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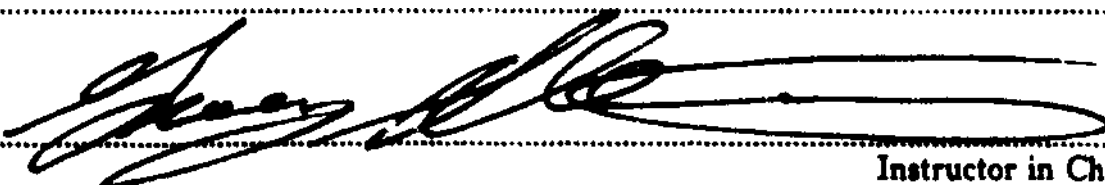
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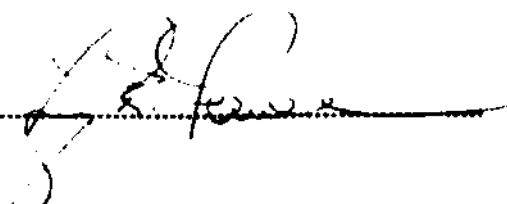
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DEGREE OF.....Bachelor of Science in Chemistry.....

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Instructor in Charge

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**SYNTHESIS OF PRECURSORS  
FOR  
A STUDY OF THE NEOPHYL REARRANGEMENT**

**BY**

**BINAIFER S. KHAMBATTA**

**THESIS  
FOR THE  
DEGREE OF BACHELOR OF SCIENCE  
IN  
CHEMISTRY**

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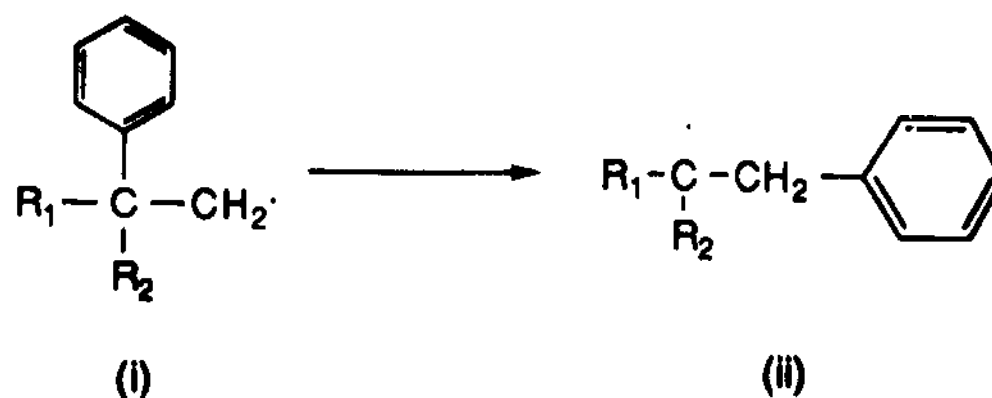
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## INTRODUCTION

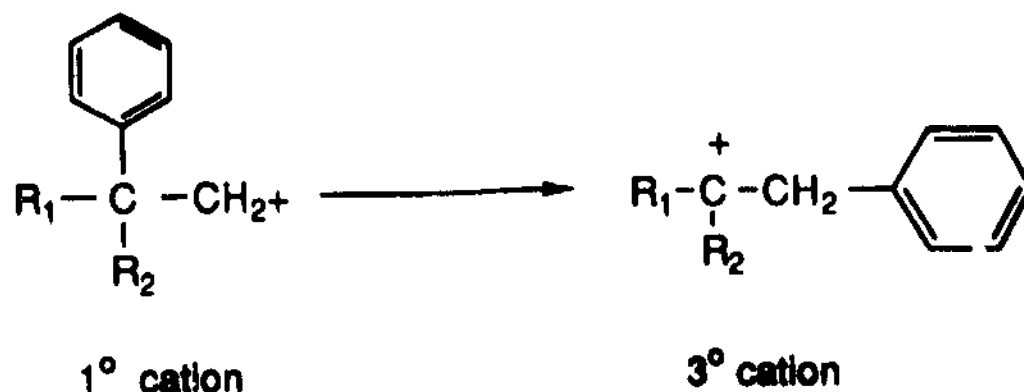
Free radical chemistry has fascinated chemists for many years. Of particular interest are the migrations or rearrangements of the free radicals. This has been well documented in the cases of carbon centered radicals involving the 1,2 shift of an aryl group. Rearrangements of this type are known as carbon or C-neophyl rearrangements<sup>1,2</sup> (fig. 1).

