Nitrogen-*n*-Decane System in the Two-Phase Region

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The vapor-liquid equilibrium in the nitrogen-*n*-decane system has been investigated. The experimental concentrations of the conjugate phases are present at isotherms of 100, 160, 220, 280° F. and pressures up to 5000 p.s.i.a.

THERE are not many reported data on systems involving nitrogen and hydrocarbons at elevated pressures and temperatures. The heaviest binary nitrogen-hydrocarbon system presented so far involves heptane (*1*).

In this work the nitrogen-*n*-decane system was studied. Isotherms were established for temperatures of 100, 160, 220 and 280° F. at pressures up to 5000 p.s.i.a.

EXPERIMENTAL

The equilibrium cell used in this work was a high pressure Sloan-type equilibrium variable volume cell equipped with an internal mixer.

The cell was mounted in an oil bath, equipped with observation windows which were in line with the windows in the cell. A temperature regulator in the oil bath, maintained the bath temperature within ± ½° F. Pressure inside the cell was measured using three Bourdon-type gages, calibrated against a dead weight tester.

Equilibrium was attained by driving the mixing motor for a period of two hours. At the end of this period the motor was turned off, the cell contents were allowed to stand for one hour before samples were taken of the coexisting phases.

ANALYTICAL

The samples were withdrawn from the cell and were trapped between two high pressure valves. These samples were then expanded into a 500 cc. sampling flask. The whole sampling assembly was placed in a high temperature air bath in order to secure complete evaporation of the trapped sample into the flask. The samples were analyzed in a Beckman GC-2 chromatograph. A pair of 12 ft.

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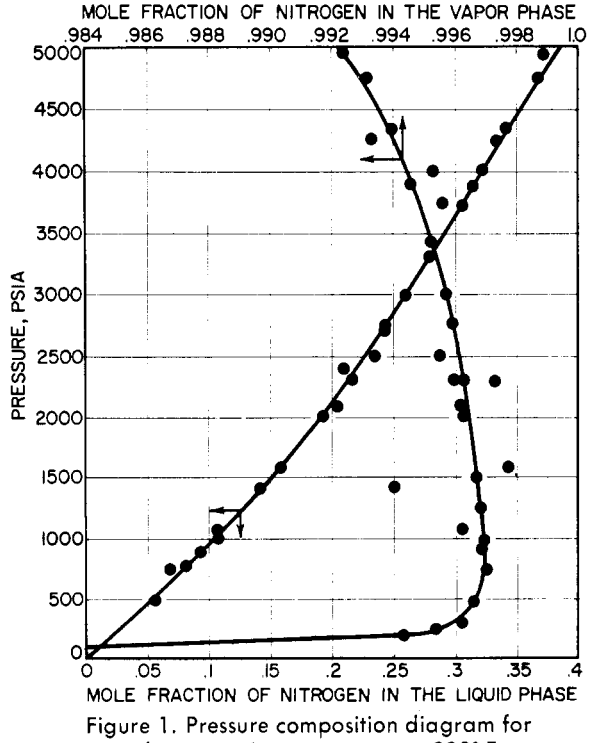

Figure 1. Pressure composition diagram for *n*-decane—nitrogen system at 220° F.

