

THE SYNTHESIS OF 1,2-CYCLOHEPTANEDIONE DIOXIME¹

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The successful application of 1,2-cyclohexanedione dioxime (Nioxime) to the analytical chemistry of nickel and palladium by Voter, Banks, and Diehl (1, 2) led naturally to the study of cyclic homologs of this compound as analytical reagents. Preliminary studies of 1,2-cyclopentanedione dioxime and 1,2-cycloheptanedione dioxime indicated that the former was of no value in this connection, but that the latter possessed certain properties that warranted its further consideration. The object of the work reported here was to develop the preparation of 1,2-cycloheptanedione dioxime so as to make it available to the analyst for more extended study and use.

Godchot and Cauquil (3) obtained 1,2-cycloheptanedione dioxime as a derivative of 1,2-cycloheptanedione, which they prepared by oxidation of cycloheptanone with selenium dioxide in an alcoholic medium. No further experimental details are given by them for either the diketone or the dioxime preparation.

Rauh, Smith, Banks, and Diehl (4) have outlined three methods of attack for the preparation of 1,2-cyclohexanedione dioxime, all of which should be applicable here if cycloheptanone is used as the starting material instead of cyclohexanone. The first is the Riley oxidation of cyclohexanone with selenium dioxide, followed by oximation. The second is the method of Jaeger and van Dijk, which was attempted by Rauh, *et al.*, and employed more successfully by Geissman and Schlatter (5). This involves the condensation of cyclohexanone with diethyl oxalate to give cyclohexanoneoxalylic ester, which is then pyrolyzed to cyclohexanonecarboxylic ester. The carboxylic ester is converted into 1,2-cyclohexanedione monoöxime by shaking with alkali and sodium nitrite in the absence of air, followed by acidification. The dioxime is prepared by oximation of the monoöxime. The third procedure consists in the more direct preparation of the monoöxime through the action of 2-ethyl-*n*-hexyl nitrite on cyclohexanone, with subsequent oximation to the dioxime.

The simplicity of the selenium dioxide oxidation method and the fact that the oxidizing reagent can be largely recovered made this procedure at once the most attractive of those considered. We concentrated on this method, therefore, and obtained quite satisfactory yields from it.

Cycloheptanone is available commercially, but at a price that permits only very limited use. Cycloheptanone is easily prepared by the dry distillation of the calcium or thorium salt of suberic acid (6), but the latter material is also prohibitively expensive, in the quantities that were needed. We found it economically advantageous to prepare cycloheptanone by the method of Meerwein (7), as utilized and improved by Kohler, Tishler, Potter, and Thompson (8). This in-

¹ This document is based on work performed in the Ames Laboratory of the Atomic Energy Commission.

volves the ring enlargement of cyclohexanone through the action of diazomethane, which is produced in the reaction vessel by the decomposition of nitrosomethylurethan. Nitrosomethylurethan was prepared from ethyl-N-methylcarbamate by the method of Hartman and Phillips (9); ethyl-N-methylcarbamate was synthesized according to the directions of Hartman and Brethen (10).

The following procedures for the preparation of 1,2-cycloheptanedione and 1,2-cycloheptanedione dioxime were found to give the best yields.

EXPERIMENTAL

1,2-Cycloheptanedione. A solution of 336 g. (3.0 moles) of cycloheptanone in 700 ml. of absolute ethyl alcohol was placed in a 5-liter flask. The latter was fitted with a Glascol mantle, a reflux condenser, and a dropping-funnel. A solution of 333 g. (3.0 moles) of sublimed selenium dioxide, prepared by the method of Riley and Gray (11), in a mixture of 500 ml. of absolute ethyl alcohol and 1600 ml. of 95% ethyl alcohol was placed in the dropping-funnel. The cycloheptanone-alcohol solution was heated to refluxing and then the selenium dioxide solution was added over a period of one and one-quarter hours. The resultant mixture was refluxed for an additional six hours, allowed to stand at room temperature for about eighteen hours, and then filtered. About one liter of alcohol was distilled from the filtrate at atmospheric pressure; the residue was then filtered again, and the distillation continued under reduced pressure. The diketone came over as a deep yellow liquid; yield 340 g. (90%), b.p. 107-109°/17 mm.

1,2-Cycloheptanedione and water were observed to form a constant-boiling mixture; the absolute alcohol-95% alcohol mixture was used as the solvent in order to separate the water from the diketone in the distillation. The use of this mixture materially increased the yield.

The selenium separated by the filtrations (80% or better was recovered in most of the runs) was in suitable condition, after washing and drying, for reoxidation and reuse. That which remained in the reaction mixture through the distillation could not be used again for it was contaminated with organic material that could not be washed out, and attempts to reoxidize it resulted in explosively violent reactions.

Over a period of several weeks, 1,2-cycloheptanedione decomposes and darkens noticeably; consequently it should be used soon after its preparation.

1,2-Cycloheptanedione dioxime. Separate solutions of 139 g. (2.0 moles) of hydroxylamine hydrochloride in 250 ml. of water and 80 g. (2.0 moles) of sodium hydroxide in 150 ml. of water were prepared, cooled below 5°, and mixed in a 3-liter beaker immersed in an ice-salt-water bath. Then 200 ml. of methyl alcohol was added to this solution. A solution of 63 g. (0.50 mole) of 1,2-cycloheptanedione in 400 ml. of methyl alcohol was placed in a 500-ml. separatory funnel suspended above the beaker. When the solution in the beaker had cooled below 0°, the diketone solution was added slowly, with rapid mechanical stirring, over a period of one and one-half hours. The stirring was continued for twenty-four hours, the reaction mixture being allowed to warm to room temperature as the ice in the bath melted. At the end of this period, the ice and salt in the bath were replenished and the reaction mixture was cooled below 0° for two hours. The crystalline precipitate was filtered off, and the filtrate was distilled under reduced pressure until tarry bubbles started to form on the surface of the liquid. The distillation was stopped, and the mixture was extracted hot with two 100-ml. portions of petroleum ether (Skellysolve D, b.p. range 75-120°), which removed the tarry bubbles. The aqueous phase was cooled to 0° and filtered to remove additional dioxime. About 150 ml. of water was added to the filtrate, which was then evaporated to about 350 ml., cooled to 0°, and filtered to remove the final crop of dioxime. On some runs it was found necessary to repeat the hot petroleum ether extraction because of the second appearance of tarry bubbles during the evaporation. The extraction process serves to separate unreacted and decomposed diketone from the reaction mixture,

and a much purer product is obtained. The crystalline product was recrystallized from water; yield 36 g. (46%), m.p. 179–180°.

1,2-Cycloheptanedione dioxime crystallizes from water with one molecule of water; this is lost at 85–87°. Recrystallization from benzene (convenient for the recrystallization of small amounts only), yields the anhydrous dioxime, m.p. 182°.

Anal. (recrystallized from benzene). Calc'd for $C_7H_{12}N_2O_2$: N, 17.94.

Found: N, 17.75, 17.90.

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SUMMARY

A method has been devised for the preparation of 1,2-cycloheptanedione dioxime in amounts large enough to be useful in inorganic analytical application. The scheme involves oxidation of cycloheptanone to 1,2-cycloheptanedione with selenium dioxide, and conversion of the diketone to the dioxime with hydroxylamine. An over-all yield of 40% is obtained.

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