$\Delta\lambda_{Ph} > \Delta\lambda$. Table II demonstrates the conjugative interaction of the rings with the common carbomethoxy substituent, as modified by the substituents of Table I. In general, it is clear that the furan ring is more nucleophilic and less electrophilic than the benzene ring.

EXPERIMENTAL

Furan (Du Pont) on redistillation boiled at 31.5°.

2-Substituted furans were prepared by the methods previously reported.[2]

Methyl 5-chloro-2-furoate was prepared in 42% yield (m.p. 40–41°) by passing chlorine through rapidly stirred methyl 2-furoate at 150° for 3 hr.

Methyl 5-bromo-2-furoate and *methyl 5-methoxy-2-furoate* were prepared as previously reported.[2]

Methyl 5-nitro-2-furoate (m.p. 79–80°) was prepared by the usual method.[4]

Methyl 5-phenoxy-2-furoate was prepared by reaction of the acid[2] with diazomethane in 98% yield; b.p. 133–135°/0.3 mm.

Anal. Calcd. for $C_{12}H_{10}O_4$: C, 66.1; H, 4.62. Found: C, 66.1; H, 4.63.

Methyl 5-thiophenoxy-2-furoate was prepared by reaction of the acid[2] with diazomethane in 98% yield; b.p. 146–148°/0.5 mm. m.p. 39–40°.

Anal. Calcd. for $C_{12}H_{10}O_2S$: C, 61.5; H, 4.30. Found: C, 61.5; H, 4.36.

Phenyl 5-carbomethoxy-2-furyl sulfone was obtained in quantitative yield by reaction of methyl 5-thiophenoxy-2-furoate with excess 30% hydrogen peroxide in glacial acetic acid. Recrystallization from methanol-water gave white needles melting at 102–103°.

Anal. Calcd. for $C_{12}H_{10}O_5S$: C, 54.1; H, 3.79. Found: C, 54.1; H, 3.90.

Methyl benzoate b.p. 85°/15 mm. 220.8 mμ (4.08).

Methyl p-bromobenzoate m.p. 77–78°. 245.0 mμ (4.26).

Methyl p-anisate m.p. 47–48°. 256.5 mμ (4.43).

Methyl p-nitrobenzoate m.p. 95–96°. 259.0 mμ (4.12).

Dimethyl terephthalate m.p. 139–140°. 242.0 mμ (4.47).

Diphenyl sulfone m.p. 128–130°. 236.3 mμ (4.17).

Diphenyl sulfide b.p. 151–153°/15 mm. 231.8 (3.80), 250.4 (4.07), 275.0 (3.28).

Diphenyl ether b.p. 129.5°/12 mm. 226.7 mμ (4.01).

Methyl p-phenoxybenzoate. The *p*-phenoxy acid[5] (m.p. 158–159°) was prepared by carbonation of the Grignard reagent from *p*-bromophenyl phenyl ether (Eastman). Direct esterification of the acid followed by recrystallization from 95% ethanol gave the product m.p. 56–57°, 258.0 mμ (4.26).

Anal. Calcd. for $C_{14}H_{12}O_3$: C, 73.7; H, 5.30. Found: C, 73.5; H, 5.05.

Methyl p-thiophenoxybenzoate. *p*-Thiophenoxybenzoic acid[6] was prepared by adding a cold solution of diazotized *p*-aminobenzoic acid to a solution of thiophenol in dilute sodium hydroxide. A poor yield of the product was obtained which after several recrystallizations from 95% ethanol melted at 170–174°. Direct esterification followed by recrystallization from 95% ethanol gave the ester, m.p. 69–70°, 293.2 mμ (4.23).

Anal. Calcd. for $C_{14}H_{12}O_2S$: C, 69.0; H, 4.57. Found: C, 68.9; H, 4.74.

Phenyl p-carbomethoxyphenyl sulfone was prepared by the action of hydrogen peroxide on methyl *p*-thiophenoxybenzoate. The product was recrystallized from 95% ethanol, m.p. 145–146°, 242.5 mμ (4.29).

