3B

RECEIVED
USDOE/PETC
91 FEB 25 PM 2:23
ACQUISITION & ASSISTANCE DIV.

February 15, 1991
Department of Chemistry
Oklahoma State University
Stillwater, OK 74078

U. S. Department of Energy
Pittsburgh Energy Technology Center
Acquisition and Assistance Division
P. O. Box 10940
Pittsburgh, P. A.

Attention: Jeffrey C. Bogdan:

Dear Mr. Bogdan:

The second quarterly Technical Progress Report for Task I: Synthesis of 6-Methyl-9-propyldibenzothiophene-4-ol (DE-AC22-90PC 90035) is enclosed.

According to Part III, Section J, Attachment B, of the contract, this is to be a draft copy. I have labeled this version of the report accordingly. I assume that you will contact me for changes which are to be included in the final draft.

Sincerely yours,

E. J. Eisenbraun
Regents Professor
Principal Investigator
(405) 744 6673 or 5934

XC: S.J.Firsan, OSU
Lisa Thompson, OSU (405) 744 5654
Malvina Farcasiu, U.S. DOE/PETC
V.U. Rao, U.S. DOE/PETC

DOE\PC\90035--T2

U. S./DOE Patent Clearance is not required prior to publication of this document."

February 15, 1991
Technical Progress Report No. 2 (draft copy)
Report period: Oct. 25, 1990-January 25, 1991

CONTRACT TITLE AND NUMBER:
Task I: Synthesis of 6-Methyl-9-propyldibenzothiophene-4-ol
DE-AC22-90PC 90035

CONTRACTOR NAME: Oklahoma State University
Stillwater, OK 74078

CONTRACT PERIOD: July 25, 1990- July 25, 1992

CONTRACT OBJECTIVE: Synthesis and purification of the title compound.

The Synthesis Plan: The synthesis route for the preparation of the title compound, shown as number **7a** in the enclosed synthesis sequence (Scheme I), has been carried out on a small scale to the preparation of a mixture of isomers **6a,6b**. Because the conversion in the photocyclization of **5a** and the accompanying isomer **5b** proceeded in low conversion to **6a,6b**, we are currently exploring alternative routes for the cyclization of **5a,5b**. These new routes to **6a,6b** are summarized in Scheme II and are described in more detail on pp 4 and 5.

TECHNICAL SUMMARY:

In the first Quarterly Technical Progress Report, we showed that commercially available 4'-methylpropiophenone (**1**) could be readily converted to 1-methyl-4-*n*-propylbenzene (**2**) in high yields of distilled product. Literature reports claiming specificity in the bromination of **2** to 2-methyl-5-*n*-propyl-1-bromobenzene (**3a**) were shown to be in error. Instead a mixture of **3a** and the isomer, 5-methyl-2-*n*-propyl-1-bromobenzene (**3b**), was obtained in a 2.3:1 ratio (reaction b, Scheme I). This mixture was used in the initial preparation of the sulfide mixture **5a,5b.**

Because the iodo derivatives **4a,4b** (obtained from reaction c, Scheme I) would be more reactive in forming **5a,5b** and could favor the formation of **5a,** they have been used in the subsequent preparations of **5a,5b.** While bromination to **3a,3b** as compared to iodination to **4a,4b** gives a higher yield of halogenated material, the improvement in yield of the sulfides **5a,5b** in the subsequent step (reaction d, Scheme I) and the increased proportion of **5a** (2.8:1 as compared to 1.7:1 when **3a,3b** was used) justifies the switch to **4a,4b.** Reducing the consumption of the expensive tetrakis(triphenylphosphine)palladium(0) and 2-methoxybenzenethiol in the step from **5a,5b** to **6a,6b** was a major factor in making this change
.

