The tetragonal unit cell of air-dried lysozyme chloride grown at a *p*H of 4.5 has dimensions of a = 71.1 kX and c = 31.3 kX. There are eight molecules in the unit cell. The density of the crystals was measured by suspension in a mixture of toluene and ethylene bromide. The observed density has been corrected for adhering sodium chloride (1.27%) to give 1.305 ± 0.003 g./cc. at 27°. The corrected density has been used to calculate the weight per molecule in the unit cell. This value was then corrected for moisture (9%) and hydrochloric acid bound to the amino groups (2.45%) to give a value for the molecular weight of dry, chloride-free, lysozyme of 13,900 ± 600.

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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF KANSAS]

Compound Formation between 2,6-Lutidine and Polyhalogenated Methanes

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In phase equilibrium studies recently reported from this laboratory,[1] evidence was obtained for the existence of eight addition compounds of pyridine with various polyhalogenated methanes. Because the structure of all of these compounds could not be explained in terms of a single consistent theory, the present investigation of the systems consisting of 2,6-lutidine with each of these same polyhalogenated methanes was undertaken in the hope that further light might be shed upon the process of addition compound formation in such systems. Selection of 2,6-lutidine was suggested by the following considerations: (1) because of its electronic structure, its nitrogen atom would be expected to exhibit a greater tendency than that of pyridine to act as an electron donor; (2) because of the proximity of the two substituent groups to the nitrogen atom, steric factors might be expected to interfere with the coördination of several lutidine molecules about a single molecule of polyhalogenated methane.

Experimental[2]

Purification of Materials.—The 2,6-lutidine, obtained from the Reilly Tar and Chemical Corporation, was purified by repeated recrystallization of the hydrochloride from concentrated hydrochloric acid. The base was regenerated by means of concentrated sodium hydroxide solution, and, after separation from the aqueous layer, was dried over sodium hydroxide pellets for ten days. Fractional distillation through a five-foot packed column gave pure 2,6-lutidine, b. p. 142.5° at 738 mm., f. p. (from cooling curve) −5.5°. The purified material was stored in a dark bottle and was guarded against contact with moisture and carbon dioxide.

The chloroform, bromoform and carbon tetrachloride were dried over drierite, then fractionally distilled through the column referred to above. The physical constants observed for the pure compounds are as follows: for chloroform, b. p. 60.7° at 745 mm., f. p. (from cooling curve) −62.1°; for bromoform, b. p. 148.2° at 740 mm., f. p. (from cooling curve) 8.3°; for carbon tetrachloride, b. p. 76.1° at 741 mm., f. p. (from cooling curve) −21.8°. Eastman Kodak Co. iodoform and bromoform were recrystallized twice from ethanol; the former melted at 121.1°, the latter at 90.9°.

Apparatus and Procedure.—The freezing point cell used in the determination of the temperature-composition diagrams was similar to that described in a previous publication from this Laboratory,[3] except that the cell was constructed in two parts joined to each other by means of a ground glass joint. This design makes possible the easy removal of the stirrer. All cooling curves were recorded directly by means of a Brown Electronik Strip Chart potentiometer which had been calibrated at the m. p. of ice, the b. p. of ammonia, and the sublimation point of solid carbon dioxide. Each freezing point was determined at least twice. Data obtained by this method are believed to be correct, even for the steeper portions of the freezing point curves, to 1.5°.

Results

The experimental data are shown in tabular and graphical form below. Compositions, as indicated, are given in mole %.

