[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, THE UNIVERSITY OF TEXAS]

Synthesis of Ketone Derivatives of Biphenyl by the Friedel–Crafts Reaction[1]

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Although several biphenyl alkyl and aryl ketones have been prepared by previous investigators,[3] no systematic attempt has been made to extend the series to include more than the first few members. Especially is this true of the *p,p'*-diacyl biphenyl ketone type. Therefore, the purpose of this investigation has been to complete both the mono- and diketone series through the *n*-hexyl derivative, and also to include a number of ketones containing branched-chain alkyls.

In a rather extensive investigation Silver and Lowy[3k] have shown conclusively that acyl halides react with biphenyl in the Friedel–Crafts reaction to form 4-mono- and 4,4'-disubstitution products. Hence, the ketones prepared for the first time in this study have been formulated as having the same configurations without further proof.

To prepare the alkyl biphenylyl ketones, a solution of the appropriate acyl halide and biphenyl in carbon disulfide was added to anhydrous aluminum chloride suspended in carbon disulfide. Despite the fact the six members of this series synthesized previously by other workers have been reported to be yellow solids, we find that upon sufficient purification white, crystalline solids are obtained in every case. It may be assumed that the lower melting points recorded elsewhere are indicative of a lesser degree of purity than that obtained in this study.

In general, the diketones were obtained by using slightly more than double the ratio of acyl halide[4] and anhydrous aluminum chloride to biphenyl. In a few cases, purification through recrystallization was less efficient than fractional distillation. Attempts to prepare diketones from biphenyl by interaction with 2-methylvaleryl chloride and 2-ethylbutyryl chloride were unsuccessful.

We wish to thank Parke, Davis and Company for their financial aid in this investigation.

Experimental

Preparation of Alkyl 4-Biphenyl Ketones.—Merck sublimed, anhydrous aluminum chloride (0.22 mole) was suspended in about 75 cc. of dry carbon disulfide in a three-neck 500-cc. round-bottom flask fitted with a reflux condenser, a mercury-sealed mechanical stirrer and a dropping funnel. An acid chloride (0.22 mole) and biphenyl (0.2 mole) were dissolved in a like amount of dry carbon disulfide and added to the rapidly-stirred suspension over a period of twenty minutes. Since the flask was not cooled, refluxing began at once. Stirring was continued for thirty minutes after addition was complete, and then the reaction mixture was refluxed on a steam cone for four hours. Carbon disulfide was removed by distillation and the sirupy residue was hydrolyzed by adding it slowly to 500 cc. of ice water. In most instances a semi-solid, yellow or tan material was formed which hardened after a few minutes. After filtration, the ketones were recrystallized from acetone or ethyl alcohol, using Norit to remove color. Pertinent data for certain physical properties and analyses of the mono ketones are listed in Table I.

Preparation of *p,p'*-Diacyl Biphenyls.—In preparing the diketones, 0.6 mole each of Merck sublimed, anhydrous aluminum chloride and of acid chloride were used with 0.2 mole of biphenyl. In the cases of *p,p'*-diisopropyl biphenyl and *p,p'*-diisobutyl biphenyl it was necessary to resort to fractional distillation at 3 mm. pressure in order to effect adequate purification. In distilling the former, a fraction boiling 190–200° (3 mm.) was obtained which solidified almost at once. By recrystallization from petroleum ether a 40% yield of the monoketone was obtained. Another fraction, boiling 240–260° (3 mm.), solidified much more slowly. This material was recrystallized from petroleum ether to yield the diketone. Likewise, for the isobutyl analog, the first fraction boiling 183–196° (3 mm.) upon recrystallization from petroleum ether yielded the monoketone in 33% yield. Another fraction, boiling 242–258° (3 mm.) was also recrystallized from petroleum ether and thus gave the diketone.

Certain data for the *p,p'*-diacyl biphenyls are placed in Table II. It will be noted that the melting points of the isopropyl and isobutyl members appear to be lower than expected; however, the analytical data for these compounds are wholly satisfactory. Repeated attempts to prepare diketones from biphenyl using 2-ethylbutyryl chloride yielded a sirupy liquid which would not solidify after long standing in a refrigerator. Fractional distillation yielded an initial fraction which did solidify and could

(1) Presented before the Division of Organic Chemistry at the 101st meeting of the American Chemical Society at St. Louis, Missouri, April 10, 1941.

(2) Parke, Davis and Company Research Fellow.