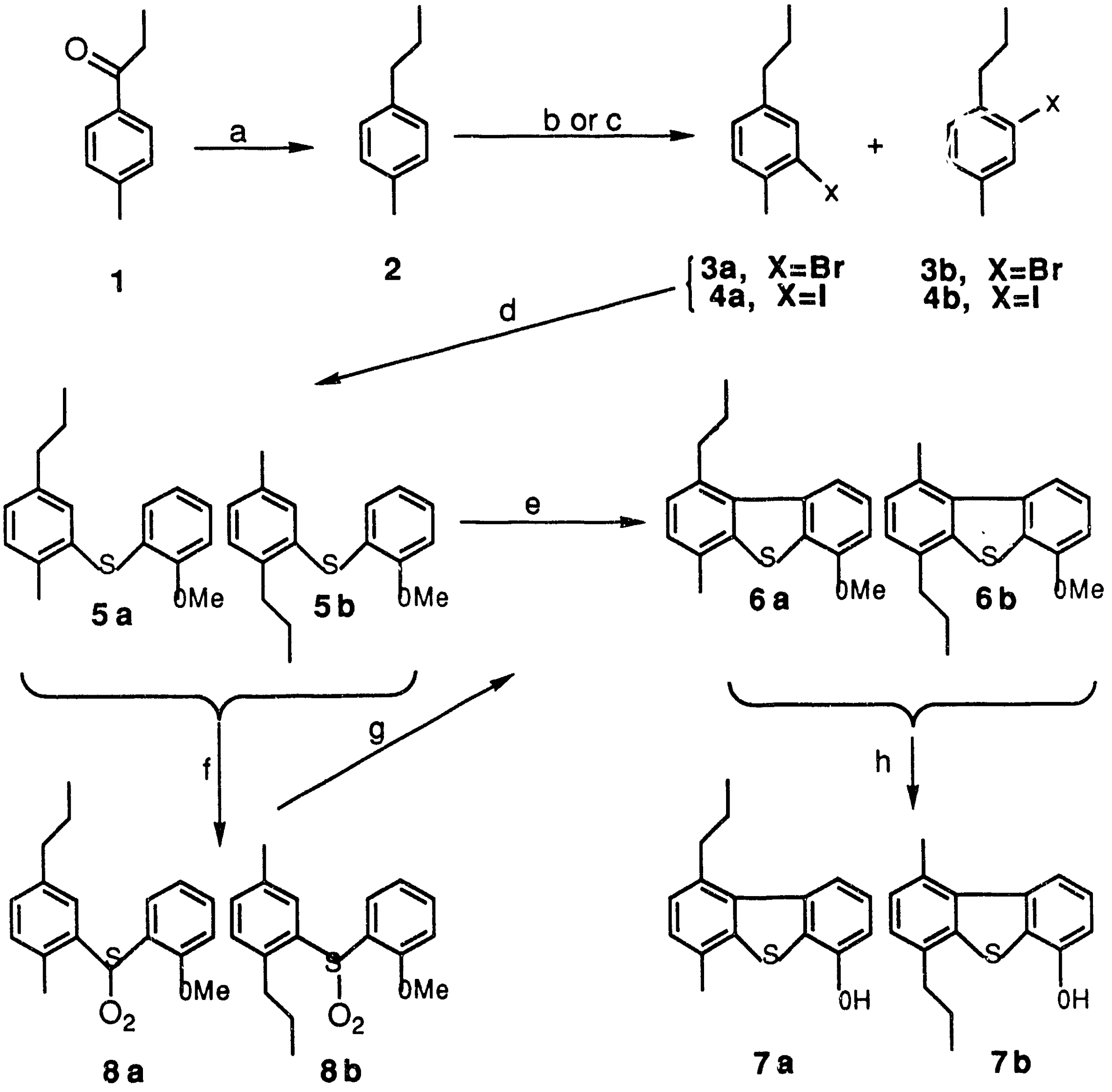
In summary, the yields are:

[**1**-- **2** (86%); **2**-- **4a,4b** (49%), (76%based on reacted hydrocarbon; **4a,4b**-- **5a,5b** (86%)

[**2**-- **3a,3b** (82%); **3a,3b**-- **5a,5b** (60%)].

The photocyclization reaction (step e of Scheme I) was repeated several times under a variety of conditions in an effort to increase the conversion to and the total yield of **6a,6b.** For example, benzene was substituted for cyclohexane as solvent to enhance the solubility of the starting sulfides **5a,5b**; the concentration was varied from 17.4 mM to 8.8 mM and then to 0.98 mM; argon was used instead of nitrogen as the inert astmosphere to reduce the chance that oxygen would inadvertantly creep back into the reaction mixture; UV light was filtered through quartz and through Pyrex (the latter filters out wavelengths below 280nm) and the UV-lamp was replaced with a new one to insure maximum intensity.

