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EVALUATION OF n-PARAFFIN MIXTURES AS DILUENT
FOR TBP IN RADIOCHEMICAL SEPARATIONS PROCESSES

Savannah River Laboratory

Aiken, South Carolina

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EVALUATION OF n -PARAFFIN MIXTURES AS DILUENT
FOR TBP IN RADIOCHEMICAL SEPARATIONS PROCESSES

by

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April 1964

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ABSTRACT

Samples of n-paraffin mixtures were evaluated to determine their suitability for use as diluent for TBP in solvent extraction processes. The n-paraffin mixtures were produced by separating n-paraffins from petroleum with urea or with molecular sieves or by hydrogenating normal α -olefins. The n-paraffin mixtures from sieve processes or from the hydrogenation of normal α -olefins were found to be the most suitable commercial products based on purity, stability, and price.

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INTRODUCTION

Work at the Savannah River Laboratory^(1,2,3) has shown that n-paraffin mixtures are the most-stable* commercially available diluents for TBP (tri-n-butyl phosphate) in solvent extraction processes for separating radiochemicals. "Adakane" 12,** a relatively expensive n-paraffin mixture, has given excellent service in the Purex first cycle at the Savannah River Plant.^(4,5) Therefore, a search has been undertaken for cheaper n-paraffin mixtures that could be used throughout the solvent extraction processes at the Savannah River Plant.

To provide n-paraffins for biodegradable detergents, several commercial processes for separating n-paraffins are, or soon will be, in operation. In these processes, n-paraffins are separated from petroleum by the formation of solid urea - n-paraffin complexes⁽⁶⁾ or by molecular sieves.^(7,8) Other commercial processes produce mixtures of normal α -olefins, which may be hydrogenated to n-paraffins.

SUMMARY

Samples of n-paraffin mixtures in the C₁₂ range were evaluated to determine their suitability for use as diluent for TBP in solvent extraction processes. In the evaluation of each sample, the following were considered:

- Composition, which was determined from the gas chromatogram, infrared spectrum, and ultraviolet spectrum.
- Stability toward chemical degradation, which was determined by Garrett's "Z" Test.⁽⁹⁾
- Commercial availability.

* Stability = resistance to chemical and radiolytic degradation that produces fission product - complexing ligands.

**"Adakane" is the trademark of Archer-Daniels-Midland Co. for its normal paraffin products.

The n-paraffin mixtures were produced by three types of processes:

- Processes that use urea to separate n-paraffins from petroleum. Urea forms a solid complex with n-paraffins. This complex can be separated from the other constituents of petroleum.
- Processes for separating n-paraffins from petroleum with molecular sieves.
- Hydrogenation of normal α -olefins that are products of (1) the Ziegler process for polymerizing ethylene or (2) the cracking of paraffin waxes.

Large variations were observed in the composition and stability of n-paraffin mixtures from each process. "Adakane" 12 and n-paraffin mixtures produced by hydrogenating normal α -olefins from the Ziegler process were found to be the most stable of the available n-paraffins. Normal paraffin mixtures produced by molecular sieve processes are potentially purer, more stable, and cheaper, but the present commercial products from these processes are less stable than "Adakane" 12 and the hydrogenated Ziegler α -olefins.

DISCUSSION

The commercial availability, composition, and stability of each sample tested are shown in Table I.

TABLE I
Compositions and Stabilities of n-Paraffin Mixtures

Sample ^(a)	Commercial Product	UV Abs at 2700 Å	Aromatic Content, ^(b) wt %	n-Paraffin Content, mol %	Instability Ratio ^(c)
A-1	No	0.69	0.02	89.9	9
A-2	No	0.21	<0.01	97.0	1.3
A-3	No	0.49	0.01	98.6	1.5
B-1	No	0.60	1.3	(d)	11
B-1(e)		0.08	0.01	98.4	3.5
B-2	No	3.9	0.08	99.9	1.3
B-3	No	17.2	0.4	(d)	3.2
B-3(e)		0.02	<0.01	99.8	0.9
B-4	Yes	145	3.1	(d)	24
B-4(e)		1.5	0.03	97.0	6
B-5	Yes	9.1	0.2	94.2	7
B-6	No	2.0	0.04	99.6	1.5
B-7	Yes	4.5	0.1	98.2	2.6
B-7(e)		<0.2	<0.01	(d)	2.4
C-1	Yes ^(f)	184	3.9	(d)	85
C-1(e)		0.26	<0.01	91.9	32
C-2	Yes ^(f)	64	1.4	(d)	88
C-2(e)		0.20	<0.01	96.4	13
C-3	Yes ^(f)	8.4	0.2	(d)	1.6
C-3(e)		0.20	<0.01	97.8	1.4
C-4	Yes ^(f)	0.01	<0.01	95.5	1.3
C-5	Yes ^(f)	0.13	<0.01	97.8	2.0
C-6	No	28	0.6	(d)	~200
C-7	Yes ^(f)	<0.2	<0.01	95.7	1.6
"Adakane" 12	Yes	<0.2	<0.01	99.4	1.2
Reference ^(g)	Yes	<0.2	<0.01	(d)	1.0