(3) (a) Adam, *Ann. Chim.*, [6] **15**, 255 (1888); *Bull. soc. chim.*, **49**, 98 (1888); (b) Ullmann and Meyer, *Ann.*, **332**, 79 (1904); (c) Vorländer, *Ber.*, **40**, 4535 (1907); (d) Willgerodt and Scholtz, *J. prakt. Chem.*, [2] **81**, 394 (1910); (e) Wolf, *Ber.*, **14**, 2031 (1881); (f) Staudinger and Kon, *Ann.*, **384**, 97 (1911); (g) Scholl and Seer, *ibid.*, **394**, 148 (1912); (h) Schlenk and Brauns, *Ber.*, **48**, 723 (1915); (i) Dilthey, *J. prakt. Chem.*, [2] **101**, 194 (1921); (j) Auwers and Jülicher, *Ber.*, **55**, 2183 (1922); (k) Silver and Lowy, THIS JOURNAL, **56**, 2429 (1934); (l) de Milt and Sartor, *ibid.*, **62**, 1954 (1940).

(4) Silver and Lowy, ref. 3k, report that acetic anhydride will not react with biphenyl to form a diketone.

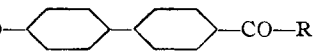
TABLE I

ALKYL 4-BIPHENYLYL KETONES 

—R	M. p., °C. (cor.)	Yield, %	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
—CH_3[3a,3d,3i]	121	90				
—CH_2CH_3[3i]	89	79				
—$CH_2CH_2CH_3$[3i]	94	78				
—$CH(CH_3)_2$[3i]	62	68				
—$CH_2CH_2CH_2CH_3$[a]	76.0–78.0	63	85.67	85.41	7.61	7.64
—$CH_2CH(CH_3)_2$[3i]	74.0–76.5	65				
—$CH_2CH_2CH_2CH_2CH_3$[a]	96.5	67	85.67	85.62	7.99	8.06
—$CH_2CH_2CH(CH_3)_2$[a]	71.0–72.5	62	85.67	85.65	7.99	7.99
—$CH(CH_3)CH_2CH_2CH_3$[a]	64	40	85.67	85.54	7.99	8.02
—$CH(CH_2CH_3)_2$[a]	77.0–79.0	45	85.67	85.74	7.99	8.02
—$CH_2CH_2CH_2CH_2CH_2CH_3$[a]	85.5–86.5	52	85.67	85.83	8.32	8.41
—C_6H_5[3e,3f]	106	75				

[a] New compounds.

TABLE II

p,p'-DIACYL BIPHENYLS R—CO—  —CO—R

—R	M. p., °C. (cor.)	Yield, %	Carbon, % Calcd.	Carbon, % Found	Hydrogen, % Calcd.	Hydrogen, % Found
—CH_3[3i,3k]	191	45				
—CH_2CH_3[3i]	168	31				
—$CH_2CH_2CH_3$[a]	174.2	31	81.59	81.59	7.53	7.50
—$CH(CH_3)_2$[a]	103.0	27	81.59	81.85	7.53	7.59
—$CH_2CH_2CH_2CH_3$[a]	162.0–163.0	31	81.95	81.54	8.13	7.98
—$CH_2CH(CH_3)_2$[a]	113.0	37	81.95	82.08	8.13	8.16
—$CH_2CH_2CH_2CH_2CH_3$[a]	164.5	32	82.24	82.25	8.63	8.68
—$CH_2CH_2CH(CH_3)_2$[a]	138.0–140.0	34	82.24	82.27	8.63	8.66
—$CH_2CH_2CH_2CH_2CH_2CH_3$[a]	157.1	29	82.49	82.26	9.05	8.97
—C_6H_5[3b,3h]	218	50				

[a] New compounds.

be recrystallized from petroleum ether to yield 35% of the monoketone. All efforts to obtain pure diketone from the higher boiling fractions were unsuccessful. Essentially the same results were noted in attempts to synthesize a diketone from interaction of biphenyl and 2-methylvaleryl chloride.

Finally, the monophenyl and diphenyl biphenylyl ketones were resynthesized. By refluxing the reaction mixtures for thirty hours, much higher yields of ketones were obtained. These facts suggest that a long period of heating the reaction mixtures under reflux might be beneficial for the production of the alkyl ketones in higher yield.

Summary

1. Nine ketone derivatives of biphenyl have been resynthesized. Several of these ketones, previously reported to be yellow in color, have been obtained as white, crystalline solids of higher melting point.

2. Seven new alkyl 4-biphenylyl ketones and six new bis-(4-phenyl alkyl ketones) have been prepared. All of these are white, crystalline substances.

AUSTIN, TEXAS RECEIVED APRIL 29, 1941