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The chemistry of Deniges test for adrenaline

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Abstract

The phenol groups in adrenaline are activated, step by step, by interaction with sodium acetate. A phenoxide reacts with mercuric chloride (SN2 reaction), giving an organomercurial intermediate. The second phenoxide ion reacts differently because there is a swift internal reaction. The phenolate is connected with the organometallic chain through a double bond, and its electrodotic property gives rise to a concerted mechanism in which an ortho-benzoquinone is formed and the organometallic chain is broken down. Instead of a normal leaving group, elemental mercury and a chloride ion are formed. The red ortho-quinone obtained is in accordance with the red colour observed in the test. There is an analogue fission in an oxygen-mercury-cyanide chain.

Keywords: Adrenaline; Catechol amine; Mercuric chloride; Organometallic intermediate; Ortho-benzoquinone derivative; Phenoxides

1. Introduction

Adrenaline is normally produced by both the adrenal glands located above the kidneys, and a small number of neurons in the brain, where it acts as neuro transmitter.

Adrenaline is used to treat a number of conditions, including cardiac arrest, anaphylaxis, ,bronchospasm, and low blood sugar.

This hormone is secreted by the body when a person is frightened, angry, or excited, which makes the heart beat faster, prepares the body to react to danger, [1, 2].

This communication is a follow up of our studies on reaction mechanism, [3, 7].

2. Study Method and Process

This is a Theoretical Study involving both Organic and Inorganic Chemistry. It is based on the chemical deportment of reagent and substrate. All is in accordance with the reaction medium and the nature of the oxidizer employed. The steps leading to the final product are entirely commented as well as the reaction mechanism.

3. Antecedents

Adrenaline is a catechol amine. It has been named 3,4,β-trihydroxy-N-methyl-phenethylamine. The IUPAC name is (R)-4-(1-hydroxy-2-methylamino)-ethylbenzene-1,2-diol. The structure is in Figure 1.

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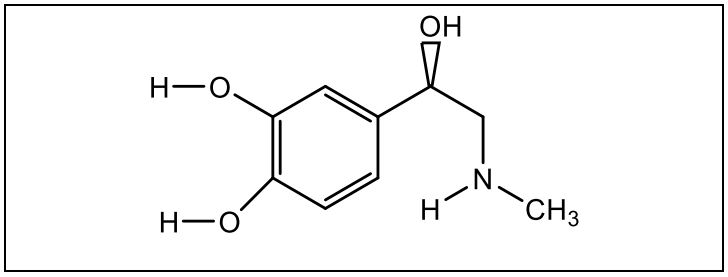


Figure 1 Chemical structure of adrenaline

The test under study is due to Professor Georges Deniges. He published his work in France [8], and was registered in a book on Organic Analysis, [9].

There is a biographical article dedicated to Georges Deniges, [10].

The test is as follows: to 5 ml of dilute aqueous solution of adrenaline, add 5 ml of 10% aqueous solution of sodium acetate and 2 drops of 5% mercuric chloride. A pink or red colour is developed.

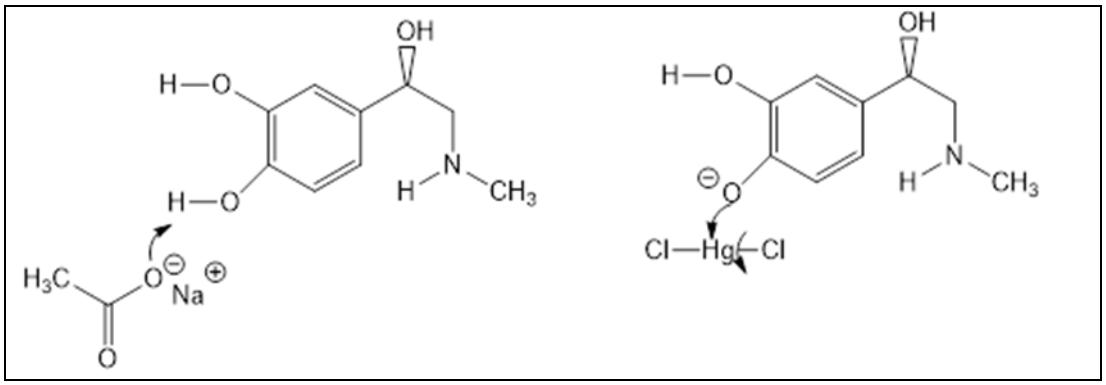
Other tests for adrenaline have been proposed, [11, 12]. For the synthesis of adrenaline see [13, 14].

