DOI 10.1007/s10553-019-01062-0
Chemistry and Technology of Fuels and Oils, Vol. 55, No.5, November, 2019 (Russian Original No.5, September – October, 2019)

CHEMMOTOLOGY

QUALITY OF BASE OILS PRODUCED FROM HYDROCRACKING RESIDUE

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Hydrocracking residue meeting physicochemical and chemical composition requirements for hydrocracking oil feedstock was studied. The optimal scheme for producing API group III base oils was determined.
Keywords: *hydrocracking residue, base oils.*

Base oils are the most important components of lubricants. Various types of lubricants contain a weighted average of ~95% base oils.

Lubricants are widely used in various technology sectors, e.g., rocket, nuclear, and space. The reliability and service life of equipment depends largely on the quality and correct use of lubricants. A current trend in technology development is increased lubricant service life and reduction of technical service costs. Development of hydrogenation processes is the main direction in production of base oils that meet current operating and environmental requirements. The most promising processes in this direction are associated with the use of hydrocracking residue (HCR) [1].

Only rather viscous HCR obtained at pressures above 10 MPa can be used to produce high-quality base oils meeting current requirements for API classification [2].

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Table 1

Indices	Analytical method	Standard	Type A
Kinematic viscosity, mm^2/s	GOST 33	Not standardized	
at 40°C		≥4 mm^2/s	26.42
at 100°C			5.2
Viscosity index	GOST 25371	Not standardized	130
Density at 20ºC, kg/m^3	GOST 3900	Not standardized	834
Gel point, °C	GOST 20287		+ 17
Flash point (open cup), °C	GOST 4333		217
Refractive index at 50°C	GOST 18995.221		1.4661
Noack volatility, wt.%	ASTM D 5800		12.66

Table 2

Fraction, °C	Yield, wt.%	
	per feedstock	total per feedstock
IBP-410°C	13.15	13.15
410-440°C	35.32	48.47
440-480°C	25.24	73.71
480-520°C	17.02	90.73
Residue >520°C	8.95	99.68
Losses	0.32	100

Therefore, unconverted residue from fuel hydrocracking seemed promising for producing API group II and III oils. This would require use of selective purification and solvent deparaffinization.

The present work analyzed HCR obtained from vacuum gasoil on a hydrocracking unit with up to 75% conversion (reactor pressure up to 15 MPa).

Table 1 presents the physicochemical characteristics of the HCR (type A). The hydrocracking unit feedstock was vacuum gasoil AVT and its mixtures with extract, petrolatum fraction 340ºC-EP, and heavy coking gasoil.

HCR typically had a high viscosity index and high gel point.

Narrow fractions were produced from the HCR using laboratory vacuum distillation according to ASTM D 5236 of HCR in a Fisher apparatus with residual pressure 1 mm Hg to give clearly separated fractions at a slow distillation rate. Table 2 presents the results [3-5].

The fractional composition of the HCR (type A) became lighter if oil purification extracts were used as feedstock.

Table 3 presents the physicochemical characteristics of the fractions obtained after distillation. Fractions 440-480, 480-520, and >520ºC had the greatest viscosity indices.

Gel points could be lowered by deparaffinization of HCR (type A) without separation into fractions using a MEK/toluene 40/60 mixture in a 3/1 ratio at filtration temperature –25°C. The yield of deparaffinized HCR was 89% of the feedstock mass.

Table 3

Fraction, ºC	Density at 20ºC, kg/m^3	Kinematic viscosity, mm^2/s		Viscosity index	Refractive index at 50ºC
		at 40ºC	at 100ºC		
IBP-410	-	12.67	3.094	102	1.4678
410-440	829	15.29	3.606	120	1.4652
440-480	827	20.17	4.35	126	1.4645
480-520	831	32.33	5.928	130	1.4660
>520	840	72.10	10.49	132	1.4701

Table 4

Fraction, ºC	Kinematic viscosity, mm^2/s		Viscosity index	Refractive index at 50ºC	Gel point, ºC	Density at 20ºC, kg/m^3
	at 40ºC	at 100ºC				
410-440	15.47	3.547	109	1.4655	-17	831
440-480	20.97	4.386	119	1.4652	-12	830
480-520	30.80	5.642	124	1.4665	-14	832

Table 5

Fraction, ºC	Gel point, ºC	Refractive index at 50ºC
410-440	44	1.4420
440-480	43	1.4447
480-520	45	1.4504