(a) A = n-paraffins separated from petroleum by formation of urea - n-paraffin complexes; B = n-paraffins separated from petroleum by molecular sieves; C = n-paraffins produced by hydrogenating normal α -olefins

(b) Calculated with an assumed absorptivity of 1×10^3 liters/(cm)(mol) (See Appendix C)

(c) Ratio of "Z" number of 30 vol % TBP - 70 vol % sample to "Z" number of 30 vol % TBP - 70 vol % n-dodecane after chemical degradation of both solutions (See Appendix D)

(d) Not determined

(e) Washed with oleum to remove aromatics

(f) The normal α -olefins are commercially available. Custom hydrogenation of these olefins is available from at least 2 sources.

(g) Olefin-free n-dodecane from Humphrey-Wilkinson, Inc.

n-PARAFFIN MIXTURES SEPARATED FROM PETROLEUM WITH UREA

Three samples were n-paraffin mixtures that were separated from petroleum by the formation of solid urea - n-paraffin complexes. The composition and stability of these samples varied considerably as shown in Table I (the A series).

Composition

Since these samples were derived from petroleum, the carbon chains have both even and odd numbers of carbon atoms. The chromatograms in Figure 1 show the great difference in the amount of non-n-paraffins (all hydrocarbons other than n-paraffins) in the samples. The infrared (IR) absorption spectrum of Sample A-1, shown in Figure 2, is representative of all three samples. The strong absorption bands at 3.4, 6.8, 7.3, and 13.9 microns and the several weak absorption bands are typical of n-paraffins. Experimental techniques used for gas chromatography and IR spectrophotometry are given in Appendices A and B, respectively.

The ultraviolet (UV) absorption spectra, UV instruments and techniques, and method of calculating the aromatic content of samples are described in Appendix C.

The boiling points listed in Table II suggest that the major impurities may be 2-methyl alkanes. The boiling points of the impurities were determined from their retention times

TABLE II

Comparison of Sample A-2
Impurities and 2-Methyl Alkanes

Boiling Point of Impurity in Sample A-2, °C	2-Methyl Alkane	
	Carbon Number	Boiling Point ⁽¹⁰⁾ , °C
166.8	10	166.0
189.2	11	188.6
210.0	12	209.0

and a plot of the logarithm of retention time vs. boiling point (Figure 3). In the isothermal separation of hydrocarbons by gas chromatography, the retention times for members of a homologous series are very nearly related to boiling points by the straight line function

$$\log \text{ retention time} = k_1(\text{boiling point}) + k_2$$

FIG. 1 GAS CHROMATOGRAMS OF SAMPLES A-1 THROUGH A-3

FIG. 2 INFRARED ABSORPTION SPECTRUM OF SAMPLE A-1

The data in Figure 3 are for n-paraffins, but are equally valid for isoparaffins because of the retention characteristics of the gas chromatographic column.

FIG. 3 RETENTION TIME vs. BOILING POINT FOR PARAFFINS

A highly branched C_{13} alkane, which could have a boiling point similar to the 2-methyl C_{12} alkane (2-methylundecane), should not be present because of the characteristics of the urea process. Rossini, in his discussion of molecular compounds of hydrocarbons⁽¹¹⁾, classifies urea-hydrocarbon compounds as compounds in which the urea forms a framework of channels with the long, straight hydrocarbon chains trapped in the channels. The molecular diameter of highly branched hydrocarbons is too large for the molecules to fit into the channels, but long chains attached to a branched alkyl group, cycloparaffin, or aromatic ring can fit in the channels with the large group at the end of the chain remaining outside the channels.

