γ_{BaCl_2} in $HCl-BaCl_2$ mixtures (*4*), both at $I = 1.0$, are also shown in the figure. As can be seen, the plot of the log γ_{LaCl_3} in $HCl-LaCl_3$ mixtures is now consistent with the corresponding plots in the other two systems.

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Enthalpies of Ternary System Pentane–Cyclohexane–Benzene

JOHN M. LENOIR[1] and MUZAFFER BAL
University of Southern California, Los Angeles, Calif. 90007

HOWARD G. HIPKIN
C. F. Braun & Co., Alhambra, Calif. 91802

A flow calorimeter was used to measure enthalpy differences for the ternary system *n*-pentane–cyclohexane–benzene. The results are presented for three compositions with temperatures up to 600°F and pressures extending to 1400 psia.

The results of enthalpy measurements for the binary systems *n*-pentane–cyclohexane (*8*), *n*-pentane–benzene (*7*), and cyclohexane–benzene (*6*) have been published, but the enthalpy values for the ternary mixture of pentane–cyclohexane–benzene have not previously been reported. Three compositions of this ternary mixture of a paraffin, naphthalene, and aromatic have been studied, one rich in pentane, one an equimolar mixture, and the third, rich in benzene. Table I shows the exact compositions of the mixtures. The mixtures were prepared by weighing the pure components for samples of 5000 grams. All the hydrocarbons were obtained from the Phillips Petroleum Co. and their purity established with the use of a Loenco chromatograph. The *n*-pentane had only a trace of isopentane present with a purity of 99.96%, and density at 75°F of 0.6219 g/cc, with refractive index of $\eta^{20}D = 1.3757$. The benzene density was 0.8730 g/cc, with refractive index of $\eta^{20}D = 1.50030$, and a purity of 99.87%. The cyclohexane had a purity of 99.5%, with density of 0.7749 g/cc, and $\eta^{20}D = 1.42604$. The uncertainty of the mixture compositions due to weighing errors was less than 0.2%.

The enthalpy of the mixtures was obtained with a flow calorimeter that measured the isobaric change in enthalpy between a relatively high inlet temperature and an outlet temperature of 75.0°F. As the hydrocarbon mixture flowed through the calorimeter, the enthalpy was transferred to saturated liquid Freon-11. By measuring the volumetric flow rate of both the hydrocarbon and the Freon-11, the enthalpy lost by the hydrocarbon mixture was determined. The details of this apparatus have been presented (*9*). Repeated studies (*5*, *7–9*) performed by comparing the results with published values for *n*-pentane (*2–4*) and liquid water (*11*) have shown that the accuracy of measurement is within 1.5 Btu/lb.

[1] To whom correspondence should be addressed.

Table I. Properties of Liquid Phase at 75°F and 1 Atm

n-Pentane		Benzene		Density,	Heat of mixing,	H needed for −200°F basis,
Mol %	Wt %	Mol %	Wt %	g/cc	Btu/lb	Btu/lb
60.1	57.3	20.0	20.5	0.6944	3.6	114.5
33.3	30.8	33.3	33.3	0.7449	4.1	103.4
20.0	18.5	59.8	59.8	0.7920	5.3	100.1

A total of 573 measurements was made on the ternary mixtures of pentane, cyclohexane, and benzene. These results, presented relative to the liquid state at 75°F and the pressure of measurement, have been tabulated and deposited with the ACS Microfilm Depository Service. These measured values were converted to a zero enthalpy basis of −200°F and the saturated liquid condition of the pure components, corresponding to the base level used by the API data book (*1*). As a first step in performing this conversion, the measured values are corrected to account for the change in enthalpy with increasing pressure at 75°F in the liquid phase. This was done using the thermodynamic equation of state (*9*), and amounted to a maximum change of 3.4 Btu/lb at 1400 psia. This correction was made with greater preciseness than the accuracy of measurement.

The enthalpy value needed to convert the enthalpy values of the pure components from 75° to −200°F has already been established for *n*-pentane (*9*), cyclohexane (*8*), and benzene (*5*). For the mixtures, the number needed to convert the data to the −200°F basis is a weight average of the conversion numbers for the pure components plus the heat of mixing at 75°F in the liquid phase. The heat of mixing was computed using the procedure presented by Tsao and Smith (*12*). Table I shows the computed heats of mixing, and also the enthalpy needed to convert the enthalpy values relative to 75°F and the saturated liquid phase to the −200°F basis.

