# Synthesis and Evaluation of 24-(Isopropyl[$^{75}$Se]seleno)chol-5-en-3$\beta$-ol

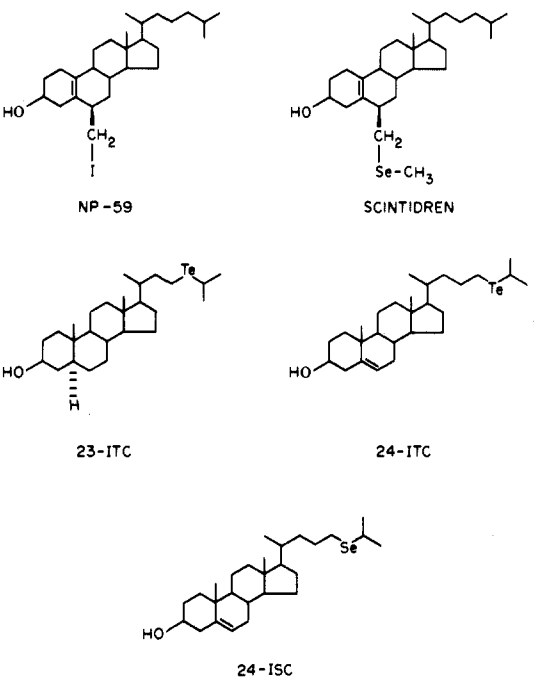
F. F. Knapp, Jr.,*† T. A. Butler,† L. A. Ferren,† A. P. Callahan,† C. E. Guyer,† and J. L. Coffey‡

*Nuclear Medicine Group, Health and Safety Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830, and Medical and Health Sciences Division, Oak Ridge Associated Universities, Oak Ridge, Tennessee 37830.*
*Received December 20, 1982*

Selenium-75-labeled 24-(isopropylseleno)chol-5-en-3$\beta$-ol (4) has been prepared by reaction of sodium isopropyl-[$^{75}$Se]selenol ([$^{75}$Se]2) with 3$\beta$-acetoxy-24-bromochol-5-ene (3). This new $^{75}$Se-labeled adrenal imaging agent shows pronounced adrenal uptake in rats. The concentration of radioactivity in rat adrenals increased steadily from 1 to 24 h after injection and then decreased slowly over the 21-day period. After 3 days the adrenal/blood and adrenal/liver ratios were 85:1 and 32:1, respectively, which are sufficient for adrenal imaging by single photon techniques. After 6 h the adrenal/blood ratio was 17:1 and the adrenal/liver ratio was 7:1. We propose that these ratios are sufficiently high for positron emission tomography of the adrenals. The absorbed radiation dose values to human organs have been estimated for the $^{75}$Se- and $^{73}$Se-labeled agent.

The use of steroids labeled with $\gamma$-emitting radionuclides is the most effective noninvasive method for the diagnosis of many types of adrenal disease.[1] Radioiodinated-6$\beta$-(iodomethyl)-19-norcholest-5(10)-en-3$\beta$-ol (NP-59)[2,3] and 6$\beta$-[(methyl[$^{75}$Se]seleno)methyl]-19-norcholest-5(10)-en-3$\beta$-ol (Scintidren)[4] are presently the two agents of choice for the clinical diagnosis of adrenal pathologies (Chart I). The Se-75-labeled agent offers several advantages over NP-59, which include a considerably longer shelf life and the absence of significant radiation dose to the thyroid glands encountered with use of I-131-labeled NP-59.[4,5] In an effort to prepare new adrenal imaging agents labeled with radionuclides that have imaging properties superior to either I-131 or Se-75, we have recently prepared and tested a variety of Te-123m-labeled steroids.[6-10] Two of these Te-123m-labeled agents, 24-(isopropyltelluro)chol-5-en-3$\beta$-ol (24-ITC) and 23-(isopropyltelluro)-24-nor-5$\alpha$-cholan-3$\beta$-ol (23-ITC), showed pronounced adrenal uptake in experimental animals.[7,8,10] The adsorbed radiation dose estimates for Te-123m-labeled 23-ITC and 24-ITC are similar to values calculated from animal tissue distribution data for [$^{131}$I]-NP-59 and [$^{75}$Se]Scintidren.[11] In the present investigation we have prepared 24-(isopropyl-[$^{75}$Se]seleno)chol-5-en-3$\beta$-ol ([$^{75}$Se]4], the selenium analogue of 24-ITC. The Se-75-labeled compound could represent a readily available, chemically stable adrenal imaging agent that would be available to a large patient population, and these studies would also indicate whether the preparation and testing of the Se-73-labeled agent would be feasible. The use of Se-73-labeled steroids for positron-emission tomographic visualization of adrenal masses would be potentially powerful tool for the diagnosis of adrenal disease.

