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Experimental Liquid Viscosity of Pentane + Octane + Decane Mixtures from 298.15 to 373.15 K up to 25 MPa

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We have measured the liquid viscosity of the ternary system *n*-pentane + octane + decane using a rolling-ball viscometer at temperatures from 298.15 to 373.15 K with pressures up to 25 MPa. These mixture measurements agree with calculated results from existing correlations within 6%.

Introduction

Experimental viscosities are important for studying the structure of liquids. In addition, mass-transfer and fluid-flow calculations require knowledge of this property. The petrochemical industry needs reliable viscosities for hydrocarbon mixtures to validate simulation programs.

Unfortunately, literature results for binary hydrocarbon mixtures are limited, for example Assael et al. (1992b), and few experimental measurements exist for multicomponent mixtures. Predictive techniques must overcome this problem. Recent efforts, for example Dymond, et al. (1985) and Assael et al. (1992b), have attempted to base correlations upon exact hard sphere theory. Assael et al. (1992b) propose a correlation that predicts the behavior of liquid hydrocarbon mixtures within 5% of the experimental viscosity data.

New experimental measurements for multicomponent mixtures are necessary to test existing theories and to develop new ones. Recently, Estrada-Baltazar et al. (1998a), Estrada-Baltazar et al. (1998b), and Barrufet et al. (1999) have measured viscosities for the binary systems that form the ternary system pentane + octane + decane. These measurements cover the entire range of compositions for temperatures between 298.15 and 373.15 K at pressures up to 25 MPa.

This work presents new measurements for the system pentane + octane + decane at high pressures over the entire composition range. These measurements, together with the earlier work, represent the most comprehensive set of data for the viscosity of the systems formed by pentane, octane, and decane. Figure 1 illustrates the composition distribution of the viscosity measurements. For each mixture composition, we have measured 36 viscosity values at six temperatures between 298.15 and 373.15 K and for six pressures up to 25 MPa.

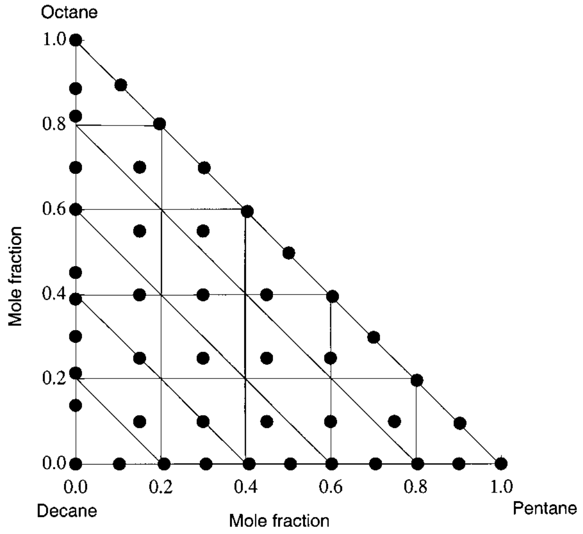

Figure 1. Mole fraction distribution of the viscosity measurements. Each mixture composition represents 36 measurements.

Experimental Apparatus

We have used a high-pressure, Ruska Model 160 viscometer to measure the viscosities for the ternary system pentane + octane + decane. The apparatus uses a rolling-ball principle in which the roll time of a 0.6 cm diameter ball determines the fluid viscosities. The measuring system consists of a control unit and a mechanical assembly. The mechanical assembly is a high-pressure, stainless steel housing. Figure 2 is a schematic diagram of the housing. Inside the housing is a fluid chamber containing a stainless steel sphere that rolls on a polished surface. A plug containing a seal closes one end while a plug containing a seal and a solenoid closes the other end. When the contact valve is closed, both ends of the fluid chamber are sealed and the sphere rolls through the fluid inside the chamber; if the valve is not closed completely, the sphere can stir the fluid chamber.

