COMPONENTS:	EVALUATOR:
(1) Propane; C_3H_8; [74-98-6] Butane; C_4H_{10}; [106-97-8] (2) Hydrocarbon solvents at high pressure	Walter Hayduk Department of Chemical Engineering University of Ottawa Ottawa, Canada K1N 9B4 November, 1984

CRITICAL EVALUATION:

The high pressure solubilities of *propane* are available in several crude oils[1], in kerosene[2] of average molecular weight 167 and in spray oil[2] of average molecular weight 287, as well as of both *propane*[3] and *butane*[4] in hydrocarbon oil of average molecular weight 337.5. Except for the solubilities in the crude oils, mole fraction solubilities were calculated to test the consistency of the data using plots of mole fraction versus *propane* partial pressure on logarithmic scales. As previously observed, (see Critical Evaluation for alkane solvents at high pressure) it is possible to ascertain whether Henry's law is obeyed on such a plot and whether the vapor pressure of the pure solute gas can be obtained by extrapolation to a gas composition corresponding to pure gas. Mole fraction solubilities were calculated based on the data supplied and such plots were constructed for the four different gas-solvent systems excluding the crude oils. In the calculations it was assumed that the solvents, of relatively high molecular weight, were essentially non-volatile. The data for *propane* in kerosene, hydrocarbon oil and spray oil were all found to be highly consistent. The data for *butane* solubility, however, indicated that Henry's law was not obeyed even at low gas pressures for the hydrocarbon oil solvent. It appears possible that there is some error in the data for *butane* solubilities especially at low pressures although this cannot be confirmed.

These data are all classified as tentative.

References

1. Safronova, T.P.; Zhuze, T.P. *Khim. i Tekhnol. Topliva i Masel* 1958, *3* (2), 41-46.

2. Hill, E.S.; Lacey, W.N. *Ind. Eng. Chem.* 1934, *26*, 1327-1331.

3. Sage, B.H.; Lacey, W.N.; Schaafsma, J.G. *Ind. Eng. Chem.* 1934, *26*, 874-877.

4. Sage, B.H.; Lacey, W.N. *Ind. Eng. Chem.* 1936, *28*, 106-111.

COMPONENTS:	ORIGINAL MEASUREMENTS:
(1) Propane; C_3H_8; [74-98-6] (2) Petroleum, crude oils	Safronova, T. P.; Zhuze, T. P. *Khim. i Tekhnol. Topliva i Masel* 1958, *3* (2), 41-46. *Chem. Abstr.* 1958, *52*, 8518d.
VARIABLES: T/K = 373 p_1/kPa up to 20.3	PREPARED BY: H. L. Clever

EXPERIMENTAL VALUES:

Temperature		Pressure	Bunsen Coefficient
t/°C	T/K	p_1/atm	α/cm^3(STP)cm^{-3}atm^{-1}
1. Nebit-Dag (Akchagylian layer) crude oil, Specific gravity, d_4^{20} = 0.8713, kinematic viscosity = 8.70 centistokes.			
100	373	10	1.618
		25	2.190
		50	3.252
		100	2.197
		150	2.005
		200	1.856
2. Romashkino oilfield crude oil, Specific gravity, d_4^{20} = 0.8530, kinematic viscosity = 6.54 centistokes.			
100	373	10	1.911
		21	2.02
		50	2.83
		75	3.09
		100	2.210
3. Surakhany oil field crude oil, Specific gravity, d_4^{20} = 0.8494, kinematic viscosity = 5.19 centistokes			
100	373	25	1.751
		50	3.649
		100	3.063
		150	2.676