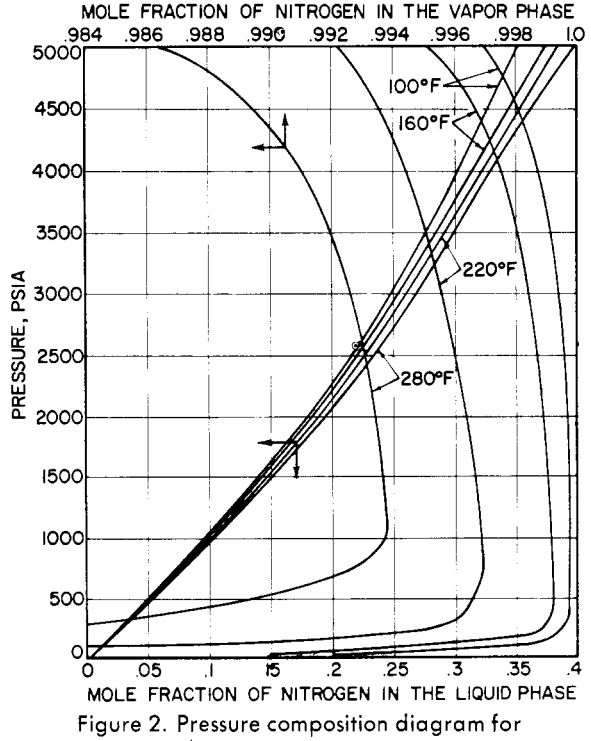

Figure 2. Pressure composition diagram for *n*-decane—nitrogen system

Table I. Experimental Data Binary System

Pressure P.S.I.A.	Mole Fraction Nitrogen Liquid Phase	Mole Fraction Nitrogen Vapor Phase
	100° F.	
80		0.99676
100		0.99776
150		0.99756
200		0.99940
250		0.99964
400	0.0385	
500	0.0482	0.9977
680	0.0665	0.9993
750	0.0710	0.99976
800	0.0735	
800	0.0763	0.99972
1000	0.0930	0.9997
1050	0.1000	
1350	0.1242	0.99971
1400	0.1268	0.99940
1700	0.1530	0.99940
1900	0.1715	0.99920
2100	0.1875	0.99974
2400	0.2130	0.99840
2400	0.2110	0.99959
2500	0.2130	0.99920
2650	0.2280	0.99980
3400	0.2710	0.99870
3400	0.2690	0.99950
3600	0.2822	0.99930
4000	0.2990	0.99850
4000	0.3050	0.99960
4000	0.3030	0.99870
4250	0.3180	0.99860
4700	0.3380	
5000	0.3550	0.99680
	160° F.	
100		0.9928
150		0.9970
200		0.9967
250		0.99923
420	0.0422	
500	0.0513	0.9990
700	0.0602	0.9993
800	0.0780	
900	0.0890	
950	0.0912	0.99775
1200	0.1130	0.99910
1250	0.1186	0.9970
1330		0.9987
1700	0.1713	0.99896
1750	0.1630	0.99900
1750	0.1700	
2000	0.1980	0.99871
2100	0.1935	0.99841
2500	0.2190	
2500	0.2280	0.99817
2600	0.2270	0.99819
2800	0.2440	0.99844
3000	0.2590	0.99824
3000	0.2510	0.99845
3250	0.2755	0.99850
3400	0.2780	
3500	0.2910	0.99802
3750	0.3010	0.99757
4100	0.3270	0.99744
4250	0.3339	0.99649
4300	0.3350	0.99846
4500	0.3500	0.99660
4700	0.3590	0.99734
4900	0.3730	0.99660
5000	0.3630	0.99500

Pressure P.S.I.A.	Mole Fraction Nitrogen Liquid Phase	Mole Fraction Nitrogen Vapor Phase
	220° F.	
80		0.9797
100		0.9847
200		0.9943
300	0.0350	0.9962
500	0.0575	0.9965
750	0.0682	0.9970
800	0.0804	
900	0.0925	0.9970
1000	0.1070	0.9967
1100	0.1075	0.99617
1400	0.1360	0.9939
1500	0.1520	0.99679
1600	0.1590	0.99788
1900	0.1860	
2000	0.1990	0.99614
2100	0.2030	0.99612
2300	0.2180	0.9963
2300	0.2170	0.9870
2300	0.2170	0.99590
2500	0.2350	0.99550
2700	0.2410	0.99330
2750	0.2410	0.9958
3000	0.260	0.9956
3300	0.2760	
3400	0.2850	0.9951
3750	0.3070	0.9950
3900	0.3130	0.9945
4000	0.3230	0.9955
4250	0.3330	0.99312
4500	0.3420	0.9942
4750	0.3650	0.9932
4950	0.370	0.9923
	280° F.	
40		0.6640
60		0.8140
80		0.8536
100		0.9030
150		0.9506
250	0.0329	0.9268
500	0.0550	0.98990
800	0.0825	0.99365
900	0.0966	
1000	1.1064	0.9938
1350	0.1365	0.9910
1500	0.1520	0.99354
1950	0.1930	0.99302
2150	0.2150	
2500	0.2380	0.9932
2500	0.2420	0.9924
2950	0.2670	0.99336
3100	0.2770	0.9940
3250	0.2800	0.9924
3500	0.297	0.9920
3800	0.3245	0.9914
4000	0.3320	0.9906
4250	0.3510	0.9902
4450	0.3600	
4700	0.3820	0.9883
4700	0.3770	
5000	0.3980	0.9860

brations using a known composition mixture of the methane-decane system (*3*).

