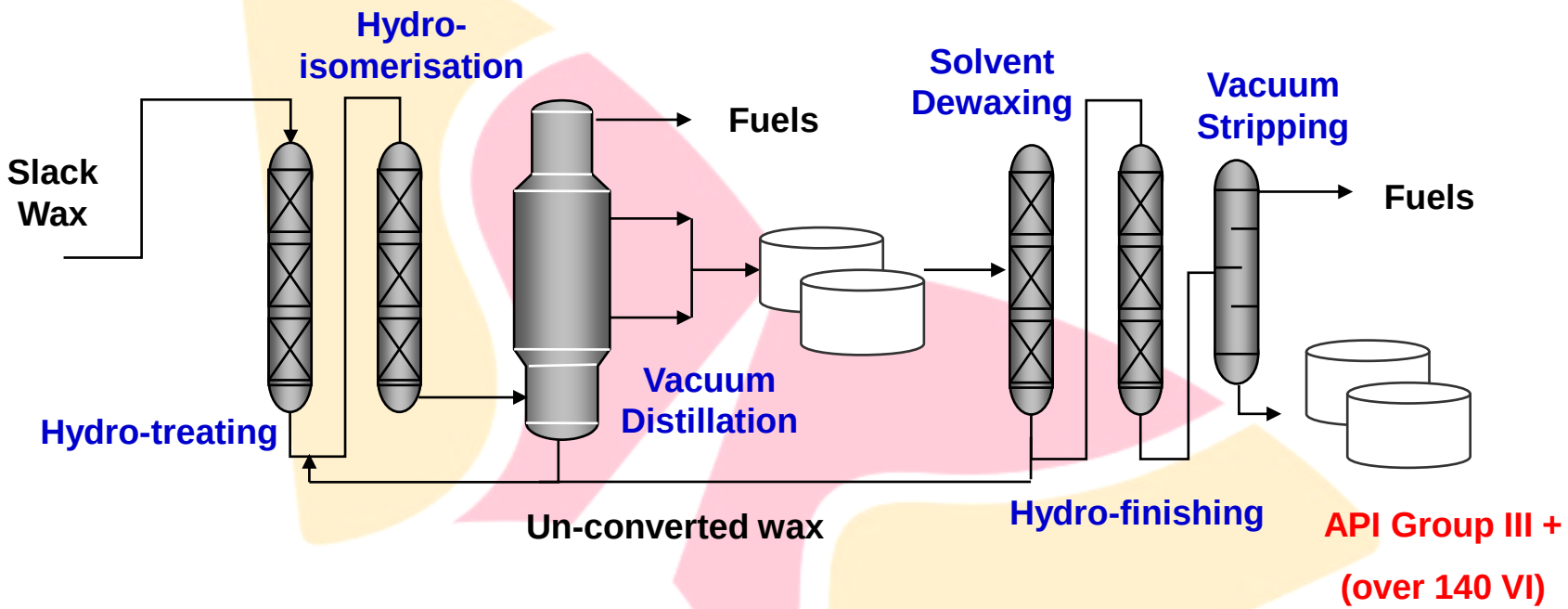
Review of VHVI base oil manufacture

- from Fuels hydrocracker residues (II)