AUXILIARY INFORMATION

METHOD/APPARATUS/PROCEDURE:	SOURCE AND PURITY OF MATERIALS:
A detailed diagram of the high pressure apparatus is given in the paper. The propane solubility data are given in figures of solubility/cm^3 (STP) cm^{-3} *vs.* p_1/ atm. Data on a fourth crude oil propane system are given graphically only. The oil is 4. Tuimazy oil field crude oil, specific gravity d_4^{20} = 0.8510, kinematic viscosity = 4.46 centistokes. Solubilities are shown to a maximum pressure of 25 atm.	(1) Propane. (2) Petroleum crude oils. Four crude oils. Description given above and to the left. Additional information on the composition given in the paper.
	ESTIMATED ERROR: The compiler estimates the data have an uncertainty of 3 to 5 percent.
	REFERENCES:

COMPONENTS:	ORIGINAL MEASUREMENTS:
1. Propane; C_3H_8; [74-98-6] 2. Spray oil	Hill, E. S.; Lacey, W. N. *Ind. Eng. Chem.* 1934, *26*, 1327-1331.
VARIABLES: *T*/K: 303.2 - 333.2 *P*/MPa: 0.216 - 1.395	PREPARED BY: C. L. Young

EXPERIMENTAL VALUES:

T/K (t/°F)	*P*/psi	*P*/MPa	S[a]	C[b]	Mole fraction in liquid, $x_{C_3H_8}$
303.15	31.3	0.216	20.80	19.28	0.2271
(86)	61.9	0.427	48.08	40.62	0.4045
	104.7	0.722	136.41	92.01	0.6601
318.15	26.5	0.183	12.04	11.30	0.1451
(113)	26.4	0.182	11.86	11.13	0.1434
	95.9	0.661	58.70	47.18	0.4532
	131.9	0.909	107.54	75.72	0.6029
333.15	32.6	0.225	10.80	10.04	0.1322
(140)	33.5	0.231	10.50	9.75	0.1292
	115.6	0.797	51.85	42.23	0.4227
	202.4	1.395	114.50	91.00	0.6711

[a] Volume of gas per unit volume of oil both measured at 60 °F and 30 in Hg pressure.

[b] Volume of gas measured at 60 °F and 30 in Hg pressure dissolved by unit volume of saturated oil at experimental temperature and pressure.

AUXILIARY INFORMATION

METHOD/APPARATUS/PROCEDURE:

Measurements were carried out in a brass absorption cell designed for diffusion measurements and described in ref. 1.

SOURCE AND PURITY OF MATERIALS:

1. Obtained by distillation of commercial propane. Product purity about 99.2 mole per cent; major impurity 2-methylpropane.

2. Average molecular weight 287.

ESTIMATED ERROR:

REFERENCES:

1. Pomeroy, R. D.; Lacey, W. N.; Scudder, N. F.; Stapp, F. P. *Ind. Eng. Chem.* 1933, *25*, 1014.

COMPONENTS:	ORIGINAL MEASUREMENTS:
(1) Propane; C_3H_8; [74-98-6] (2) Kerosene	Hill, E. S.; Lacey, W. N. *Ind. Eng. Chem.* 1934, *26*, 1327-1331.
VARIABLES: T/K: 303.2-333.2 P/MPa: 0.180-1.385	PREPARED BY: C. L. Young

EXPERIMENTAL VALUES:

T/K (t/°F)	P/psi	P/MPa	S[a]	C[b]	Mole fraction in liquid, $x_{C_3H_8}$
303.2 (86)	30.5	0.210	27.49	24.98	0.1967
	31.4	0.216	29.25	26.51	0.2068
	45.2	0.312	47.49	40.66	0.2973
	61.0	0.421	72.32	57.27	0.3919
	31.4	0.216	29.40	26.63	0.2076
	61.7	0.425	74.94	59.14	0.4004
	104.5	0.721	222.24	123.43	0.6645
	31.4	0.216	29.78	26.99	0.2098
318.2 (113)	26.1	0.180	17.25	15.94	0.1335
	76.2	0.525	63.89	50.85	0.3632
	149.3	1.029	243.56	123.25	0.6850
333.2 (140)	30.8	0.212	14.36	13.17	0.1072
	60.8	0.419	31.95	27.63	0.2223
	121.3	0.836	84.65	62.98	0.4309
	121.3	0.836	82.64	61.55	0.4251
	200.9	1.385	225.86	114.27	0.6690

[a] Volume of gas per unit volume of oil both measured at 60 °F and 30 in Hg pressure.
[b] Volume of gas measured at 60 °F and 30 in Hg pressure dissolved by unit volume of saturated oil at experimental temperature and pressure.