Chart I. Structures of Radiolabeled Steroid Adrenal Imaging Agents




**Chemistry.** The new selenium sterol 4 was prepared (Scheme I) by coupling of the selenol 2, prepared by in situ $NaBH_4$ reduction of the diselenide (1), with 3$\beta$-acetoxy-24-bromochol-5-ene (3), in an analogous fashion to that described earlier for the synthesis of the tellurium analogue, 24-(isopropyltelluro)chol-5-en-3$\beta$-ol.[9,10] The 3$\beta$-acetoxy-24-bromochol-5-ene substrate (3) was prepared by the following route: methyl 3$\beta$-methoxychol-5-en-24-oate → 3$\beta$-methoxy-24-hydroxychol-5-ene → 3$\beta$-methoxy-24-bromochol-5-ene → 3$\beta$-acetoxy-24-bromochol-5-ene.[9,10] The [$^{75}$Se]4 was obtained by the same route and exhibited a single radioactive component that cochromatographed with the unlabeled standard on TLC.

The synthesis of [$^{73}$Se]4 sterol is also possible. Selenium-73 is a long-lived ($t_{1/2}$ = 7.2 h) positron-emitting radionuclide, and $^{73}$Se-labeled radiopharmaceuticals could be distributed over long distances. Although the production yield of Se-73 by the usual $^{70}$Ge($\alpha$,n)$^{73}$Se,[12,13] the $^{72}$Ge($\alpha$,3n or $^3$H, 2n)$^{73}$Se,[12-16] and the $^{73}$Ge($^3$He,3n)$^{73}$Se[12-15]

† Oak Ridge National Laboratory.
‡ Oak Ridge Associated Universities.

(1) Thrall, J. H.; Freitas, J. E.; Beierwaltes, W. H. *Semin. Nucl. Med.* **1978**, *8*, 23.
(2) Sarkar, S. D.; Beierwaltes, W. H.; Ice, R. D.; Basmadjian, G. P.; Hetzel, K. R.; Kennedy, W. P.; Mason, M. M. *J. Nucl. Med.* **1975**, *16*, 1038.
(3) Kojima, M.; Maeda, M.; Nitta, K.; Ito, T. *J. Nucl. Med.* **1975**, *16*, 666.
(4) Reiley, A. L. M. *J. Labeled Compd. Radiopharm.* **1979**, *16* 28 (abstr).
(5) Chatal, J. F.; Chardonnel, B.; Guihard, D. *Clin. Nucl. Med.* **1978**, *3*, 71.
(6) Knapp, F. F., Jr.; Callahan, A. P. *J. Nucl. Med.* **1977**, *18*, 610 (abstr).
(7) Knapp, F. F., Jr.; Ambrose, K. R. *J. Nucl. Med.* **1977**, *18*, 600 (abstr).
(8) Knapp, F. F., Jr.; Ambrose, K. R.; Callahan, A. P. *J. Nucl. Med.* **1980**, *21*, 251.
(9) Knapp, F. F., Jr.; Ambrose, K. R.; Callahan, A. P. *J. Labeled Compd. Radiopharm.* **1979**, *16*, 35 (abstr).
(10) Knapp, F. F., Jr.; Ambrose, K. R.; Callahan, A. P. *J. Nucl. Med.* **1980**, *21*, 258.
(11) Woo, D. V.; Knapp, F. F., Jr.; Ambrose, K. R.; Callahan, A. P.; Coffey, J. L. *J. Nucl. Med.* **1980**, *21*, 454.
(12) Guillaume, M.; Lambrecht, R. M.; Wolf, A. P. *Int. J. Appl. Radiat. Isot.* **1978**, *29*, 411.
(13) Nozaki, T.; Itoh, Y.; Ogawa, K. *Int. J. Appl. Radiat. Isot.* **1979**, *30*, 595.