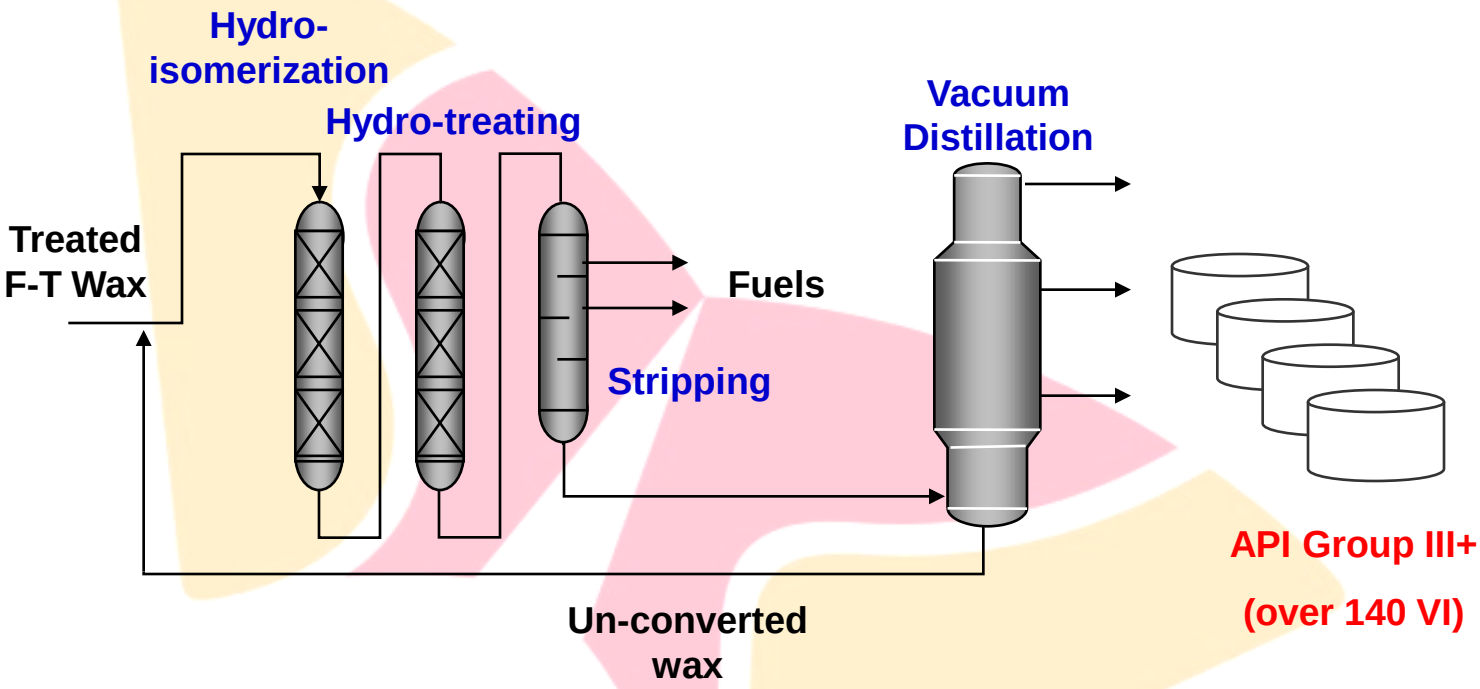
Review of VHVI base oil manufacture

- from Slack wax isomerisation route



Review of VHVI base oil manufacture

- from F-T wax isomerisation route



Next generation Group III base oil

New YUBASE

- SK's No.3 LBO Plant in Dumai, Indonesia
- Adopted same technology, SK UCO lube process
- Higher VI Group III base oils from fuels hydrocracker residues

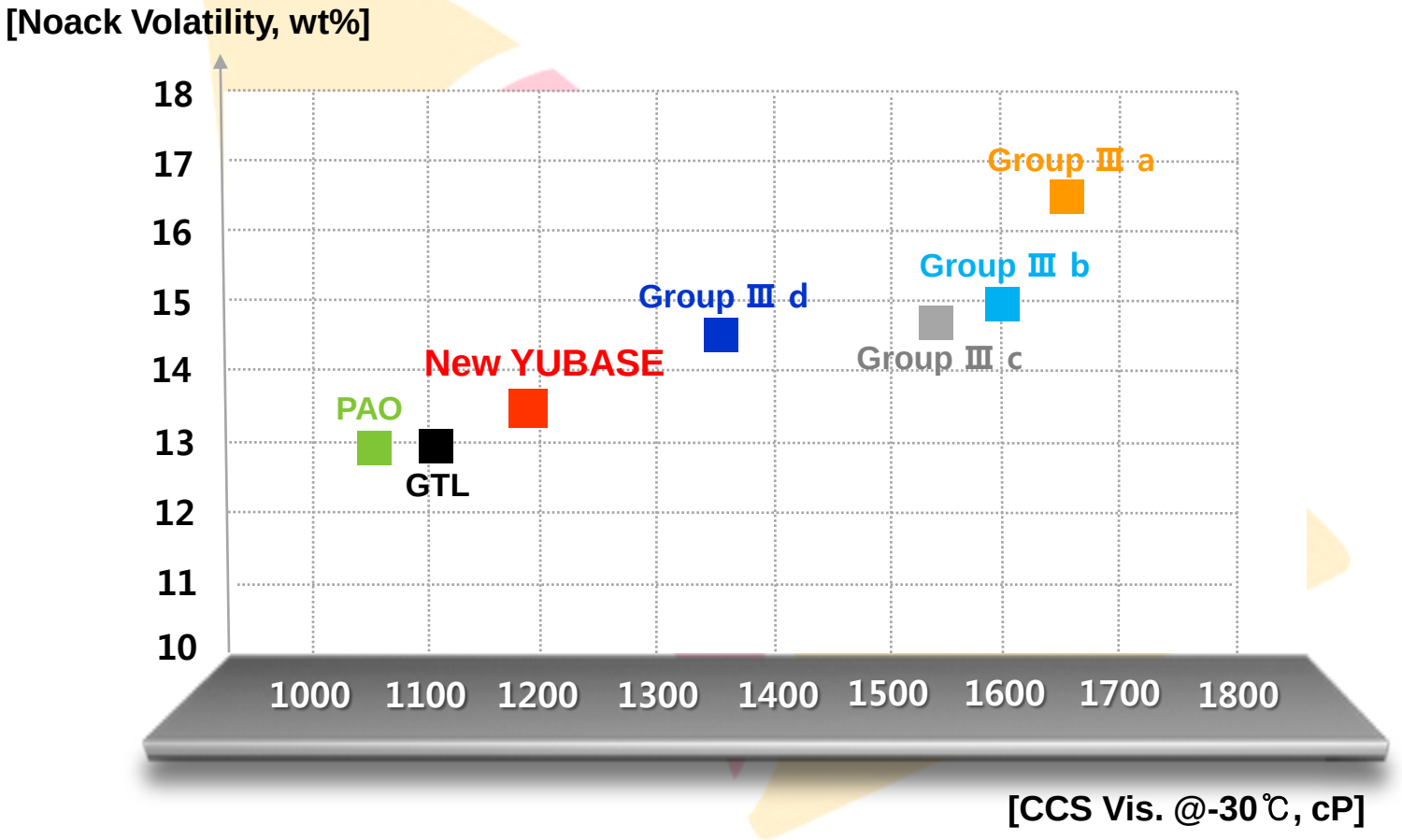
Physical - Chemical properties of New YUBASE