AUXILIARY INFORMATION

METHOD/APPARATUS/PROCEDURE:

Measurements were carried out in a brass absorption cell designed for diffusion measurements and described in ref. 1.

SOURCE AND PURITY OF MATERIALS:

1. Obtained by distillation of commercial propane. Product purity about 99.2 mole per cent; major impurity 2-methylpropane.
2. Average molecular weight 167.

ESTIMATED ERROR:

REFERENCES:

1. Pomeroy, R. D.; Lacey, W. N.; Scudder, N. F.; Stapp, F. P. *Ind. Eng. Chem.* 1933, *25*, 1014.

COMPONENTS:	ORIGINAL MEASUREMENTS:
(1) Propane; C_3H_8; [74-98-6] (2) Hydrocarbon Oil	Sage, B.H.; Lacey, W. N.; Schaafsma, J. G. *Ind. Eng. Chem.* 1934, *26*, 874-877.
VARIABLES: T/K: 294.3-366.5 P/MPa: 0.230-1.863	PREPARED BY: C. L. Young

EXPERIMENTAL VALUES:

T/°F	T/K	P/psia	P/MPa	Solubility, $S^{\#}$	V
70.0	294.3	33.4	0.230	0.4002	0.01956
		45.3	0.312	0.6135	0.02030
		55.8	0.384	0.8441	0.02106
		64.9	0.447	1.066	0.02180
		72.8	0.502	1.308	0.02258
		79.7	0.549	1.541	0.02343
		85.2	0.587	1.766	0.02419
		90.1	0.621	2.007	0.02502
		94.4	0.651	2.241	0.02586
100.0	310.9	29.7	0.205	0.2223	0.01916
		53.5	0.369	0.4652	0.02000
		72.4	0.499	0.7022	0.02092
		87.2	0.601	0.9340	0.02169
		100.4	0.692	1.175	0.02254
		111.6	0.769	1.419	0.02351
		121.2	0.835	1.668	0.02429
		129.5	0.893	1.906	0.02512
		136.4	0.940	2.144	0.02604
140.0	333.2	40.1	0.277	0.2043	0.01962
		75.6	0.521	0.4464	0.02040
		105.3	0.725	0.6918	0.02133
		130.7	0.892	0.9391	0.02225
		152.6	1.052	1.198	0.02320

(cont.)

AUXILIARY INFORMATION

METHOD/APPARATUS/PROCEDURE:

Static pressure-volume-temperature cell as described in ref. (1). Propane was added to cell containing oil in increasing amounts. Amount of propane dissolved calculated from increase in pressure.

SOURCE AND PURITY OF MATERIALS:

1. Philgas sample, C.P. grade.
2. Refined oil with molecular weight of 337.5.

ESTIMATED ERROR:

δT/K = ±0.1; δP/psia = ±1;
$\delta S/S$ = ±0.001.

REFERENCES:

1. Sage, B. H.; Lacey, W. H. *Ind. Eng. Chem.* 1934, *26*, 103.

COMPONENTS:	ORIGINAL MEASUREMENTS:
(1) Propane; C_3H_8; [74-98-6]	Sage, B. H.; Lacey, W. N.; Schaafsma, J. G.
(2) Hydrocarbon Oil	*Ind. Eng. Chem.* 1934, *26*, 874-877.