Fig. 1:



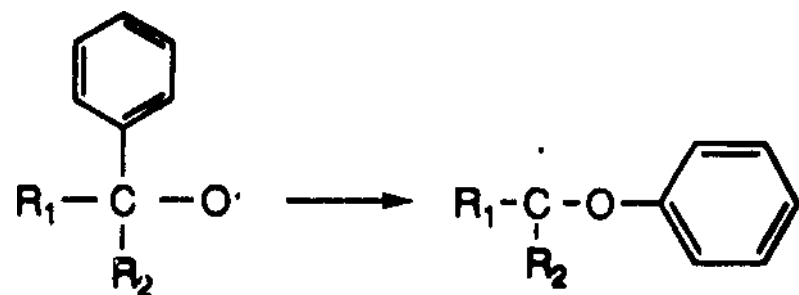
The increased stability of (ii) vs. (i) is clear when relating it to the similar 1,2 aryl shifts of carbocations<sup>3</sup> (fig. 2), whereby the 3° cation is in a lower energy state and thus, in a more stable conformation than the 1° cation.

Fig. 2:

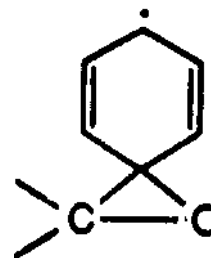


In this light, emerged another type of rearrangement, namely the O-neophyl rearrangement, involving the free radical centered on the oxygen, undergoing an aryl 1,2 shift<sup>4,5</sup> (fig. 3).

**Fig. 3:**



**Fig. 4:**

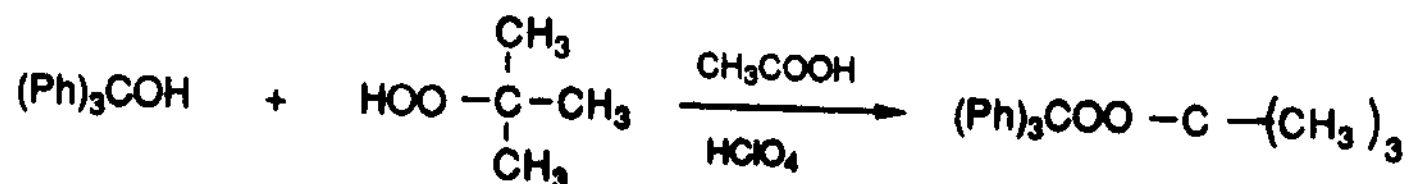


This type of alkoxy radical rearrangement has not been extensively studied, and in order to examine the proposed bridged radical intermediate (fig.4) by transient absorption spectroscopy<sup>6</sup>, the goal of this paper is to outline the synthetic steps of various peroxides and ethers.