Physical properties

	New YU-4	YU-4	New YU-6	YU-6
Vis. @40℃, cSt	18.4	19.5	35.4	36.9
Vis. @100℃, cSt	4.20	4.22	6.65	6.48
Viscosity Index	136	122	146	130
Pour Point, ℃	-18	-15	-12	-12
CCS @-25℃, cP	-	-	2420	2920
CCS @-30℃, cP	1190	1590	4160	5200
Noack (A), wt%	13.5	15.2	4.1	7.5

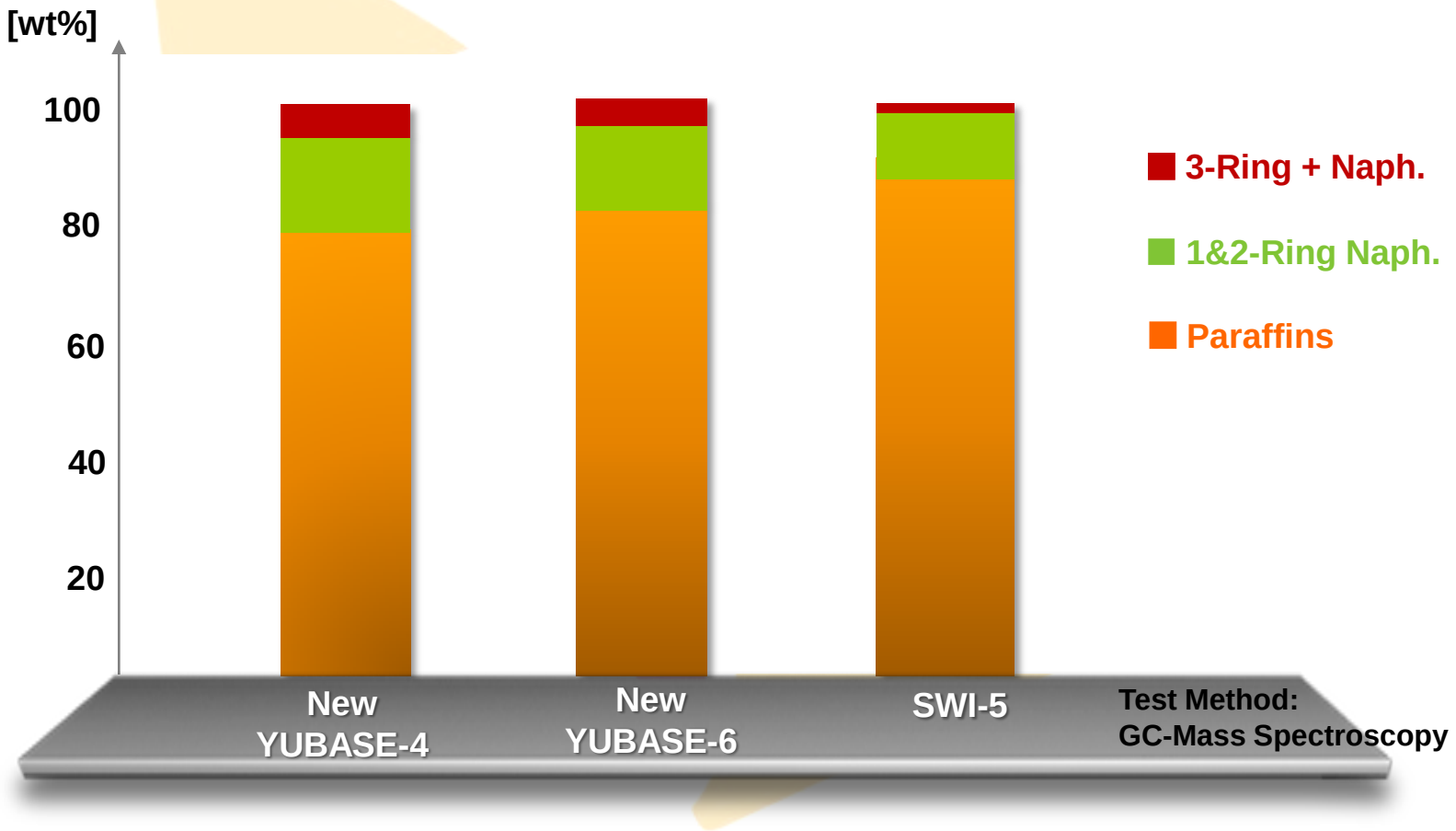
Physical - Chemical properties of New YUBASE

