

BRIEF
COMMUNICATIONS

Synthesis of 4-Vinylmorpholine Based on Acetylene

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Abstract— It has been shown that from the possible methods for the synthesis of 4-vinylmorpholine, the vinylation of morpholine with acetylene remains acceptable. A technologically accessible method for vinylation of morpholine with acetylene at atmospheric pressure was developed.

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The main method of synthesizing 4-vinylmorpholine is the direct vinylation of morpholine at high pressures and elevated temperatures [1], where caustic alkalis are used as catalysts.

In order to synthesize 4-vinylmorpholine based on 4-(2-chloroethyl) morpholine [2], the dehydrochlorination of the latter in alcohol solutions of alkalis was studied in [3], since it can lead to the production of 4-vinylmorpholine without the use of explosive acetylene.

However, contrary to expectations, instead of 4-vinylmorpholine [2], corresponding ethers were formed [3].

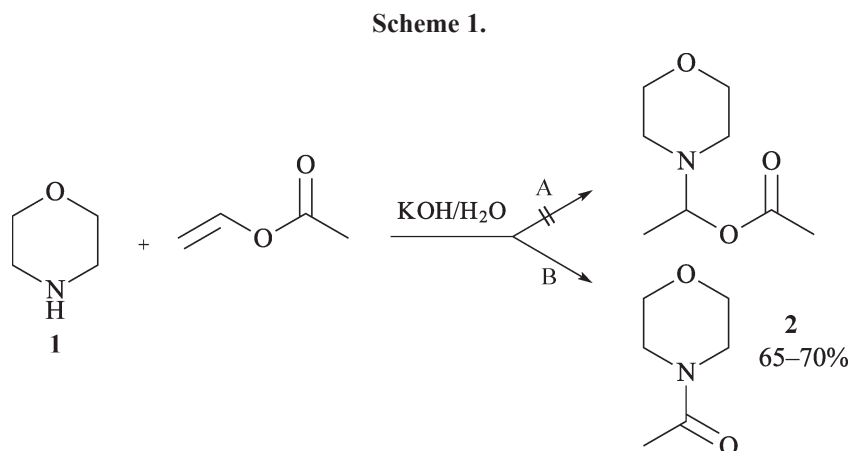
The addition of vinyl esters to compounds containing the NH group, followed by pyrolysis of the adducts

formed, is of interest as one of the methods for the preparation of *N*-vinyl amine derivatives [4, 5].

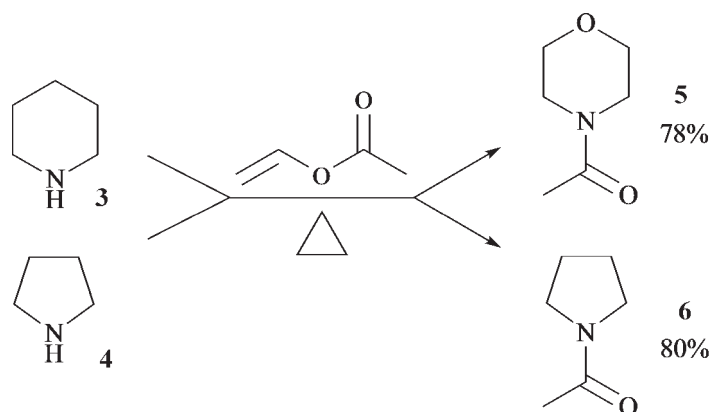
In this report, an attempt has been made to add morpholine (**1**) to vinyl acetate (VA) in a water–acetone medium with potassium hydroxide as a catalyst. It turned out that morpholine (**1**) under these conditions at a temperature of 20–25°C very easily reacts with vinyl acetate (Scheme 1).

Spectral studies (IR, ¹H NMR) of the product obtained showed that the reaction of morpholine with vinyl acetate proceeds along path B to form the corresponding 4-acetylmorpholine (**2**).

The product formed along path A, i.e., the addition



Scheme 2.



of morpholine to the α -hydrocarbon atom of the vinyl group of vinyl acetate, was not detected. The selectivity of the reaction of morpholine with vinyl acetate in the temperature range 0–25°C does not change, although with an increase in temperature to 50°C there is a tendency to decrease the yield of 4-acetylmorpholine (2) due to side processes, mainly as a result of resin formation.

It should be noted that 4-acetylmorpholine (2) is obtained by this method even in the absence of a base, i.e., the basicity of morpholine (1) (pK_a 8.3) is sufficient to initiate this reaction.

When studying the reaction of vinyl acetate with other cyclic amines, piperidine (3) (pK_a 11.2) and pyrrolidine (4) (pK_a 11.3) (Scheme 2), it was found that changes in the selectivity of the acetylation reactions are not observed.