## RESULTS AND DISCUSSION

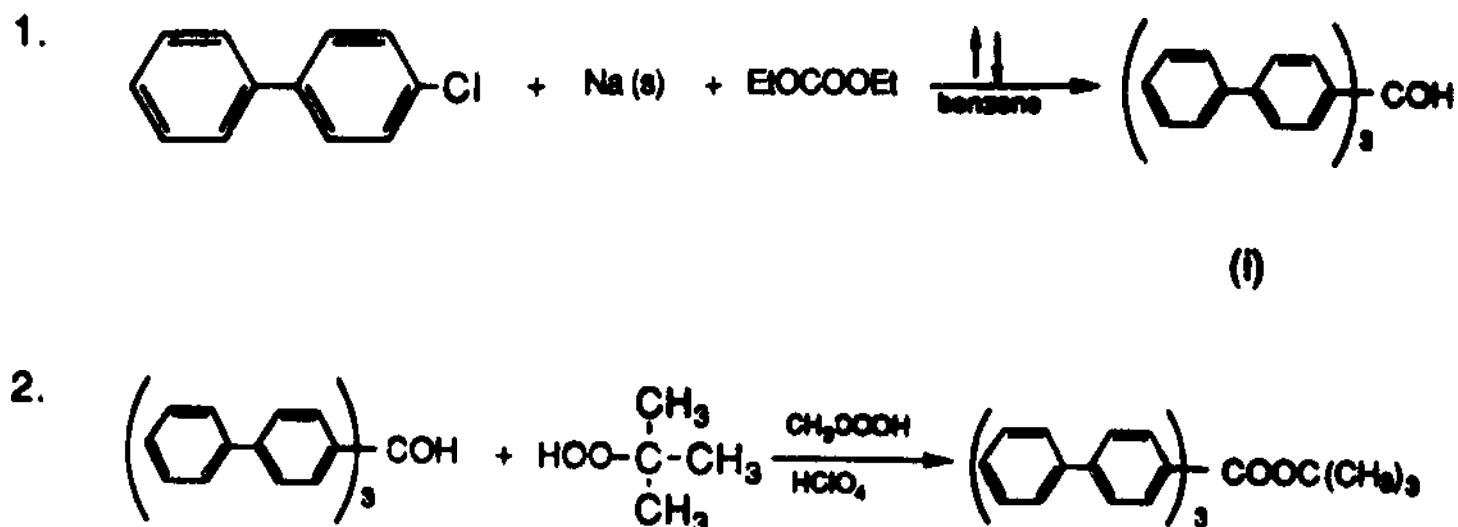
The primary peroxides synthesized in this experiment were trityl t-butyl peroxide and trisbiphenyl-t-butyl peroxide. They were chosen specifically for their aryl system in the hopes that it would stabilize the bridged radical intermediate. The trityl-t-butyl peroxide was prepared by the procedure illustrated in scheme 1, by Kharasch et al<sup>7</sup>.

**Scheme 1:**



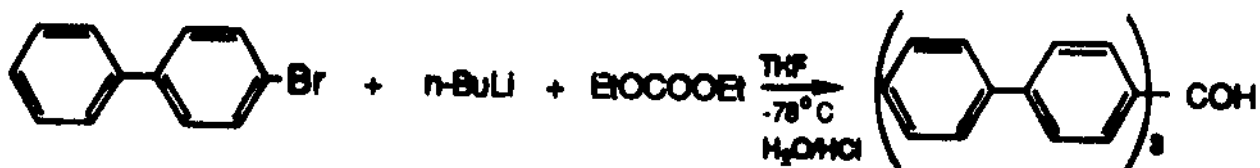
Trace impurities of phenol and benzophenone, which would affect spectroscopic studies, were removed by chromatographic separation. The purity of the peroxide was then checked by HPLC. No benzophenone (<.2%) was detected.

**Scheme 2**, outlines the reaction steps of trisbiphenyl-t-butyl peroxide.



The biphenyl chloride was recrystallized from ethanol, and used to prepare the trisbiphenyl alcohol by the method described by Wiselogle and Bachmann<sup>8</sup>. Earlier attempts to synthesize (i) by substituting biphenyl bromide for biphenyl chloride resulted in a significantly lower yield of (i) (13-15%), and attempts to synthesize (i) by scheme 3 failed to produce the alcohol in yields greater than 2%.

