ACTA CHEMICA SCANDINAVICA 4 (1950) 703–709

Researches on Plant Growth Substances

II. On 1-Napthylacetaldehyde 2 *

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In continuation of our work on l-naphthylacetaldehyde (preceding publication) we have investigated the applicability of the following reactions to the preparation of this aldehyde:

a. Decarboxylation of l-naphthylpyruvic acid.
b. Hydrolysis and decarboxylation of α-benzoylamino-β-l-naphthylacrylic acid.
c. Oxidation of β-l-naphthylalanine with ninhydrin.
d. Heating of barium 1-naphthylacetate with barium formate.
e. Rosenmund reduction of 1-naphthylacetyl chloride.
f. Reduction of ethyl 1-naphthylthiolacetate with Raney nickel.
g. Stephen reduction of 1-naphthylacetonitrile.
h. Hydrolysis of β-1-naphthyl-α,α-dicarbethoxyamino-ethane (β-1-naphthylidene diurethane).
i. Hydrolysis of ethyl 1-naphthylformyl acetate.
j. Oxidation of α-1-naphthylacrylamide with sodium hypochlorite.
k. Reaction of β-1-naphthylacrylic acid with hydrazoic acid.

We did not succeed in reducing the thiol ester (f) or in preparing the aldehyde by the Schmidt reaction (k), which applied to cinnamic acid gives a fair yield of phenylacetaldehyde (Oesterlin [1]). In all other cases 1-naphthylacetaldehyde could be isolated as the semicarbazone, but in most cases the yields were only small. Only by the reactions h and j could good yields of the aldehyde be obtained. The value of these methods, however, is severely dimi-

* This investigation has been supported by grants from *Danmarks tekniske Højskoles teknisk-kemiske Fond* and *Carlsbergfondet.*

nished by the circumstance that the starting materials, *i. e.* β-1-naphthylidene diurethane and β-1-naphthylacrylamide, are not too easily accessible. None of these methods are decidedly superior to the Hershberg reaction described in the preceding paper. The most serious drawback to this reaction is the troublesome transformation of 1-allylnaphthalene into 1-(1-naphthyl)-2,3-propanediol. Therefore we tried to prepare this glycol directly by the reaction of allylnaphthalene with hydrogen peroxide and osmium tetroxide. The desired reaction took place, but the glycol was rather impure and after purification a yield of only ca. 20 % was obtained. It was found that the crude product could be oxidized directly with lead tetraacetate, but without essentially increasing the yield. We also tried to prepare 1-naphthylacetaldehyde by ozonization of 1-allylnaphthalene, but, although 1-naphthylacetaldehyde was formed, the reaction product was very impure and difficult to purify.

As a conclusion we think that only the three methods mentioned can be considered as convenient for preparing 1-naphthylacetaldehyde; using naphthalene as starting material the three routes proceed via the following reactions:

1. Naphthalene $\xrightarrow{85\ \%}$ Bromonaphthalene $\xrightarrow{74\ \%}$ 1-Allylnaphthalene $\xrightarrow{60\ \%}$ 1-(1-Naphthyl)-2,3-propanediol-dibenzoate $\xrightarrow{90\ \%}$ 1-(1-Naphthyl)-2,3-propanediol $\xrightarrow{90\ \%}$ 1-Naphthylacetaldehyde. Over-all yield ca. 33 %.

2. Naphthalene $\xrightarrow{80\ \%}$ Chloromethylnaphthalene $\xrightarrow{72\ \%}$ 1-Naphthylmethylmalonic ester $\xrightarrow{95\ \%}$ 1-Naphthylmethylmalonic dihydrazide $\xrightarrow{90\ \%}$ β-1-Naphthyl-α,α-dicarbethoxyethane $\xrightarrow{88\ \%}$ 1-Naphthylacetaldehyde. Over-all yield ca. 43 %.

3. Naphthalene $\xrightarrow{80\ \%}$ 1-Chloromethylnaphthalene $\xrightarrow{67\ \%}$ 1-Naphthaldehyde $\xrightarrow{58\ \%}$ β-1-Naphthylacrylic acid $\xrightarrow{90\ \%}$ β-1-Naphthylacroyl chloride $\xrightarrow{90\ \%}$ β-1-Naphthylacrylamide $\xrightarrow{78\ \%}$ Ethyl β-1-naphthylvinylcarbamate $\xrightarrow{87\ \%}$ 1-Naphthylacetaldehyde. Over-all yield ca. 16 %.

