BULLETIN OF THE CHEMICAL SOCIETY OF JAPAN, VOL. 48 (3), 1071—1072 (1975)

Synthesis of 1,3-Diaryl-1,2-propanedione by Dehydrochlorination of 3-Chloro-2-hydroxy-1,3-diaryl-1-propanone Catalyzed by Hydrogen Chloride

Takane UCHIDA, Yo MIYAGI,* and Kazuhiro MARUYAMA*

Department of Chemistry, Faculty of Education, Fukui University, Bunkyo, Fukui 910

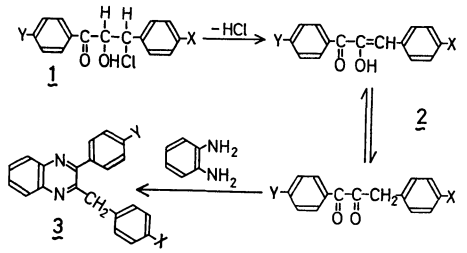
**Department of Chemistry, Faculty of Science, Kyoto University, Sakyo-ku, Kyoto 606*

(Received September 17, 1974)

Synopsis. Dehydrochlorination of 3-chloro-2-hydroxy-1,3-diaryl-1-propanone proceeds to give 1,3-diaryl-1,2-propanedione in a high yield on heating its dioxane solution with a catalytic amount of hydrogen chloride. Kinetic studies were carried out.

α-Diketones have usually been prepared by oxidation of the corresponding ketones with selenium oxide. However, when the α-diketone to be synthesized has another methylene group at the α-position, the α-diketone produced is further oxidized to polyketones and the yield of α-diketone is, in general, not satisfactory because of the production of tarry matter.

We found a novel method for synthesis of α-diketones by chloride ion catalyzed dehydrochlorination in an acidic medium. *erythro-* and *threo*-3-Chloro-2-hydroxy-1,3-diaryl-1-propanones, (*erythro*-**1a**—**c**) and (*threo*-**1a**—**f**), underwent dehydrochlorination to give 1,3-diaryl-1,2-propanediones (**2a**—**f**) in good yields on heating their dioxane solutions containing hydrogen chloride at 70—90 °C for 20—40 hr (Scheme 1). The products (**2a**—**f**) were identified as 2-aryl-3-aroylquinoxalines (**3a**—**f**) which were produced by reaction with *o*-phenylenediamine. The yields of **3** were 80—90% (Table 1).



1—**3**: **a**, X=Y=H; **b**, X=Cl, Y=H; **c**, X=H, Y=Cl; **d**, X=CH_3, Y=H; **e**, X=H, Y=CH_3; **f**, X=H, Y=CH_3O

Scheme 1.

The significant feature of this reaction is the use of acidic medium since halide ion catalyzed dehydrohalogenation[1] is usually carried out in an aprotic solvent in the presence of amine, that is, in slightly basic medium in which carbonyl compounds are not stable enough to be isolated.

House[2] also obtained **2a**, identified as **3a**, by reaction of *erythro*-**1a** (10% yield) and *threo*-**1a** (26% yield) with sodium acetate in ethanol.* He assigned the diastereomeric configurations of *erythro-* and *threo*-**1a**, supposing that the phenyl and benzoyl groups of *erythro*-**1a** were eclipsed at the transition state for the *trans* elimination. We confirmed the diastereomeric configurations of *erythro-* and *threo*-**1a** by their NMR spectra. The reactants, *erythro*-**1b**—**c** and *threo*-**1b**—**f**, were prepared in the same manner as *erythro*-**1a**[2] and *threo*-**1a**.[3]

Some details of the kinetics of the reaction were investigated. The rate of the reaction was first order in both reactant and hydrogen chloride.** It was established that the reaction was promoted by chloride ion but not by protons, since no reactions were detectable when *p*-toluenesulfonic acid was used instead of hydrogen chloride (at 80.0 °C for 8 hr).