Stability

Samples A-2 and A-3 were as stable as olefin-free n-dodecane, but Sample A-1 was considerably less stable. It is doubtful that 2-methyl alkanes contribute to the instability of Sample A-1, since Sample A-2 contains an appreciable amount of 2-methyl alkanes and is stable. This difference in stability must be due to the compositional differences that are highlighted in Figure 4. The height

FIG. 4 COMPARISON OF GAS CHROMATOGRAMS
OF SAMPLES A-1 AND A-2

and shape of the curves between the $n\text{-C}_{12}$ and $n\text{-C}_{13}$ peaks suggest that Sample A-1 contains several components that are not in Sample A-2. It is possible that these components are slightly branched alkanes, but it seems more likely that the separation process did not achieve a good separation of the n -paraffins from highly branched components that would cause the sample to be less stable.

n -PARAFFIN MIXTURES SEPARATED FROM PETROLEUM WITH MOLECULAR SIEVES

Seven of the samples evaluated were n -paraffins separated from petroleum with molecular sieves. Three of these samples were from a plant in commercial production. The composition and stability of the samples varied considerably as shown in Table I (the B series).

Composition

The n -paraffin content of three of these samples was about 99%. The chromatograms of these three samples are shown in Figure 5. The other samples contained smaller amounts of n -paraffins as indicated by the chromatograms in Figure 6. The chromatograms for samples B-1, B-3, and B-4 were obtained with oleum-washed samples.

FIG. 5 GAS CHROMATOGRAMS OF SAMPLES B-2, B-3, AND B-6

FIG. 6 GAS CHROMATOGRAMS OF SAMPLES B-1, B-4, B-5, AND B-7

The chromatograms in Figure 6 show the non-n-paraffin constituents to be more numerous and probably of more complex structure than the 2-methyl alkanes discussed previously. Identification of these constituents was not attempted. The appreciable non-n-paraffin content of some of these samples may be due to insufficient flushing of the molecular sieves before desorption of the n-paraffin product. Carson and Broughton⁽⁷⁾ and Griesmer et al.⁽⁸⁾ describe molecular sieve processes in more detail.

The IR absorption spectrum in Figure 2 is typical of these samples, also. The IR spectrum of the least pure sample, B-5, was not significantly different from that of the other samples or that of pure n-dodecane. The UV absorption spectra are shown in Appendix C.

Stability

The stability of these samples appeared to be related to the content of both aromatics and isoparaffins. In all samples of appreciable aromatic content, oleum washing removed the aromatics and improved the stability. There was a direct correlation between UV absorbance and instability ratio of the unwashed samples. Figure 7 is a plot of instability ratio vs. UV absorbance and calculated aromatic content; the solid line is a least-squares fit of the data to a straight line. The exactness of the correlation is perhaps fortuitous, since the aromatic content is only an approximation, and the effect of isoparaffin content on stability is neglected. The intercept of the line gives an instability ratio of about 1, which is that expected for negligible aromatic content.

The stability is dependent on the non-n-paraffin content as shown in Figure 8. Again, the solid line is a least-squares fit of the data to a straight line. Since the aromatic content of these samples is very low, the figure shows the dependence of the stability on the isoparaffin content. From a comparison of concentration data in Figures 7 and 8, aromatics have a greater effect on stabilities of n-paraffin mixtures than do isoparaffins. Therefore, particular attention should be given to minimizing the aromatic content of diluent for radiochemical separations.

These correlations between instability ratio and aromatic or isoparaffin content are useful in the consideration of n-paraffin diluents from sieve processes and possibly could be used to predict the instability ratio.

FIG. 7 EFFECT OF AROMATIC CONTENT ON INSTABILITY RATIO OF MOLECULAR SIEVE PRODUCTS

FIG. 8 EFFECT OF NON-n-PARAFFIN CONTENT ON INSTABILITY RATIO OF MOLECULAR SIEVE PRODUCTS

n-PARAFFIN MIXTURES FROM HYDROGENATION OF NORMAL α -OLEFINS

These samples were produced by hydrogenating, on a laboratory scale, olefins from petrochemical sources. The composition and stability of hydrogenated olefins (see Table I) depend principally on the source of the olefins. The sources are:

- Vegetable oils ("Adakane" 12 and olefin-free n-dodecane)
- Petrochemicals from Ziegler polymerization of ethylene (Samples C-3, C-4, C-5, and C-7)
- Petrochemicals from cracking of waxes (Samples C-1, C-2, and C-6)

Samples C-1, C-3, C-4, C-5, and C-6 were hydrogenated by the Central Research Department of E. I. du Pont de Nemours & Co. The Ziegler olefins hydrogenated rapidly at room temperature with platinum catalysts (5% on carbon) and about 1000-psig hydrogen pressure. The other olefins hydrogenated more slowly, perhaps due to a slow reaction at a point of internal unsaturation. Samples C-2 and C-7 were hydrogenated by the Archer-Daniels-Midland Co. under conditions that were not revealed.

