Preparation of Succinic Acid from Maleic Anhydride: A Simple Organic Laboratory Reduction

Most introductory laboratory manuals do not include an example of hydrogenation of a carbon-carbon double bond, even though the reaction is always included in the lecture portion of the course. Manuals that do include hydrogenations normally necessitate the use of rather elaborate equipment or expensive chemicals. In the experiment described in this paper reduction is accomplished in good yield using readily available chemicals and simple equipment in a short (2 hr) experiment.

Maleic anhydride, a commercial compound with U.S. production greater than 200 million pounds a year, is commonly used in several experiments in the beginning organic course. Laboratory manuals often include the isomerization of maleic anhydride to fumaric acid by heating with HCl or by the action of bromine plus light. This latter experiment was described in *this Journal* as a demonstration in 1941.[1] The Diels-Alder reaction of maleic anhydride with a diene such as cyclopentadiene or furan is also found in many laboratory manuals. In recent years *this Journal* has published several interesting experiments utilizing maleic anhydride. These include the use of maleic anhydride in preparing unsaturated polyesters,[2] the photoaddition of maleic anhydride to benzene,[3] and a means for rapidly distinguishing between maleic and fumaric acids.[4]

We wish to add to these experiments cited above, the reduction of maleic to succinic acid. That this reduction is experimentally easy to accomplish was brought to our attention by Professor Emmet Reid in a most interesting account of his first seventy-six years in research.[5] He reported that maleic anhydride could be reduced with zinc and HCl. After a few preliminary trials, the procedure described below was found to give excellent yields, in the 80% range, in the hands of college sophomores during the first weeks of the course.

This simple reduction is not limited to maleic anhydride. Fumaric acid, 2-methyl maleic anhydride (citraconic anhydride) and acetylene dicarboxylic acid are all reduced to the corresponding saturated acids by this basic procedure. We might add that the reaction need not be pictured as one of HCl addition followed by reduction of the active alphachloro carboxylic acid, since zinc with H_2SO_4 or H_3PO_4 can also reduce maleic to succinic acid. The scope of this reaction and a comparison with the Clemmensen reduction is under further study.

Procedure

Weigh 3.0 g (0.046 moles) of 20 or 40 mesh zinc into a 125 or 150 ml Erlenmeyer flask and cover the zinc with 25 ml of deionized water. Heat the water to boiling and obtain 5.0 g (0.043 moles) of maleic anhydride. When the water boils, remove the Erlenmeyer from the heat and *slowly* add the maleic in small portions over a 5–10-min period with occasional swirling of the flask. For the next 5 min allow the flask to stand with occasional swirling. Then slowly add 10 ml of concentrated HCl with constant swirling over a 10-min period. (CAUTION: There is some hydrogen liberated, so the experiment should be done in a hood or with a simple glass funnel vapor trap.) The zinc will be observed to slowly dissolve. As the zinc dissolves, white crystals, succinic acid, may appear. When all the zinc seems dissolved heat the solution until it is clear and then allow it to cool in an ice bath to produce white crystals. Suction filter the cold solution to obtain the crystals, allow them to dry overnight and determine their melting point. The melting point should be in the range of 178–182°C. If a lower or higher melting point is obtained recrystallization from water (~10 ml) may be necessary. Weigh the product and determine the percentage yield.

[1] Grummitt, O., J. CHEM. EDUC., **18,** 477 (1941).
[2] Stevens, M. P., J. CHEM. EDUC., **44,** 160, (1967).
[3] Bozak, R. E. and Alvarez, V. E., J. CHEM. EDUC., **47,** 589, (1970).
[4] Noldan, L. R., and Pollard, B., J. CHEM. EDUC., **50,** 457 (1973).
[5] Reid, E. E., *Chem. Technol.,* 745 (Dec. 1972).

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