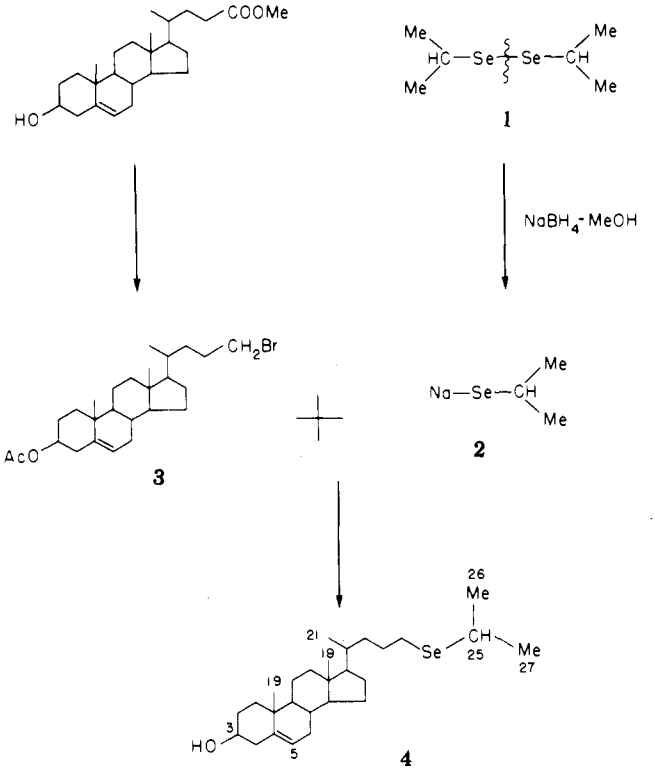
0022-2623/83/1826-1538$01.50/0 

Table I. Distribution of Radioactivity in Female Rat Tissues at Various Time Intervals from 1 h to 21 Days After Intravenous Administration of 24-(Isopropyl[$^{75}$Se]seleno)-chol-5-en-3$\beta$-ol

| Period After Injection | % dose/g (range) | | | | |
|---|---|---|---|---|---|
| | Tissue | | | | |
| | Adrenals | Blood | Liver | Ovaries | Kidneys |
| 1 Hour | 15.65 (12.53-17.77) | 3.97 (3.74-4.32) | 6.73 (6.27-7.58) | 2.24 (1.88-2.57) | 1.31 (1.20-1.37) |
| 6 Hours | 35.61 (31.31-40.53) | 2.08 (2.00-2.22) | 4.93 (4.72-5.24) | 4.95 (4.44-5.90) | 1.69 (1.59-1.76) |
| 18 Hours | 42.97 (32.82-59.79) | 1.00 (0.95-1.07) | 2.78 (2.61-3.13) | 6.12 (4.70-7.35) | 1.87 (1.81-1.96) |
| 24 Hours | 47.75 (37.94-54.93) | 0.71 (0.68-0.73) | 1.76 (1.70-1.79) | 5.29 (4.37-5.75) | 1.59 (1.41-1.76) |
| 3 Days | 32.32 (29.66-35.53) | 0.38 (0.36-0.40) | 0.99 (0.96-1.04) | 3.81 (3.25-4.84) | 1.48 (1.35-1.55) |
| 7 Days | 29.50 (28.27-30.52) | 0.26 (0.23-0.30) | 0.68 (0.61-0.73) | 3.82 (3.35-4.07) | 1.34 (1.26-1.43) |
| 14 Days | 18.23 (16.63-20.69) | 0.16 (0.16-0.17) | 0.50 (0.49-0.51) | 2.83 (2.78-2.90) | 0.91 (0.87-0.96) |
| 21 Days | 15.22 (14.51-15.96) | 0.11 (0.10-0.14) | 0.34 (0.30-0.42) | 2.52 (2.08-2.95) | 0.64 (0.54-0.83) |