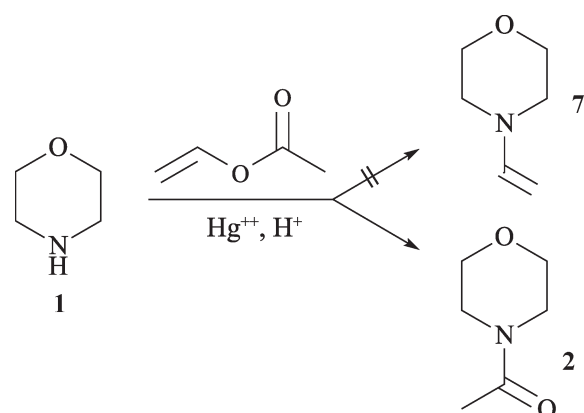
It should be noted that this method of synthesis of acetylaminos 2, 5, 6 allows replacing the use of the corresponding anhydrides or acid chlorides.

It is known that mercury acetate in the presence of strong acids catalyzes the vinyl exchange reaction between vinyl ester (vinyl acetate) and NH-derivatives of heterocyclic compounds [6].

In connection with this fact, a scheme for the vinylation of morpholine (1) with vinyl acetate in the presence of mercuric acetate was considered. The first experiments showed that the morpholine/ $Hg(OAc)_2$ /VA system leads to the predominant formation of 4-acetylmorpholine (2) (Scheme 3).

The study of the reaction of morpholine (1) with vinyl butyl ether also proved to be unsuccessful: the final reaction products were polymerized.

Scheme 3.



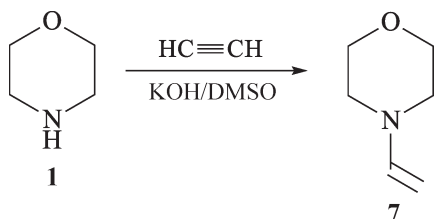
Thus, in the case under consideration, the basicity of the amines is of the greatest importance. Cyclic amines 1, 3, 4 compared with aromatic amines (pyrrole, pK_a 0.27, pyrazole pK_a 2.53, 1,2,4-triazole, pK_a 1.17) react with vinyl acetate in the absence of carbonyl catalysts, and with aromatic amines in the presence of catalysts along the α -carbon atom of the vinyl group [5, 6].

The above data indicate that the most successful way of synthesizing 4-vinylmorpholine (7) is vinylation with acetylene [1].

As is known, the introduction of NH-containing amines in the process of vinylation is not carried out because of the need to use acetylene under pressure and at high temperature. As a rule, those syntheses based on acetylene, which are carried out at atmospheric or near atmospheric pressure (production of vinyl chloride, vinyl acetate, etc.) are widely used in industry.

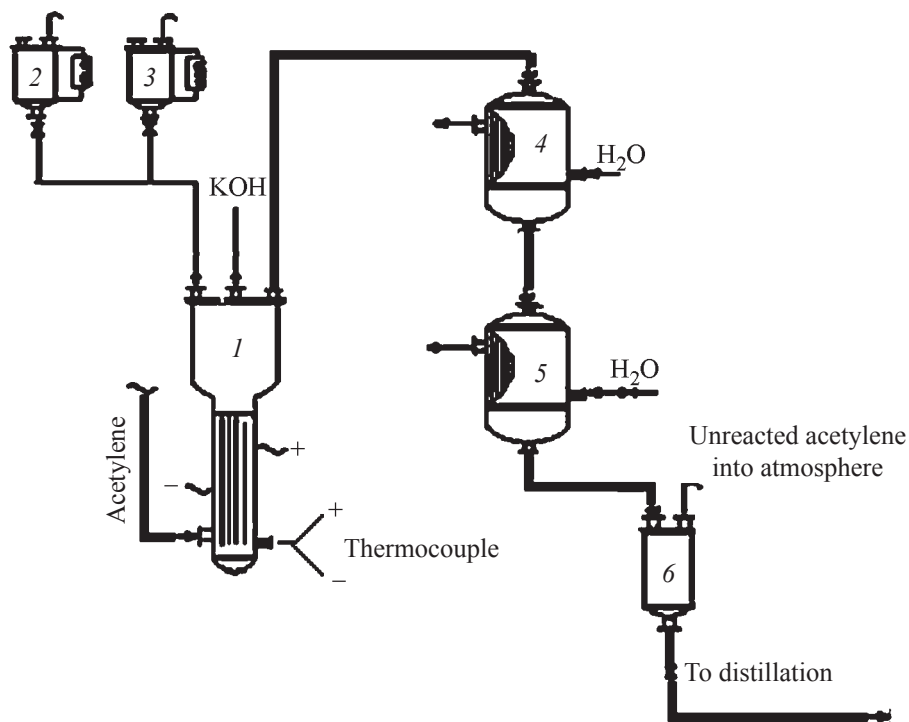
Based on the foregoing, technologically acceptable conditions for the preparation of 4-vinylmorpholine **7** at atmospheric pressure have been developed.