The kinetic results are listed in Table 2 and can be

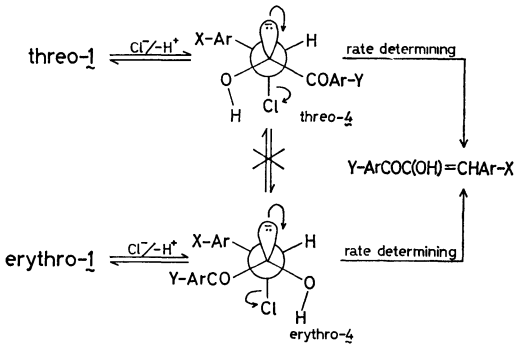
TABLE 1. YIELDS, MELTING POINTS, AND ELEMENTAL ANALYSES OF 2-BENZYL-3-PHENYLQUINOXALINES **3a**—**f**

Starting material	Products	Yield (%)	Mp[a] (°C)	Found (%) C	H	N	Cl	Calcd (%) C	H	N	Cl
erythro-**1a**	**3a**	84	96[b]	85.22	5.36	9.46		85.11	5.44	9.45	
threo-**1a**	**3a**	84								($C_{21}H_{16}N_2$)	
erythro-**1b**	**3b**	82	146	75.09	4.57	8.36	10.59	76.25	4.57	8.47	10.72
threo-**1b**	**3b**	85								($C_{21}H_{15}N_2Cl$)	
erythro-**1c**	**3c**	78	137	76.44	4.57	8.37	10.82				
threo-**1c**	**3c**	88									
threo-**1d**	**3d**	80	133	84.97	6.03	8.89		85.12	5.85	9.03	
threo-**1e**	**3e**	89	113	85.31	5.96	9.06				($C_{22}H_{18}N_2$)	
threo-**1f**	**3f**	87	141	81.03	5.37	8.63		80.95	5.56	8.58	
										($C_{22}H_{18}N_2O$)	

a) Uncorrected. b) Lit,[2] 96 °C.

* The reaction time was indicated as appropriate.

** The rate constants were calculated from $kt=(1/a+b)\times \ln a(b+x)/b(a-x)$; where a and b are initial concentrations of hydrogen chloride and reactant respectively, and x is the variation in reactant concentration.



Scheme 2.

Table 2. Rate constants of elimination reactions of *erythro*- and *threo*-**1**

Reactant	Temp[a]	$k\times10^{2}$[b]	$k_{threo}/k_{erythro}$
erythro-**1a**	60.0	0.481	
	70.0	0.780	
	80.0	1.45[c]	
erythro-**1b**	80.0	1.49	
threo-**1a**	70.0	2.42	3.1
	80.0	4.82[d,e]	3.3
	90.0	6.55	
threo-**1b**	80.0	5.26[e]	3.5
threo-**1c**	80.0	2.59[e]	
threo-**1d**	80.0	5.04[e]	
threo-**1e**	80.0	7.89[e]	
threo-**1f**	80.0	11.4[e]	

a) °C. b) 1/mol min; initial concentrations: reactant, 5.00×10^{-2} M; HCl, 5×10^{-2} M. c) $\Delta H=12.9$ kcal/mol, $\Delta S=40.8$ eu at 80.0 °C. d) $\Delta H=12.4$ kcal/mol, $\Delta S=39.9$ eu at 80.0 °C. e) $\rho=-1.3$ *vs.* σ.

summarized as follows; i) the reaction of a *threo* isomer is faster than that of the corresponding *erythro* isomer; ii) the reaction rate is enhanced by electron donating substituents (Y) on the aroyl group, whereas substituents (X) on the aryl group show little effect on the rate. From these results the reaction mechanism shown in Scheme 2 can be suggested as a plausible one.

Substituents, (X) and (Y), may not affect the equilibrium of intermediate **4** formation but the rate of C–Cl bond rupture of **4**. The formation of *erythro*-**4** may not be preferred because of eclipsing of the aryl and aroyl groups. The diastereomeric configurations of *erythro*- and *threo*-**4** may be retained, because, if they invert, the reaction rates of an *erythro* compound and the corresponding *threo* compound should become similar as the reaction proceeds but this was not the case.