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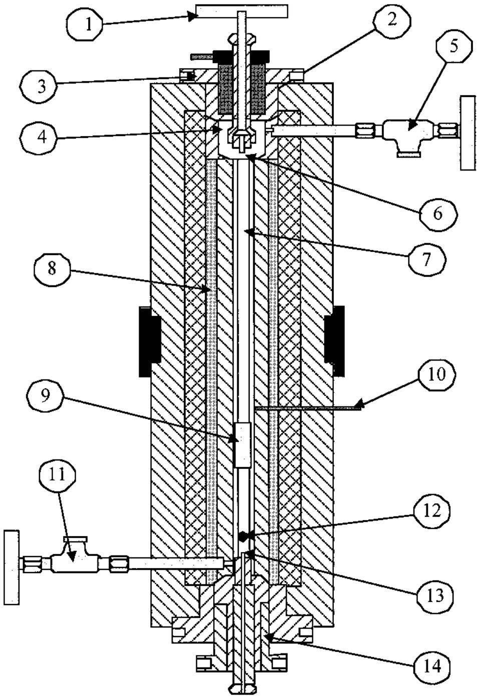

1) Contact valve
2) Solenoid
3) Upper plug
4) Gas chamber
5) Vacuum valve
6) Upper point contact
7) Fluid chamber
8) Heating jacket
9) Stirrer
10) Thermocouple
11) Feed valve
12) Ball
13) Lower point contact
14) Lower plug

Figure 2. Schematic diagram of the viscometer.

The solenoid holds the steel sphere in the upper part of the chamber and does not let it fall until the control unit interrupts the solenoid current. Human error is eliminated from timing the sphere roll time because the timer is activated electronically when the current is interrupted and stops when the sphere reaches the end of its travel. The repeatability of the roll time measurements is ±0.1%.

One feature of this viscometer is that it can use spheres of different diameter and/or various inclination angles to modify the measurement range. Measurements can be performed at inclinations of 23°, 45°, and 70°. Higher viscosities require a larger inclination angle and/or a sphere of smaller diameter.

Electric jackets heat the viscometer and control the temperature within ±0.2 K. Thermal equilibrium can be reached in 3 to 4 h. A Ruska high-pressure (68 MPa) pump injects the sample fluid into the system. The pressure can be read with an accuracy of ±0.001 MPa. The estimated accuracy of mixture preparation is better than ±0.01 mass %.

Calibration

The experimental method consists of a measurement of the roll time of a stainless steel sphere through a fluid of unknown viscosity at known temperature and pressure. The viscosity is a function of the roll time and the density difference between the sphere and fluid

$$\eta = K(t,P,T)(\rho_s - \rho_f) \tag{1}$$

where η is the absolute viscosity, t is the sphere roll time, ρ_s is the density of the sphere, ρ_f is the density of the fluid, and K is a function obtained by calibrating the viscometer with a substance of known viscosity and density at a given inclination angle.

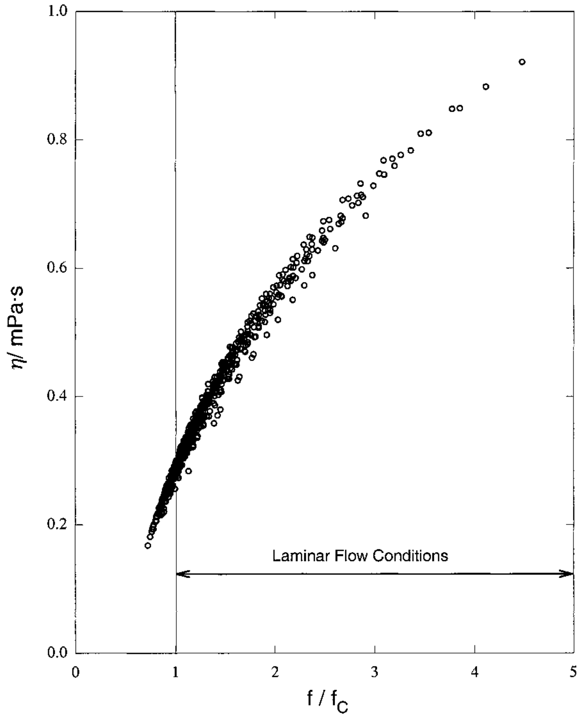

Figure 3. Variation of the measured viscosity data with the resistance factor ratio as suggested by Hubbard and Brown (1943).