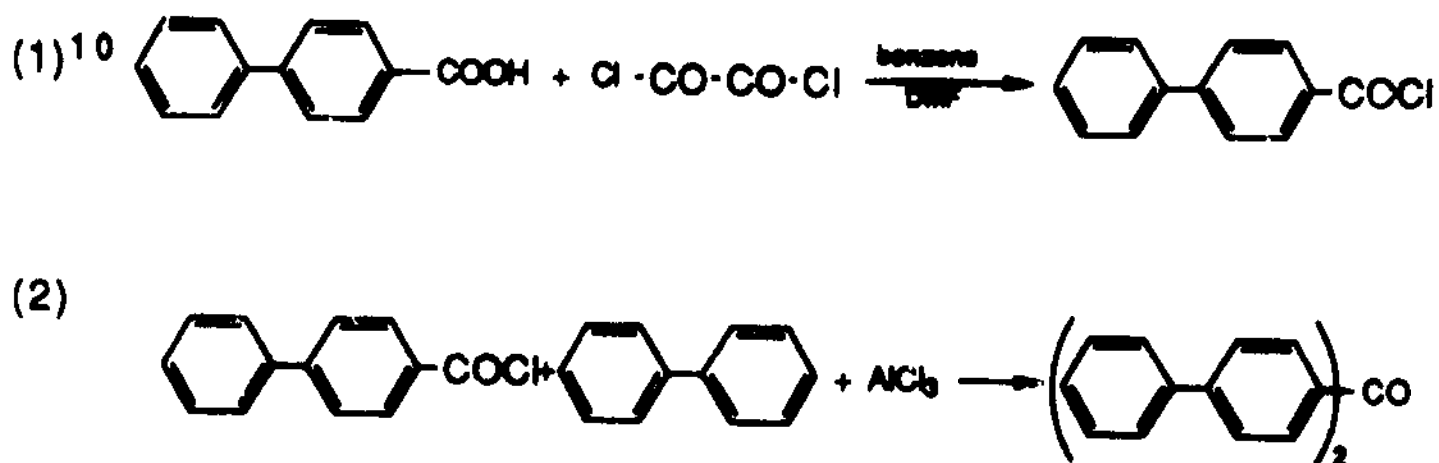
**Scheme 3:**



The trisbiphenyl alcohol was then suspended in glacial acetic acid with t-butyl hydroperoxide, and cooled. When the catalyst,  $\text{HClO}_4$  was added to the solution, the mixture immediately turned pink, due to the formation of the trisbiphenyl cation. After approximately 12 hours of stirring at room temperature, the mixture was poured on to ice and filtered. The lavender solid was purified by chromatographic

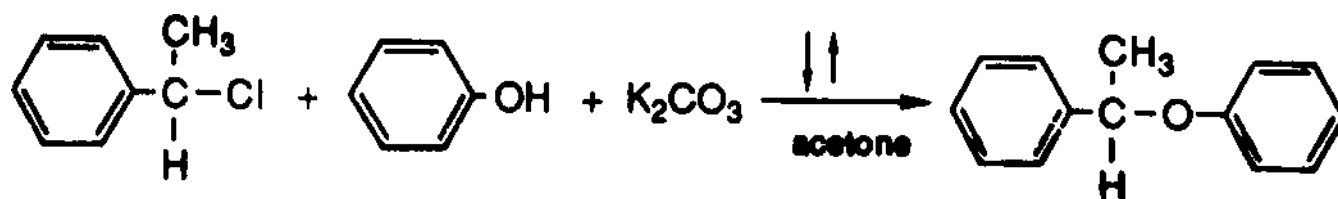
separation to remove traces of the biphenyl ketone side product and was then crystallized from pet. ether.

In order to check for trace impurities in the trisbiphenyl-t-butyl peroxide, an authentic sample of the biphenyl ketone was made, with a slight variation to Schenk and Bergmann's preparation.<sup>9</sup> This compound later proved to be useful in the laser studies. Scheme 4, outlines the reaction steps for biphenyl ketone.



