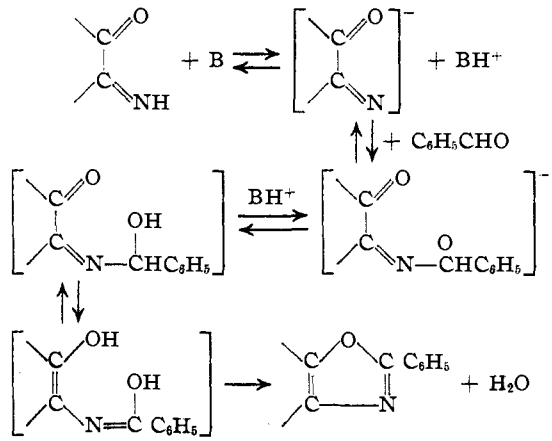
[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING OF THE UNIVERSITY OF PENNSYLVANIA]

The Reactions of Retenequinonimine and Phenanthraquinonimine with Aldehydes. A New Example of an Aldol-Type of Condensation[1]

BY CHARLES W. C. STEIN[2] AND ALLAN R. DAY

In the course of the preliminary work leading to the present investigation, it was noted that the interaction of retenequinonimine, benzaldehyde, and *n*-butylamine gave excellent yields of 2-phenylretenoxazole. When aniline was substituted for the *n*-butylamine, a much lower yield of 2-phenylretenoxazole was obtained. The use of retenequinonimine, *n*-butyraldehyde, and *n*-butylamine produced 2-propylretenoxazole in excellent yields. Careful consideration of the components involved suggested two possible courses of reaction: (1) the aldehyde may undergo an aldol-type of condensation with retenequinonimine under the influence of the basic catalyst *n*-butylamine; and (2) the aldehyde and amine may react to form the Schiff base, benzal-*n*-butylamine, which then might condense with the quinonimine. It is possible that both courses of reaction could proceed simultaneously in the reactions noted above. Since the reactions of aldehydes with the quinonimine proved to be less complicated, they are presented first.

Several types of aldol condensations have been reported for compounds which contain the carbonyl group but apparently none have been reported where a quinonimine furnishes the labile hydrogen. To test the possibility of basic catalysis, amines were chosen which could not react with aldehydes to form Schiff bases. It was found that retenequinonimine and benzaldehyde reacted in the presence of triethylamine or piperidine to give excellent yields of 2-phenylretenoxazole. When the weaker base pyridine was used, however, no oxazole was formed. The above evidence indicates an aldol-type of condensation as the first step in the reaction. This is followed by an allylic-type shift of hydrogen and subsequently by the splitting out of water to form the oxazole. The course of the reaction may be represented as shown in the accompanying formulas. The last step, being irreversible, is an important determining factor in the reaction. In all of the reactions in which oxazole was formed, the solutions became dark red within a few minutes and then changed to yellow. Alcoholic potassium hydroxide can also be used to catalyze the reaction but the yields of oxazole (about 25%) were greatly reduced, due to side reactions between the quinonimine and potassium hydroxide. When sodium ethylate was employed, no oxazole was formed.



This reaction appears to be a general method for the preparation of 2-substituted retenoxazoles. For example, when *n*-butyraldehyde was used with triethylamine as the catalyst, a 92% yield of 2-propylretenoxazole was isolated. Even salicylaldehyde, which is known to produce a mixture of 2-(2′-hydroxyphenyl)-retenoxazole and 2-(2′-hydroxyphenyl)-retenimidazole when treated with retenequinone in the presence of ammonia, yields only the oxazole when treated with retenequinonimine and an amine.

The reactions of phenanthraquinonimine with aromatic aldehydes yielded similar results. The direct action of phenanthraquinonimine and benzaldehyde in the absence of basic reagents failed to produce 2-phenylphenanthroxazole. In the presence of piperidine and triethylamine good yields of the oxazole were obtained, but with the weaker base, aniline, lower yields were obtained. The reactions of *n*-butyraldehyde and phenanthraquinonimine gave similar results.