We calibrated the viscometer using a Cannon certified viscosity standard, pentane, and octane. Details of the calibration procedure appear in Estrada-Baltazar et al. (1998a), who determined the calibration function to be

$$K(T,P,t) = \frac{\kappa(t)}{X(T,P,t)} \tag{2}$$

where

$$\kappa(t) = -0.06929 + 0.01153(t/s) - 1.3 \times 10^{-4}(t/s)^2 \tag{3}$$

and

$$X(T,P,t) = 0.75218 + 9.207 \times 10^{-5}(T/K)(P/\text{MPa}) - 9.352 \times 10^{-6}(T/\text{K})^{1.5} + 722.511(t/s)^{-3.5} - 7793.08(t/s)^{-4.5} + 0.81681(T/\text{K})^{-0.5} + 0.83608(T/\text{K})^{-1.5}(P/\text{MPa}) + 0.02604[(t/s)(P/\text{MPa})]^{-4.5} \tag{4}$$

Hubbard and Brown (1943) suggest that to obtain accurate viscosity values the fluid should be in a laminar regime. We calculate the friction factor at the conditions of the experiment and the critical friction factor when the fluid leaves a laminar regime. Friction factors are calculated using the procedure proposed by Hubbard and Brown (1943). Figure 3 presents the viscosity as a function of the ratio of the friction factor to the critical friction factor. In addition, Figure 3 demonstrates that our experiments fall mostly in the laminar region ($f/f_c \geq 1$) with some measurements occurring in a transition region near the laminar region.

Samples

The pentane, octane, and decane samples were purchased from Lancaster Synthesis Inc. with a minimum

Table 1. Experimental Viscosities for Pentane (1) + Octane (2) + Decane (3) at Mole Fractions x_i