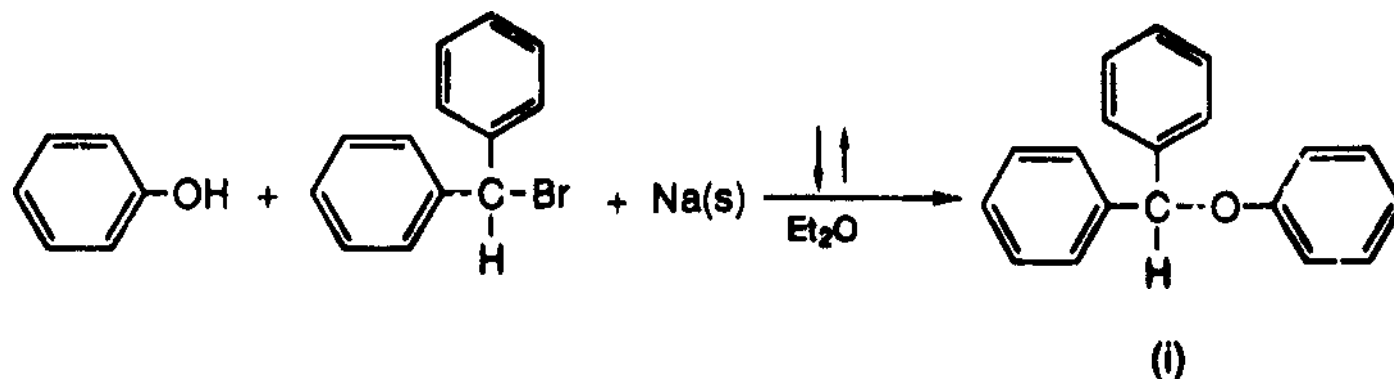
Attempts to repeat Gomberg's preparation of ditrityl peroxide<sup>11</sup>, were unsuccessful. The only product isolated was triphenyl methanol.

The final two compounds prepared were  $\alpha$ -phenyl ethyl phenyl ether and phenyl-diphenylmethyl ether. The former was simply prepared by following the procedure by Hart and Eleuterio<sup>12</sup> as shown in scheme 5:

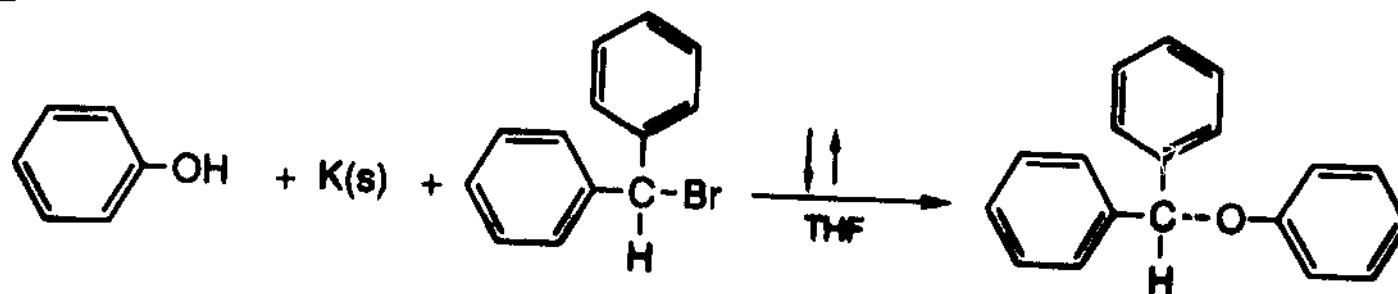


Phenyl-diphenyl methyl ether (i) however, proved to be the most challenging synthesis of all. Complications were later attributed to misinterpretation of the <sup>1</sup>H-NMR spectra's singlet at 6.2 ppm and 5.7 ppm, and the difficulty in isolating and recrystallizing the low melting product. The first few attempts at synthesizing the ether

were carried out according to the preparation by Schorigin<sup>13</sup> as illustrated in scheme 6:



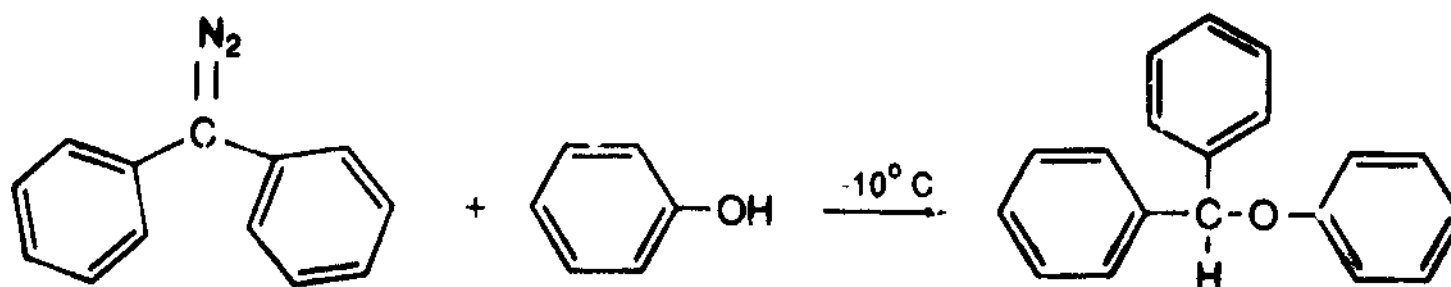
Starting materials were later purified (freshly distilled phenol and snow-white crystals of sublimed diphenylbromomethane) and reaction times were increased. A crude <sup>1</sup>H-NMR spectra indicated a strong singlet at 6.2 ppm and a smaller singlet at 5.7 ppm among many side products. The peak at 5.7 ppm was interpreted as a small amount of the ether, since Ph<sub>2</sub>CH<sub>2</sub>OH has a chemical shift of 5.7 ppm. The starting material, diphenylbromomethane exhibited a singlet at ca. 6.3 ppm, thus incorrectly indicating that the reaction didn't go to completion. The reaction by Wittig and Clausnizer<sup>14</sup> was also attempted, as shown in scheme 7:



However, an <sup>1</sup>H-NMR of the crude residue was very similar to the one of the previous synthesis. Everything finally became clear after the following synthesis was carried out, as described by Busch and Knoll<sup>15</sup>.



**Scheme 8:**



Note: the diphenyldiazomethane was obtained from a former graduate student, Yu Zho Li.

The resulting residue was also an orange-red color as in previous attempts, but more importantly, the <sup>1</sup>H-NMR of the crude product displayed a strong singlet at 6.2 ppm. Therefore by elimination, this peak could not be biphenylbromomethane, and must in fact, be the desired ether. At this point, the pure starting material spectra and the crude product's NMR were overlapped, and the peaks were found to be separated by 1/10 ppm. The ether had indeed formed, but was difficult to separate and purify, since it has a low melting point. Chromatographic separation with a solvent system of 5% ethyl acetate in hexane, yielded the ether in the second fraction. Careful recrystallization from ethanol also yields pure ether.

### CONCLUSION

This collection of various compounds were used in the study of O-neophyl rearrangements. For more information and details on the results of the trityl-t-butyl peroxide, trisbiphenyl-t-butyl peroxide and biphenyl ketone, please refer to reference 8. The α-phenyl ethyl phenyl ether and phenyl-diphenyl methyl ether results were inconclusive.

## EXPERIMENTAL

**General:**  $^1\text{H-NMR}$  spectra were recorded on a Varian XL-200 (200MHz), and IR spectra were obtained on an IBM FT-IR 32 instrument. The melting points were determined on a melting point apparatus and are uncorrected. Mass spectra were obtained from the University of Illinois Mass Spec. lab, and a Hewlett Packard G.C./M.S. using an HP-1 capillary column. Chromatographic separations were conducted on 2mm silica plates with a chromatatron. Elemental analysis were performed by the University of Illinois Analytical lab. All chemicals were used as purchased, unless otherwise specified.