The third method gives the smallest over-all yield, because of the many intermediate products, but the reagents used are rather cheap and readily accessible, and the operations involved are less delicate than in the first two methods. For preparation on a larger scale, therefore, the last method may well be the most convenient.

EXPERIMENTAL

1-Naphthylpyruvic acid. This compound was prepared either from the corresponding azlactone or from ethyl β-1-naphthyl-β-cyanopyruvate analogous to the preparation of phenylpyruvic acid (Bistrzycki [2]). The latter is the most satisfactory method.

a. A mixture of 7.5 g of 1-naphthaldehyde, 4.7 g of anhydrous sodium acetate, 7.0 g of hippuric acid and 19 ml of acetic anhydride was heated for one hour at 100°. On cooling yellow crystals of 2-phenyl-4-(naphthylmethylene)-oxazolone-(5) separated; these were filtered off and washed with water and ethanol. M. p. 170—171°.

$C_{20}H_{13}O_2N$ (299.3)	Calc.	N	4.68
	Found	»	4.53

Five g of the oxazolone was boiled for 5 hours with 50 ml of 10 % sodium hydroxide. The solution was acidified and the benzoic acid removed by steam distillation. The hot solution was filtered and cooled. The crystals, which separated, were recrystallized from hot water. Yield 1.5 g = 46 %. M. p. 157°.

$C_{13}H_{10}O_3$ (214.2)	Calc.	C	72.85	H	4.67	Eq.wt.	214
	Found	»	72.98	»	4.77	» »	215

b. A mixture of 400 ml of conc. sulphuric acid, 736 ml of water and 16 g of ethyl β-1-naphthyl-β-cyanopyruvate was heated to boiling. As soon as the ester had dissolved, the solution was filtered through glass wool and cooled. 1-Naphthylpyruvic acid separated as almost white crystals. Yield 70 %. Melting point 157° after recrystallization from water.

Decarboxylation of 1-naphthylpyruvic acid. A solution of 1-naphthylpyruvic acid (80 mg) in diethylaniline (3 ml) was heated for 20 min. On addition of hydrochloric acid and steam distillation a distillate was obtained, from which 1-naphthylacetaldehyde was isolated in form of the semicarbazone (m. p. 191°). Yield 50 %.

With quinoline instead of diethylaniline the aldehyde was also obtained (yield 38 %).

Ethyl β-1-naphthyl-β-cyano-pyruvate. This compound was prepared in the same way as the corresponding 2-naphthylderivative [3]. To a solution of 0.85 g of sodium in 10 ml of absolute ethanol 6.1 g of 1-naphthylacetonitrile and 5.4 g of ethyl oxalate was added. The mixture was stirred for about 12 hours at room temperature and was then poured into water. The aqueous solution was extracted twice with ether to remove unreacted nitrile and ethyl oxalate and the pyruvate was precipitated by addition of acid. Recrystallized from benzene the pyruvate was obtained as colourless crystals with melting point 115°. Yield 60 %.

$C_{16}H_{13}O_3N$ (267.3)	Calc.	N	5.24	
	Found	»	5.41	5.08

1-Naphthylacetaldehyde from β-1-naphthyl-α-benzoylamino-acrylic acid. This compound has previously been prepared by Kikkoji [4] by hydrolysis of the azlacetone of 1-naphthaldehyde with 5 % sodium hydroxide.

By heating with diethylaniline, addition of hydrochloric acid and steam distillation a 42 % yield of 1-naphthylacetaldehyde was obtained (isolated as the semicarbazone, m. p. 191°).

1-Naphthylacetaldehyde from β-1-naphthylalanine (*a*-naphthylalanine). This amino acid was first synthesized by Kikkoji by the azlactone method, reducing the acrylic acid with sodium amalgam, and has recently been synthesized from 1-chloromethylnaphthalene by the acetamidomalonic ester method [5]. We have prepared this compound in good yield by at the same time hydrolyzing and reducing the azlactone with hydriodic acid and red phosphorus in the same way as described for phenylalanine (Gillespie and Snyder [6]). Yield 61 %. M. p. 238°.

