Organic Syntheses

A Publication
of Reliable Methods
for the Preparation
of Organic Compounds

Working with Hazardous Chemicals

The procedures in *Organic Syntheses* are intended for use only by persons with proper training in experimental organic chemistry. All hazardous materials should be handled using the standard procedures for work with chemicals described in references such as "Prudent Practices in the Laboratory" (The National Academies Press, Washington, D.C., 2011; the full text can be accessed free of charge at http://www.nap.edu/catalog.php?record_id=12654). All chemical waste should be disposed of in accordance with local regulations. For general guidelines for the management of chemical waste, see Chapter 8 of Prudent Practices.

In some articles in *Organic Syntheses*, chemical-specific hazards are highlighted in red "Caution Notes" within a procedure. It is important to recognize that the absence of a caution note does not imply that no significant hazards are associated with the chemicals involved in that procedure. Prior to performing a reaction, a thorough risk assessment should be carried out that includes a review of the potential hazards associated with each chemical and experimental operation on the scale that is planned for the procedure. Guidelines for carrying out a risk assessment and for analyzing the hazards associated with chemicals can be found in Chapter 4 of Prudent Practices.

The procedures described in *Organic Syntheses* are provided as published and are conducted at one's own risk. *Organic Syntheses, Inc.*, its Editors, and its Board of Directors do not warrant or guarantee the safety of individuals using these procedures and hereby disclaim any liability for any injuries or damages claimed to have resulted from or related in any way to the procedures herein.

These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

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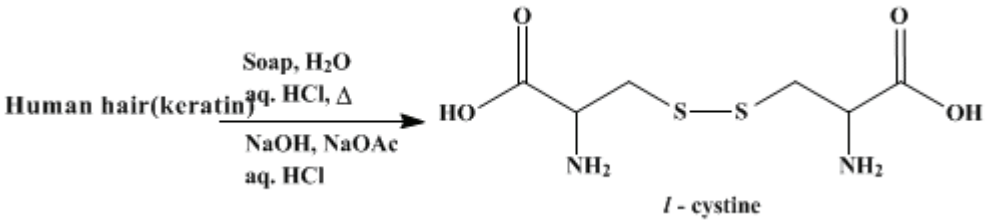
l-CYSTINE



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1. Procedure

Human hair (Note 1) is freed from foreign matter (Note 2), washed well with a lukewarm solution of soap (Note 3), then twice with cold distilled water, and dried. This washing removes the natural oils from the hair (Note 4). Two kilos of the dry, washed hair is pushed into a 12-l. round-bottomed Pyrex flask, and 4 l. of 20 per cent hydrochloric acid (Note 5) is added. An air-cooled reflux condenser, consisting of a wide glass tube, is attached to the flask. The hair is hydrolyzed by heating on the steam bath (Note 6) until the biuret reaction is entirely negative; this requires one hundred twenty to one hundred forty-four hours.

The mixture is filtered hot, and the insoluble residue is washed with distilled water. The total filtrate is now partially neutralized with 300 cc. of 40 per cent sodium hydroxide solution, while the mixture is well stirred and cooled, and then a saturated solution of 3750 g. of crystallized sodium acetate is added. The Congo red test for mineral acid should then be entirely negative. Care must be taken *not to make the solution alkaline* with sodium hydroxide (Note 7). After standing for three days at room temperature, the precipitated cystine is filtered on a suction funnel. This crude material, containing, in addition to the cystine, some "humin" pigments and tyrosine, is dissolved in 3 l. of 3 per cent hydrochloric acid. The solution is filtered and completely decolorized by two to five treatments with 20–25 g. portions of decolorizing carbon (Norite) which has been completely freed from calcium phosphate by boiling with dilute hydrochloric acid and washing with cold water. The filtrate after decolorizing should be water-clear, or at the most only slightly yellow. If it shows more color, the treatment with decolorizing carbon should be carried out again. The solution should finally be filtered once by gravity to remove traces of a solid impurity which is apt to pass through the suction funnel.

The cystine is precipitated from the clear solution by adding a filtered saturated solution of 900–1000 g. of crystallized sodium acetate until the Congo red reaction is negative. After standing five to six hours (Note 8), the cystine is filtered and washed twice with 100–200 cc. portions of hot, distilled water to remove the last traces of tyrosine. By this method the typical colorless hexagonal plates of cystine are obtained. The yield is 100–106 g. (5.0–5.3 per cent of the weight of the starting material).

2. Notes

1. Crude sheep's wool may also be employed, but the yield is not so high (about 2.6 per cent).
2. Hair obtained from barber shops generally contains matches, paper, hair-pins, and cigarette butts, and similar impurities which should be sorted out by hand as completely as possible. The other principal contamination is sand which causes little trouble and need not be removed.
3. A high grade of soap should be employed. Hair kept in hot dilute sodium carbonate solution for one to two hours yields little or no cystine.
4. The oily material may also be removed by extracting with gasoline or benzene, but this procedure involves considerably more labor.
5. The constant-boiling (20 per cent) hydrochloric acid may be prepared by adding 2000 cc. of water to 2700 cc. of concentrated hydrochloric acid (sp. gr. 1.20).

6. The hydrolysis can be carried out in a much shorter time by heating over a flame or on a sand bath, but there is great danger of breaking the flask on account of bumping, and of racemizing the cystine.
7. An alkaline reaction must always be avoided, as even dilute sodium carbonate decomposes cystine. For this reason some have preferred to omit the partial neutralization with sodium hydroxide and to employ sodium acetate only.
8. If the mixture is allowed to stand for a longer time, tyrosine tends to crystallize out with the cystine.

3. Discussion

l-Cystine may be obtained by the hydrolysis of a large number of proteins. However, the keratins are the only common proteins rich enough in cystine to serve as a source for this amino acid. Many investigators have devised methods for its isolation from the hydrolytic products of human hair,[1] wool,[2] horn,[3] nail,[3] feathers,[3] and horse hair.[4] The method of Folin[5] is the basis for most of the others. The procedure described does not claim to give so high a yield as some of those reported in the literature, but is convenient and gives consistent results.

References and Notes

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Appendix
Chemical Abstracts Nomenclature (Collective Index Number); (Registry Number)

gasoline

hydrochloric acid (7647-01-0)

Benzene (71-43-2)

sodium acetate (127-09-3)

sodium hydroxide (1310-73-2)

sodium carbonate (497-19-8)

decolorizing carbon,
decolorizing carbon (Norite) (7782-42-5)

cystine,
L-Cystine (56-89-3)

tyrosine (60-18-4)

calcium phosphate