the residue of the ether–petroleum ether extraction were unsuccessful.

9-Benzyladenine.—To a suspension of 2.3 g of adenine thallium(I) salt in 25 ml of dimethylformamide was added 1.1 g of benzyl bromide, and the mixture was stirred at room temperature for 10 hr. The suspended thallium(I) bromide was removed by filtration, the filtrate concentrated to dryness and the residue recrystallized from ethanol to give 0.70 g (48%) of 9-benzyladenine, mp 230°, identical with an authentic sample prepared by the method of Montgomery and Thomas.[9]

Methylation of Purine Thallium(I) Salt.—To a suspension of 1.0 g of purine thallium(I) salt in 25 ml of dimethylformamide was added 0.54 g of methyl iodide, and the mixture was stirred at room temperature for 8 hr. The orange thallium(I) iodide was removed by filtration and the filtrate was evaporated to dryness. The residual yellow-brown solid was extracted first with 50 ml of hot petroleum ether and then with 30 ml of hot methanol–acetone (1:1). The petroleum ether extract was decolorized with charcoal, filtered, and the filtrate evaporated to dryness. Recrystallization of the crystalline residue from *n*-hexane gave 0.12 g (30%) of 9-methylpurine, mp 159–160° (lit. mp 158–159,[11] 161–162,[12] 162–163°[13]). Evaporation of the methanol–acetone extract to dryness followed by recrystallization of the residue from methanol–acetone gave 0.13 g (15%) of 7,9-dimethylpurinium iodide as light yellow needles, mp 225–226° dec.

Anal. Calcd for $C_7H_9N_4I$: C, 30.43; H, 3.26; N, 20.29. Found: C, 30.58; H, 3.45; N, 20.02.

Treatment of 1.0 g of purine thallium(I) salt with an excess of methyl iodide in 25 ml of dimethylformamide under the above conditions, followed by filtration, evaporation to dryness, extraction of the residue with hot petroleum ether, and recrystallization of the residual solid from methanol–acetone gave 0.55 g (65%) of 7,9-dimethylpurinium iodide, mp 225–226° dec. Pyrolysis of 0.5 g of this material at 220–230° gave a white crystalline sublimate which was extracted with hot petroleum ether. Tlc on the extract (ethanol–chloroform 2:8) showed the presence of 9-methylpurine and a trace of 7-methylpurine. The petroleum ether extract was treated with charcoal, filtered and the filtrate evaporated to dryness. Recrystallization of the residue from *n*-hexane gave 0.063 g (25%) of pure 9-methylpurine as colorless crystals, mp 158–159°.

Nebularine was prepared crystalline in 2% yield by utilizing the procedure of Brown and Weliky[17] with the modification that the chloromercuri salt was replaced by the purine thallium(I) salt and the ribosidation was conducted in anhydrous dimethylformamide at room temperature. Utilization of the thallium(I) salt of adenine in the procedure of Davoll and Lowy,[18] modified as above, gave **adenosine**, as determined by chromatographic comparison with authentic material. No attempts were made to find optimum conditions for these ribosidation reactions.

Registry No.—Purine thallium(I) salt, 19165-45-8; 6-chloropurine thallium(I) salt, 19365-46-9; adenine thallium(I) salt, 19165-47-0; 7,9-dimethylpurinium iodide, 19165-48-1.

[17] G. B. Brown and V. S. Weliky, *J. Biol. Chem.*, **204**, 1019 (1953).

[18] J. Davoll and B. A. Lowy, *J. Amer. Chem. Soc.*, **73**, 1650 (1951).