By addition of ninhydrin (45 mg) to a suspension of β-1-naphthylalanine (25 mg) in water (5 ml) and steam distillation 1-naphthylacetaldehyde was formed (yield 5.4 mg of the semicarbazone, m. p. 190°).

Rosenmund reduction of 1-naphthylacetyl chloride. The acid chloride (Boiling point 174° at 15 mm) was prepared from 1-naphthylacetic acid and thionyl chloride, and was reduced under the usual conditions (*cf.* Mosettig and Mozingo [7]), using a 4 % palladium-barium-sulphate catalyst (2 g to 4 g of the acid chloride in 16 ml of toluene). By steam distillation of the reaction mixture a 35 % yield of 1-naphthylacetaldehyde was obtained.

Ethyl 1-naphthylthiolacetate. To a solution of 3 g of 1-naphthylacetyl chloride in 10 ml of dry ether 2.5 g of lead ethylmercaptide was added. There was a feeble evolution of heat. After standing over night the solution was filtered, the ether evaporated and the residue distilled *in vacuo*. B. p. 137—139° at 0.5 mm. Yield 2.45 g = 73 %. Colourless oil.

$C_{14}H_{16}OS$ (230.3)	Calc.	C	73.01	H	6.13	S 13.92
	Found	»	72.77	»	5.74	» 13.72

We did not succeed in reducing this thiolester with Raney nickel according to the method of Wolfrom and Karabinos [8].

Stephen reduction of 1-naphthylacetonitrile. The reduction was carried out in accordance with the directions for the reduction of β-naphthonitrile [9], and the aldehyde formed isolated by steam distillation of the reaction product. Only 0.5 g of the semicarbazone (m. p. 190—191°) was obtained from 4 g of 1-naphthylacetonitrile. This is presumably due to the sensitivity of 1-naphthylacetaldehyde towards strong acid.

Ethyl 1-naphthylmethylmalonate. This compound was prepared by v. Braun and Nelles [10] by reaction of 1-chloromethylnaphthalene with sodium ethylmalonate. Following these directions we obtained the ester as a viscous oil which crystallized after standing for several weeks and then had m. p. 32°.

1-Naphthylmethylmalonic dihydrazide. This and the following compound were prepared in the same way as the corresponding phenyl derivatives (Curtius [11]): To 50 g of ethyl 1-naphthylmethylmalonate, 25 g of hydrazine hydrate and 5 ml of abs. alcohol were added and the mixture heated for one hour on a water bath. By the reaction the mixture was transformed into a solid mass, which was ground with water, filtered and washed with water, alcohol and ether. Yield 39 g = 91 %. M. p. 215—216°. The compound is very slightly soluble in most solvents. A small portion was recrystallized from ethanol without change of the melting point.

$C_{14}H_{16}O_2N_4$ (272.3)	Calc.	N	20.57
	Found	»	20.38

β-1-Naphthyl-a,a-dicarbethoxyamino-ethane. The dihydrazide (11 g) was dissolved in conc. acetic acid (20 ml), the solution was cooled in ice and sodium nitrite (10.3 g in 20 ml of water) added slowly with stirring. After the addition of the nitrite, 50 ml of water was added, which caused the azide to separate completely as a yellowish solid or semisolid mass. The azide is rather unstable, so we did not isolate it, but after standing for some minutes the acetic acid was removed by decantation and 100 ml of abs. alcohol was added to the azide and the solution boiled on a water bath for three hour. On cooling the diurethane crystallized and was recrystallized from ethyl acetate as white plates, m. p. 206—208°. Yield 11.3 g = 85 %.

$C_{18}H_{22}O_4N_2$ (330.4)	Calc.	N	8.48
	Found	»	8.45

Hydrolysis: A suspension of 2 g of the diurethane in 25 ml of 2 % sulphuric acid was steam distilled. By addition of semicarbazide hydrochloride to the distillate 1.15 g of 1-naphthylacetaldehyde semicarbazone (melting point 191—192°) was obtained, *i. e.* a yield of 87 %.