**Trityl-t-butyl peroxide:** This compound was prepared by the condensation of triphenylmethanol and 70% t-butyl hydroperoxide and catalyzed by perchloric acid, according to the procedure outlined by Kharasch et al<sup>7</sup>. The crude product (98% yield) was recrystallized from petroleum ether, and resulted in a fine white powder (31% ), mp.70-72°C. Benzophenone was reported previously as an impurity. This was removed by chromatographic separation. The solvent system was 15% ethyl acetate/hexane and the peroxide was collected in the first fraction. After removing the solvent in vacuo, a pure, white powder remained, mp. 71-72.5°C. Lit. mp. 72-73° C. The peroxide was also checked for purity by HPLC (reverse-phase, 25 cm cyano column, 20% H<sub>2</sub>O in CH<sub>3</sub>CN). The absorbance was monitored at 266 nm. No benzophenone (< 0.2%) was detected.  $^1\text{H-NMR}$  (CDCl<sub>3</sub>):  $\delta$  7.5-7.2 (m 16H), 1.0 (s 9H).

**Trisbiphenyl alcohol:** The starting material, biphenyl chloride was recrystallized from ethanol (mp. 74-75°C), before following the synthesis described by Bachman and Wiselogle<sup>8</sup>.

Variations to their procedure were carried out following the hydrolysis of the crude product. This was then extracted with methylene chloride and the organic layer was dried over anhydrous magnesium sulfate. Following a hot filtration with benzene, a small amount of hexane was added to aid crystallization. The resulting orange-yellow solid was recrystallized a second time with benzene/hexane. The trisbiphenyl alcohol was now an ivory powder, mp. 210-210.5° C (32% yield). The alcohol was characterized by an earlier preparation which underwent the same reaction with the only difference being that the biphenyl bromide was substituted for biphenyl chloride. This variation resulted in a 13-15% yield, mp. 205-208°C. Lit. mp. 208-210°C. IR (nujol,  $\text{cm}^{-1}$ ): broad OH stretch 3500-3300. Mass spectrum: m/e: 488 (parent), 335 (57%), 181 (base). Anal. calcd. for  $\text{C}_{37}\text{H}_{28}\text{O}$ : C, 90.95 %; H, 5.78%. Found: C, 89.82%; H, 5.84%.

Trisbiphenyl-t-butyl peroxide: The trisbiphenyl alcohol (.545g, 1.11mmol) prepared as described in the procedure above, was suspended in glacial acetic acid(10ml) with 90% t-butyl hydroperoxide (.26ml) and stirred magnetically, while externally cooled to ca. 15° C. Ten drops of a 10%  $\text{HClO}_4$ / glacial acetic acid solution were carefully added to the suspension. The solution immediately turned pink and was stirred at room temperature for 12 hours. The resulting mixture was poured on to 100 ml ice-water and filtered. The crude product was a lavender solid, and was purified by chromatographic separation on a chromatatron. A 15% ethyl acetate/hexane solvent system was used and the first fraction collected yielded .341 g (55%) of the peroxide. White, snowflake crystals resulted after recrystallization from pet. ether, mp. 84-86°C. (This compound was not previously prepared).

Trisbiphenyl-t-butyl peroxide was characterized from a previous run, which gave a lower yield (32%) mp. 80-84°C.  $^1\text{H-NMR}$  ( $\text{CDCl}_3$ ):  $\delta$ 1.03 (s 9H), 7.25-7.7 (m 28H). Mass spectrum: m/e: 487 (5.15%), 170 (base). No molecular ion could be detected. Anal. calcd. for  $\text{C}_{41}\text{H}_{36}\text{O}_2$ : C, 87.82%; H, 6.47%; active O, 1.43%. Found: C, 87.61%; H, 6.41%; active O, 1.53%.