TABLE I

SYSTEM 2,6-LUTIDINE–CHLOROFORM

Mole % chloroform	Temp., °C.
Solid phase C_7H_9N	
0.0	− 5.5
5.75	− 8.9
8.10	−10.9
11.1	−11.9
13.4	−13.8
16.3	−15.1
18.4	−17.9
21.1	−20.0
23.4	−21.5
26.0	−24.5
28.2	−27.3
30.5	−30.0
36.2	−40.0
38.4	−44.5
40.4	−48.0
41.2	−49.0
42.4	−51.0
Solid phase $C_7H_9N\cdot CHCl_3$	
43.8	−51.5
44.3	−50.5
45.9	−49.5
48.7	−48.3
49.9	−48.3
52.1	−49.0
54.3	−49.1
57.2	−51.5
59.8	−53.8
62.8	−56.7
63.3	−57.3
66.9	−62.9
68.2	−64.3
72.9	−72.0
74.5	−74.5
75.9	−77.0
Solid phase $CHCl_3$	
76.5	−76.3
78.5	−74.0
83.0	−71.0
87.3	−67.2
91.4	−65.0
93.6	−63.2
95.6	−63.0
100.0	−62.1

A. As shown graphically in Fig. 1, curve A, 2,6-lutidine and chloroform form a single stable

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[1] Davidson, VanderWerf and Boatright, THIS JOURNAL, **69**, 3045 (1947).

[2] Melting points corrected, boiling points uncorrected.

[3] Davidson, Sisler and Stoenner, THIS JOURNAL, **66**, 779 (1944).

compound, $C_7H_9N{\cdot}CHCl_3$, which melts congruently at −48.3°. The eutectics are: (a) 43.6 mole % chloroform, f. p. −51.6°, and (b) 75.7 mole % chloroform, f. p. −77.0°.

TABLE II

SYSTEM 2,6-LUTIDINE–BROMOFORM

Mole % bromoform	Temp., °C.
Solid phase C_7H_9N	
0.0	− 5.5
2.10	− 8.0
5.90	−10.1
11.3	−14.2
13.2	−15.9
16.8	−19.3
19.2	−21.5
21.1	−24.1
23.7	−27.0
26.2	−30.0
27.7	−30.9
29.3	−33.5
Solid phase $C_7H_9N{\cdot}CHBr_3$	
31.9	−30.5
33.3	−29.0
34.1	−27.9
35.8	−26.0
38.8	−23.9
42.6	−22.8
43.7	−22.3
45.9	−21.0
49.9	−21.0
50.5	−21.0
51.4	−21.5
54.8	−21.8
59.2	−23.8
62.2	−24.2
Solid phase $CHBr_3$	
64.9	−24.3
67.1	−21.0
69.9	−17.2
74.1	−13.7
76.5	−10.2
79.8	− 7.8
81.2	− 5.0
85.0	− 2.1
86.0	− 0.8
87.9	1.2
89.2	1.3
91.6	3.1
97.2	7.1
100.0	8.3

B. As indicated in Fig. 1, curve C, 2,6-lutidine and bromoform form a single stable compound, $C_7H_9N{\cdot}CHBr_3$, which melts congruently at −21.0°. The eutectics are: (a) 29.5 mole % bromoform, f. p. −33.9°, and (b) 64.2 mole % bromoform, f. p. −24.8°.

TABLE III

SYSTEM 2,6-LUTIDINE–IODOFORM

Mole % iodoform	Temp., °C.
Solid phase C_7H_9N	
0.0	− 5.5
1.78	− 8.0
7.45	−13.3
8.58	−11.9
10.3	−15.5
13.4	−17.0
14.6	−18.1
16.0	−18.9
16.6	−19.3
Solid phase $2C_7H_9N{\cdot}CHI_3$	
17.2	−17.5
18.5	− 8.4
18.9	− 8.0
19.7	− 6.3
20.8	−4.5
21.8	−1.0
22.3	−0.5
22.7	1.3
Solid phase CHI_3	
24.1	21.7
28.5	41.0
31.3	50.8
33.7	57.5
34.2	57.5
37.6	66.0
42.5	74.0
55.5	91.0
67.5	99.0
100.0	121.0