MATERIAL USED

The normal decane used was Phillips Petroleum Co. research grade with a minimum purity of 99.43%. The length columns of ½ inch aluminum tubing packed with silicone SE-30 impregnated fire brick, which was placed in a thermotrac, was used to separate nitrogen and decane. A full description of the equipment, sampling procedure and analytical calculations are available (*2*). Since the calibration for methane and nitrogen on the thermotrac was the same, occasional checks were made on the cali-

Table II. Smoothed Data for Binary Systems

Pressure P.S.I.A.	100° F. Mole Fraction Nitrogen Liquid Phase	100° F. Mole Fraction Nitrogen Vapor Phase	160° F. Mole Fraction Nitrogen Liquid Phase	160° F. Mole Fraction Nitrogen Vapor Phase	Pressure P.S.I.A.	100° F. Mole Fraction Nitrogen Liquid Phase	100° F. Mole Fraction Nitrogen Vapor Phase	160° F. Mole Fraction Nitrogen Liquid Phase	160° F. Mole Fraction Nitrogen Vapor Phase
80	0.0090	0.9977	0.0090	0.9910	80	0.0085	0.9801	0.0085	0.8500
100	0.0106	0.9982	0.0106	0.9935	100	0.0105	0.9850	0.0104	0.8840
150	0.0158	0.9989	0.0157	0.9960	150	0.0156	0.9915	0.0156	0.9500
250	0.0261	0.9995	0.0261	0.9989	250	0.0260	0.9955	0.0260	0.9651
500	0.0502	0.9998	0.0510	0.9993	500	0.0510	0.9965	0.0522	0.9894
750	0.0730	0.9998	0.0750	0.9992	750	0.0770	0.9969	0.0790	0.9912
1000	0.0950	0.9998	0.0980	0.9992	1000	0.1030	0.9969	0.1050	0.9939
1250	0.1180	0.9997	0.1210	0.9991	1250	0.1260	0.9968	0.1300	0.9938
1500	0.1400	0.9997	0.1430	0.9991	1500	0.1490	0.9967	0.1530	0.9937
1750	0.1600	0.9997	0.1650	0.9990	1750	0.1720	0.9966	0.1760	0.9936
2000	0.1810	0.9997	0.1850	0.9989	2000	0.1920	0.9964	0.1970	0.9935
2250	0.2000	0.9997	0.2050	0.9988	2250	0.2110	0.9962	0.2170	0.9933
2500	0.2180	0.9996	0.2230	0.9987	2500	0.2280	0.9961	0.2360	0.9931
2750	0.2340	0.9995	0.2400	0.9986	2750	0.2450	0.9959	0.2540	0.9929
3000	0.2500	0.9994	0.2560	0.9984	3000	0.2610	0.9956	0.2700	0.9926
3250	0.2640	0.9993	0.2710	0.9982	3250	0.2770	0.9954	0.2860	0.9924
3500	0.2780	0.9991	0.2860	0.9980	3500	0.2920	0.9950	0.301	0.9920
3750	0.2910	0.9990	0.3000	0.9978	3750	0.3080	0.9948	0.317	0.9915
4000	0.3040	0.9987	0.3160	0.9975	4000	0.3230	0.9944	0.3320	0.9910
4250	0.3170	0.9984	0.3310	0.9971	4250	0.3380	0.9940	0.3490	0.9902
4500	0.3300	0.9980	0.3460	0.9966	4500	0.3540	0.9935	0.3640	0.9894
4750	0.3410	0.9975	0.3620	0.9960	4750	0.3700	0.9929	0.3820	0.9882
5000	0.3520	0.9968	0.3800	0.9950	5000	0.3860	0.9921	0.4000	0.9860

nitrogen used was OP grade with a minimum purity of 99.9 mole %.

RESULTS

The results of analysis are tabulated in Table I, A P–X diagram for each isotherm was prepared similar to that shown in Figure 1. In Figure 2 the four isotherms are shown. It can be seen that the solubility of nitrogen in normal decane increases with temperature. This fact is in agreement with findings of other investigators (*1, 4*).

Smoothed data for each isotherm were obtained by plotting the best curve passing through experimental data points on a P–X diagram. These are tabulated in Table II.

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Densities, Refractive Indices, Molar Refractions, and Viscosities of Ethylene Glycol Dimethyl Ether-Water Solutions at 25°

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DENSITIES, refractive indices, and viscosities of mixtures of water and ethylene glycol dimethyl ether have been determined at 25° C. as part of a study of polyether and polyether-water solvent systems. These data as well as the molar refractions of these solutions are presented.

EXPERIMENTAL

Technical ethylene glycol dimethyl ether (Ansul Chemical Co., Ansul E-121) was treated with lithium aluminum hydride and then fractionated immediately before use. The ether had a boiling point of 85.2° (uncorr.), gave a negative peroxide test (*2*), and analysis by gas chromatography indicated a purity of 99.9+ per cent. Water used for the solutions was distilled from dilute potassium permanganate solution in a seasoned all Pyrex assembly.

The mixtures were prepared in 100 ml. batches by weighing out the liquids to the nearest tenth of a milligram. Refractive indices were measured at 25.00 ± 0.01° with a Bausch and Lomb Precision Refractometer (Abbe) using the sodium D line. Readings were reproducible to within ±0.00003.

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