Composition

Samples C-1, C-2, and C-6 were obtained from cracked-wax olefins and are characterized by high aromatic content and lower n-paraffin content. The n-paraffins in these samples are composed of approximately equal amounts of even and odd carbon number molecules. Samples C-3, C-4, C-5, and C-7 were obtained from Ziegler olefins and are characterized by moderate to negligible aromatic content and greater than 95% n-paraffin content. These samples are composed principally of even carbon number molecules. For comparison, "Adakane" 12 is obtained from vegetable oil olefins and is characterized by greater than 99% n-paraffins, mostly n-C₁₂.

Infrared absorption spectra are shown in Figure 9 for sample C-3 before and after hydrogenation. The "after" spectrum is essentially identical with the spectrum for n-paraffins shown in Figure 2. The "before" spectrum has

several absorption bands typical of normal α -olefins:

<u>Vibrational Assignment</u>	<u>Wavelength, microns</u>
CH stretching for $=CH_2$	3.23
CH_2 out-of-plane deformation for $=CH_2$	11.0
	5.45 (1st overtone)
CH out-of-plane deformation for $=CH_2$	10.05
C = C stretching	6.05

The spectra in Figure 9 are typical of all these olefins and their hydrogenation products. UV spectra are shown in Appendix C.

Before Hydrogenation

After Hydrogenation

FIG. 9 INFRARED ABSORPTION SPECTRA OF SAMPLE C-3

The differences between n-paraffin mixtures from Ziegler and cracked-wax olefins are quite large as can be seen in Table I and the chromatograms in Figures 10 and 11. The

FIG. 10 GAS CHROMATOGRAMS OF "ADAKANE" 12 AND SAMPLES FROM ZEIGLER OLEFINS

non-n-paraffins in the Ziegler products appear as doublets between n-paraffin peaks in the chromatograms. These doublets probably represent only a few compounds of each carbon number. The approximate boiling points of these materials can be determined from a plot of logarithm of retention time vs. boiling point as previously discussed. These data predict boiling points of 207.2 and 210.5°C for C₁₂ non-n-paraffins. Some of the slightly branched paraffins that have boiling points in this range are listed in Table III.

FIG. 11 GAS CHROMATOGRAMS OF OLEFIN-FREE *n*-DODECANE AND SAMPLES FROM CRACKED-WAX OLEFINS

TABLE III

Boiling Points of C_{12} Non-*n*-Paraffins

Observed Boiling Points for C_{12} Non- <i>n</i> -paraffins in Sample C-4, °C	Boiling Points Reported ⁽¹⁰⁾ for C_{12} Isoparaffins	
	Boiling Point, °C	Isoparaffin
207.2	206	5-methylundecane 6-methylundecane 2,3-dimethyldecane
210.5	210	2-methylundecane 3-methylundecane

Similar compounds could easily arise from hydrogenation of $R_1R_2C=CH_2$ and $R_1R_2C=CR_3R_4$, which were listed by the vendor as minor constituents of Ziegler olefins.

Stability

The n-paraffin mixtures obtained from Ziegler olefins are considerably more stable than those from cracked-wax olefins. This difference in stability can be attributed to the more complex composition of the non-n-paraffins in cracked-wax products as shown by comparison of the height and complexity of the chromatograms for C-1 and C-4 in Figure 12. The height of the baseline and broadness of the intermediate peak for C-1 (which is from a cracked-wax olefin) is an indication of the complex nature of the impurities. Oleum washing of the n-paraffin mixtures from the hydrogenation of cracked waxes removed the aromatic constituents and considerably improved the stabilities of the products.

FIG. 12 COMPARISON OF GAS CHROMATOGRAMS OF SAMPLES C-1 AND C-4

CONCLUSIONS

At the present time the best commercial process for production of n-paraffins with highest stability as a diluent in solvent extraction processes is hydrogenation of normal α -olefins derived from vegetable oils (eg, "Adakane" 12) or from Ziegler polymerization of ethylene. Although the n-paraffins from Ziegler olefins are less pure and of more variable stability than "Adakane" 12, their cost is only about half that of "Adakane" 12. Olefins from cracked waxes are a less promising source of n-paraffin diluent.