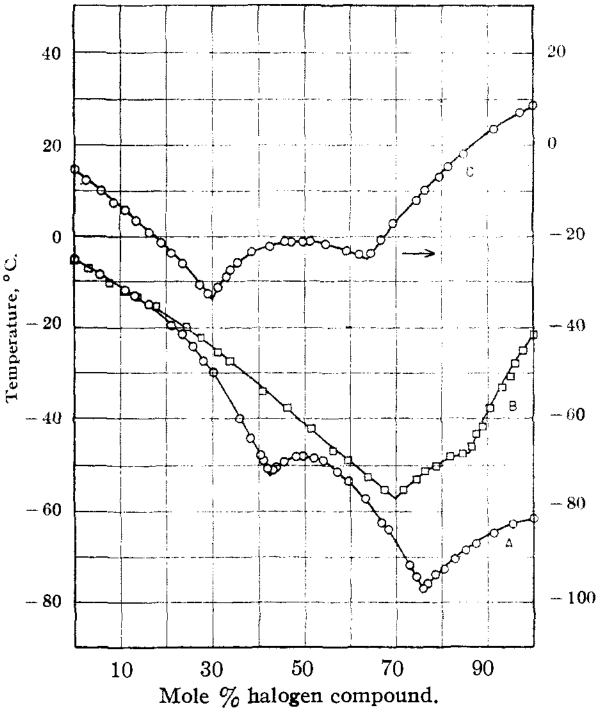

Fig. 1.—Systems 2,6-lutidine–polyhalogenated methanes: curve A, chloroform; curve B, carbon tetrachloride; curve C, bromoform (use temperature scale on right).

C. As represented in Fig. 2, curve B, 2,6-lutidine and iodoform form a single compound which undergoes transition into iodoform and solution at 2.0°. Inasmuch as the compound does not melt congruently, its composition is not definitely indicated, but from the course of the curve it appears

TABLE IV

SYSTEM 2,6-LUTIDINE–CARBON TETRACHLORIDE

Mole % carbon tetrachloride	Temp., °C.
Solid phase C_7H_9N	
0.0	− 5.5
2.74	− 7.5
7.40	−10.2
10.7	−12.2
13.5	−13.6
17.6	−15.8
20.6	−17.9
24.3	−20.0
27.4	−22.7
31.0	−25.5
33.8	−27.9
37.1	−30.0
38.7	−31.9
40.9	−34.0
42.8	−35.7
44.8	−37.0
46.2	−38.0
48.6	−40.0
51.7	−42.0
54.0	−45.3
56.3	−47.0
59.5	−49.0
61.9	−51.1
64.0	−52.0
66.8	−54.0
67.5	−55.3
Solid phase α-CCl_4	
72.0	−55.5
75.1	−53.2
76.7	−51.0
79.0	−51.0
82.2	−48.2
84.9	−47.5
Solid phase β-CCl_4	
87.0	−46.5
87.9	−43.2
89.4	−42.0
90.9	−37.5
93.6	−33.0
95.4	−31.1
96.5	−28.0
98.1	−25.2
100.0	−21.8

likely that it is $2C_7H_9N\cdot CHI_3$. Extrapolation indicates that the melting point of the compound would be about 7.5°. The eutectic is 16.8 mole % iodoform, f. p. −19.4°.