[a] Percent dose per gram values are the mean and range for three female rats. The radioactive contents of the following tissues were also analyzed: heart, lungs, pancreas, spleen, small and large intestines.

Scheme I




reactions are only modest (10–40 mCi/$\mu$A·h), the yields (>300 mCi/$\mu$A·h) of Se-73 reported for the $^{75}$As(p,3n or d,4n)$^{73}$Se[13] reactions suggest that large amounts of this radionuclide can be produced by using high-energy (>30 MeV) proton accelerators.

The chemical synthesis and purification of [$^{75}$Se]4 can be easily completed within a 7-h period, indicating that the Se-73-labeled agent could be available in less than 1 half-life after end of bombardment (EOB) of the cyclotron target. The time required to synthesize 4 could be considerably shortened by using an alternative approach to prepare the sodium isopropylselenol (2). In the present studies, 2 was generated by $NaBH_4$ reduction of 1. There are alternative routes for more rapid generation of 2, such as $NaBH_4$, reduction of Se in ethanol solution, followed by controlled alkylation to form the selenol 2.[17] This route would be preferred for the rapid generation of sodium isopropyl[$^{75}$Se]selenol ([$^{75}$Se]2) from $^{73}$Se.

**Biological Studies.** Table I summarizes the results of tissue distribution studies in female rats for time periods varying from 1 h to 21 days after administration of [$^{72}$Se]4. The concentration of radioactivity in nontarget tissues, such as blood, liver, and kidneys, decreased steadily over the 21-day period. In contrast, the radioactive content of the adrenals and ovaries increased rapidly and peaked between 18 and 24 h after administration of [$^{75}$Se]4. To illustrate the close similarity in tissue distribution of radioactivity after injection of [$^{75}$Se]4 and [$^{123m}$Te]-24-ITC, the adrenal/tissue ratios calculated from the 1 h data shown in Table I are compared in Table II with similar data reported earlier for the Te-123m-labeled agent.[11] Approximately 38% of the injected radioactivity was excreted in 7 days, primarily in the feces, after injection of [$^{75}$Se]4. Excretion studies with [$^{123m}$Te]-24-ITC gave similar results; about 41% of the administered radioactivity was excreted in 7 days.

The tissue distribution data shown in Table I and excretion data were used to estimate the absorbed radiation dose values to humans from [$^{75}$Se]4 (Table III). These calculations were performed by the standard Medical Internal Radiation Dose (MIRD) method in the same manner as recently described in detail for the radiation dose calculations for [$^{123m}$Te]-24-ITC and related steroids.[11]

## Discussion

The tissue distribution and excretory properties of [$^{75}$Se]4 and [$^{123m}$Te]-24-ITC[6-10] are very similar, which indicates that substitution of tellurium with selenium in the C-25 position of the steroid side chain has little effect on the biological properties of these compounds. The

(14) Woodard, H. Q.; Laughlin, J. S.; Hara, T.; Tilbury, R. S.; Freed, B. R. *Int. J. Appl. Radiat. Isot.* **1973**, *24*, 377.
(15) Gelbard, A. S.; Hara, T.; Tilbury, R. S.; Laughlin, J. S. *I.A.E.A. Publ.* **1973**, *IAEA-SM-171/93*, 239.
(16) Guillaume, M.; Lambrecht, R. M.; Christians, L.; Wolf, A. P.; Renson, M. *J. Labeled Compd. Radiopharm.* **1978**, *16*, 126.
(17) Basmadjain, G. P.; Hetzel, K. R.; Ice, R. D. *Int. J. Appl. Radiat. Isot.* **1975**, *26*, 695.