Scheme I-Revised Synthesis Plan for **7a**



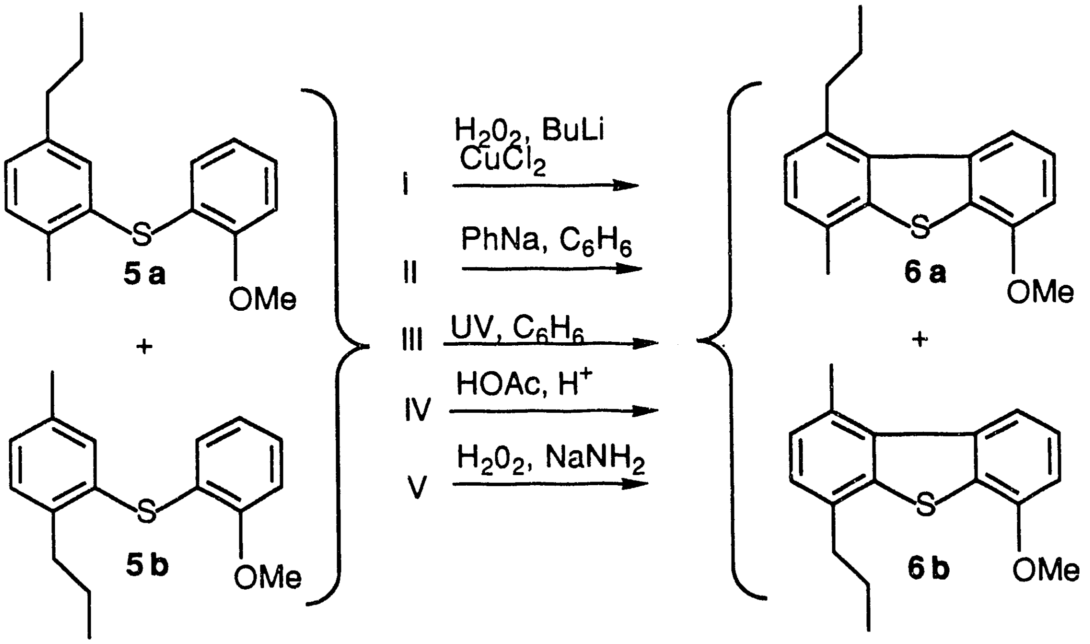
[a] NH_2NH_2, OH^-, DEG, heat. [b] Br_2, Fe, I_2 catalyst. [c] I_2, H_5I0_6, H^+, HOAc, heat. [d] Na, EtOH, 2-Methoxybenzenethiol, Tetrakis(triphenylphosphene) palladium (0), heat. [e] UV light, I_2, solvent. [f] H_20_2 (30%), HOAc. [g] See proposed routes in Scheme II. [h] BBr_3-Me_2S complex.

In addition, three runs using 300-308 equivalents of propylene oxide were carried out. The latter is known to be a scavenger of hydrogen iodide which is thought to be liberated in the dehydrogenation step following cyclization. These reaction mixtures were irradiated for 8 hours or for 24 hours and it was found that the Pyrex-filtered light failed to provide a cyclized product. The switch to benzene, as well as, the presence of the propylene oxide did not result in a measurable increase in conversion.

The quartz-filtered light gave after 8 h a product mixture very similiar to the one described in the first quarterly Technical Progress Report, consisting of unreacted sulfide mixture **5a,5b** (major), cyclized material **6a,6b** (minor) and 2-iodoanisole (minor). However, after prolonged irradiation (24h) the quartz-filtered light caused extensive fragmentation of **5a,5b** resulting in numerous side-products.

Thus, in spite of these efforts, the conversion of **5a,5b** to **6a,6b** has not been improved without causing serious side reactions. This failure forced reconsideration of the cyclization process and a literature search provided the alternative routes shown in Scheme II. These routes are discussed with literature references in the order we consider most feasible.

Scheme II-Proposed Routes for Cyclization of **5a,5b** to **6a,6b**



Route I. Reaction of diphenyl sulfide with an excess of hydrogen peroxide produces the corresponding sulfone. When this latter compound was treated with two equivalents of butyl lithium[1] followed by anhydrous cupric chloride[2] dibenzothiophene (20%) and dibenzothiophene 5,5-dioxide (50%) were produced. Treatment of this mixture with lithium aluminum hydride reduced the sulfone component and resulted in a total yield of 70% of dibenzothiophene.[2a] The authors report[2a] that diphenyl sulfide and diphenyl sulfoxide do not undergo this reaction; however, they did not provide experimental details. This route offers the added benefit of the possible crystallinity of the sulfones (**8a,8b**) derived from **5a,5b** and hence the possibility for separation of isomers and purification at this stage[3].