Thallium in Organic Synthesis. VI. Synthesis of Primary Aliphatic Bromides[1]

ALEXANDER MCKILLOP, D. BROMLEY,

School of Chemical Sciences, University of East Anglia, Norwich, England

AND

EDWARD C. TAYLOR

Department of Chemistry, Princeton University, Princeton, New Jersey 08540

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The reaction of halogens with dry metal salts of carboxylic acids to give halides, with concomitant decarboxylation, is known as the Hunsdiecker reaction.[2,3] When a 1:1 ratio of halogen to a silver carboxylate is employed (the normal experimental conditions), the reaction can be summarized as shown in eq 1. This reaction is most useful for the preparation

$$RCO_2Ag + X_2 \longrightarrow RX + AgX + CO_2 \qquad (1)$$

of bromides, and yields (particularly with aliphatic carboxylic acids) are generally good. The extreme sensitivity of the reaction to trace amounts of water and the difficulty encountered in preparing dry silver carboxylates have led to a number of modifications of the Hunsdiecker reaction. The most useful appears to be the method of Cristol and Firth,[4-6] which involves the addition of bromine to a slurry of excess red mercuric oxide in a refluxing solution of the carboxylic acid in carbon tetrachloride, bromotrichloromethane,[7] or 1,2-dibromoethane.[7]

Thallium(I) carboxylates, in contrast to silver carboxylates, are easily prepared and purified by recrystallization, and are stable indefinitely.[8] We have found that treatment of aliphatic thallium(I) carboxylates with bromine in carbon tetrachloride leads to a smooth Hunsdiecker reaction, with formation of primary alkyl bromides. Inspection of the inorganic product of this reaction, however, showed that it was neither thallium(I) bromide nor thallium(III) bromide, indicating that the stoichiometry of the conversion was not analogous to that observed in the normal silver salt procedure. Its properties were in closest agreement with those reported for the so-called "thallium dibromide" (Tl_2Br_4) [$Tl^{+1}(Tl^{+3}Br_4)^-$].[9] The actual stoichiometry for the bromine–thallium(I) carboxylate reaction would thus appear to be as shown in eq 2 in which

$$2RCO_2Tl + 3Br_2 \longrightarrow 2RBr + 2CO_2 + Tl_2Br_4 \qquad (2)$$

the intervention of thallium(III) is seen to play a key role. Facile interchanges between the Tl^{+1} and Tl^{+3} oxidation states appear to be a common feature of thallium chemistry.[10] As a consequence of these considerations, the following sequence (eq 3–5) for the Hunsdiecker reaction with thallium(I) carboxylates and bromine can be postulated, which demands a ratio

$$RCO_2Tl + Br_2 \longrightarrow RCO_2TlBr_2 \qquad (3)$$

$$2RCO_2TlBr_2 + Br_2 \longrightarrow 2RCO_2Br + Tl_2Br_4 \qquad (4)$$

$$RCO_2Br \longrightarrow RBr + CO_2 \qquad (5)$$

of RCO_2Tl/Br_2 of 1:1.5. Indeed, use of this ratio of reactants rather than the 1:1 ratio initially employed by analogy with the common silver salt method raised

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[2] R. G. Johnson and R. T. Ingham, *Chem. Rev.*, **56**, 219 (1956).

[3] C. V. Wilson, *Org. Reactions*, **9**, 332 (1957).

[4] S. J. Cristol and W. C. Firth, Jr., *J. Org. Chem.*, **26**, 280 (1961).

[5] S. J. Cristol, L. K. Gaston, and T. Tiedeman, *ibid.*, **29**, 1279 (1964).

[6] J. A. Davis, J. Herynk, S. Carroll, J. Bunds, and D. Johnson, *ibid.*, **30**, 415 (1965).

[7] F. W. Baker, H. D. Holtz, and L. M. Stock, *ibid.*, **28**, 514 (1963).

[8] E. C. Taylor, G. W. McLay, and A. McKillop, *J. Amer. Chem. Soc.*, **90**, 2422 (1968).

[9] F. A. Cotton and G. Wilkinson, "Advanced Inorganic Chemistry," Interscience Publishers, New York, N. Y., 1965, p 337.

[10] A. N. Nesmeyanov and R. A. Sokolik, "Methods of Elemento-Organic Chemistry, Vol. I. The Organic Compounds of Boron, Aluminum, Gallium, Indium and Thallium," The World Publishing Company, New York, N. Y., 1967, pp 581–583.