Table II. Adrenal/Tissue Ratios Calculated from Percent Dose per Gram of Tissue Values Determined 1 Day After Intravenous Administration of 24-(Isopropyl[$^{123m}$Te]telluro)chol-5-en-3β-ol ([$^{123m}$Te]-24-ITC) and 24-(Isopropyl[$^{75}$Se]seleno)chol-5-en-3β-ol ([$^{75}$Se]-24-ISC) to Female Rats

| | Adrenal:Tissue ratios | | | |
|---|---|---|---|---|
| Tissue | Se-75-(24-ITC)[a] | Te-123m-(24-ITC)[b] | 6β-([$^{131}$I]iodomethyl)-19-nor-cholest-5(10)en-3β-ol (NP-59)[c] | 6β-[(methyl[$^{75}$Se]-seleno)-methyl]-19-nor-cholest-5(10)-en-3β-ol[d] |
| Blood | 67.3 | 54.8 | 92.1 | 105 |
| Liver | 27.1 | 27.1 | 52.2 | 42 |
| Ovaries | 9.0 | 4.9 | 3.0 | 3.2 |
| Lung | 10.9 | 18.7 | ... | 28.9 |
| Kidneys | 30.0 | 56.2 | 107.8 | 52.5 |
| Spleen | 19.2 | 14.0 | ... | 27.1 |
| Pancreas | 46.4 | 122.8 | ... | ... |

[a] Calculated from data summarized in Table I. [b] From ref 11. [c] From ref 2. [d] Personal communication, A. Peacegood, Radio-Chemical Center, Amersham, England.

Table III. Absorbed Radiation Dose Values to Human Organs from 24-(Isopropyl[$^{75}$-Se]seleno)chol-5-en-3β-ol ([$^{75}$Se]-24-ISC) and [$^{73}$Se]-24-ISC Estimated from Rat Tissue Distribution Data

| | dose, rd/mCi | |
|---|---|---|
| organ | [$^{75}$Se]-24-ISC | [$^{73}$Se]-24-ISC[a] |
| adrenals | 30 | 1.6 |
| kidneys | 3.8 | 0.67 |
| liver | 3.7 | 1.7 |
| lungs | 3.2 | 1.7 |
| ovaries | 5.9 | 1.2 |
| pancreas | 3.4 | 0.50 |
| small intestine | 3.5 | 0.64 |
| spleen | 3.4 | 1.9 |
| total body | 1.8 | 0.24 |

[a] Se-73 ($t_{1/2}$ = 7.2 h) decays to As-73 ($t_{1/2}$ = 80.3 days); however, the complete decay of 1 mCi of Se-73 produces a maximum of 3.7 μCi of As-73. If the Se-73 is injected without As-73 present, the dose from the As-73 produced in the body would not add significantly to the dose from Se-73.

adrenal/tissue ratios determined 1 day after administration of these two agents are compared in Table II. In addition to potential adrenal visualization with [$^{75}$Se]4, the use of steroids labeled with Se-73 ($t_{1/2}$ = 7.2 h; 65% $\beta^+$) for positron emission tomographic visualization[18] of adrenal masses could represent a unique and potentially powerful tool for the diagnosis of adrenal disease. The adrenal/blood (17:1) and adrenal–liver (7:1) ratios are sufficiently high within 6 h after administration of [$^{75}$Se]4 (Table II) to indicate that adrenal visualization by positron emission tomography should be possible with [$^{73}$Se]4. In addition to the moderate adrenal/tissue ratios, the absolute uptake of radioactivity in the female rat adrenal glands is quite high (1.6% injected dose). By extrapolation of the rat tissue distribution data, an approximation of the levels of radioactivity that would be expected to accumulate in human adrenals can be made. If adrenal visualization were not attempted until 6 h after administration of this agent (~2 half-lives after the end of bombardment), sufficient radioactivity would be retained (50% of the injected dose) to indicate that the expected 1.6% adrenal uptake would permit visualization of the adrenal. Thus, administration of 10 mCi of [$^{73}$Se]4 would be expected to result in the accumulation of about 80 μCi of the radioactive label in the adrenal glands after 6 h. The calculated absorbed radiation dose values for [$^{75}$Se]4 (Table III) are considerably lower than similar values for [$^{131}$I]-NP-59, [$^{75}$Se]-Scintidren, and [$^{123m}$Te]-24-ITC that have been estimated from rat data.[11,19] No toxicity has been detected in rats over a 21-day period after injection of ~1 mg/kg of 4. The absence of any observed chemical toxicity and the low radiation dose estimates suggest that the $^{75}$Se-labeled agent may represent an attractive new agent for adrenal imaging in humans.