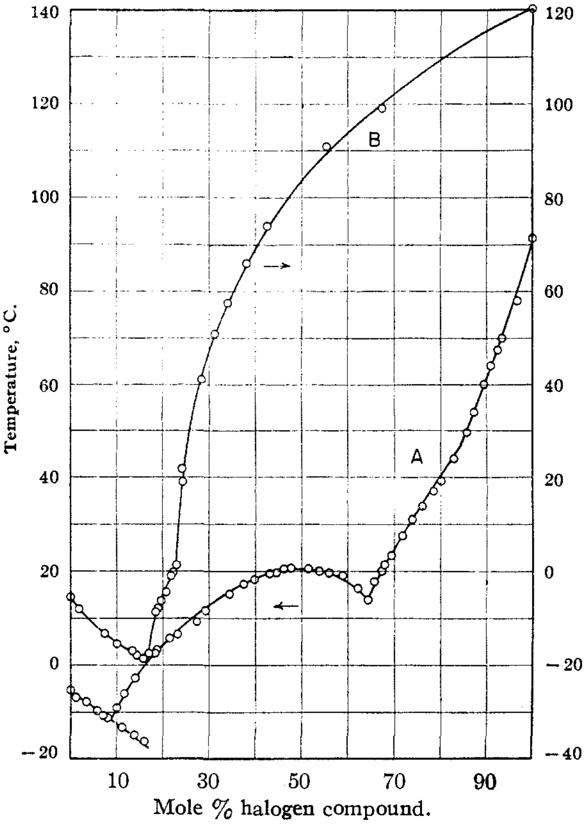

Fig. 2.—Curve A, system 2,6-lutidine–carbon tetrabromide (use temperature scale on left); curve B, system 2,6-lutidine–iodoform (use temperature scale on right).

D. As shown in Fig. 1, curve B, no compound formation occurs between 2,6-lutidine and carbon tetrachloride. The single eutectic is 70.4 mole % carbon tetrachloride, f. p. −57.0°. The distinct change in the slope of the curve at −46.5° results from the transition from the α- to the β-form of carbon tetrachloride.

E. As indicated in Fig. 2, curve A, 2,6-lutidine and carbon tetrabromide form a single stable compound, $C_7H_9N\cdot CBr_4$, which melts congruently at 20.7°. The eutectics are: (a) 8.3 mole % carbon tetrabromide, f. p. −11.3°, and (b) 64.5 mole % carbon tetrabromide, f. p. −11.3°, and (b) 64.5 mole % carbon tetrabromide, f. p. 13.9°. The change in the slope of the curve at 47° corresponds to the transition from the α- to the β-form of carbon tetrabromide at that temperature.

Discussion

In general, the number and complexity of the stable solid addition compounds between the polyhalogenated methanes and 2,6-lutidine is less than in the corresponding systems with pyridine, a fact which may probably be attributed to the steric factors effective in the 2,6-lutidine molecule. The fact that the compound of 2,6-lutidine with chloroform appears to be more stable than the corresponding compound of pyridine is noteworthy; in this case, the enhanced stability of the compound may be attributed to the greater tendency of the disubstituted base to act as an electron donor, resulting from the electron releasing effects of the two methyl groups.

TABLE V

SYSTEM 2,6-LUTIDINE–CARBON TETRABROMIDE

Mole % carbon tetrabromide	Temp., °C.
Solid phase C_7H_9N	
0.0	− 5.5
1.35	− 6.9
3.61	− 7.8
6.00	− 9.9
7.33	−10.8
8.10	−11.3
Solid phase $C_7H_9N\cdot CBr_4$	
10.0	− 9.3
10.7	− 6.7
11.8	− 6.3
13.4	− 3.4
14.3	− 3.0
16.8	1.2
18.6	2.5
18.8	3.2
19.1	3.3
21.5	5.8
23.4	6.5
27.6	9.3
29.2	11.5
34.5	15.2
37.7	17.4
40.0	18.3
43.7	19.7
44.8	19.8
46.4	20.5
47.8	20.6
50.8	20.1
51.4	20.7
53.8	20.2
56.0	19.8
59.0	19.0
62.2	16.3
64.4	14.0
Solid phase α-CBr_4	
65.9	17.8
67.5	20.0
68.0	21.3
69.4	23.2
72.0	27.5
74.1	31.0
76.3	33.9
78.6	37.0
80.4	39.3
83.5	44.2
Solid phase β-CBr_4	
85.7	49.5
87.5	54.0
89.4	60.0
91.0	64.0
92.6	67.5
93.5	70.8
95.8	78.0
100.0	91.0

Summary

1. Temperature–composition data are presented for systems consisting of 2,6-lutidine with each of several polyhalogenated methanes.

2. It has been shown that chloroform, bromoform and carbon tetrabromide each form a 1:1 addition compound with 2,6-lutidine, and that a 2:1 addition compound is formed in the system 2,6-lutidine–iodoform.

3. The behavior of 2,6-lutidine toward the polyhalogenated methanes is compared with that of pyridine in similar systems.

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