Comparison of CCS and volatility, 4cSt



Physical - Chemical properties of New YUBASE

Chemical properties, Composition



Physical - Chemical properties of New YUBASE

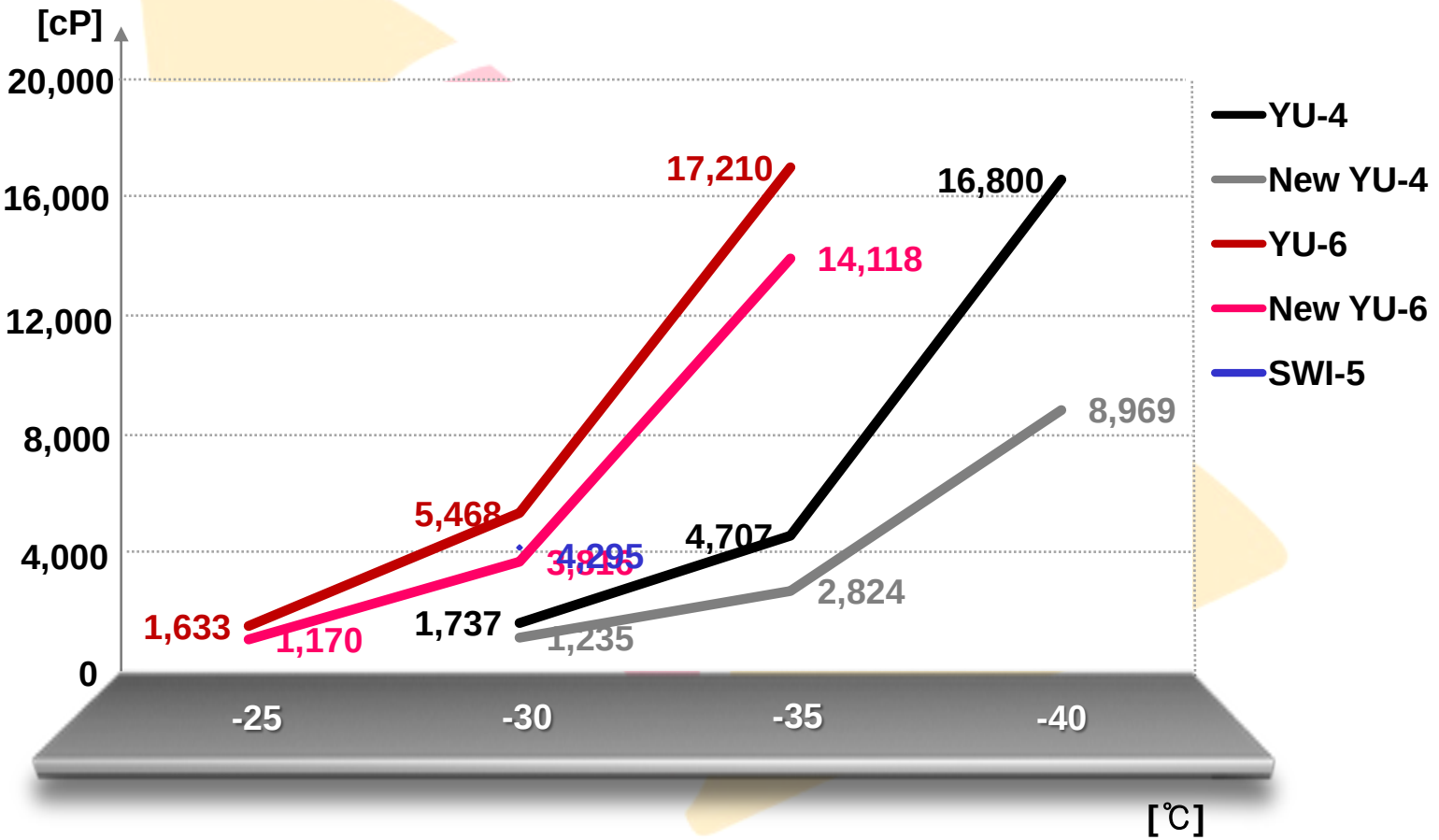
Concerning points of highly paraffinic oils