1-Naphthylacetaldehyde by hydrolysis of ethyl 1-naphthylformylacetate. Wislicenus and Elvert [12] prepared two forms (keto and enol form) of ethyl 1-naphthylformylacetate by condensation of ethyl 1-naphthylacetate with ethyl formate. We have prepared these two forms and transformed both into 1-naphthylacetaldehyde by boiling with 90 % acetic acid for 4 hours, removing of the acetic acid *in vacuo* and steam distilling. Yield 70 % of 1-naphthylacetaldehyde, isolated as the semicarbazone (melting point 191—192°). By hydrolysis with 2 % sulphuric acid instead of acetic acid the yields were much smaller (12 and 8 %).

β-1-Naphthylacrylic acid chloride. Naphthylacrylic acid (10 g) was suspended in benzene (25 ml), pure thionyl chloride (5 ml) was added, and the mixture heated cautiously untill the acid had dissolved (5 min.) Benzene and excess of thionyl chloride were removed in vacuo. The residue crystallized spontaneously and was recrystallized from petroleum ether. Yield 90 %. M. p. 52°.

$C_{15}H_9OCl$ (218.7)	Calc.	C	72.06	H	4.18	Cl	16.37
	Found	»	71.93	»	3.95	»	16.28

β-1-Naphthylacrylic amide. The acid chloride was melted and poured into 200 ml of aqueous ammonia. The suspension was heated for ½ hour at 100°, cooled and filtered. Yield 8 g. M. p. 172—173° after recrystallization from water. From the mother liquor 1 g of naphthylacrylic acid could be recovered, making the yield of amide 90 %.

$C_{13}H_{11}ON$ (197.2)	Calc.	C	79.16	H	5.62	N	7.10
	Found	»	79.20	»	5.43	»	7.16

Methyl β-1-naphthylvinylcarbamate. The amide was dissolved in methanol (80 ml) by warming, and the equivalent amount of 1 N sodium hypochlorite solution was added in one portion. After 5 minutes the solution began to deposit crystals. and was then cooled

in ice. The crystals were filtered and recrystallized from methanol. Yield 6.2 g = 78 %. M. p. 120–121°.

$C_{14}H_{13}O_2N$ (227.3)	Calc.	N	6.16
	Found	»	6.09

1-Naphthylacetaldehyde by hydrolysis of the urethane: 4.3 g were dissolved in 30 ml of warm ethanol, 7 ml of 6 N oxalic acid was added and the solution distilled with steam. The distillate was extracted with ether, the ether solution dried with sodium sulphate and evaporated in vacuo at room temperature. The residue crystallized in colourless needles. M. p. 34°. Yield 2.6 g = 81 %.

Oxidation of 1-allylnaphthalene with hydrogen peroxide. To a solution of 5 g 1-allylnaphthalene in 50 ml of methanol were added 3.4 ml of 30 % hydrogen peroxide and 0.40 ml of a solution of osmium tetroxide, containing 0.1 g OsO_4 in 9 ml of *tert.*-butanol. The solution was left for 2 days in ice box and then for 12 hours at room temperature. Most of the methanol was removed *in vacuo*, and water was added, which caused a green semisolid precipitate to separate. By repeated recrystallizations from water this gave 1.2 g of 1-(1-naphthyl)-2,3-propanediol with melting point 111° = 20 %.

$C_{13}H_{14}O_2$ (202.2)	Calc.	C	77.21	H	6.98
	Found	»	77.66	»	7.10

Other experiments with acetic acid or acetic acid + acetic anhydride as solvents gave no better yield.

SUMMARY

Several reactions were investigated with a view to preparing 1-naphthylacetaldehyde. From most of the reactions some 1-naphthylacetaldehyde was obtained, but only two of them are suited for preparative purposes, *viz.* the hydrolysis of β-1-naphthyl-α, α-dicarbethoxyamino-ethane and the Hofmann degradation of β-1-naphthylacrylic amide.

The following new compounds are described: 1-Naphthylpyruvic acid, ethyl β-1-naphthyl-β-cyano-pyruvate, ethyl 1-naphthylthiolacetate, 1-naphthylmethylmalonic dihydrazide, β-1-naphthyl-α,α-dicarbethoxyamino-ethane, β-1-naphthylacrylic acid chloride, β-1-naphthylacrylic amide, methyl β-1-naphthylvinylcarbamate.

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Received March 16, 1950.