Route II. At least two reports have described the conversion of diphenyl sulfide to dibenzothiophene directly using phenyl sodium (0.15 mol) in benzene[4] or diphenyl lithium sodium (9 mmol) in ether[5] resulting in 30% and 57% yield of purified material, respectively. We are hesitant, however, to explore this route first owing to the greater hazard[6] as compared to route I.

Route III. As pointed out above, we no longer consider this route to be feasible for production of cyclized product on the needed scale. It could be used to give identifiable products, provided separation could be achieved.

Route IV. Wieland and Mueller[7] have reported that diphenyl hydroxylamine (2 g) is converted to carbazole in 39% yield with conc. sulfuric acid-acetic acid at -20 °C. Even though no diaryl sulfide has, to our knowledge, been treated with these reagents we wish to try this at least once, since the reagents and conditions suggest a convenient and straightforward reaction.

Route V. The oxidation of dialkyl and diaryl sulfides to sulfoxides with one equivalent of hydrogen peroxide in acetic acid or acetic anhydride has been reported[8]. Treatment of diphenyl sulfoxide[9] (404 g) and 1,1'-dinaphthyl sulfoxide[10] (4 g) with sodium amide in refluxing toluene has been reported to yield the corresponding purified dibenzothiophenes in 31% and 26% yields, respectively. In the former case the remainder of the material was unreacted diphenyl sulfoxide (29%), diphenyl sulfide (9%), aniline and other side-products.

Current and Future Effort. We emphasize that up to this point, Steps a, c and d in Scheme I resulting in the mixture of sulfides **5a,5b** have worked well giving us multigram quantities of isolated, distilled materials and yields of 86%, 49% (76% based on reacted hydrocarbon), and 86% respectively. Work on the fourth step, the photochemical cyclization (Step e, Scheme I) has been halted. We are now trying to effect the conversion of sulfides **5a,5b** to the dibenzothiophenes **6a,6b** by a chemical method and are focusing on Route I, Scheme II instead. We have prepared the corresponding sulfone mixture **8a,8b** (Scheme I) and are attempting the cyclization of the latter using butyl lithium followed by treatment with anhydrous cupric chloride (also part of Route I, Scheme II).

References and Notes

1. (a) Gilman, H.; Esmay, D.L. *J. Am. Chem. Soc.* **1953**, *75*, 278. (b) Oita, K.; Gilman, H. *J. Org. Chem.* **1957**, *22*, 336.

2. (a) Gogte, V.N.; Palkar, V.S.; Tilak, B.D. *Tetrahedron Lett.* **1960**, (6), 30-34. (b) Pandya, L.J.; Rao, D.S.; Tilak, B.D. *J. Sci. Industr. Res. India* **1959**, *18B*, 516.

3. It is worth noting that a sulfone can be converted back to the corresponding sulfide with lithium aluminum hydride,[9a] and a sulfoxide can be reduced to the sulfide with stannous chloride-hydrochloric acid (Ho, T.-L.; Wong, C.M. *Synthesis* **1973**, 206).

4. Luettringhaus, A.; Wagner-v. Saeaef, G.; Sucker, E.; Borth, G. *Justus Liebigs Ann. Chem.* **1947**, *557*, 46-49.

5. Wittig, G.; Benz, E. *Chem. Ber.* **1958**, *91*, 873-882.

6. For instance sodium hydride is a by-product of the reaction!

7. Wieland, H.; Mueller, C. *Chem. Ber.* **1913**, *46*, 3304-3314.

8. (a) Sviridova, A.V.; Laba, V.I.; Prilezhaeva, E.N. *J. Org. Chem. USSR (Engl. Transl.)* **1971**, *7*, 2577-2580. (b) Schill, G.; Jones, P.R. *Synthesis* **1974**, 117-118. (c) Ogura, K.; Tsuchihashi, G.-i. *Bull. Chem. Soc. Jpn* **1972**, *45*, 2203-2204. (d) Drabowicz, J.; Mikolajczyk, M. *Org. Prep. Proced. Intl.* **1982**, *14*, 45-89.

9. (a) Courtot, C.; Chaix, M.; Nicolas, L.; Delepine, M. *C.R. Hebd. Acad. Sci.* **1932**, *194*, 1660-1661. (b) Schoenberg, A. *Chem. Ber.* **1923**, *56*, 2275.

10. Wilputte, R.; Martin, R.H. *Bull. Soc. Chim. Belg.* **1956**, *65*, 874-898.

END

DATE FILMED

7/15/93