- Low temperature low shear performance
- Solubility and seal compatibility
- Fuel economy in multi-grade engine oils

Physical - Chemical properties of New YUBASE

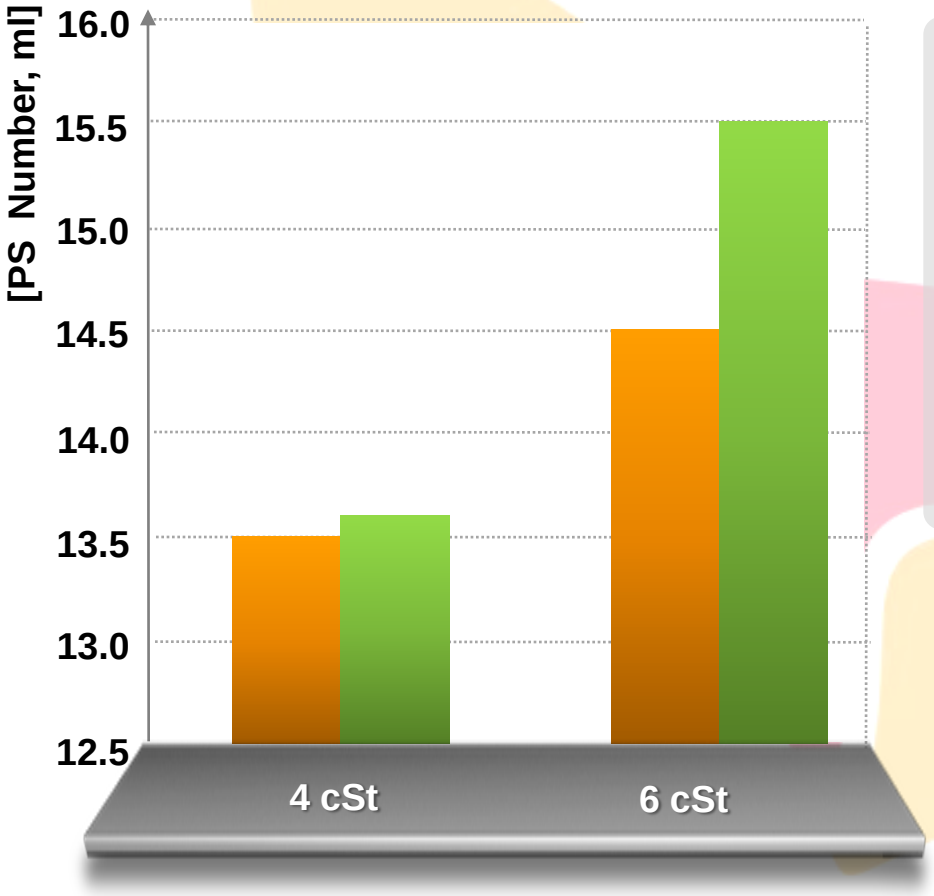
Low temperature properties, MRV

- LTLS Property – MRV (Base Oils with 0.3 wt% PPD)



Physical - Chemical properties of New YUBASE

Solvency properties



Storage stability in finished engine oils

54℃	- No haze - No precipitation - No separation
15℃	
0℃	
-18℃	

Blending study results with New YUBASE

SAE 0W-20, API SM / ILSAC GF-4 PCMO

Fomula [wt%]	A	B	C	D	
YUBASE-4	82.75	72.75	-	-	
New YUBASE-4	-	-	82.75	63.75	
PAO-4	-	10.00	-	-	
YUBASE-6	-	-	-	20.00	
VII	7.00	7.00	7.00	6.00	
Additives	balance	balance	balance	balance	
Properties					
Vis. @40℃, cSt	43.5	43.0	40.9	43.5	-
Vis. @100℃, cSt	8.41	8.33	8.21	8.38	5.6 ~ <9.3
Viscosity Index	173	174	181	173	-
CCS @-35℃, cP	6250	5760	4560	5830	Max. 6200
Noack (A), wt%	14.4	13.2	12.3	11.5	Max. 15.0
HTHS Viscosity, cP	-	2.63	-	2.69	Min. 2.6

Blending study results with New YUBASE

SAE 0W-30, API SM/ ILSAC GF-4 PCMO

Fomula [wt%]	A	B	
YUBASE-4	67.70	-	
New YUBASE-4	-	77.70	
PAO-4	10.00	-	
VII	10.00	10.00	
Additives	balance	balance	
Properties			
Vis. @40℃, cSt	57.6	56.0	
Vis. @100℃, cSt	10.64	10.52	9.3 ~ <12.5
Viscosity Index	178	181	
CCS @-35℃, cP	5980	5770	Max. 6200
Noack (A), wt%	12.3	11.5	Max. 15.0
HTHS Viscosity, cP	3.09	3.08	Min. 2.9