T/K	P/MPa	η/mPa·s	T/K	P/MPa	η/mPa·s	T/K	P/MPa	η/mPa·s
$x_1 = 0.6014$, $x_2 = 0.2505$								
297.95	0.101	0.3582	328.05	0.101	0.2490	358.25	0.101	
297.95	4.995	0.3530	328.05	4.995	0.2745	358.25	4.995	0.2125
297.95	9.913	0.3692	328.05	9.913	0.2898	358.25	9.913	0.2257
297.95	14.815	0.3891	328.05	14.815	0.3034	358.25	14.815	0.2398
297.95	21.696	0.4072	328.05	21.696	0.3139	358.25	21.696	0.2504
297.95	24.626	0.4277	328.05	24.626	0.3310	358.25	24.626	0.2653
313.05	0.101	0.2730	343.15	0.101	0.2170	373.35	0.101	
313.05	4.995	0.3033	343.15	4.995	0.2418	373.35	4.995	0.1893
313.05	9.913	0.3175	343.15	9.913	0.2555	373.35	9.913	0.2002
313.05	14.815	0.3311	343.15	14.815	0.2680	373.35	14.815	0.2132
313.05	21.696	0.3462	343.15	21.696	0.2789	373.35	21.696	0.2259
313.05	24.626	0.3652	343.15	24.626	0.2951	373.35	24.626	0.2385
$x_1 = 0.1489$, $x_2 = 0.7033$								
297.95	0.101	0.4956	328.05	0.101	0.3689	358.25	0.101	0.2765
297.95	4.995	0.5586	328.05	4.995	0.4022	358.25	4.995	0.3057
297.95	9.913	0.5877	328.05	9.913	0.4241	358.25	9.913	0.3216
297.95	14.815	0.6188	328.05	14.815	0.4434	358.25	14.815	0.3396
297.95	21.696	0.6442	328.05	21.696	0.4650	358.25	21.696	0.3570
297.95	24.626	0.6724	328.05	24.626	0.4847	358.25	24.626	0.3722
313.05	0.101	0.4343	343.15	0.101	0.3190	373.35	0.101	0.2375
313.05	4.995	0.4634	343.15	4.995	0.3489	373.35	4.995	0.2650
313.05	9.913	0.4959	343.15	9.913	0.3663	373.35	9.913	0.2817
313.05	14.815	0.5179	343.15	14.815	0.3860	373.35	14.815	0.2982
313.05	21.696	0.5408	343.15	21.696	0.4027	373.35	21.696	0.3162
313.05	24.626	0.5618	343.15	24.626	0.4210	373.35	24.626	0.3312
$x_1 = 0.3008$, $x_2 = 0.5495$								
297.95	0.101	0.4307	328.05	0.101	0.3318	358.25	0.101	0.2528
297.95	4.995	0.4840	328.05	4.995	0.3545	358.25	4.995	0.2765
297.95	9.913	0.5094	328.05	9.913	0.3717	358.25	9.913	0.2893
297.95	14.815	0.5345	328.05	14.815	0.3879	358.25	14.815	0.3027
297.95	21.696	0.5563	328.05	21.696	0.4047	358.25	21.696	0.3156
297.95	24.626	0.5846	328.05	24.626	0.4303	358.25	24.626	0.3270
313.05	0.101	0.3772	343.15	0.101	0.2896	373.35	0.101	0.2149
313.05	4.995	0.4139	343.15	4.995	0.3147	373.35	4.995	0.2381
313.05	9.913	0.4347	343.15	9.913	0.3308	373.35	9.913	0.2490
313.05	14.815	0.4558	343.15	14.815	0.3449	373.35	14.815	0.2611
