tion of sodium hydroxide, followed by 50 cc. of 30% hydrogen peroxide. The reaction mixture was extracted with ether, the ether extract washed four times with water to remove diglyme, dried and distilled. There was obtained 18.2 g. (80% yield) of 2-(*p*-anisyl)-ethanol, b.p. 138–140° at 10 mm., m.p. 27–28°. Gas chromatographic analysis indicated a purity of at least 98%.

RICHARD B. WETHERILL LABORATORY
PURDUE UNIVERSITY HERBERT C. BROWN
LAFAYETTE, INDIANA GEORGE ZWEIFEL

RECEIVED MAY 9, 1960

BIS-3-METHYL-2-BUTYLBORANE AS A SELECTIVE REAGENT FOR THE COMPETITIVE HYDROBORATION OF OLEFINS AND DIENES

Sir:

Bis-3-methyl-2-butylborane, readily prepared by the hydroboration of 2-methyl-2-butene, exhibits a high selectivity for the less hindered of the two carbon atoms of a double bond.[1] This observation suggested that this reagent might exhibit a marked selectivity for olefins of varying structural types and prompted an examination of the relative rates of reaction of this reagent with a series of representative olefins.

The reactivity of olefins toward bis-3-methyl-2-butylborane decreases in the order: 1-hexene ≥ 3-methyl-1-butene > 2-methyl-1-butene > *cis*-2-hexene ≥ cyclopentene > *trans*-2-hexene > *trans*-4-methyl-2-pentene > cyclohexene > 1-methylcyclopentene > 2-methyl-2-butene ≥ 1-methylcyclohexene ≥ 2,3-dimethyl-2-butene.

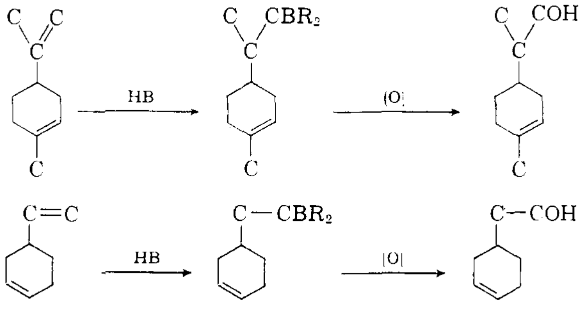
In many instances these differences in reactivity are quite large, suggesting the utility of the reagent for the selective hydroboration of a more reactive olefin in a mixture of two or more olefins. This possibility was tested by treating synthetic mixtures of two olefins in diglyme at 0° with a slight excess of the reagent, following the course of the reaction by gas chromatographic analysis for residual olefin.

In this way 1-pentene was essentially quantitatively removed from 2-pentene, and 2,4,4-trimethyl-1-pentene was removed from 2,4,4-trimethyl-2-pentene. Similarly, 1-pentene was selectively reacted in the presence of 2-methyl-1-pentene, and 1-hexene was quantitatively removed from cyclohexene. An equimolar mixture of cyclopentene and cyclohexene yielded a product which consisted of 95% cyclohexene.

Even more remarkable is the large difference in reactivity exhibited by *cis–trans* isomers, permitting the selective removal of the more reactive *cis* isomer from the *trans*. Treatment of a commercial sample of 2-pentene, 18% *cis*- and 82% *trans*-, with the reagent yielded *trans*-2-pentene in a purity of at least 97%.

It was demonstrated previously that the hydroboration of acetylenes makes available the *cis* olefin in a state of high purity.[2] Consequently, hydroboration now provides a synthetic route to the preparation of both *cis* and *trans* olefinic isomers in high purity.

Previously, we had attempted the selective hydroboration of *d*-limonene with diborane, without success.[3] However, the new reagent permitted a clean reaction involving the selective hydroboration of the exocyclic double bond in both *d*-limonene and 4-vinylcyclohexene.



The reagent, bis-3-methyl-2-butylborane, should be exceedingly helpful for the selective hydroboration of many terpenes and steroids.[4] A representative procedure is given.

To 0.165 mole of bis-3-methyl-2-butylborane, freshly prepared in diglyme,[1] was added (at 0°) 20.4 g. of a *d*-limonene (0.15 mole, $n^{20}\mathrm{D}$ 1.4730, $[\alpha]^{25}\mathrm{D}$ $+125°$) over a period of five minutes. After three hours at room temperature, the reaction mixture was oxidized with alkaline hydrogen peroxide in the usual manner. There was obtained 18.3 g. (79% yield) of primary terpineol, b.p. 115–116° at 10 mm., $n^{20}\mathrm{D}$ 1.4855, $[\alpha]^{25}\mathrm{D}$ $+99°$ (*c*, 4.2 in benzene), m.p. 3,5-dinitrobenzoate 91–92°.

