An over-all isotopic conversion efficiency of 22% from $BaC^{14}O_3$ was achieved.

RADIOCHEMICAL DIVISION
TEXAS RESEARCH FOUNDATION
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Synthesis for Carbon-14 Labeled *dl*-Glutamic Acid

BY ROBERT J. SPEER, AMMARETTE ROBERTS, MARGARET MALONEY AND HENRY R. MAHLER

Under the auspices of the Atomic Energy Commission, Contract AT-(40-1)-274, synthetic methods for *dl*-glutamic acid-5-C^{14} and *dl*-glutamic acid-1,2-C^{14} have been developed. *dl*-Glutamic acid-5-C^{14} has been successfully prepared by modification of the method of Marvel and Stoddard[1] through the sequence of reactions[2,3]

$$BaC^*O_3 \xrightarrow[85\text{–}95\%]{NH_3,\ Fe} KC^*N \xrightarrow[80\%]{ClCH_2CH_2OH[5]} \underset{I}{}$$

$$HOCH_2CH_2C^*N \xrightarrow[92\%]{HBr[5]} BrCH_2CH_2C^*OOH \xrightarrow[88\%]{C_2H_5OH[1]}$$

II III

$$BrCH_2CH_2C^*OOC_2H_5 + [C_6H_4(CO)_2]NCH(COOC_2H_5)_2 \xrightarrow[70\text{–}75\%]{(1)\ NaOH[1]\ (2)\ HCl}$$

IV

$$HOOCCH(NH_2)CH_2CH_2C^*OOH$$

V

By this procedure, an over-all isotopic conversion efficiency of 47% on the basis of potassium cyanide was achieved.

The synthesis of *dl*-glutamic acid-1,2-C^{14}, reported by Koegl, *et al.*,[2] during the course of this work, was achieved as follows

$$C^*O_2 \xrightarrow[80\%]{C_2H_5MgBr[6]} CH_3CH_2C^*OOH \xrightarrow[80\%]{(1)\ KMnO_4[7,8]\ NaOH\ (2)\ Ca^{++}}$$

VI

$$(C^*OO)_2Ca \xrightarrow[92\%]{(1)\ IR\text{-}100\text{-}H\ (2)\ Ag^+} (C^*OOAg)_2 \xrightarrow[70\%]{CH_3I[2]}$$

VII VIII

$$(C^*OOCH_3)_2 \xrightarrow[60\text{–}70\%]{(1)\ (CH_2COOC_2H_5)_2[9]\ KOCH_3\ (2)\ HCl}$$

IX

$$HOOCCH_2CH_2C^*OC^*OOH \xrightarrow[64\%]{Pd\text{–}C[2]\ NH_3\text{–}H_2}$$

X

$$HOOCCH_2CH_2C^*H(NH_2)C^*OOH$$

XI

Utilization of the techniques developed by these investigators, together with modifications from this Laboratory, served to attain an over-all isotopic yield of 20.4% from the starting propionic acid-1-C^{14}.

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(3) For full experimental details order Document 3502 from American Documentation Institute, 1719 N Street, N. W., Washington 6, D. C., remitting $1.00 for microfilm (images 1 inch high on standard 35-mm. motion picture film) or $1.00 for photocopies (6 × 8 inches) readable without optical aid.

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Yeast Biosynthesis of Radioactive Sulfur Compounds

BY JOHN L. WOOD[1] AND JESSE D. PERKINSON, JR.

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The possibility of synthesis of isotope labeled compounds by microörganisms is often dismissed by the organic chemist for lack of special equipment and because of the complexity of the mixtures of products obtained. These problems are minimized in sulfur labeling, due to the distribution of the isotope among relatively few compounds, and by the utilization of yeast culture in ordinary glassware. Moreover, the yeast itself is well established as a dietary supplement and source of protein. Radioactive yeast may be fed for introduction of labels into body sulfur compounds.

The production of yeast labeled with radioactive sulfur has been carried out by use of a synthetic medium[2] containing only the small amount of sulfur furnished by the impurities in C.P. chemicals.[3] Carrier-free S^{35} sulfate, furnished by the Oak Ridge National Laboratory, was quantitatively incorporated by the yeast which was grown in 500-ml. erlenmeyers on a shaker. The labeled yeast was produced with a high specific radioactivity to permit dilution as desired before use.

Yeast prepared in separate runs of this procedure has been found to vary little in composition. It contained 6% nitrogen which was 50% non-protein. The protein fraction, however, contained 95% of the radioactivity labeled compounds. The biological availability of the sulfur was demonstrated by feeding the yeast as part of the diet of 3 rats. Radioactivity determinations done on blood, liver, kidney, muscle and urine showed an active metabolism of the sulfur compounds had occurred. The direct isolation of radioactive L-methionine and L-cystine from hydrolyzed yeast has been described.[4] Specific activities of the order of one microcurie per microgram of sulfur were obtained after a preliminary dilution of the product, with no indication that this was a limiting value. Analyses showed a moisture content of 5.3%, ash, 6%. Corrected percentage values

(1) Department of Chemistry, University of Tennessee, Memphis.

(2) A. S. Schultz and D. K. McManus, *Archiv. Biochem.*, **25**, 401 (1950).

(3) For complete experimental details order Document 3482 from American Documentation Institute, 1719 N St., N. W., Washington 6, D. C., remitting $1.00 for microfilm (images 1 inch high on standard 35-mm. motion picture film) or $1.95 for photocopies (6 × 8 inches) readable without optical aid.

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