313.05	21.696	0.4741	343.15	21.696	0.3589	373.35	21.696	0.2725
313.05	24.626	0.4969	343.15	24.626	0.3743	373.35	24.626	0.2844
$x_1 = 0.4487$, $x_2 = 0.3989$								
297.95	0.101	0.3797	328.05	0.101	0.2930	358.25	0.101	0.2251
297.95	4.995	0.4312	328.05	4.995	0.3235	358.25	4.995	0.2461
297.95	9.913	0.4509	328.05	9.913	0.3403	358.25	9.913	0.2607
297.95	14.815	0.4713	328.05	14.815	0.3553	358.25	14.815	0.2761
297.95	21.696	0.4925	328.05	21.696	0.3714	358.25	21.696	0.2887
297.95	24.626	0.5159	328.05	24.626	0.3880	358.25	24.626	0.3041
313.05	0.101	0.3355	343.15	0.101	0.2586	373.35	0.101	
313.05	4.995	0.3710	343.15	4.995	0.2665	373.35	4.995	0.2165
313.05	9.913	0.3896	343.15	9.913	0.3011	373.35	9.913	0.2299
313.05	14.815	0.4081	343.15	14.815	0.3146	373.35	14.815	0.2453
313.05	21.696	0.4249	343.15	21.696	0.3267	373.35	21.696	0.2598
313.05	24.626	0.4441	343.15	24.626	0.3414	373.35	24.626	0.2756
$x_1 = 0.7507$, $x_2 = 0.1001$								
297.95	0.101	0.2834	328.05	0.101	0.2200	358.25	0.101	
297.95	4.995	0.3239	328.05	4.995	0.2468	358.25	4.995	0.1930
297.95	9.913	0.3380	328.05	9.913	0.2591	358.25	9.913	0.2058
297.95	14.815	0.3547	328.05	14.815	0.2710	358.25	14.815	0.2177
297.95	21.696	0.3690	328.05	21.696	0.2829	358.25	21.696	0.2290
297.95	24.626	0.3859	328.05	24.626	0.2948	358.25	24.626	0.2405
313.05	0.101	0.2557	343.15	0.101		373.35	0.101	
313.05	4.995	0.2791	343.15	4.995	0.2163	373.35	4.995	0.1678
313.05	9.913	0.2934	343.15	9.913	0.2289	373.35	9.913	0.1813
313.05	14.815	0.3061	343.15	14.815	0.2424	373.35	14.815	0.1933
313.05	21.696	0.3187	343.15	21.696	0.2522	373.35	21.696	0.2064
313.05	24.626	0.3310	343.15	24.626	0.2645	373.35	24.626	0.2176
$x_1 = 0.1499$, $x_2 = 0.5477$								
297.95	0.101	0.5502	328.05	0.101	0.3899	358.25	0.101	0.2902
297.95	4.995	0.5836	328.05	4.995	0.4253	358.25	4.995	0.3198
297.95	9.913	0.6152	328.05	9.913	0.4473	358.25	9.913	0.3375
297.95	14.815	0.6471	328.05	14.815	0.4694	358.25	14.815	0.3556
297.95	21.696	0.6776	328.05	21.696	0.4901	358.25	21.696	0.3736
297.95	24.626	0.7106	328.05	24.626	0.5138	358.25	24.626	0.3925
313.05	0.101	0.4514	343.15	0.101	0.3340	373.35	0.101	0.2509
313.05	4.995	0.4956	343.15	4.995	0.3631	373.35	4.995	0.2796