Experimental

erythro-*3-Chloro-1,3-diaryl-2-hydroxy-1-propanones* (erythro-***1a-c***). *erythro*-**1a-c** was prepared by a method similar to the one described by House.[2] To a solution of 1-aroyl-2-arylethylene oxide[4] (10 g) in methanol (100 ml), cooled by ice, concentrated hydrochloric acid (100 ml) was added. After two hours' stirring, the mixture was stored in a refrigerator overnight. Precipitated crystals were filtered and recrystallized from benzene. Yields, melting points, and elemental analyses of *erythro*-**1a-c** are shown in Table 3.

threo-*3-Chloro-1,3-diaryl-2-hydroxy-1-propanones* (threo-***1a-f***). Using the same method as for *threo*-**1a**,[3] *threo*-**1b-f** was prepared from 1-aroyl-2-arylethylene oxide.[4] Yields, melting points, and elemental analyses of *threo*-**1a-f** are shown in Table 3.

NMR Spectra of erythro- *and* threo-**1a**. NMR signals of the aliphatic protons of *erythro*- and *threo*-**1a** in $CDCl_3$ were observed at $\delta=5.23$ (1H, d, $J=3.5$ Hz), 5.48 (1H, d, $J=3.5$ Hz), and 3.60 (OH, s), and 5.26 (1H, d, $J=1.8$ Hz), 5.42 (1H, d, $J=1.8$ Hz), and 3.98 (OH, s, broader than the signal of *erythro*-**1a** at 3.60). The larger coupling constant of *erythro*-**1a** than that of *threo*-**1a** supports the assignment of their diastereomeric configurations.[2]

Products (2-Aryl-3-aroylquinoxalines (3a-f)). A reactant (**1**) (*ca.* 0.5 mmol) was dissolved in 0.05 M HCl-dioxane (10 ml). The solution was heated at 80.0 °C for 20—40 hr in an ampoule and then poured into an ethanol solution of *o*-phenylenediamine (*ca.* 0.075 mmol). After standing overnight, the solution was concentrated under reduced pressure. The residue was crystallized from aqueous ethanol. Yields, melting points, and elemental analyses of products (**3**) are shown in Table 1.

Kinetics. Kinetic measurements were carried out as usual using ampoules. The acid was titrated with methanolic sodium methoxide solution.

References

1) W. H. Saunders, "Mechanisms of Elimination Reactions," John Wiley & Sons, New York, N. Y., (1973), p. 345.
2) H. O. House, *J. Org. Chem.*, **21**, 1306 (1956).
3) H. O. House, *J. Amer. Chem. Soc.*, **76**, 1235 (1954).
4) H. O. House and G. D. Ryerson, *ibid.*, **83**, 979 (1961).

Table 3. Yields, melting points, and elemental analyses of *erythro*- and *threo*-**1**

Compound	Yield (%)	Mp[a] (°C)	Found (%) C	H	Cl	Calcd (%) C	H	Cl
erythro-**1a**	50	106.8[b]	68.77	5.24	13.63	69.10	5.03	13.60
threo-**1a**	43[d]	72.5[c]				($C_{15}H_{13}O_2Cl$)		
erythro-**1b**	52	99.5—101	60.99	4.02	23.84			
threo-**1b**	88	129	60.80	4.38	24.28	61.03	4.09	24.02
erythro-**1c**	52	93—96	61.30	4.34	24.05	($C_{15}H_{12}O_2Cl_2$)		
threo-**1c**	86	104	61.03	4.20	24.36			
threo-**1d**	50	121	70.07	5.45	12.73	69.94	5.50	12.90
threo-**1e**	89	94.6	70.20	5.60	13.18	($C_{16}H_{15}O_2Cl$)		
threo-**1f**	73	112.5	65.84	5.47	12.22	66.09	5.20	12.19
						($C_{16}H_{15}O_3Cl$)		

a) Uncorrected. b) Lit,[2] 105—107 °C. c) Lit,[2] 71—72 °C. d) Ref. 2.