Blending study results with New YUBASE

SAE 5W-30, API SM/CF, ACEA A5/B5-04 PCDO

Fomula [wt%]	A	B	
YUBASE-4	78.30	-	
New YUBASE-4	-	54.40	
YUBASE-6	-	25.00	
VII	9.10	8.00	
Additives	balance	balance	
Properties			
Vis. @40℃, cSt	58.5	58.4	-
Vis. @100℃, cSt	10.49	10.50	9.3~<12.5
Viscosity Index	171	172	-
CCS @-30℃, cP	4110	4130	Max. 6600
Noack (A), wt%	12.8	10.1	Max. 13.0
HTHS, cP	3.09	3.13	2.9~3.5

Blending study results with New YUBASE

SAE 5W-40, API SM/CF, ACEA A3/B3/B4/C3-04 PCDO

Fomula [wt%]	A	B	
YUBASE-4	55.60	-	
New YUBASE-4	-	38.40	
YUBASE-6	19.20	37.20	
VII	12.60	11.80	
Additives	balance	balance	
Properties			
Vis. @40℃, cSt	82.1	81.8	
Vis. @100℃, cSt	13.84	13.79	12.5~<16.3
Viscosity Index	174	174	
CCS @-30℃, cP	5600	5570	Max. 6600
Noack (A), wt%	11.1	9.5	Max. 13.0
HTHS, cP	3.71	3.72	Min. 3.5

Blending study results with New YUBASE

Daimler Chrysler ATF+4

Fomula [wt%]	A	B	
YUBASE-3	55.75	55.75	
YUBASE-4	23.90	-	
New YUBASE-4	-	23.90	
Additives	balance	balance	
Properties			
Viscosity @40℃, cSt	34.2	33.6	-
Viscosity @100℃, cSt	7.58	7.52	7.3~7.8
Viscosity Index	199	202	Min. 115
Brookfield Vis.@-40℃, cP	9530	9440	Max. 10000
Pour Point, ℃	-45.0	-45.0	Max. -40.0