Table 1 (Continued)

$x_1 = 0.1489$, $x_2 = 0.7033$								
313.05	9.913	0.5239	343.15	9.913	0.3842	373.35	9.913	0.2967
313.05	14.815	0.5488	343.15	14.815	0.4021	373.35	14.815	0.3151
313.05	21.696	0.5733	343.15	21.696	0.4218	373.35	21.696	0.3321
313.05	24.626	0.6008	343.15	24.626	0.4428	373.35	24.626	0.3503
$x_1 = 0.3008$, $x_2 = 0.4001$								
297.95	0.101	0.4656	328.05	0.101	0.3535	358.25	0.101	0.2737
297.95	4.995	0.5275	328.05	4.995	0.3870	358.25	4.995	0.3004
297.95	9.913	0.5546	328.05	9.913	0.4077	358.25	9.913	0.3171
297.95	14.815	0.5802	328.05	14.815	0.4276	358.25	14.815	0.3343
297.95	21.696	0.6112	328.05	21.696	0.4466	358.25	21.696	0.3511
297.95	24.626	0.6401	328.05	24.626	0.4700	358.25	24.626	0.3688
313.05	0.101	0.4102	343.15	0.101	0.3101	373.35	0.101	0.2365
313.05	4.995	0.4505	343.15	4.995	0.3390	373.35	4.995	0.2607
313.05	9.913	0.4729	343.15	9.913	0.3574	373.35	9.913	0.2779
313.05	14.815	0.4972	343.15	14.815	0.3759	373.35	14.815	0.2947
313.05	21.696	0.5203	343.15	21.696	0.3937	373.35	21.696	0.3119
313.05	24.626	0.5450	343.15	24.626	0.4121	373.35	24.626	0.3281
$x_1 = 0.4483$, $x_2 = 0.2488$								
297.95	0.101	0.4250	328.05	0.101	0.3117	358.25	0.101	0.2503
297.95	4.995	0.4565	328.05	4.995	0.3417	358.25	4.995	0.2641
297.95	9.913	0.4813	328.05	9.913	0.3589	358.25	9.913	0.2801
297.95	14.815	0.5067	328.05	14.815	0.3758	358.25	14.815	0.2948
297.95	21.696	0.5301	328.05	21.696	0.3926	358.25	21.696	0.3097
297.95	24.626	0.5555	328.05	24.626	0.4122	358.25	24.626	0.3253
313.05	0.101	0.3570	343.15	0.101	0.2827	373.35	0.101	
313.05	4.995	0.3928	343.15	4.995	0.2976	373.35	4.995	0.2316
313.05	9.913	0.4125	343.15	9.913	0.3137	373.35	9.913	0.2461
313.05	14.815	0.4331	343.15	14.815	0.3311	373.35	14.815	0.2612
313.05	21.696	0.4520	343.15	21.696	0.3459	373.35	21.696	0.2770
313.05	24.626	0.4735	343.15	24.626	0.3636	373.35	24.626	0.2907
$x_1 = 0.5994$, $x_2 = 0.0998$								
297.95	0.101	0.3705	328.05	0.101	0.2760	358.25	0.101	
297.95	4.995	0.4067	328.05	4.995	0.3046	358.25	4.995	0.2276
297.95	9.913	0.4276	328.05	9.913	0.3205	358.25	9.913	0.2414
297.95	14.815	0.4494	328.05	14.815	0.3364	358.25	14.815	0.2564
297.95	21.696	0.4695	328.05	21.696	0.3505	358.25	21.696	0.2699
297.95	24.626	0.4933	328.05	24.626	0.3677	358.25	24.626	0.2842
313.05	0.101	0.3208	343.15	0.101	0.2433	373.35	0.101	
313.05	4.995	0.3341	343.15	4.995	0.2705	373.35	4.995	0.1973
313.05	9.913	0.3433	343.15	9.913	0.2862	373.35	9.913	0.2120
313.05	14.815	0.3606	343.15	14.815	0.3014	373.35	14.815	0.2270
313.05	21.696	0.4004	343.15	21.696	0.3155	373.35	21.696	0.2415
313.05	24.626	0.4197	343.15	24.626	0.3306	373.35	24.626	0.2551
$x_1 = 0.1498$, $x_2 = 0.4013$								
297.95	0.101	0.5892	328.05	0.101	0.4234	358.25	0.101	0.3145
297.95	4.995	0.6208	328.05	4.995	0.4600	358.25	4.995	0.3432
297.95	9.913	0.6815	328.05	9.913	0.4854	358.25	9.913	0.3628
297.95	14.815	0.7142	328.05	14.815	0.5086	358.25	14.815	0.3831
297.95	21.696	0.7459	328.05	21.696	0.5325	358.25	21.696	0.4023
297.95	24.626	0.7833	328.05	24.626	0.5596	358.25	24.626	0.4231
313.05	0.101	0.4951	343.15	0.101	0.3650	373.35	0.101	0.2699
313.05	4.995	0.5435	343.15	4.995	0.3963	373.35	4.995	0.2997
313.05	9.913	0.5726	343.15	9.913	0.4178	373.35	9.913	0.3178
313.05	14.815	0.6013	343.15	14.815	0.4389	373.35	14.815	0.3366
313.05	21.696	0.6289	343.15	21.696	0.4591	373.35	21.696	0.3546
313.05	24.626	0.6588	343.15	24.626	0.4823	373.35	24.626	0.3741
$x_1 = 0.3002$, $x_2 = 0.2494$								
297.95	0.101	0.5195	328.05	0.101	0.3665	358.25	0.101	0.2744
297.95	4.995	0.5793	328.05	4.995	0.3876	358.25	4.995	0.2971
297.95	9.913	0.6108	328.05	9.913	0.4332	358.25	9.913	0.3162
297.95	14.815	0.6426	328.05	14.815	0.4418	358.25	14.815	0.3314
297.95	21.696	0.6690	328.05	21.696	0.4627	358.25	21.696	0.3492
297.95	24.626	0.7017	328.05	24.626	0.4887	358.25	24.626	0.3691
313.05	0.101	0.4423	343.15	0.101	0.3184	373.35	0.101	0.2477
313.05	4.995	0.4728	343.15	4.995	0.3354	373.35	4.995	0.2640
313.05	9.913	0.5012	343.15	9.913	0.3543	373.35	9.913	0.2828
313.05	14.815	0.5273	343.15	14.815	0.3739	373.35	14.815	0.2998
313.05	21.696	0.5530	343.15	21.696	0.3949	373.35	21.696	0.3170
313.05	24.626	0.5797	343.15	24.626	0.4163	373.35	24.626	0.3214
$x_1 = 0.4485$, $x_2 = 0.0999$								
297.95	0.101	0.4602	328.05	0.101	0.3507	358.25	0.101	0.2619
297.95	4.995	0.5178	328.05	4.995	0.3820	358.25	4.995	0.2903
297.95	9.913	0.5434	328.05	9.913	0.4013	358.25	9.913	0.3072
297.95	14.815	0.5720	328.05	14.815	0.4200	358.25	14.815	0.3244