TABLE I

Tl(I) salt of	Product	Yield, %[a]	Bp(mm), °C	Lit. bp (mm), °C
Octanoic acid	1-Bromoheptane	98	70–75 (15)	62–65 (12)[b]
Decanoic acid	1-Bromononane	89	83–85 (10)	113 (27)[c]
Lauric acid	1-Bromoundecane	85	102–105 (2)	131–134 (15)[d]
Myristic acid	1-Bromotridecane	92	160–162 (5)	148–149 (9.5)[e]
Palmitic acid	1-Bromopentadecane	84	171–176 (5)	170–175 (8–10)[f]
Stearic acid	1-Bromoheptadecane	83	mp 27–29	mp 32[g]
β-Carbomethoxypropionic acid	Methyl β-bromopropionate	86	75–80 (22)	64–66 (18)[h]

[a] No attempt was made to optimize yields. All products were >98% pure as isolated, as determined by glpc. [b] J. Cason, M. J. Kalm, and R. H. Mills, *J. Org. Chem.*, **18**, 1670 (1953). [c] M. Tuot, *Bull. Soc. Chim. Fr.*, 363 (1946). [d] A. Lüttringhaus and D. Schade, *Chem. Ber.*, **74**, 1565 (1941). [e] H. Suida and F. Drahowzal, *ibid.*, **75**, 991 (1942). [f] T. N. Mehta, V. S. Mehta, and V. B. Thosar, *J. Ind. Chem. Soc., Ind. Ed.*, **3**, 137 (1940). [g] J. W. H. Oldham, *J. Chem. Soc.*, 100 (1950). [h] "Organic Syntheses," Coll. Vol. III, E. C. Hornung, Ed., John Wiley & Sons, Inc., New York, N. Y., 1955, p 576.

the yields of primary aliphatic bromides from about 30 to 85–95%.

Experimental Section

Melting points were determined on a Kofler hot stage apparatus and are uncorrected. Infrared (ir) spectra were recorded on a Perkin-Elmer Model 325 grating spectrophotometer; the normal Nujol mull technique was used for solids; and liquids were recorded as liquid films. Gas–liquid phase chromatograms were recorded on a Perkin-Elmer Model 452 instrument, using a standard 1-m glass column with Apiezon L on Chromosorb as packing. Microanalyses were performed by Mr. D. L. Fyans. All glass apparatus was dried at 100° prior to use. Carbon tetrachloride and bromine were dried over phosphorus pentoxide.

Preparation of Thallium(I) Carboxylates.—Thallium(I) ethoxide[11] (0.09 mol) was pipetted into a stirred solution of the carboxylic acid (0.1 mol) in petroleum ether (100 ml, bp 60–80°). The salt precipitated immediately. Stirring was continued for 15 min, after which the solid was filtered, washed well with cold ether, and recrystallized from aqueous ethanol. The thallium(I) carboxylates were obtained in 90–98% yield as colorless needles.

Thallium(I) octanoate had mp 119–120°. *Anal.* Calcd for $C_8H_{15}O_2Tl$: C, 27.64; H, 4.35. Found: C, 27.60; H, 4.37.

Thallium(I) decanoate had mp 134–135°. *Anal.* Calcd for $C_{10}H_{19}O_2Tl$: C, 31.96; H, 5.08. Found: C, 31.66; H, 4.99.

Thallium(I) laurate had mp 119–120°. *Anal.* Calcd for $C_{12}H_{23}O_2Tl$: C, 35.72; H, 5.75. Found: C, 36.10; H, 6.20.

Thallium(I) myristate had mp 120–121°. *Anal.* Calcd for $C_{14}H_{27}O_2Tl$: C, 38.94; H, 6.30. Found: C, 38.50; H, 6.60.

Thallium(I) palmitate had mp 116–117° (lit.[12] mp 116–118°).

Thallium(I) stearate had mp 117–119° (lit.[13] mp 119°).

Reaction of Thallium(I) Carboxylates with Bromine. Preparation of *n*-Alkyl Bromides.—A solution of bromine (0.015 mol) in carbon tetrachloride (20 ml) was added dropwise during 15 min to a stirred suspension of the thallium(I) carboxylate (0.01 mol) in carbon tetrachloride. The resulting yellow solution was stirred and refluxed under nitrogen for 4 hr and cooled, the yellow inorganic salt was filtered off, and the filtrate was washed with aqueous sodium bisulfite solution followed by aqueous sodium bicarbonate solution and then dried over anhydrous sodium sulfate. The solvent was removed under reduced pressure, the residual oil was dissolved in chloroform, and the solution was passed through a short column of alumina to remove traces of thallium salts. Removal of the chloroform and distillation gave the *n*-alkyl bromides (Table I), whose identity was confirmed by comparison of infrared spectra and glpc retention times with those of genuine samples.