The urea process can produce n-paraffins of good purity and stability but may never be economically competitive.

Sieve processes are capable of producing n-paraffins of highest purity, best stability, and lowest price. Even the poorest sieve product tested is superior to refined kerosene for use in solvent extraction processes and should replace kerosene when the costs become more competitive. However, at this time the only commercial sieve product is less stable than other available n-paraffins.

The future should bring a supply of high-quality n-paraffins from sieve processes and also an increased supply of Ziegler α -olefins at lower prices. The only questions are whether n-paraffins produced for use in detergents will be of sufficient purity to meet the needs of the atomic energy industry, and if not, whether custom production of small lots of high purity n-paraffins (10,000-50,000 gal) will be possible at prices under \$1 per gallon.

APPENDIX A

DETERMINING n-PARAFFIN CONTENTS FROM GAS CHROMATOGRAMS

Experimental Technique

Gas chromatograms shown in Figures 1, 5, 6, 10, and 11 were obtained with a F & M Model 609 Programmed Temperature Gas Chromatograph.* A flame ionization detector was used with a range setting of 50. Sample sizes ranged from 0.2 to 0.7 microliter. These small sample sizes were required for linear detector response. The most-sensitive attenuator setting used was X16 (X1 in figures), and the least sensitive was X512 (X32 in figures).

A 6-ft column of 10% "Apiezon" L** on Diatoport S* was used with the following conditions:

Initial column temperature	125°C
Program rate	4.6°C/min
Detector block temperature	300°C
Injection port temperature	320°C
Hydrogen flow	50 cc/min
Air flow	500 cc/min
Initial carrier (He) flow	~100 cc/min

Elution of the column liquid phase (shown by elevation of the base line at end of chromatograms) occurred when temperatures exceeded 250°C.

Reproducible injection of sample quantities under 1 microliter was hampered by volatilization of sample in the needle of the Hamilton 701N syringe.*** A simple method for eliminating this effect was:

1. Fill the syringe with distilled water, eject the excess, and leave the needle full of water

* Product of F & M Scientific Corporation, Avondale, Pa.

** "Apiezon" is a trademark of Metropolitan-Vickers Electrical Co., Ltd.

***Product of Hamilton Company, Inc., Whittier, California.

2. Draw the desired amount of hydrocarbon sample into the syringe, and then draw both water and sample into the syringe barrel (leaving the needle full of air).
3. Insert the needle through the septum and inject the sample.

Some of the water was vaporized, but the detector did not respond to water, and no adverse effects were noted. Quantities of sample as small as 0.2 microliter were injected reproducibly.

In a few instances, isothermal chromatograms were obtained with the same chromatograph but with a 16-ft column of silicone oil on "Gas-Chrom" Z* (120/140 mesh). Column temperature was 200°C.

Calculation of n-Paraffin Content

Peak areas were measured with a K & E 4236 Polar Planimeter.** Calculations of normal and isoparaffin contents were made with the assumption that peak area sensitivity was constant over the carbon number range considered (C₉-C₁₈).

$$\% \text{ n-paraffin} = \frac{\text{n-paraffin peak area}}{\Sigma \text{ all peak areas}} \times 100$$

$$\% \text{ isoparaffin} = \frac{\text{isoparaffin peak area}}{\Sigma \text{ all peak areas}} \times 100$$

* "Gas-Chrom" is a trademark of Applied Science Laboratories Inc., State College, Pa.

**Product of Keuffel & Esser Co.

APPENDIX B

MEASURING INFRARED SPECTRA

Infrared spectra were measured with a Perkin-Elmer Model 221 Recording Spectrophotometer equipped with a NaCl prism. A sealed cell of 0.025-mm nominal pathlength was used. Scan parameters are indicated below.

Scan time	10 min with programmed scan
Pen response	3 sec
Amplifier gain	~3.5
Slit program	927

APPENDIX C

DETERMINING AROMATIC CONTENTS FROM ULTRAVIOLET SPECTRA

Experimental Technique

UV spectra were measured with a Cary Model 11M Recording Spectrophotometer.* Sample cells were of 1-cm pathlength and had fused silica windows. The baseline was adjusted with spectrograde isooctane (2,2,4-trimethylpentane) in both sample and reference beams. Sample spectra were measured against isooctane in the reference beam, and the samples were diluted with isooctane when necessary. The spectra are shown in Figure C-1.