## Experimental Section

**General.** All solvents and chemicals were analytical grade and were used without further purification. Silica gel G plates (250-μm thickness), obtained from Analtech, Inc., were used for the thin-layer chromatographic (TLC) analyses. Column chromatography was performed with silicic acid ($SiO_2$; 60–200 mesh, A grade) pruchased from Sigma Chemical Co. The Se-75 was produced in the Oak Ridge High Flux Reactor ($2.5 \times 10^{15}$ n·cm$^2$/s) by neutron irradiation of 58.19% enriched Se-74 by the $^{74}$Se-(n,γ)$^{75}$Se nuclear reaction. The low-resolution 70-eV mass spectrum (MS) was obtained with a Dupont 21-490B instrument. High-resolution MS were determined with an AEI MS-50 instrument equipped with an DS-50 data system. Nuclear magnetic resonance spectra (NMR) were recorded at 80 MHz with a Varian FT-80 instrument.

**Animal Tissue Distribution Studies.** Female Fischer 344 rats (160–180 g) were used for the tissue distribution studies. Both food and water were allowed ad libitum during the experiments. The crystalline steroid was dissolved in EtOH and formulated in a Tween 80–EtOH–saline mixture in the usual manner.[8] The rats were lightly anesthetized with $Et_2O$, and the solution (5–10 μCi) was administered (1 mL total volume) by injection in a lateral tail vein. Three animals were used for each time point. The animals were killed by decapitation after being anesthetized with $Et_2O$, and the organs were removed, rinsed with saline, blotted dry, weighed, and counted in a gamma spectrometer. For the excretion studies, three rats were individually housed in metabolism cages, and urine and feces were collected daily over the 21-day period.

**24-(Isopropylseleno)chol-5-en-3β-ol (4).** Selenium (316 mg, 4 mmol) was refluxed with Na (92 mg, 4 mmol) in 20 mL of freshly distilled ethylenediammine under argon for 3 h. Following cooling

(18) Derenzo, S. E., Budinger, T. F.; Cahoon, J. L. *IEEE Trans. Nucl. Sci.* **1977**, *NS-24(1)*, 554.

(19) Carey, J. E.; Thrall, J. H.; Freitas, J. E.; Beierwaltes, W. H. *J. Nucl. Med.* **1979**, *20*, 60.