Registry No.—Thallium(I) octanoate, 18993-50-5; thallium(I) decanoate, 18993-51-6; thallium(I) laurate, 18993-52-7; thallium(I) myristate, 18993-53-8.

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(11) G. Brauer, Ed., "Handbook of Preparative Inorganic Chemistry," Vol. I, 2nd ed., Academic Press, New York, N. Y., 1963, p 877.

(12) A. Menzies and E. M. Wilkins, *J. Chem. Soc.*, **125**, 1148 (1925).

(13) A. Menzies, *ibid.*, **127**, 2369 (1924).

Some Extensions of the *ortho*-Lithiation Reaction[1]

RICHARD T. HAWKINS AND DOYLE B. STROUP

Department of Chemistry, Brigham Young University, Provo, Utah 84601

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The *ortho*-lithiation reaction has been established to be of synthetic utility. Compounds of the type $Ar(CH_2)_nNR_2$ where $n = 0$, 1, and 2 have been *ortho* lithiated and the resultant carbanions treated with electrophiles.[2–4] Although substrates with active hydrogen are not commonly employed in these reactions, reports have appeared concerning the *ortho* lithiation of primary amines,[5] secondary amines,[6] and secondary sulfonamides.[7] The lithiation reaction has also been applied to sulfones[8] and thiophenes.[6,9–11] Now we wish to report our efforts along these lines including further studies of benzyl- and thenylamines.

Treatment of N,N-dimethylbenzylamine with *n*-butyllithium followed by condensation of the resulting carbanion with methyl borate afforded *o*-(dimethylaminomethyl)benzeneboronic anhydride (I), previously prepared by a different route.[12] At the time this work was completed, boron compounds had not been derived from similar lithiation-produced carbanions; such has since been reported.[13]

When a similar reaction was carried out using N-*n*-

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(2) F. N. Jones, M. F. Zinn, and C. R. Hauser, *J. Org. Chem.*, **28**, 663, (1963); F. N. Jones, R. L. Vaulz, and C. R. Hauser, *ibid.*, **28**, 3461 (1963); K. P. Klein and C. R. Hauser, *ibid.*, **32**, 1479 (1967); and R. L. Gay and C. R. Hauser, *J. Amer. Chem. Soc.*, **89**, 2297 (1967).

(3) N. S. Narasimhan and A. C. Ranade, *Tetrahedron Lett.*, 603 (1966).

(4) A. R. Lepley, *et al.*, *J. Org. Chem.*, **31**, 2047, 2051 (1966).

(5) C. Eaborn, P. Golborn, and R. Taylor, *J. Organometal. Chem.*, **10**, 171 (1967).

(6) H. Gilman and J. W. Morton, *Organic Reactions*, **8**, 258 (1954).

(7) H. Watanabe, R. L. Gay, and C. R. Hauser, *J. Org. Chem.*, **33**, 900 (1968).

(8) F. M. Stoyanovich and B. P. Federov, *Angew. Chem. Intern. Ed. Engl.*, **5**, 127 (1966).

(9) C. G. Screttas and J. F. Eastham, *J. Amer. Chem. Soc.*, **87**, 3276 (1965).

(10) Y. L. Goldfarb and V. P. Litvinov, *Bull. Acad. Sci. USSR, Div. Chem. Sci.*, 1987 (1964).

(11) H. J. Jakobsen, E. H. Larsen, and S. O. Lawesson, *Tetrahedron*, **19**, 1867 (1963).

(12) R. T. Hawkins and H. R. Snyder, *J. Amer. Chem. Soc.*, **82**, 3863 (1960).

(13) G. Marr, R. E. Moore, and B. W. Rockett, *J. Organometal. Chem.*, **7**, 11 (1967).