The computed heats of mixing are similar to the corresponding values measured by Mathiesen and Thynne (*10*) for the hexane–cyclohexane–benzene system. The measured en-

Table II. Values of Enthalpy for Mixture 57.3 Wt % *n*-Pentane, 22.2 Wt % Cyclohexane, and 20.5 Wt % Benzene

Units: Btu/lb
Datum: Pure saturated liquid components at −200°F

	Psia									
Temp, °F	0	200	300	400	500	600	700	800	1000	1400
75		115.0	115.2	115.5	115.8	116.1	116.3	116.6	117.1	118.1
316.2		255.2[a]								
320	380.4	288.0	257.9							257.2
330	385.7	345.1	264.7							263.4
340	390.8	376.7[a]	271.5						273.8	269.6
360	401.0	387.3	285.4						286.1	282.1
360.6			285.9[a]							
370	406.3	392.9	342.5	292.8					292.5	288.6
380	411.7	398.3	387.7	300.0						
380.4			389.8[a]						298.9	295.0
395				311.1[a]						
400	422.2	409.5	400.8	344.1	315.0	314.8	314.0	313.3	312.0	308.4
409.8				394.9[a]						
420	433.1	421.0	413.0	403.0	331.9	331.0	328.8	327.8	326.1	322.9
424					335.6[a]					
430	438.8	427.1	419.5	410.3	370.0	339.7	337.4	335.6	333.9	330.2
435.6					396.4[a]					
440	444.1	433.0	426.0	417.9	403.4	350.3	346.1	344.0	341.1	337.9
450	449.9	439.0	432.3	425.0	411.9	370.0	355.4	352.8	348.9	345.1
460	455.2	449.1	438.7	431.6	419.9	398.5	366.8	361.6	356.8	353.0
470	461.0	451.0	445.1	438.2	427.7	411.9	381.7	371.9	364.9	360.7
480	466.8	457.4	451.7	444.9	435.0	422.3	401.7	383.9	374.0	368.4
500	478.1	469.8	464.6	458.7	450.0	440.5	427.7	408.8	393.2	384.5
520	489.8	481.9	477.1	472.0	464.5	456.5	445.9	434.4	413.3	401.0
540	501.9	494.1	489.9	485.1	479.0	471.8	463.1	454.2	432.2	417.4
560	514.0	506.6	502.7	498.6	493.0	486.2	479.1	471.0	450.9	434.0
580	526.0	519.0	515.5	511.6	506.8	500.3	494.4	487.1	469.0	451.0
600	538.1	531.9	528.3	524.4	520.0	514.5	509.1	503.1	486.4	468.0

	Psia						
Temp, °F	450	530	550	570	580	586	640
409.7	323.0[a]						
420	375.9						
424.2	396.6[a]	335.8					
430	402.5	341.1					
432.3	404.9	343.3[a]					
437.1	409.1	367.5	348.8[a]				
440	411.6	384.5	363.9	352.1			348.9
442.1		395.1[a]	375.5	354.8			
443.7		398.4	384.0	357.0[a]			
445.7		401.3	394.1[a]	371.0	360.6		355.2
447.1		403.1	396.8	380.0	365.0[a]		357.3
449.2		416.0	400.1	390.0[a]	377.8	372.1	
449.5					380.0	374.5[b]	
450.1	419.1	406.9	401.1	392.8	385.1		361.5
452	420.4	408.3	403.7	396.9	390.5		364.4
456	423.2	411.6	407.3	402.9	398.8		372.5
460	426.1	415.0	411.2	407.0	405.0		386.8
470	433.1	423.2	420.0	416.8	415.2		403.4
480	440.2	431.6	429.0	426.2	424.6		415.8

[a] On saturation locus. [b] Critical point.

Table III. Values of Enthalpy for Mixture 30.8 Wt % *n*-Pentane, 35.9 Wt % Cyclohexane, and 33.3 Wt % Benzene

Units: Btu/lb
Datum: Pure saturated liquid components at −200°F

	Psia							
Temp, °F	0	200	300	400	600	800	1000	1400
75		103.9	104.2	104.4	104.9	105.4	105.9	106.9
340	374.9	249.0						248.2
342.1		250.3[a]						
360	385.1	371.2[a]	262.1					260.6
380	395.0	382.8	275.4					273.2
387.8			285.8[a]					
400	405.1	394.0	340.9	289.3			288.4	286.5
407.9			378.8[a]					
420	415.3	404.2	394.7	303.7			302.4	299.3

(*Continued on next page*)

Table III. (*Continued*)

Units: Btu/lb
Datum: Pure saturated liquid components at −200°F

	Psia							
Temp. °F	0	200	300	400	600	800	1000	1400
422.4				305.5[a]				
440	425.8	414.7	407.1	387.2	318.5		316.5	312.7
443				395.7[a]				
460	436.3	425.7	418.8	407.8	334.4	333.3	332.2	330.6
480	447.1	437.0	430.3	421.8	353.5	347.4	344.8	340.0
481.5					355.1[a]			
488.4					393.9[a]			
490	452.3	442.4	436.7	428.3	397.1	356.4	352.2	347.0
500	458.0	448.2	442.3	435.2	410.1	366.1	360.3	354.2
520	468.8	459.5	453.9	448.2	429.3	389.2	377.5	369.3
540	480.2	471.3	466.3	460.8	445.7	418.8	398.3	385.2
560	491.6	483.2	478.9	473.6	461.0	441.7	418.4	401.5
580	503.2	495.3	491.1	486.4	475.2	460.2	438.3	418.3
600	515.0	507.3	503.4	499.2	489.3	477.2	457.3	435.9