Biphenyl acid chloride: To an oven-dried 250 ml round-bottom flask fitted with a drying tube, was added biphenyl carboxylic acid (4.0 g, .02 mol) which was suspended in dry benzene (100 ml)\* and stirred with a magnetic stir bar. Oxalyl chloride (2.6 ml, .024 mol) was slowly added to the flask and followed by 3 drops of dry dimethylformamide. As the mixture stirred at room temperature for 3.5 hrs, the suspension turned from a cloudy, ivory color to a clear golden solution. Excess oxalyl chloride was then carefully evaporated on the rotary evaporator without any added heat or water. Benzene was then removed with the application of a steam bath. The resulting golden solid was allowed to dry under a high vacuum for 2.5 hrs. Crude biphenyl acid chloride was produced in high yield (99%), mp. 109-110°C. Lit.<sup>16</sup> mp. 110-112°C. IR (nujol,  $\text{cm}^{-1}$ ): 1767.

\* note: the volume of the flask should be at least twice the volume of the benzene used, due to the evolution of gases.

Di-(4,4'-biphenyl) ketone: This compound was prepared by the method stated by Schenk and Bergman<sup>9</sup>, with a slight variation in the workup. Under a nitrogen atmosphere, biphenyl (.86g, 5.5 mmol), carbon disulfide (25 ml) and aluminum trichloride (1.2g, 8.9 mmol) were added to an oven-dried, round-bottom flask. This was fitted with an addition funnel, charged with biphenyl acid chloride( 1.15 g, 5.3 mmol) and

carbon disulfide (25 ml). The contents of the addition funnel were added dropwise to the mixture and stirred for 24 hrs. The CS<sub>2</sub> had evaporated, so the olive-green mixture was poured on to 350 ml water and 30 ml concentrated HCl. This was extracted with methylene chloride, and the organic layer was dried over magnesium sulfate. The ketone was a golden solid, with a crude yield of 85.8% (1.52 g), mp. 231.5-234° C. Recrystallization from benzene resulted in 51.4% yield, mp. 235-236° C. Lit. mp. 233-234° C. <sup>1</sup>H-NMR (CDCl<sub>3</sub>): δ 7.31-7.69 (m). Mass spectrum: m/e: 181 (base), 334 (parent). IR (nujol, cm<sup>-1</sup>): 1640.

α-phenyl ethyl phenyl ether: This ether was obtained by repeating the synthetic route outlined by Hart and Eleuterio<sup>12</sup>. The product was distilled and collected between 118-123°C at 3 torr (ca. 40.8 % yield). Lit. bp. 143-145°C at 10 torr. <sup>1</sup>H-NMR (CDCl<sub>3</sub>): δ 6.75-7.5 (m, 9.2 H), 5.2-5.4 (q, 1H, J=6 Hz), 1.5-1.8 (d, 3H, J=6.2 Hz).

Phenyl-diphenyl methyl ether: All of the preparations by Schorigin<sup>13</sup>, Wittig and Clausnizer<sup>14</sup>, and Busch and Knoll<sup>15</sup> result in this ether. The isolation and purification steps involved after obtaining the crude residue was the same for all three procedures. Chromatographic separation with a 5% ethyl acetate/hexane solvent system, resulted in the presence of the ether in the second fraction. A small amount of delicate, slightly yellow crystals formed and was carefully recrystallized twice, from ethanol (9.5% yield from the Wittig prep.) mp. 47-48°C. Lit. mp. 52.5-53° C. <sup>1</sup>H-NMR (CDCl<sub>3</sub>): δ 6.8-7.5 (m, 15H), 6.2 (s, 1H). IR (nujol, cm<sup>-1</sup>): 1220. Mass spectrum: m/e: 260 (parent) 167 (base). Anal. calcd. for C<sub>19</sub>H<sub>16</sub> O: C, 87.66%; H, 6.20%. Found: C, 87.27%; H, 6.15 %.

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