The physicochemical characteristics of deparaffinized oil from HCR (type A) without separation into fractions were:

Density at 20°C, kg/m^3 832
Kinematic viscosity, mm^2/s
at 40°C 25.71
at 100°C 5.075
Viscosity index 128
Refractive index at 50°C 1.467
Gel point, °C .... –14
Yield, % 89

The obtained sample of deparaffinized oil had a high viscosity index (>120) and rather low gel point. The physicochemical characteristics of the paraffins from HCR (type A) were:

Melting point, °C 44
Refractive index at 50°C 1.4495

Three fractions of HCR (type A) (410-440, 440-480, and 480-520°C) were deparaffinized using an MEK/toluene 40/60 mixture in a 3/1 ratio at filtration temperature –25°C to increase the yield of deparaffinized oil and to produce oils of various viscosities.

Table 4 presents the physicochemical characteristics of deparaffinized oils from narrow fractions 410-440, 440-480, and 480-520°C.

The obtained from fraction 480-520°C had the highest viscosity index (>120). Furthermore, the obtained deparaffinized oils had low gel points and could be used to produce current commercial oils for various applications.

Table 5 presents characteristics of HCR (type A) narrow paraffin fractions 410-440, 440-480, and 480-520°C.

Selective purification of HCR by *N*-methylpyrrolidone at 65°C with a solvent:feedstock ratio of 1.2:1 and without separation into fractions was studied in the next stage of the work because the color of HCR during storage and transportation was reported to be unstable [3-5].

The gel point could be lowered by deparaffinization of the HCR (type A) raffinate using an MEK/toluene 40/60 mixture in a 3/1 ratio at filtration temperature –25°C. The yield of deparaffinized oil from HCR (type A) raffinate was 94 mass% for feedstock and 88 mass% for the corresponding HCR [4].

Table 6 presents the physicochemical characteristics of the raffinate, extract, and deparaffinized oil of HCR (type A). The obtained deparaffinized oil had a high viscosity index (136) and high gel point (–4°C). Thus, all obtained products were high quality and could be used to produce current commercial oils. It is noteworthy that the oil samples obtained from HCR that were only deparaffinized became darker than oil samples that were selectively purified and deparaffinized after storage for one month in the light.

The raffinate, hydrocracking oil component, and paraffins obtained during pilot testing were studied by us. Table 7 presents the physicochemical properties.

The color of the samples changed considerably (to dark-brown) after storage for a month in the light. Furthermore, the hydrocracking oil component had become more cloudy. This was explained by the much lower purity under pilot-testing conditions than in the laboratory.

Table 6

Name	Density at 20ºC, kg/m^3	Kinematic viscosity, mm^2/s		Viscosity index	Index of refraction at 50ºC	Gel point, ºC
		at 40ºC	at 100ºC			
Raffinate	846	26.48	5.300	137	1.4656	+16
Extract					1.5091	
Deparaffinized oil	847	26.59	5.443	136	1.4660	**-4**

Table 7

Name	Density at 20ºC, kg/m^3	Kinematic viscosity, mm^2/s		Viscosity index	Refractive index at 50ºC	Gel point, ºC
		at 40ºC	at 100ºC			
Hydrocracking raffinate	839	25.85	4.99	120	1.4531	+16
Hydrocracking oil component	840	27.19	5.07	115	1.4541	-4

It is noteworthy that the viscosity indices of the raffinate and oil component obtained on the industrial unit were much inferior to those of analogous laboratory samples.

The chemical composition and physicochemical characteristics of the HCR met requirements for feedstock for hydrocracking oils. Selective purification with high yields could be used to improve the oil physicochemical properties. Fraction 440-480ºC was considered the most acceptable for producing oil using selective purification and solvent deparaffinization. The overall oil yield per HCR was up to 50 wt.%. The oil quality met all requirements for API group III base oils. Base oils from HCR did not darken during storage in the light and did not lose their properties. The low-viscosity deparaffinized oil from fraction 410-440ºC could be used as a base for various hydraulic fluids, transformer oils, and oils for electrospark stands. The product from selective purification and deparaffinization of HCR without separation into fractions could be used to produce high-quality motor oils. Deparaffinized oil from fractions 440-480 and 480-520ºC could be used to produce high-quality motor and hydraulic oils.

ACKNOWLEDGEMENT

The study was financially supported by the Ministry of Science and Higher Education of the Russian Federation (unique project identifier RFMEFI57717X0252).

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