Table 1 (Continued)

				$x_1 = 0.4485$, $x_2 = 0.0999$				
297.95	21.696	0.5978	328.05	21.696	0.4378	358.25	21.696	0.3405
297.95	24.626	0.6278	328.05	24.626	0.4587	358.25	24.626	0.3574
313.05	0.101	0.4024	343.15	0.101	0.3036	373.35	0.101	
313.05	4.995	0.4420	343.15	4.995	0.3319	373.35	4.995	0.2554
313.05	9.913	0.4646	343.15	9.913	0.3495	373.35	9.913	0.2719
313.05	14.815	0.4875	343.15	14.815	0.3682	373.35	14.815	0.2890
313.05	21.696	0.5078	343.15	21.696	0.3846	373.35	21.696	0.3067
313.05	24.626	0.5336	343.15	24.626	0.4021	373.35	24.626	0.3219
				$x_1 = 0.1502$, $x_2 = 0.2500$				
297.95	0.101	0.6312	328.05	0.101	0.4540	358.25	0.101	0.3338
297.95	4.995	0.7129	328.05	4.995	0.4923	358.25	4.995	0.3637
297.95	9.913	0.7470	328.05	9.913	0.5175	358.25	9.913	0.3859
297.95	14.815	0.7763	328.05	14.815	0.5417	358.25	14.815	0.4078
297.95	21.696	0.8110	328.05	21.696	0.5698	358.25	21.696	0.4290
297.95	24.626	0.8491	328.05	24.626	0.5971	358.25	24.626	0.4505
313.05	0.101	0.5359	343.15	0.101	0.3853	373.35	0.101	0.2863
313.05	4.995	0.5900	343.15	4.995	0.4313	373.35	4.995	0.3160
313.05	9.913	0.6188	343.15	9.913	0.4524	373.35	9.913	0.3361
313.05	14.815	0.6477	343.15	14.815	0.4767	373.35	14.815	0.3559
313.05	21.696	0.6749	343.15	21.696	0.4916	373.35	21.696	0.3768
313.05	24.626	0.7084	343.15	24.626	0.5152	373.35	24.626	0.3980
				$x_1 = 0.3007$, $x_2 = 0.0996$				
297.95	0.101	0.5731	328.05	0.101	0.4068	358.25	0.101	0.2982
297.95	4.995	0.6293	328.05	4.995	0.4441	358.25	4.995	0.3278
297.95	9.913	0.6612	328.05	9.913	0.4676	358.25	9.913	0.3479
297.95	14.815	0.6978	328.05	14.815	0.4915	358.25	14.815	0.3669
297.95	21.696	0.7284	328.05	21.696	0.5137	358.25	21.696	0.3870
297.95	24.626	0.7595	328.05	24.626	0.5415	358.25	24.626	0.4075
313.05	0.101	0.4796	343.15	0.101	0.3462	373.35	0.101	0.2645
313.05	4.995	0.5254	343.15	4.995	0.3792	373.35	4.995	0.2962
313.05	9.913	0.5535	343.15	9.913	0.4006	373.35	9.913	0.3145
313.05	14.815	0.5817	343.15	14.815	0.4213	373.35	14.815	0.3263
313.05	21.696	0.6085	343.15	21.696	0.4414	373.35	21.696	0.3446
313.05	24.626	0.6376	343.15	24.626	0.4633	373.35	24.626	0.3650
				$x_1 = 0.1501$, $x_2 = 0.0994$				
297.95	0.101	0.6816	328.05	0.101	0.4865	358.25	0.101	0.3529
297.95	4.995	0.7702	328.05	4.995	0.5290	358.25	4.995	0.3841
297.95	9.913	0.8092	328.05	9.913	0.5595	358.25	9.913	0.4080
297.95	14.815	0.8478	328.05	14.815	0.5885	358.25	14.815	0.4307
297.95	21.696	0.8827	328.05	21.696	0.6142	358.25	21.696	0.4538
297.95	24.626	0.9213	328.05	24.626	0.6484	358.25	24.626	0.4772
313.05	0.101	0.5849	343.15	0.101	0.4136	373.35	0.101	0.2997
313.05	4.995	0.6364	343.15	4.995	0.4501	373.35	4.995	0.3317
313.05	9.913	0.6730	343.15	9.913	0.4753	373.35	9.913	0.3528
313.05	14.815	0.7059	343.15	14.815	0.5006	373.35	14.815	0.3744
313.05	21.696	0.7317	343.15	21.696	0.5256	373.35	21.696	0.3972
313.05	24.626	0.7677	343.15	24.626	0.5524	373.35	24.626	0.4191