Experimental

All of the melting points given below are corrected values, and, unless otherwise stated, check the literature values.

(1) Presented at the Memphis Meeting of the American Chemical Society in April, 1942.

(2) Present Address, General Aniline Works, Grasselli, N. J.

Preparation of Retenequinone.—This compound was prepared by the method of Kreps and Day[3] from retene (Eastman Kodak Co. practical grade). It was recrystallized from chloroform: yield 50%; m. p. 197–199°.

Preparation of Retenequinonimine.—The quinonimine was prepared by the method of Bamberger and Hooker.[4] This preparation must be carried out in the absence of moist air. The crude product was recrystallized from absolute alcohol saturated with dry ammonia (below 55°), yield 60%, m. p. 107–108°.

Preparation of Phenanthraquinone.—In this preparation the directions of Graebe[5] for the oxidation of phenanthrene were modified, in that the purification was carried out according to Courtot[6]; m. p. 208–209.5°.

Phenanthraquinonimine.—The method of Pschorr[7] was used for preparing phenanthraquinonimine. The crude product was recrystallized from absolute alcohol saturated with ammonia. As in the case of retenequinonimine, the temperature should be kept below 55° and the time of heating should not exceed fifteen to twenty minutes; yield 75%; m. p. 156–157.5°.

Reactions of Retenequinonimine with Aldehydes and Amines.—In general the reactions were carried out by dissolving 2 g. (0.0076 mole) of retenequinonimine, 0.0076 mole of the aldehyde, and 0.0076 mole of the amine in 50 cc. of absolute alcohol and refluxing the solution on the water-bath.

(1) **With Benzaldehyde and *n*-Butylamine.**—The solution was refluxed for one hour. After cooling, the 2-phenylretenoxazole was removed by filtration and recrystallized from absolute alcohol; yield 68%; m. p. 174.5–175°.[8]

Anal. Calcd. for $C_{25}H_{21}NO$: N, 3.99. Found: N, 4.02.

(2) **With Benzaldehyde and Aniline.**—In this case the refluxing was continued for four hours. On cooling and diluting with water, a mixture of retenequinonimine and 2-phenylretenoxazole separated. Pure 2-phenylretenoxazole was obtained by recrystallization from 80% dioxane–water solution and subsequently from absolute alcohol; yield 9.7%; m. p. 174.5–176°.

(3) **With *n*-Butyraldehyde and *n*-Butylamine.**—After refluxing for four hours, the 2-*n*-propylretenoxazole was precipitated by the addition of water to the hot solution. The crude product was recrystallized from 60% dioxane–water and finally from dilute alcohol and obtained as colorless needles; yield 85%; m. p. 100.5–101.3°. This compound has not been reported previously.

Anal. Calcd. for $C_{22}H_{23}NO$: C, 83.17; H, 7.31; N, 4.42. Found: C, 82.99; H, 7.12; N, 4.26.

(4) **With Benzaldehyde and Triethylamine.**—The solution was refluxed for four hours. On cooling, an 84% yield of crude 2-phenylretenoxazole was obtained. It was recrystallized from absolute alcohol; yield 74%; m. p. 178.5–180°.

Anal. Calcd. for $C_{25}H_{21}NO$: N, 3.99. Found: N, 3.93.

(5) **With Benzaldehyde and One-half an Equivalent of Triethylamine.**—After refluxing for four hours, a 78% yield of 2-phenylretenoxazole was obtained. Recrystallization from absolute alcohol gave the characteristic white, fibrous needles, m. p. 177–178.5°.

(6) **With Benzaldehyde and Piperidine.**—After refluxing for four hours and cooling, a 92% yield of 2-phenylretenoxazole was obtained. It was recrystallized from absolute alcohol, m. p. 174.5–176°.