Anal. Calcd. for $C_{14}H_{12}O_4S$: C, 60.9; H, 4.38. Found: C, 60.8; H, 4.26.

Spectra were taken in 95% ethanol at a concentration of 10 mg./l. on a Warren Recording Spectrophotometer.

The vapor spectrum of furan was obtained by placing one drop of furan in the bottom of the dry cell and allowing about 10 min. for the vapor to reach equilibrium.

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Synthesis of Xanthurenic Acid-4-C^{14}

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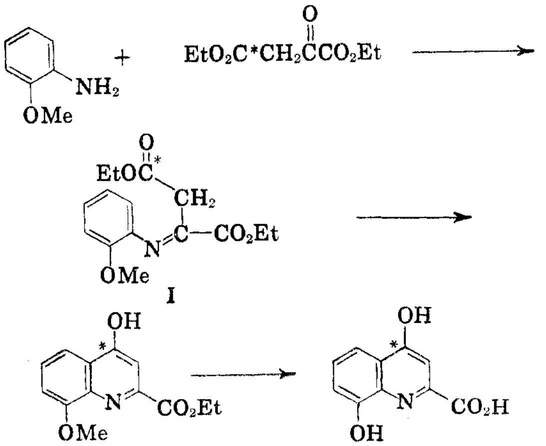
Xanthurenic acid has been known for some time as a tryptophan metabolite in mammals. In order to study the metabolism of this compound, it was desirable to incorporate a radioactive carbon atom into the molecule. A small scale synthesis (7mM) of xanthurenic acid-4-C^{14} was therefore undertaken utilizing the general procedure of Furst and Olsen[2]:



Numerous changes in the original procedure had to be made in order to provide a simple, continuous synthetic pathway starting from relatively inexpensive sodium acetate-1-C^{14}. These changes have more than doubled the over-all yield of xanthurenic

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[1] This work was supported by a research grant from the Hobson Fund to the Cancer Research Institute, School of Medicine, University of California.

[2] A. Furst and C. J. Olsen, *J. Org. Chem.*, **16**, 412 (1951).

acid. The increase in yield appears to be primarily due to a new method for preparing the anil, I. A solution of *o*-anisidine and ethyl oxaloacetate in ether was refluxed in a Soxhlet extractor using calcium hydride in the extraction thimble, so that the hydride continuously removed the water produced by anil formation. For comparative yields, a preparation of ethyl oxaloacetate (synthesized from ethyl acetate and ethyl oxalate) was divided into two parts, and one part run as originally described[2] (refluxing benzene over Na_2SO_4) and one part as described above. Cyclization of the anils without isolation gave yields of 20% and 50%, respectively, of the ester, II, based on ethyl acetate.

It was found that hydrolysis of the ester, II, did not take place effectively, at least on this small scale, using the proportions of potassium iodide and 95% phosphoric acid recommended.[2] However, by increasing the relative amount of phosphoric acid, a nearly quantitative yield of xanthurenic acid was obtained from II.

EXPERIMENTAL

Preparation of ethyl oxaloacetate-4-C^{14}. Ethyl acetate-1-C^{14}, prepared in approximately 86% yield from 588 mg. (7.17 mM., 4.8 mc.) of sodium acetate-1-C^{14} essentially by the method of Ropp,[3] was mixed with 0.825 ml. of diethyl oxalate in 2 ml. of dry ether. This solution was added dropwise with stirring to a cooled (ice bath) suspension of sodium ethoxide (from 153 mg. of sodium hydride and 0.356 ml. of absolute ethanol) in 2 ml. of dry ether. The mixture was stirred in the cold for 2 hr. and then allowed to stand overnight at room temperature. The resulting grey paste was treated with a solution of 3 ml. of 6N H_2SO_4 in 10 ml. of water, and then was extracted 4 times with ether. The combined ether extracts which contained the ethyl oxaloacetate-4-C^{14} were dried over Na_2SO_4.