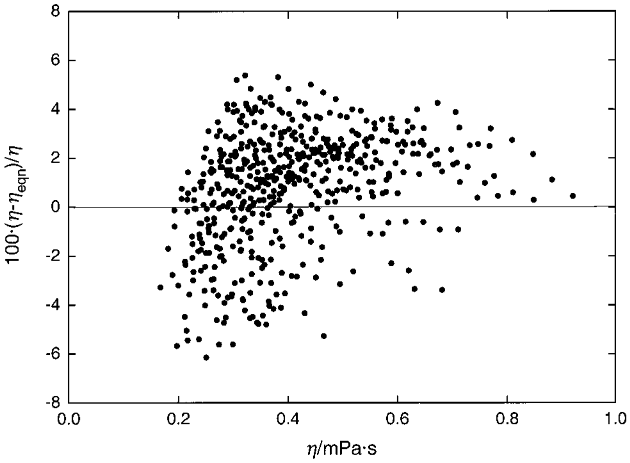

Figure 4. Relative deviation of measured viscosities from the equation of Assael et al. (1992b).

stated purity of 99+%. The hydrocarbon mixtures were prepared gravimetrically using a Mettler PM4600 balance with an accuracy of ±0.01 g.

Results and Discussion

All the measurements used a sphere of 0.6 cm diameter and an inclination angle of 23°. Fluid densities were calculated with a correlation proposed by Assael et al. (1994), who report an average deviation of 0.1% (with a maximum deviation of 0.4%) for their correlation compared to experimental density values for binary hydrocarbon mixtures.

Each viscosity value is the result of an average of over 10 measurements of the roll time at thermal and mechanical equilibrium. Table 1 presents the experimental values for pentane + octane + decane at different pressures, temperatures, and mole fraction compositions.

Unfortunately, experimental viscosity measurements for the ternary system do not exist in the literature. Therefore, we have only compared our results to the correlation published by Assael et al. (1992b). As shown in Figure 4, the predictive ability of the correlation is rather good, considering that it has been developed using only measurements for the binary systems. The agreement between this correlation and the experimental measurements is within ±6%.

Conclusions

We have measured the viscosity of the system pentane + octane + decane. While other experimental measurements do not exist for this system, we have compared our measurements to a correlation developed by Assael et al. (1992a, 1992b). The equation is adequate for prediction of the viscosity for this ternary system. The average deviation of the correlation from the experimental measurements is within 6% at different pressures and temperatures.

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