Anal. Calcd. for $C_{25}H_{21}NO$: N, 3.99. Found: N, 3.89.

(7) **With Benzaldehyde and Small Amounts of Alcoholic Potassium Hydroxide.**—One and one-half grams (0.0057 mole) of retenequinonimine, 0.59 g. (0.0056 mole) of benzaldehyde, and 10 drops of 10% alcoholic potassium hydroxide were mixed with 50 cc. of absolute alcohol and refluxed for four hours. On cooling, a mixture of orange and yellow solids separated. Recrystallization from 80% dioxane–water and finally from absolute alcohol gave a 25% yield of 2-phenylretenoxazole, m. p. 174–175.5°. Evaporation of the original filtrate produced a reddish-brown intractable gum. The substitution of one equivalent of sodium ethylate for the potassium hydroxide in the above reaction gave no observable yield of oxazole.

(8) **With *n*-Butyraldehyde and Triethylamine.**—After refluxing for sixteen hours, the solution was diluted with water and cooled. The 2-propylretenoxazole so obtained was washed with 50% alcohol and then recrystallized from 80% alcohol; yield 92%; m. p. 100–101°.

Anal. Calcd. for $C_{22}H_{23}NO$: N, 4.42. Found: N, 4.40.

(9) **With Salicylaldehyde and *n*-Butylamine.**—The solution was refluxed for thirty-five minutes. After cooling, the crude 2-(2'-hydroxyphenyl)-retenoxazole was removed by filtration. The filtrate was evaporated to dryness and the residue treated with hot 95% alcohol. The yellow solid remaining after this treatment was added to the first precipitate and recrystallized from a dioxane–water solution with the use of decolorizing carbon; yield 51%; m. p. 245.5–247°.

Anal. Calcd. for $C_{25}H_{21}NO_2$: N, 3.81. Found: N, 3.71.

Reactions of Phenanthraquinonimine.—In these reactions the same molar equivalents of reactants were used as in the reactions with retenequinonimine.

(1) **With Benzaldehyde.**—When an absolute alcohol solution of phenanthraquinonimine and benzaldehyde was refluxed, no reaction occurred and only unchanged quinonimine could be isolated.

(2) **With Benzaldehyde and Aniline.**—The solution was refluxed for four hours. After cooling for several hours, the crude product was removed and recrystallized from 80% dioxane–water until colorless needles of 2-phenylphenanthroxazole were obtained; yield 17.5%, m. p. 205–206°.

Anal. Calcd. for $C_{21}H_{13}NO$: N, 4.74. Found: N, 4.62.

(3) Kreps and Day, *J. Org. Chem.*, **6**, 140 (1941).
(4) Bamberger and Hooker, *Ann.*, **229**, 102 (1885).
(5) Graebe, *ibid.*, **167**, 140 (1873).
(6) Courtot, *Ann. chim.*, (10) **14**, 69 (1920).
(7) Pschorr, *Ber.*, **35**, 2739 (1902).
(8) The pure samples of 2-phenylretenoxazole obtained during the course of the work usually melted at 174–176°, but occasionally a higher melting sample (178–180°) was obtained. However, careful examination disclosed the fact that all the samples had the same crystal structure and mixed melting point determinations showed no appreciable depression.

(3) **With Benzaldehyde and Piperidine.**—The solution was refluxed for two hours. The 2-phenylphenanthroxazole, obtained after cooling the solution, was recrystallized from absolute alcohol; yield 97%; m. p. 204.5–205.5°.

Anal. Calcd. for $C_{21}H_{13}NO$: N, 4.74. Found: N, 4.58.

(4) **With Benzaldehyde and Triethylamine.**—In this reaction the solution was refluxed for only thirty minutes. The 2-phenylphenanthroxazole, obtained after cooling the solution, was recrystallized from absolute alcohol; yield 77%; m. p. 204–205.5°.