Formation of the anil (I). To the ether solution of ethyl oxaloacetate-4-C^{14}, still over Na_2SO_4, was added 1.2 ml. of freshly distilled *o*-anisidine. A precipitate of *o*-anisidine hydrosulfate was formed, presumably because of a small amount of H_2SO_4 carried over from the extraction procedure. The salt was removed by filtration, along with the Na_2SO_4. The yellow filtrate was evaporated to a volume of about 20 ml. and transferred to a micro Soxhlet extraction apparatus.[4] The thimble (10 × 50 mm.) was half filled with calcium hydride which had been ground in a mortar, and the apparatus was protected from the atmosphere with a drying tube. After being refluxed for 12 hr. the ether solution was washed with a solution of 1 g. of citric acid in 15 ml. of water in two portions, and then with water. The ether layer was dried (Na_2SO_4) and distilled to a small volume. It was then transferred to a 15 ml. pear shaped flask[5] and the last of the ether was removed by gentle distillation, and finally under vacuum. The yellow oil which remained was presumably the anil of *o*-anisidine and ethyl oxaloacetate.

Ethyl 4-hydroxy-8-methoxy quinaldate-4-C^{14} (II). To the material in the flask was added 3.5 ml. of Dowtherm A, and a small carborundum boiling chip. A reflux condenser was set in place and the flask immersed in an oil bath at 270–280° for 11 min. (Small differences in time apparently do not affect the yield adversely.) The resulting dark brown liquid was cooled and transferred to a separatory funnel with the aid of several ml. of ether. It was extracted 4 times with a total of 6 ml. of 6*N* HCl in 25 ml. of water. The light yellow HCl extracts were washed with ether and the ether layer was discarded. The acid solution was then filtered and carefully made just alkaline with finely powdered sodium carbonate. The resulting mixture was placed in a refrigerator for 3 hr. and the precipitate filtered, washed with water, and dried *in vacuo* over P_2O_5. The yield of ester was 0.72 g. or 40.5% based on sodium acetate-1-C^{14}.

Xanthurenic acid-4-C^{14}. The ester was placed in a 20 ml. pear shaped flask, and 11.3 g. of 95% phosphoric acid was added, followed by 7.2 g. of KI. After refluxing in an oil bath at 260° for 1.5 hr. the mixture was cooled and transferred to a 125 ml. Erlenmeyer flask with the aid of 50 ml. of water. The contents of the flask were heated gently and stirred until the black color had disappeared and a bright yellow precipitate remained. The mixture was placed in a refrigerator for several hours, and the yellow solid filtered onto a sintered glass funnel. The product was washed with water and then with alcohol. The crude xanthurenic acid-4-C^{14} was passed through the filter with dilute aqueous NaOH. The filtrate was acidified with dilute HCl and the precipitate collected as above. The process was repeated once again, and the product finally dried *in vacuo* over P_2O_5. The yield of xanthurenic acid-4-C^{14} was 0.58 g., or 39% based on sodium acetate-1-C^{14} (97% from the ethyl quinaldate).

Purity: Paper chromatographs in two solvents (butanol: acetic acid:water-5:1:4 and methanol:benzene:butanol: water-4:2:2:2) each showed only one spot when examined under ultraviolet light. These spots corresponded exactly to the only spot obtained radioautographically on x-ray film, and the R_f values agreed closely with those reported by other workers. The specific activity of the xanthurenic acid-4-C^{14} was 3.4 μc/mg. (Calcd.: 3.4 μc/mg.).

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New Synthesis of Aryl Esters of Aromatic Acids

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It has been shown by several workers[1-6] that the aluminum chloride catalyzed reaction of alkyl chloroformates with aromatic hydrocarbons behaves in an abnormal manner. Alkylation of the hydrocarbon results instead of formation of the expected alkyl ester of the aromatic acid.

This note describes experiments in which aryl chloroformates react with aromatic hydrocarbons in the presence of aluminum chloride to form the expected aryl esters of aromatic acids.

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