Some notes on the reagent. Mercuric chloride is unstable in the presence of alkalies and is decomposed to metallic mercury by sunlight in the presence of organic matter. It is readily reduced to mercurous chloride and elemental mercury. Mercuric chloride is also known as corrosive sublimate, [15]. For its preparation and other properties see [16].

4. Discussion

The first step in the test of Deniges for adrenaline is reaction of one phenol group with acetate ion, transfer of a hydrion from phenic acid to the base. Figure 2. Then, the phenoxide reacts with the reagent, mercuric chloride. In this substitution reaction an organometallic intermediate is formed via simultaneous separation of chloride ion.

The other phenol group of the catechol amine reacts with acetate ion forming sodium phenolate. Now there is a completely different reaction, a faster internal reaction, in which the existing organometallic intermediate is destroyed. This takes place via the electrodotic [17. 18] property of the phenoxide which is connected to the organometallic chain by a double bond. A concerted mechanism occurs and an ortho-benzoquinone is formed. These compounds are red [19], and this is in accordance with the red colour observed in the test. The leaving group in this step breaks down into elemental mercury and chloride ion. A similar rupture has been observed in an oxygen-mercury-cyanide chain, [20].



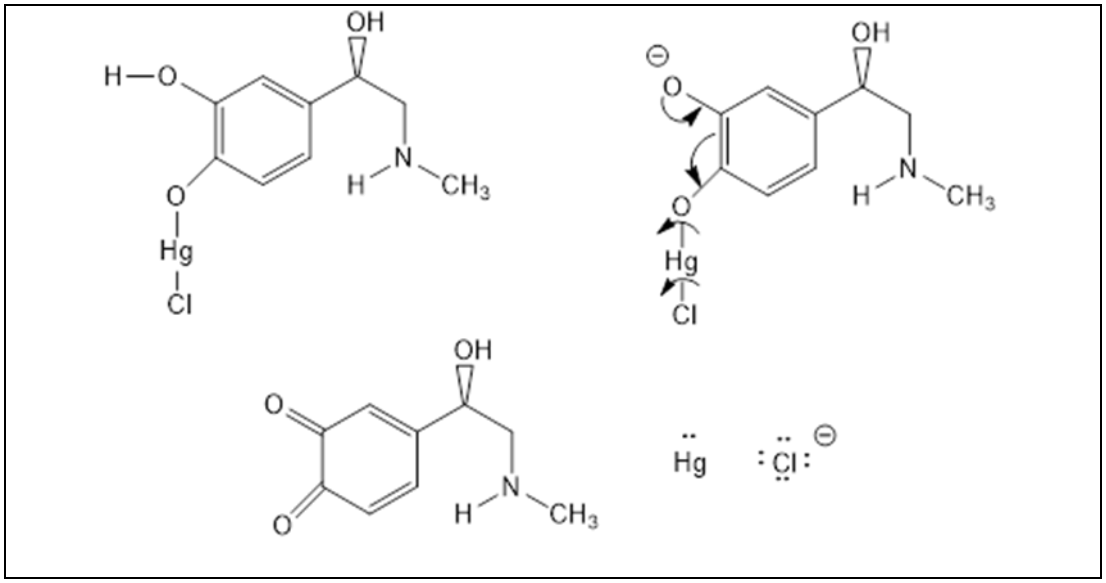


Figure 2 Oxidation of adrenaline by mercuric chloride

5. Conclusion

The reactions in the Deniges test for adrenaline are as follows: The phenol groups in the catechol amine are not activated simultaneously by interaction with sodium acetate due to electrical repulsion between vicinal negative charges. Then there is a bimolecular nucleophilic substitution between a phenoxide and mercuric chloride. An organometallic intermediate is formed with concomitant displacement of chloride ion. The next reaction is different because a rapid internal reaction occurs. A red ortho-benzoquinone is formed through a synchronous mechanism.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

There is no conflict of interest to declare

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