EXPERIMENTAL VALUES: (concluded)

T/°F	T/K	P/psia	P/MPa	Solubility, $S^{\#}$	V
140.0	333.2	172.0	1.186	1.461	0.02415
		189.4	1.305	1.733	0.02510
160.0	344.3	56.4	0.388	0.2502	0.01981
		101.0	0.696	0.5131	0.02077
		138.1	0.951	0.7789	0.02176
		168.2	1.159	1.039	0.02274
		194.7	1.342	1.312	0.02379
		217.8	1.501	1.592	0.02489
		237.8	1.638	1.871	0.02571
200	366.5	51.8	0.357	0.1557	0.01978
		97.0	0.669	0.3225	0.02042
		137.6	0.948	0.4914	0.02106
		174.6	1.203	0.6645	0.02172
		208.5	1.437	0.8388	0.02239
		240.6	1.658	1.025	0.02314
		270.5	1.863	1.214	0.02391

$S^{\#}$ Volume of propane in units of ft^3 measured at 288.7 K and a pressure of 1 atmosphere dissolved by one pound of oil.

V density of liquid in units of $ft^3\ lb^{-1}$.

COMPONENTS:	ORIGINAL MEASUREMENTS:
(1) Butane; C_4H_{10}; [106-97-8]	Sage, B. H.; Lacey, W. N.
(2) Hydrocarbon oil	*Ind. Eng. Chem.*
	1936, *28*, 106-111.
VARIABLES:	PREPARED BY:
T/K: 294-378	C. L. Young
P/MPa: 0.069-1.55	

EXPERIMENTAL VALUES:

T/°F	T/K	P/psia	P/MPa	Solubility, S/wt-%
70	294	10	0.069	4.6
		20	0.14	13.5
		30	0.21	49.9
100	311	10	0.069	2.5
		20	0.14	6.8
		30	0.21	14.0
		40	0.28	25.2
		50	0.34	60.0
130	328	10	0.069	1.7
		20	0.14	4.2
		30	0.21	8.0
		40	0.28	12.8
		50	0.34	18.7
		75	0.52	58.5
160	344	10	0.069	1.1
		20	0.14	2.7
		30	0.21	4.9
		40	0.28	7.6
		50	0.34	10.8
		75	0.52	21.1
		100	0.69	39.0
190	361	10	0.069	0.7
		20	0.14	1.7
		30	0.21	3.2
		40	0.28	4.9

(cont.)

AUXILIARY INFORMATION

METHOD/APPARATUS/PROCEDURE:

Contents of variable volume cell brought to equilibrium at desired temperature and pressure and volume determined. Volume varied by admission or removal of mercury. Bubble point determined from change in slope of pressure-volume curve.

SOURCE AND PURITY OF MATERIALS:

1. Philgas Company sample, 99.21 per cent butane, 0.18 per cent 2-methylpropane, 0.61 per cent 2-methylbutane.
2. Nonwaxy asphalt crude oil with molecular weight of between 335 and 340 (by freezing point depression).

ESTIMATED ERROR:

δT/K = ±0.13; δP/psia = ±1;
$\delta S/S$ = ±0.001

REFERENCES:

1. Sage, B. H.; Backus, H. S.; Lacey, W. N.
Ind. Eng. Chem.
1935, *27*, 686.

COMPONENTS:	ORIGINAL MEASUREMENTS:
(1) Butane; C_4H_{10}; [106-97-8]	Sage, B. H.; Lacey, W. N.
(2) Hydrocarbon oil	*Ind. Eng. Chem.*
	1936, *28*, 106-111.

EXPERIMENTAL VALUES: (concluded)

T/°F	T/K	P/psia	P/MPa	Solubility, S/wt-%
190	361	50	0.34	7.0
		75	0.52	12.9
		100	0.69	20.4
		125	0.86	30.4
		150	1.03	47.1
		175	1.21	88.4
220	378	10	0.069	0.6
		20	0.14	1.2
		30	0.21	2.1
		40	0.28	3.2
		50	0.34	4.3
		75	0.52	7.9
		100	0.69	12.4
		125	0.86	17.5
		150	1.03	23.2
		175	1.21	31.1
		200	1.38	43.3
		225	1.55	65.1