to room temperature, isopropyl iodide (680 mg, 4 mmol) was added to the murky green-colored solution, and the mixture was stirred under argon for 30 min. The mixture was poured into $H_2O$ and then extracted with $Et_2O$ (3 times), and the combined ether layers were washed with $H_2O$ (3 times), dried over anhydrous $Na_2SO_4$, and then evaporated under argon to give 363 mg (71%) of diisopropyl diselenide (1) as a yellow-colored, foul-smelling oil. The diselenide 1 was dissolved in 25 mL of a $C_6H_6$/MeOH mixture (2:3) and reduced with excess $NaBH_4$ under argon until a colorless solution of sodium isopropylselenol (2) was obtained. Following the addition of 80 mg of NaOH, the 3β-acetoxy-24-bromochol-5-ene substrate (3; 229 mg, 0.5 mmol) was added, and the mixture was refluxed for 1 h. The mixture was poured into $H_2O$, and the crude product was obtained by $Et_2O$ extraction as described above. The product was dissolved in $C_6H_6$ and chromatographed on a $SiO_2$ column (1 × 20 cm) by elution (30-mL fractions) with petroleum ether, fractions 1–5, and the following increasing concentrations of $Et_2O$ in petroleum ether: fractions 6–10, 2%; fractions 11–15, 5%; fractions 16–20, 10%; fractions 21–15, 25%; and fractions 26–30, 50%. The desired 24-(isopropylseleno)-chol-5-en-3β-ol (4) was eluted in fractions 25–27, which were combined, and evaporated, and the residue was crystallized from MeOH–$H_2O$ to give 92 mg (40): mp 91–93 °C; TLC ($CHCl_3$) $R_f$ ($CHCl_3$) 0.09, $R_f$ (4% MeOH–$CHCl_3$) 0.55; low-resolution MS (150 °C probe temperature), $m/z$ 466 (M, 82), 448 (M – $H_2O$, 29), 433 (M – $H_2O$ – $CH_3$, 12), 423 (M – $C_3H_7$, 41), 405 (M – $H_2O$ – $C_3H_7$, 53), 271 (23), 255 (M – side chain – $H_2O$, 33), 231 (23), 213 (45); high-resolution MS calcd for $C_{27}H_{46}O^{80}Se$, $m/z$ 466.2713; found, 466.2720; IR (KBr) 3495 (OH) $cm^{-1}$; NMR (200 MHz, $CDCl_3$) δ 0.61 (s, 3 H, C-18 $CH_3$), 0.86 (t, 3 H, C-21 $CH_3$, $J \simeq 6$ Hz), 0.94 (s, 3 H, C-19 $CH_3$), 1.34 (d, 6 H, C-26 and C-27 $CH_3$'s, $J \simeq 7$–8 Hz), 2.49 (2 H, m, C-24 $CH_2$), 3.10 (m, 1 H, C-25 H, $J \simeq 6$ Hz), 3.48 (m, 1 H, C-3α H), 5.29 (m, 1 H, C-5 olefinic proton). Anal. Calcd for $C_{27}H_{46}OSe$: C, 69.63; H, 9.96. Found: C, 69.42; H. 9.82.

**24-(Isopropyl[$^{75}$Se]seleno)chol-5-en-3β-ol.** The synthesis of sodium [$^{75}$Se]diselenide ([$^{75}$Se]1 was conducted on a 1-mmol scale. The Se-75 (25.13 mCi) was combined with carrier to give 80 mg of Se (1 mmol), which was stirred with Na (25 mg, 1.1 mmol) under argon in 20 mL of liquid $NH_3$. The mixture proceeded through the typical color change: blue to green to reddish-brown. After 2 h, isopropyl iodide (240 mg, 1 mmol) was added with a syringe, and the mixture was stirred for an additional 2 h. Following evaporation of the $NH_3$, the light yellow gum was extracted with small portions of $C_6H_6$ (15 mL total volume), the extract was filtered through a short bed of $SiO_2$, and the filtrate was diluted to 25 mL with MeOH. The yellow-colored solution contained 8.39 mCi (33%) of diisopropyl [$^{75}$Se]diselenide (1), which was reduced under argon with $NaBH_4$ to a colorless solution of sodium isopropyl[$^{75}$Se]selenol (2). After the addition of NaOH (~80 mg, 2 mmol), 3β-acetoxy-24-bromochol-5-ene (3; 45 mg, 0.10 mmol) was added in a small volume of $C_6H_6$, and the mixture was refluxed. After 30 min, TLC analysis ($CHCl_3$) indicated the coupling reaction to be complete (1, $R_f$ 0.80; 3, $R_f$ 0.70; 4, $R_f$ 0.10). The mixture was cooled and then poured into $H_2O$, and the aqueous layer was extracted three times with $C_6H_6$. The combined organic extracts were washed with $H_2O$ (3 times), dried over anhydrous $Na_2SO_4$, and evaporated under argon to a volume of 1–2 mL. This solution was applied to a $SiO_2$ column packed in $C_6H_6$. A nonpolar radioactive peak was eluted with $C_6H_6$ (fractions 1–10, 25 mL in volume). Further elution with 5% $Et_2O$–$C_6H_6$ removed the [$^{75}$Se]4 in fractions 12–15, which were combined to give 1.05 mCi [42% from 3β-acetoxy-24-bromochol-5-ene (3)]. TLC analysis using two solvent systems indicated a single radioactive component (>98%), which cochromatographed with authentic 24-(isopropylseleno)chol-5-en-3β-ol: $R_f$ ($CHCl_3$) 0.25, $R_f$ (10% EtOAc in $CHCl_3$) 0.75.