Anal. Calcd. for $C_{10}H_{18}O$: C, 77.86; H, 11.76. Found: C, 78.05; H, 11.96.

In the same way 16.2 g. of 4-vinylcyclohexene was converted into 13.7 g. (72% yield) of 2-(4-cyclohexenyl)-ethanol, b.p. 86–87° at 6 mm., $n^{20}\mathrm{D}$ 1.4834, m.p. 3,5-dinitrobenzoate 66–67°.

Anal. Calcd. for $C_8H_{14}O$: C, 76.13; H, 11.18. Found: C, 76.72, H, 11.30.

The selective hydroboration of the exocyclic double bond was confirmed by hydrogenation of the product over platinum oxide to 2-cyclohexylethanol, b.p. 77–78° at 4 mm., $n^{20}\mathrm{D}$ 1.4651, m.p. 3,5-dinitrobenzoate, 71–72°.[5]

---

(1) H. C. Brown and G. Zweifel, THIS JOURNAL, **82**, 3222 (1960).

(2) H. C. Brown and G. Zweifel, *ibid.*, **81**, 1512 (1959).

(3) Similar unsuccessful results were realized by R. Dulou and Y. Chrétien-Bessière, *Bull. soc. chim. France*, **9**, 1362 (1959).

(4) The utility of other substituted boranes for such selective hydroborations is under investigation by Dr. A. Moerikofer.

(5) G. S. Hiers and R. Adams, THIS JOURNAL, **48**, 2385 (1926) report b.p. 87–89° at 6 mm., $n^{25}\mathrm{D}$ 1.4636; J. J. Bost, R. E. Kepner and A. D. Webb, *J. Org. Chem.*, **22**, 51 (1957), report m.p. 3,5-dinitrobenzoate, 70.0–70.5°.

RICHARD B. WETHERILL LABORATORY
PURDUE UNIVERSITY HERBERT C. BROWN
LAFAYETTE, INDIANA GEORGE ZWEIFEL

RECEIVED MAY 16, 1960

LOSS OF RADIOACTIVITY FROM OROTATE-7-C^{14} ON ALUMINUM PLANCHETS[1]

Sir:

During August, 1959, in experiments involving the chromatography of orotate-7-C^{14} [2] on Dowex-1

---

(1) This work was supported in part by a grant (C-646) from the National Cancer Institute, NIH, USPHS.

(2) Orotate 7-C^{14} was obtained from New England Nuclear Corp.

formate resin columns,[3] and the subsequent plating of eluates in 0.2 *M* ammonium formate on aluminum planchets for the determination of radioactivity[4,5] it was found that only 25% of the radioactivity could be recovered under conditions which permitted complete recovery of radioactivity from orotate-6-C^{14}.[6] This anomalous behavior could not be repeated in November. The humidity of the ambient air was considered to be a possible factor in the loss of the radioactivity, and this was confirmed by direct experiment (Table I, Expt. A). The loss of radioactivity from orotate-7-C^{14} is greater in ammonium formate than in formic acid (Table I) and is *p*H dependent (maximum loss at *p*H 5–7). Expt. B, Table I, shows that the loss takes place on aluminum, but not on glass or stainless steel planchets. The preceding data indicate that Al^{+++}, H^+, and $HCOO^-$, are factors in the loss of radioactivity from orotate-7-C^{14}.

When the system is isolated in a sealed desiccator[7] the radioactivity lost in ammonium formate can be trapped in 2 *N* NaOH and subsequently precipitated as $BaC^{14}O_3$. Furthermore, 86% of the radioactivity trapped in NaOH is released from the alkali at *p*H 5.5. These two facts indicate that the alkali-trapped radioactivity is $C^{14}O_2$.

The loss of radioactivity from orotate-7-C^{14} in 0.2 *M* ammonium formate plated and dried on aluminum planchets under moist conditions is dependent upon the amount of orotate applied per planchet up to about 0.08 μmole. Thereafter, the amount lost (*ca.* 0.055 μmole) is independent of the amount applied. When the residual radioactivity from small applications (0.02 μmole/planchet) of either orotate-7-C^{14} or -6-C^{14} was extracted with hot water[8] and fractionated by ion-exchange chromatography,[3] several compounds less acidic than orotate but no orotate were found. Residual radioactivity from larger amounts (0.15 μmole/planchet) of orotate-7-C^{14} or -6-C^{14} extracted with hot 50% ethanol[9] or 50% ethanol–6% NH_3,[10] respectively, contained these compounds (% of residual radioactivity given in parentheses): from orotate-7-C^{14}: I, II (4.5), unchanged orotate-7-C^{14} (91); from orotate-6-C^{14}: III, IV (25.3), V, unchanged orotate-6-C^{14} (59). When 0.02 μmole of orotate-7-C^{14} is applied per planchet, 0.005 μmole of I and II, the major residual products, is found, compared to 0.008 μmole found when 0.15 μmole is applied.

