

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY OF THE STATE COLLEGE OF WASHINGTON]

The Bromination of 4-Phenylphenyl Chloroacetate

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Earlier work¹ on the bromination of 4-phenylphenyl acetate and benzoate in the presence of iron as a catalyst showed that the acetyloxy radical caused 2-orientation while the larger benzoyloxy group promoted 4'-orientation in the biphenyl nucleus. A study has now been made of the corresponding ester of chloroacetic acid in order to see whether the spatial or other possible influence of this intermediate-sized radical were large enough to inhibit 2-orientation. The results in carbon tetrachloride and 1,1,2-trichloroethane show that the chloroacetyloxy group had a steric effect, *i. e.*, caused the bromine to enter the 4'-position. Abnormal results were found, however, when the reaction was carried out in acetic acid.

Anal. Calcd. for $C_{14}H_{11}O_2Cl$: Cl, 14.4. Found: Cl, 14.3.

4-Phenylphenyl Bromoacetate.—This compound was prepared in 75.7% yield by a method essentially the same as that used for the preparation of the analogous chloro compound. The product was purified by recrystallization from ethanol and by distillation; b. p. 185° (3 mm.) and m. p. 112–112.5°. It was in the form of colorless needles, almost identical with 4-phenylphenyl chloroacetate. It is interesting to note that this bromoacetate and the corresponding chloroacetate, when mixed, melt without depression.

Anal. Calcd. for $C_{14}H_{11}O_2Br$: Br, 27.5. Found: Br, 27.6.

Chloroacetates of Bromophenylphenols.—By treatment of the appropriate phenols with one and one-half to two equivalents of chloroacetyl chloride in the presence of a little more than enough dry pyridine to combine with all of the hydrogen chloride liberated and usually in the presence of 1,4-dioxane, the esters shown in Table I were obtained.

TABLE I
CHLOROACETATES OF THE BROMOPHENYLPHENOLS

Phenol used	Yield, %	Solvent	Crystal form, colorless	M. p., °C.	Formula	Analyses, % Cl + Br	
						Calcd.	Found
2-Bromo-4-phenyl- ²	46	Ligroin (70–90°)	Short, hexagonal prisms	60.5–62	$C_{14}H_{10}O_2ClBr$	35.5	35.5
2,6-Dibromo-4-phenyl- ²	67.5	Ligroin (70–90°)	Needles	83–84	$C_{14}H_8O_2ClBr_2$	48.3	48.3
4-(4-Bromo-phenyl)- ³	45.5	Ethanol	Platelets	140–141.5	$C_{14}H_{10}O_2ClBr$	35.5	35.5

Experimental Part

4-Phenylphenyl Chloroacetate.—Seventy-eight grams of 4-phenylphenyl was dissolved in a solution containing 63 ml. of pyridine and 126 ml. of 1,4-dioxane; the solution was cooled to 5°, and 52 ml. of chloroacetyl chloride was added in small portions. The mixture was allowed to stand overnight, and it was then gradually warmed to 115° and heated at that temperature for three and one-half hours. Again it was allowed to stand overnight at room temperature. The ester was extracted from the reaction mixture with three 50-ml. portions of boiling benzene. The combined extracts were washed with water, with 10% hydrochloric acid and 5% sodium hydroxide solutions, and finally with water, and then dried with anhydrous sodium sulfate in the presence of Norite. A yield of 82.8 g. (73.2%) was obtained after removal of the benzene by distillation. After two recrystallizations from ethanol, the product, colorless needles, melted at 116–117°. The compound was also purified by distillation; b. p. 185° (3 mm.). The melting point of the distillate was 116–117°.

(1) For the last paper on substitutions in esters containing diphenyl groups see Hazlet and Kornberg, *THIS JOURNAL*, **63**, 1890 (1941).

(2) Hazlet, Alliger and Tiede, *ibid.*, **61**, 1447 (1939).

(3) Bell and Robinson, *J. Chem. Soc.*, 1127 (1927); Hazlet, *THIS JOURNAL*, **59**, 1087 (1937).

Bromination of 4-Phenylphenyl Chloroacetate in Glacial Acetic Acid ("Analytical Reagent").—(A) Fifteen grams of 4-phenylphenyl chloroacetate was dissolved in 110 ml. of glacial acetic acid ("analytical reagent"). The solution was heated to 100°, a trace of iron powder was added, and 4.1 ml. of bromine dissolved in 25 ml. of glacial acetic acid was introduced dropwise over a period of thirty minutes. Mechanical stirring, which had been provided, was continued for six hours while the mixture was heated at 118° ($\pm 2^\circ$). After standing overnight at room temperature, the dark red reaction mixture was poured into 600 ml. of water, and extraction with three 70-ml. portions of benzene followed. The combined benzene extracts were washed with 5% sodium hydroxide solution and water and dried with anhydrous sodium sulfate in the presence of Norite; the material in this solution constituted *Fraction A-I*. The alkaline solution, mentioned above, was acidified and extracted with benzene—*Fraction A-II*.