	Psia						
Temp, °F	500	550	620	632	640	660	700
453.5	329.2[a]						
460	365.1						333.3
466.8	398.7[a]	340.3					
468.0		341.4[a]					
470.0	403.1	352.1	343.3		342.9	341.9	341.1
477.8	410.1	389.0[a]	351.1				
480	411.6	401.8			352.2	351.0	349.2
487.9			364.3[a]				
490	418.8	412.0	377.5	369.1[a]	366.2	363.1	359.3
491.6			387.5[a]	374.2[a]			
491.9	420.2	413.4	388.3	375.2[b]	370.3	365.6	361.7
495	422.3	416.2	397.2		381.3	371.5	365.9
500	426.0	419.5	404.8		397.7	385.2	373.3
510	433.1	426.7	417.2		414.0	406.2	393.8
520	440.1	435.8	426.5		424.2	419.2	412.2
540	454.0	450.2	444.0		442.1	439.1	434.9

[a] On saturated locus. [b] Critical point.

Table IV. Values of Enthalpy for Mixture 18.5 Wt % *n*-Pentane, 21.7 Wt % Cyclohexane, and 59.8 Wt % Benzene

Units: Btu/lb
Datum: Pure saturated liquid components at −200°F

	Psia									
Temp, °F	0	200	300	400	500	600	700	800	1000	1400
75		100.5	100.7	101.0	101.3	101.5	101.7	102.0	102.4	103.4
380	387.3		260.2							261.8
400	396.7		273.8							274.4
401.1			275.1[a]							
420	406.2	394.4	371.8	287.7						287.4
425.3			386.1[a]							
438.3				300.5[a]						
440	415.9	404.5	396.3	308.4	301.8					300.2
450	420.8	409.6	402.0	377.7	309.0					306.8
456				394.1[a]						
460	425.7	414.6	407.4	397.2	316.1			315.2	313.8	313.1
468.3					322.0[a]					
480	435.6	425.0	418.1	410.0	388.2	331.1	330.1	328.7	327.0	326.1
483					398.3[a]					
490	440.7	430.1	423.7	416.0	405.3	339.0	337.8	335.8	333.7	332.7
493.9						342.0[a]				
500	445.8	435.7	429.2	421.9	412.4	366.9	346.0	343.5	340.8	339.4
504.8						396.9[a]				
510	450.7	440.8	434.9	427.8	418.9	403.1	355.1	352.1	348.1	346.1
520	456.0	446.1	440.3	433.8	425.3	412.0	374.9	362.2	356.0	353.1
525						416.4	394.8	368.0		
530	461.0	451.5	446.2	439.8	431.9	422.0	402.1	373.9	364.2	360.2
540	466.1	457.0	451.9	446.0	438.2	428.8	414.1	387.8	373.2	367.6
560	476.6	468.0	463.3	458.0	451.4	443.7	433.7	417.9	393.9	383.0
580	487.1	479.0	474.8	470.0	464.4	458.2	451.3	440.0	417.3	399.2
600	497.8	489.9	486.0	481.9	477.2	472.8	468.2	460.9	438.5	417.0

(*Continued on next page*)

Table IV. *(Continued)*

Units: Btu/lb
Datum: Pure saturated liquid components at −200°F

	Psia									
	450	530	550	570	580	620	636	650	750	900
454.8	312.3[a]									
460	343.0									
471.4	397.1[a]									
476.7	402.1	328.2[a]								
480	403.5	343.0	331.0							
481.5		350.0	332.1[a]							
485.9		384.6	348.5	335.8[a]						
488.3	409.2	396.0	367.0	344.4	337.7[a]					
489.3		398.7[a]	377.2	348.5	340.3	338.3				
493.1		402.8	398.6[a]	373.0	352.0	341.6				
497.8		406.7	402.8	398.1[a]	381.5	345.8				
499.2	406.7	407.7	404.3	400.0	393.6	346.0[a]				
500.3					397.9[a]	350.1	348.0			
505	420.2	411.8	409.0	406.0	403.9	372.1	353.0[a]			
509		414.4	411.8	409.2	407.1	395.0[a]	372.0	358.2		
509.3								359.0[a]		
512.5	425.0	416.9	414.5	412.0	410.0	400.1	393.0[a]	371.1		
515.9								389.1[a]	360.0	350.2
520	429.8	421.9	419.8		415.9	408.9	403.0	399.4	365.3	359.1
530	436.0		426.9		423.2	418.1		411.9	379.8	367.8
540	442.1		433.9		430.9	426.4		421.8	401.0	377.1
550	448.5		440.7		438.1	434.2		430.6	416.3	388.3

[a] On saturated locus. Estimated critical enthalpy 374.6 Btu/lb at 515.8°F.

thalpy values, converted to the −200°F basis, were cross-plotted and smoothed on large-size graph paper, resulting in the tabulations of enthalpy dependent on pressure shown in Tables II–IV. These smoothed values of enthalpy showed a standard error of estimation of 1.14 Btu/lb from the measured values. The locations of the dew and bubble point locus are shown in Tables II–IV, and also the critical enthalpy values.

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