

## New Method for Isotopic Labelling of Organic Compounds Involving Organoboranes

By GEORGE W. KABALKA,<sup>a\*</sup> E. EUGENE GOOCH,<sup>a</sup> CLAIR J. COLLINS,<sup>a,b</sup> and VERNON F. RAAEN<sup>b</sup>  
(<sup>a</sup>Department of Chemistry, University of Tennessee, Knoxville, Tennessee 37916 and <sup>b</sup>Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830)

*Summary* The use of organoboranes in the syntheses of labelled materials offers a convenient and mild alternative to traditional methods; a variety of <sup>14</sup>C-labelled materials have been synthesized in good radiochemical yields utilizing organoboranes.

THE use of organoboranes in organic synthesis has developed rapidly in recent years.<sup>1-3</sup> The organoboranes are readily prepared from substrates which may contain a variety of functional groups, and the boron atom is readily replaced by

a wide variety of atoms in a stereospecific fashion under mild conditions.<sup>4-6</sup>

Few reports have appeared in which these versatile reagents have been utilized to incorporate less abundant nuclides,<sup>7,8</sup> although organoboranes should be ideal intermediates in the syntheses of labelled compounds. We report here that the carbonylation of organoboranes with <sup>14</sup>CO is a convenient method for labelling organic molecules. The reaction complements the traditional methods involving the carbonylation of organometallic reagents<sup>9</sup> and cyanide

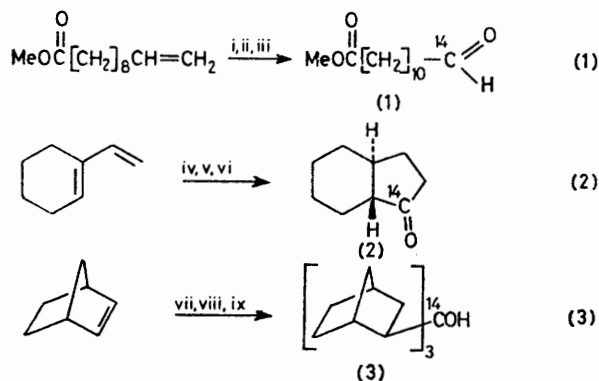
substitutions<sup>10</sup> which are frequently limited in scope owing to the high reactivity of the organometallic reagent and/or the lack of availability of suitable starting materials.

Carbonylations may be used to generate a variety of useful products, and aldehydes, alcohols, and ketones are readily prepared by modification of the conditions.<sup>4</sup> We have accordingly synthesized an example of each of these [equations (1)—(3)], and the results are summarized in the

Table. The reactions were complete in <1 h. The method clearly can provide access to a wide variety of labelled compounds.

TABLE. The synthesis of <sup>14</sup>C-labelled compounds<sup>a</sup>

Product	B.p./°C	Isolated yield/% <sup>b</sup>
(1)	102 at 0.5 Torr	59 <sup>c</sup>
(2)	49 at 1.0 Torr	50 <sup>d</sup>
(3)	137 <sup>e</sup>	72 <sup>f</sup>



i,  $\text{R}_2\text{BH}$ ; ii,  $^{14}\text{CO}$ , 1 atm,  $\text{KBH}(\text{OPr}^t)_3$ ; iii,  $\text{H}_2\text{O}_2\text{-NaOAc}$ ; iv,  $\text{Me}_2\text{CHCMe}_2\text{BH}_2$ ; v,  $^{14}\text{CO}$ , 70 atm,  $\text{H}_2\text{O}$ ; vi,  $\text{H}_2\text{O}_2\text{-NaOH}$ ; vii,  $\text{BH}_3$ ; viii,  $^{14}\text{CO}$ , 1 atm; ix,  $\text{H}_2\text{O}_2\text{-NaOH}$ .

<sup>a</sup>  $^{14}\text{CO}$  (V. F. Raaen and H. P. Raaen, 'Carbon-14,' McGraw-Hill, New York, 1968) was maintained, *via* a rubber bladder gas reservoir and septum inlet, above a well stirred solution (0.5 M; 20 ml) of the intermediate organoborane in tetrahydrofuran in a standard glass flask, except for the preparation of (2) which required the use of a Parr reactor. <sup>b</sup> The yields are based on the trialkylboranes. <sup>c</sup> The activity of the  $^{14}\text{CO}$  was 2.19 mCi/mol; the activity of the product was 2.20 mCi/mol. <sup>d</sup> The activity of the  $^{14}\text{CO}$  was 1.78 mCi/mol; the activity of the product (characterized as the oxime, m.p. = 142.5–143 °C) was 1.77 mCi/mol. <sup>e</sup> Melting point. <sup>f</sup> The activity of the  $^{14}\text{CO}$  was 2.56 mCi/mol; the activity of the product was 2.57 mCi/mol.

We thank the Division of Chemical Sciences, U.S. Department of Energy and the Union Carbide Corporation for sponsorship of this research and G.W.K. and E.E.G. thank the National Institutes of Health for support of this research.

(Received, 3rd April 1979; Com. 354.)

<sup>1</sup> H. C. Brown, 'Organic Synthesis via Boranes,' Wiley-Interscience, New York, 1975.

<sup>2</sup> H. C. Brown, 'Boranes in Organic Synthesis,' Cornell University Press, Ithaca, New York, 1973.

<sup>3</sup> G. M. L. Cragg, 'Organoboranes in Organic Synthesis,' Marcel Dekker, New York, 1973.

<sup>4</sup> H. C. Brown, *Accounts Chem. Res.*, 1969, **2**, 65.

<sup>5</sup> G. W. Kabalka and N. S. Bowman, *J. Org. Chem.*, 1973, **38**, 1607.

<sup>6</sup> G. W. Kabalka, H. C. Hedgecock, H. C. Brown, and N. R. DeLue, *J. Amer. Chem. Soc.*, 1976, **98**, 310.

<sup>7</sup> G. W. Kabalka, R. J. Newton, and J. Jacobus, *J. Org. Chem.*, 1978, **43**, 1567.

<sup>8</sup> H. C. Brown, E. Negishi, and S. K. Gupta, *J. Amer. Chem. Soc.*, 1970, **92**, 2460.

<sup>9</sup> L. F. Elsom and D. R. Hawkins, *J. Labelled Compounds*, 1978, **799**.

<sup>10</sup> R. Thomas, *J. Labelled Compounds*, 1978, **807**.