Bench test results

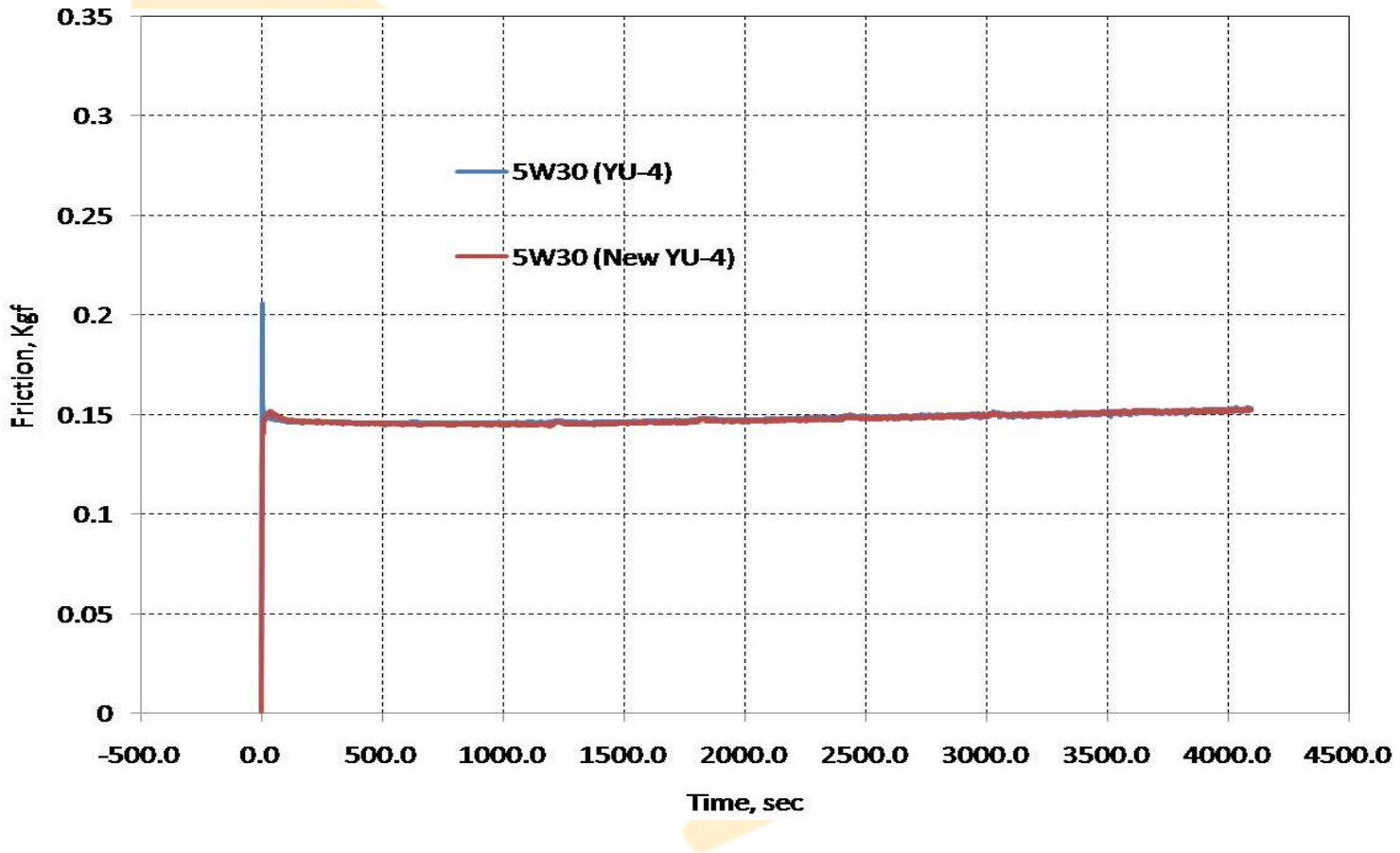
Seal compatibility in 5W-40 PCDO

New YUBASE-4 based 5W-40 PCDO

Seal Type	Results	Limits
■ NBR 34, Nitrile Butadiene		
- Hardness change, point	-1	*-8/+2*
- Tensile strength, %	-8.8	*-20 max.*
- Elongation at break, %	-33	*-35 max.*
- Volume change, %	0.4	*0/+10*
■ AK 6, Viton		
- Hardness change, point	-1	*± 5*
- Tensile strength, %	-20	*-50 max.*
- Elongation at break, %	-23	*-55 max.*
- Volume change, %	0.2	*0/+5*
■ ACM E7503, Acrylate	pass	
■ EAM D8948-200, Vamac	pass	
■ CEC L-39-T-96, Silicone (RE3-04)	pass	