**Acknowledgment.** The research in the Nuclear Medicine Group, Oak Ridge National Laboratory, was sponsored by the Office of Health and Environmental Research, U.S. Department of Energy (DOE), under Contract W-7405-eng-26 with the Union Carbide Corp. The research in the Medical and Health Sciences Division, Oak Ridge Associated Universities, was sponsored by U.S. Department of Energy Contract EY-76-C-35-0033 and also by Interagency Agreement FDA 224-75-3016, DOE 40-286-71.

**Registry No.** 1, 37826-18-9; [$^{75}$Se]1, 86508-35-2; 2, 37773-08-3; [$^{75}$Se]2, 86508-36-3; 3, 73729-03-0; 4, 86508-37-4; [$^{75}$Se]4, 86508-38-5; [$^{78}$Se]4, 86549-45-3.

# Book Reviews

**Concise Encyclopedia of Biochemistry.** By Mary Brewer and Thomas Scott. W. de Gruyter, Berlin and New York. 1983. 518 pp. 14.5 × 22 cm. ISBN 3-11-007860-0. $29.90.

An amazing amount of useful information is packed into this small volume. What's more, the definitions are readable, up-to-date, and accurate. The many structural formulas and metabolic pathways shown are clear and well-chosen. Also included are abbreviations, Enzyme Commission numbers, and and extensive cross-references. Terms used in molecular biology (for example, attenuator), immunology (for example, IGM), and natural-product studies (for example, miraculin) are included. Miraculin is a taste-modifying glycoprotein derived from the berry of *Synsepalum dulcifcum* native to West Africa. It causes sour substances to taste sweet. This encyclopedia should find wide use among all those interested in biological science, students, teachers, and researchers alike. At its modest price it is an outstanding bargain.

The work is an English translation as well as a revision of "Brockhaus ABC Biochemie" edited by H. D. Jakubke and H. Jeschkeit, the second edition of which was published in 1981. Congratulations all!

*Tufts University*
*Boston, Massachusetts 02111*
**Roy L. Kisliuk**

**New Comprehensive Biochemistry. Volume 3. Stereochemistry.** Edited by C. Tamm. Elsevier Biomedical Press, Amsterdam, The Netherlands (distributed in the U.S. and Canada by Elsevier Publishing Co., Inc., New York). 1982. x + 342 pp. 17 × 24.5 cm. ISBN 0-444-80389-0. $65.00.

This book is highly recommended to all scientists with an interest in stereochemistry, and, in particular, it should be in the libraries of all those interested in modern biochemistry. This volume contains seven chapters, each written by an expert in the particular area. Each chapter is of approximately equal length, and each contains an extensive list of references, many to work published in the late 1970's and up until 1981. Figures are freely used, are informative, and are well done.

There are two introductory chapters; the first by B. Testa, "The Geometry of Molecules: Basic Principles and Nomenclatures", defines "dissymmetric", "enantiotopic", and "diastereotopic" groups, faces, symmetry planes and rotation-reflection axes, chiral planes and axes, etc. and thus should serve as a valuable reference. The second introductory chapter, "Chemical Methods for the Investigation of Stereochemical Problems in Biology", by R. Bentley, is particularly well written and provides an interesting description of the historical development of this field. The classification of reaction types and selectivities should be useful to teachers and researchers concerned about the precise de-