Anal. Calcd. for $C_{21}H_{13}NO$: N, 4.74. Found: N, 4.69.

(5) **With *n*-Butyraldehyde and Aniline.**—No oxazole was formed in this reaction even after long refluxing.

(6) **With *n*-Butyraldehyde and Two Equivalents of Triethylamine.**—After refluxing the solution for sixteen hours, it was evaporated and the gummy residue taken up in 10 cc. of methyl alcohol. On the addition of 2 cc. of water, a dark, viscous oil slowly separated. After four hours the supernatant liquid was decanted and let stand in the ice-box overnight. On standing, a small amount of 2-propylphenanthroxazole separated. The dark, viscous oil was stirred with 50% methyl alcohol and a few pellets of sodium hydroxide until it had entirely solidified. The combined solids were recrystallized from 80% alcohol, with the aid of decolorizing carbon, until colorless crystals were obtained; yield 50%; m. p. 84–86°. This compound has not been reported previously.

Anal. Calcd. for $C_{18}H_{15}NO$: C, 82.73; H, 5.79; N, 5.36. Found: C, 82.67; H, 5.74; N, 5.38.

Summary

1. Retenequinonimine and phenanthraquinonimine have been shown to react with aldehydes, in the presence of amines, to form 2-substituted retenoxazoles or phenanthroxazoles.

2. The first step in the reaction has been shown to consist of an aldol-type of condensation, with the quinonimine supplying the labile hydrogen.

3. The base-catalyzed reaction is a new and useful method of synthesis for 2-substituted retenoxazoles and phenanthroxazoles, giving high yields and products of excellent purity.

PHILADELPHIA, PA. RECEIVED JULY 14, 1942

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING OF THE UNIVERSITY OF PENNSYLVANIA]

The Reactions of Retenequinonimine and Phenanthraquinonimine with Schiff Bases. A New Example of an Aldol-Type of Condensation[1]

BY CHARLES W. C. STEIN[2] AND ALLAN R. DAY

It was noted in the previous paper in this series[3] that the interaction of retenequinonimine or phenanthraquinonimine with aldehydes, in the presence of amines, gave excellent yields of 2-substituted retenoxazoles or phenanthroxazoles. It was shown that where secondary or tertiary amines were used, the first step in the reaction consisted of a basically catalyzed aldol-type of condensation between the aldehyde and the quinonimine. However, where a primary amine such as *n*-butylamine was employed, it was realized that another possible course of reaction existed. The amine and aldehyde may react to form a Schiff base and the latter then might undergo an aldol-type of condensation with the quinonimine. Schiff bases are known to behave like aldehydes in many respects (the =NR acting as the carbonyl oxygen) and so it appeared to be quite reasonable to expect them to undergo a similar condensation with the quinonimine.

To test this possibility, benzal-*n*-butylamine was prepared and treated with retenequinonimine. A rapid reaction took place, with the formation of good yields of 2-phenylretenoxazole. Since these reactions were carried out under anhydrous conditions, the possibility that the benzal-*n*-butylamine underwent hydrolysis before reaction was practically excluded. Definite proof was obtained, however, by testing the benzal-*n*-butylamine for free aldehyde in dry toluene solution. Addition of phenylhydrazine to the solution of the Schiff base produced no precipitate of benzaldehyde phenylhydrazone, even when heated on the water-bath for thirty minutes, the approximate time of many of the reactions. A similar test carried out with a sample of freshly distilled benzaldehyde gave an immediate precipitate of phenylhydrazone. It was further noted that *n*-butylamine was evolved in nearly quantitative amounts when retenequinonimine and benzal-*n*-butylamine in equivalent quantities were heated at 100° in dry solvents.

A consideration of all the evidence available at

(1) Presented at the Memphis Meeting of the American Chemical Society in April, 1942.

(2) Present address, General Aniline Works, Grasselli, N. J.

(3) Stein and Day, THIS JOURNAL, **64**, 2567 (1942).