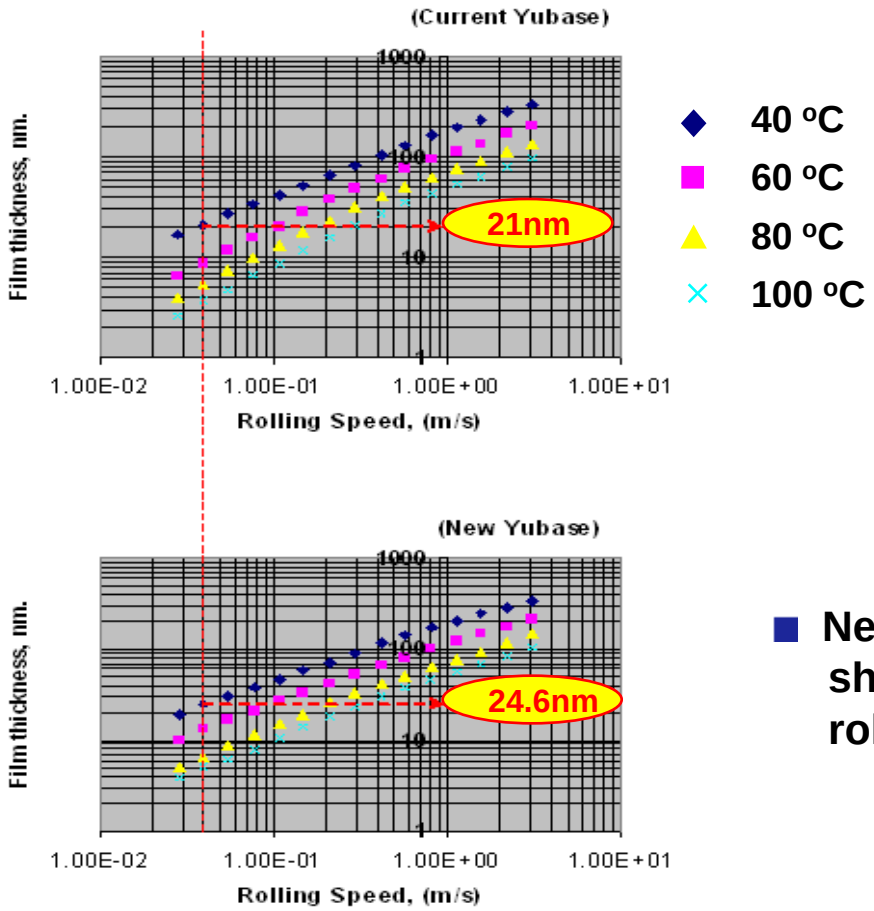
Bench test results

Friction property, SRV test result in 5W-30 PCDO



Bench test results

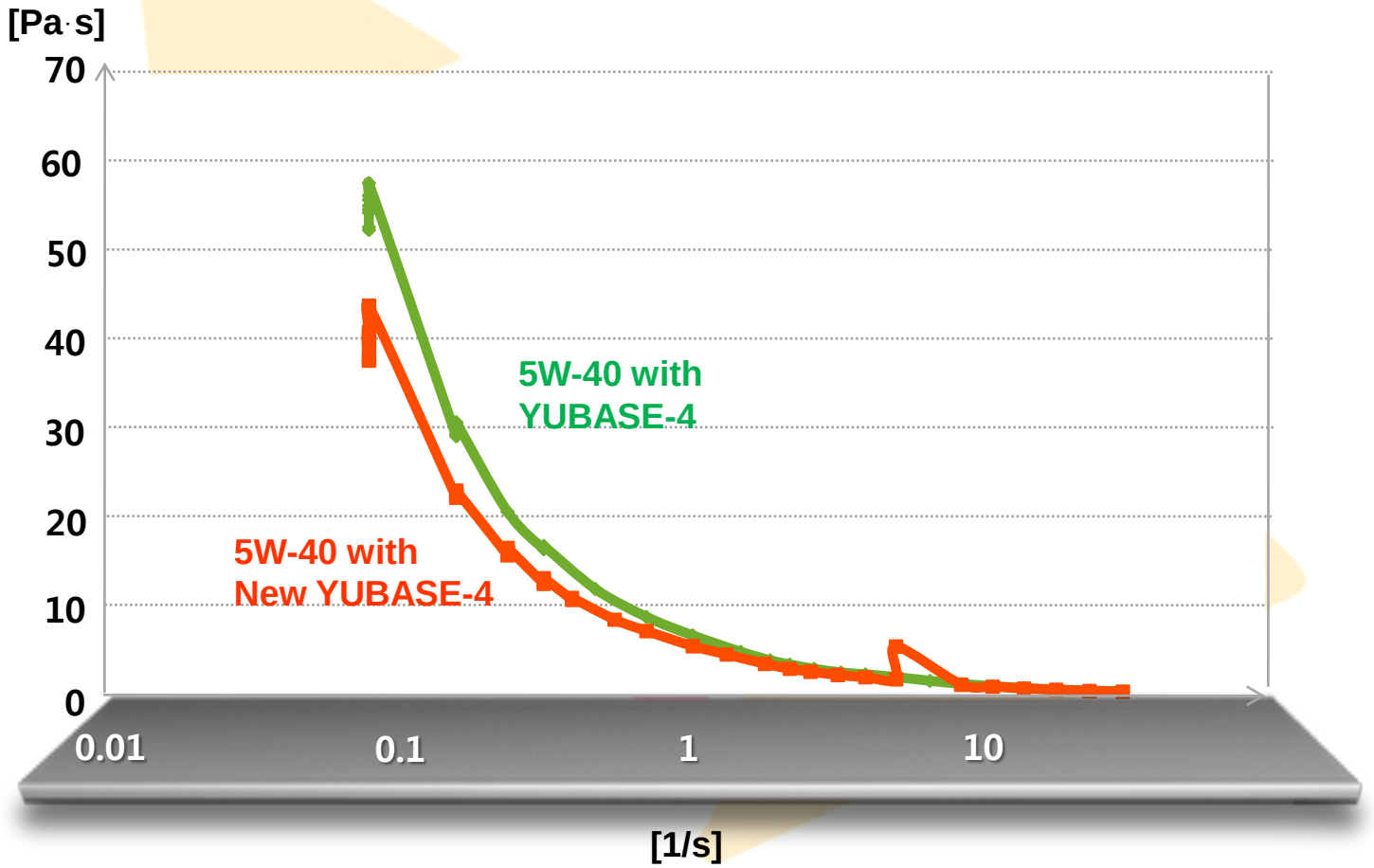
EHD oil film thickness in 5W-40 PCDO



- New YUBASE based oil sample shows thicker oil film at low rolling speeds under all temperature

Bench test results

Soot dispersancy in 5W-40 PCDO



Bench test results

Other bench test results in 5W-40 PCDO

High Temperature Deposit		SM Limit
TEOST (MHT-4), mg	26.3	Max. 35

High Temperature Corrosion		SM Limits
Copper Increase, ppm	7.0	Max. 20
Lead Increase, ppm	12.0	Max. 120
Tin Increase, ppm	0	Max. 50
Copper strip rating (D 130)	1b	Max. 3

Summary

Higher VI Group III base stock, New YUBASE

- New YUBASE has superior properties in low temperature fluidity and volatility
- SAE 0W-20 and 0W-30 PCMO can be formulated by New YUBASE without PAO treatment
- There is no advisable effect on low temperature low shear property and seal compatibility
- Need further study to confirm fuel economy in 0W-XX, 5W-XX PCMO formulations

Wings of Happiness !

Thank you