FIG. C-1 UV ABSORPTION SPECTRA
(Continued on Page C-2)

* Product of Applied Physics Corporation, Monrovia, Calif.

FIG. C-1 UV ABSORPTION SPECTRA
(Continued on Page C-3)

FIG. C-1 UV ABSORPTION SPECTRA
(Conclusion)

Calculation of Aromatic Content

The aromatic content of each sample was calculated with the following equation:

$$\text{Aromatic Content, wt \%} = 0.021 \times \text{observed absorbance} \times \text{dilution factor}$$

The factor 0.021 is based on the following:

Molar absorptivity at 2700 A for aromatic compounds	$1 \times 10^3 \text{ liters}/(\text{cm})(\text{mol})^{**}$
Specific gravity of sample	0.760
Average molecular weight of the aromatic	162 g/mol

The following dilution factors*** were used:

<u>Sample</u>	<u>Dilution Factor</u>
A-1	1
A-2	1
A-3	1
B-1	100
B-2	10
B-3	12.5
B-4	100
B-5	10
B-6	2.5
B-7	10
C-1	400
C-2	100
C-3	10
C-4	1
C-5	1
C-7	1

** A convenient, but probably inaccurate, value.

*** Dilution factor = $\frac{\text{volume of dilution}}{\text{volume of sample}}$

APPENDIX D

CHEMICAL DEGRADATION OF n-PARAFFIN MIXTURES

Samples of the n-paraffin mixtures were degraded as solutions containing 30 vol % tri-n-butyl phosphate and 70 vol % n-paraffin mixture. These solutions were contacted with an aqueous phase initially 4.0M HNO_3 and 0.1M NO_2^- (from NaNO_2) as follows:

1. Four milliliters of each sample solution was placed in a glass tube (15-mm OD x 300 mm long, sealed at one end).
2. Two milliliters each of 0.20M NaNO_2 and 8.0M HNO_3 were added in that order.
3. A magnetic stirring bar was inserted in the tube, and the tube was sealed by drawing off the open end in an oxy-gas flame.
4. The sealed tube was inserted in the stirring apparatus described by Alewine and Nicholson⁽¹²⁾, and the contents were stirred at 70°C for 65 hr.
5. The sample tube was opened, and the contents were transferred to a 60-ml pear-shaped separatory funnel with "Teflon"* stopcock.
6. The organic phase was successively washed with H_2O , 1M NaOH , H_2O , 1M HNO_3 , and H_2O .

Duplicate samples of each n-paraffin mixture and of the reference, olefin-free n-dodecane, were degraded simultaneously.

The extent of degradation of each sample was determined by Garrett's "Z" test⁽⁹⁾ modified to use 1 ml of sample, 1 ml of tracer, and 3 ml of HNO_3 scrub. The instability ratio calculated for each sample was based on the "Z" number of the simultaneously degraded reference.

*Trademark of E. I. du Pont de Nemours & Co. for fluorocarbon resin.

APPENDIX E

SPECIFICATIONS FOR n-PARAFFIN DILUENT

The following specifications were recommended for the purchase of n-paraffin diluent for the Purex process at the Savannah River Plant:

1. Minimum flash point, TCC⁽¹³⁾ 70°C
2. Maximum specific gravity (25°/25°C) 0.77
3. Maximum viscosity (at 25°C) 2.0 cp
4. Minimum n-paraffin content 98%
5. Maximum olefin content 0.1%
6. Maximum aromatic content 1.0 maximum absorbance in 1-cm cell from 2400 Å to 4000 Å vs. 2,2,4-trimethylpentane
7. Maximum alcohol content 0.05%
8. Solids None visible
9. Color Colorless
10. Maximum disengaging time of solution of 30 vol % TBP in the diluent from
 - 1M NaOH 80 sec
 - 1M HNO₃ 50 sec
11. Handling: Rigorous care must be taken to insure cleanliness of all shipping and storage vessels. A one-pint sample should be obtained from each tank car loaded, and should be supplied promptly for performance testing.

All the specifications except Specifications 4 and 11 are almost the same as those for "Adakane" 12 for use in the Purex process at the Savannah River Plant.

Specification 4 limits the iso- or cycloparaffin content. However, this specification can be waived if a use test (e.g., chemical degradation followed by "Z" test) shows the diluent to be adequately stable.

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