Compounds I and III, and II and IV (all less acidic than orotate) are chromatographically similar and do not absorb light at 260 mμ. Compound II has been identified tentatively as carbamyl aspartate by (1) comparison with authentic material by paper chromatography[11] and ion-exchange chromatography[3] and (2) formation of an immediate bright yellow color with *p*-dimethylaminobenzaldehyde reagent.[12] IV also produces an immediate bright yellow color with this reagent, but it is not carbamyl aspartate. Since II is present in hot water extracts, it probably is produced on the aluminum planchets before the radioactivity is extracted. Because no uracil has been detected in extracts of residual radioactivity from either 6- or 7-labelled material[13] the direct decarboxylation of orotate seems invalidated; the decarboxylation of a derivative is more likely. Although no detailed mechanism for the loss of $C^{14}O_2$ from orotate-7-C^{14} can be presented, it is suggested that reduction and opening of the pyrimidine ring are involved, perhaps by $HCOO^-$ acting as a reductant and by Al^{+++} catalyzing the decarboxylation reaction.

The phenomenon of $C^{14}O_2$ loss from orotate-7-C^{14} emphasizes the care that should be exercised regarding the nature of planchets and solvents, and the stability of radioactive materials, in measuring radioactivity.

TABLE I

CONDITIONS FOR THE LOSS OF RADIOACTIVITY FROM OROTATE-7-C^{14}

Expt.	Planchet	Drying conditions	Medium	% loss of radioactivity[a]
A	Al	Room air[a]	H_2O	0
		Room air	0.2 *M* $HCOONH_4$	14.3
		Moist air[b]	H_2O	9.5
		Moist air	0.2 *M* $HCOONH_4$	78.1
		Room air	4 *M* HCOOH	21.5
		Moist air	4 *M* HCOOH	55.4
B	Al	Room air	0.2 *M* $HCOONH_4$	8.7
	Glass[c]	Room air	.2 *M* $HCOONH_4$	0
	Steel	Room air	.2 *M* $HCOONH_4$	0
	Al	Moist air	.2 *M* $HCOONH_4$	77.2
	Glass	Moist air	.2 *M* $HCOONH_4$	8.7
	Steel	Moist air	.2 *M* $HCOONH_4$	4.5

[a] Control samples of orotate-7-C^{14} in water were dried in room air during the months of November through February with consistent results. All values are the means for 3 samples. Two 2-min. determinations of radioactivity[5] (*ca.* 4000 c.p.m.) were made for each sample (0.02 μmole of orotate-7-C^{14}) which was dried for 96 hours at room temp. [b] Planchets were placed around a 3 in. watch glass containing distilled H_2O, and a 6 in. watch glass was inverted over the assembly. [c] 22 mm. sq. glass cover slip.

McARDLE MEMORIAL LABORATORY
UNIVERSITY OF WISCONSIN
MADISON 6, WISCONSIN

DONALD G. R. BLAIR
VAN R. POTTER

RECEIVED APRIL 18, 1960

---

(3) J. E. Stone and V. R. Potter, *Cancer Research*, **17**, 794 (1957).

(4) Radioactive samples were spread over an area of 3.8 sq. cm. and dried in air on acetone-washed aluminum planchets. Radioactivity was determined in internal gas-flow counters.

(5) The assistance of Dr. Charles Heidelberger and his staff in all determinations of radioactivity is gratefully acknowledged.

(6) Orotate-6-C^{14} was obtained from Tracerlab, Inc.

(7) Planchets were placed around a 3 in. watch glass filled with 2 *N* NaOH on a wooden support, and a 6 in. watch glass was inverted over the arrangement of planchets. This assembly was sealed in a desiccator until the planchets were dry.

(8) 22.5–24.3% of residual radioactivity extracted.

(9) 83% of residual radioactivity extracted.

(10) 99% of residual radioactivity extracted.

(11) In Fink solvent no. 8 (K. Fink, R. E. Cline, R. B. Henderson and R. M. Fink, *J. Biol. Chem.*, **221**, 425 (1956)) II R_f = 0.367; carbamyl aspartate R_f = 0.33. In butanol:ethanol:formic acid:water (5:3:2:1 (v/v)) (R. A. Yates and A. B. Pardee, *ibid.*, **221**, 743 (1956)) II R_f = 0.51; carbamyl aspartate R_f = 0.47.

(12) R. M. Fink, C. McGaughey, R. E. Cline and K. Fink, *ibid.*, **218**, 1 (1956).

(13) Carrier uracil was added to extracts from 0.2 μmole of orotate-6-C^{14} before chromatography.[3] Extracts from 4.5 μmoles of orotate-7-C^{14} or -6-C^{14} contained traces of a nonradioactive material which chromatographed like uracil but did not have an ultraviolet light absorption spectrum like that of uracil.