(B) A second bromination was carried out in the same manner as described above, but the reaction mixture was not poured into water, and the major portion of the acetic acid was removed by distillation under reduced pressure. The residue was dissolved in ether, and the solution was shaken with solid sodium bisulfite and allowed to stand overnight with this reagent in the presence of Norite. After filtering, the ether was removed by distillation. The

residue was next distilled at low pressure. *Fraction B-I* distilled at 80–82° (5 mm.); *Fraction B-II* was collected at 137° (2 mm.); no other material distilled at this pressure up to 160° where the distillation was stopped.

The compounds isolated from these various fractions are represented below in Table II; only very small amounts of purified products were obtained.

Fraction	Compound	M. p., °C. ^a
A-I	4-Phenylphenyl chloroacetate	111.5–112.5
A-II ^b	4-Phenylphenol	154 – 158
	2,6-Dibromo-4-phenylphenol	85 – 86
B-I	Chloroacetic acid	45 – 48
B-II	4-Phenylphenyl acetate	83 – 85

^a Identification by means of a mixed melting point determination with an authentic sample was made in each case. ^b Separated by fractional crystallization.

Bromination of 4-Phenylphenyl Chloroacetate in Specially Treated Glacial Acetic Acid.—Ten grams of 4-phenylphenyl chloroacetate was dissolved in 30 ml. of acetic acid which had been freshly distilled from phosphorus pentoxide. A trace of iron powder and then 3.3 ml. of bromine were added. The reaction mixture was stirred and heated at 115–120° for ten hours. The acetic acid was removed by distillation at reduced pressure, and the residue solidified on cooling. After one crystallization from 70–90° ligroin, the product was obtained as colorless, granular crystals; 8.25 g. (70% yield). Ethanol was used for recrystallizations, and colorless needles resulted; m. p. 110–111.5°. Qualitative analysis (sodium fusion method) gave a test for bromine.

Anal. Calcd. for C₁₁H₁₁O₂Br: Br, 27.5. Found: Br, 27.5.

When the product was mixed with 4-phenylphenyl bromoacetate, a melting point of 111–112.5° was observed.

Hydrolysis of 4-Phenylphenyl Bromoacetate.—To further prove the identity of the material assumed to be 4-phenylphenyl bromoacetate, a sample of the product obtained by the bromination of 4-phenylphenyl chloroacetate in specially treated glacial acetic acid was hydrolyzed. When the phenol which was obtained (m. p. 159–161°) was mixed with a carefully purified sample of 4-phenylphenol there was no softening below 161°, and the mixture melted between 161.5 and 163°. Thus its identity as 4-phenylphenol was established.

Bromination of 4-Phenylphenyl Chloroacetate in Carbon Tetrachloride.—Four and eight-tenths grams of the chloroacetate was dissolved in carbon tetrachloride, a trace of powdered iron was added, the mixture was heated to 75°, and 1.2 ml. of bromine was added dropwise with stirring. After the mixture had been heated for four hours at 70 to 80°, it was poured into water and extracted first with ether and then with chloroform. From the ether solution there

was obtained 0.8 g. of product; m. p. 139–141°. The chloroform extract yielded 0.8 g. of product; m. p. 139.5–141.5°. The total yield was 1.6 g. (26%). Because mixtures of the two samples melted without depression, they were combined and recrystallized from ethanol; needles were obtained, m. p. 141–142.8°. This compound was shown to be 4-(4-bromophenyl)-phenyl chloroacetate; a mixture of it and 4-(4-bromophenyl)-phenyl chloroacetate, prepared as described in a previous paragraph, melted without depression.

Hydrolysis of 4-(4-Bromophenyl)-phenyl Chloroacetate.

—A small amount of the reaction product obtained by the bromination of 4-phenylphenyl chloroacetate in carbon tetrachloride solution was hydrolyzed, and the crude phenolic product was dissolved in pyridine and converted to 4-(4-bromophenyl)-phenyl benzoate as described previously.² The product, after crystallization from methanol, melted at 191° and there was no depression when mixed with a known sample of the benzoate.

Bromination of 4-Phenylphenyl Chloroacetate in 1,1,2-Trichloroethane.—The procedure for this bromination was the same as that carried out in carbon tetrachloride as described above except that after the reaction had been carried out in 1,1,2-trichloroethane, the mixture was washed with water, and then the solvent was removed by distillation. The yield of crude product was nearly quantitative but, after recrystallizations from ethanol, the needles which melted at 141–142.5° represented only a 60% yield of 4-(4-bromophenyl)-phenyl chloroacetate.

Summary

1. The bromination of 4-phenylphenyl chloroacetate in different solvents led to a variety of products: (a) glacial acetic acid (“analytical reagent”)—4-phenylphenyl chloroacetate, 4-phenylphenyl acetate, 2,6-dibromo-4-phenylphenol, 4-phenylphenol and chloroacetic acid; (b) specially treated glacial acetic acid—4-phenylphenyl bromoacetate; (c) carbon tetrachloride—4-(4-bromophenyl)-phenyl chloroacetate; (d) 1,1,2-trichloroethane—4-(4-bromophenyl)-phenyl chloroacetate.

2. The behavior in carbon tetrachloride and 1,1,2-trichloroethane in part confirms the earlier suggestion that steric effects may determine the positions taken by substituents entering an ester molecule of the type represented.

3. Several related compounds which had not been reported previously have been prepared and some of their properties reported.

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