To simplify the synthesis of 4-vinylmorpholine **7**, a method for vinylation of morpholine **1** with acetylene at atmospheric pressure was developed. The method consists in the reaction of morpholine **1** with acetylene in a solution of dimethylsulfoxide (DMSO) in the presence of potassium hydroxide in a continuous plant according to scheme:



Experimentally found conditions for the synthesis of 4-vinylmorpholine **7**: a temperature of 100–125°C, a concentration of caustic potassium of 8–10% (in terms of morpholine), an acetylene flow rate of 350–500 L/(L_{cat.sol} h).

Technological scheme for the synthesis of 4-vinylmorpholine is shown in the figure, the yield and the reaction conditions for the vinylation of morpholine with acetylene is listed in the table.



Technological scheme for the synthesis of 4-vinylmorpholine **7**. (1) Reactor; (2) morpholine measure; (3) dimeric sulfoxide measure; (4,5) capacitors; (6) raw material receiver.

EXPERIMENTAL

IR spectra were recorded on a Thermo Nicoletion Nexus spectrometer in vaseline oil. ¹H and ¹³C NMR spectra of synthesized compounds were recorded on a Varian Mercury 300 VX spectrometer (300 and 75 MHz, respectively) at a temperature of 300 K in a solution of DMSO-*d*₆-CCl₄ (1 : 3) (TMS internal standard). Elemental analysis is performed on a Eurovector EA 3000 device.

4-Acetylmorpholine (2). In a 100 mL round-bottomed flask (cooled in a water bath) equipped with a reflux condenser and a thermometer, 9.02 g (0.1 mole) of morpholine was added and 46.7 g (0.5 moles) of BA was added dropwise at such a rate that the temperature of the reaction mixture did not exceed 25°C. After feeding the vinyl acetate, the reaction mixture was left overnight. The next day, excess VA was distilled, and the remainder was distilled in a vacuum. Yield of 4-acetylmorpholine (**2**) 8.02 g (62%), bp 92–98°C (1 mmHg), *n*_D²⁰ 1.4760. IR spectrum, *v*, cm⁻¹: 1100 (C–O–C), 1640 (C=O). ¹H NMR spectra, *δ*, ppm (*J*, Hz): 1.83 s (3H, CH₃), 3.18–3.23 m (2H, O–CH₂), 3.28–3.33 m (2H, O–CH₂), 3.35–3.42 m (4H, 2N–CH₂). ¹³C NMR spectra, *δ*, ppm: 20.42 (CH₃), 45.93 [N–(CH₂)₂], 65.97 [O–(CH₂)₂], 167.35 (C=O).

Vinylation of 4-morpholine **7** with acetylene at atmospheric pressure

$T, ^\circ\text{C}$	Amount of KOH, % by weight of morpholine	Consumption of acetylene, L/(L _{cat.sol} h)	Discharge of condensate, g L ⁻¹ h ⁻¹ (content of 4-vinylmorpholine, %, in condensate)
100	8	350	15–20 (30)
110	8	400	25–30 (25)
115	10	450	20–25 (20)
125	10	500	30–35 (15)

Found, %: C 47.31, H 7.48, N 9.28. C₆H₁₁NO. Calculated, %: C, 47.05. H, 7.18, N, 9.15.

1-Acetylpiperidine (5). It was prepared in a manner similar to the previous example from 8.5 g (0.1 mole) piperidine and 46.7 g (0.5 mole) VA. Yield of 1-acetylpiperidine **5** 9.9 g (78%), bp 99°C (3 mmHg), n_D^{20} 1.4750. IR spectrum, ν , cm⁻¹: 1650 (C=O). ¹H NMR spectra, δ , ppm (J , Hz): 1.44–1.68 m (6H, 3CH₂), 1.96 s (3H, CH₃), 3.36–3.44 m [4H, N-(CH₂)]. ¹³C NMR spectra, δ ppm: 20.7 (CH₃), 24.0 (CH₂), 25.0 (CH₂), 25.9 (CH₂), 41.5 (N-CH₂), 46.5 (N-CH₂), 166.7 (C=O). Found, %: C 66.31, H 10.00, N 11.28. C₇H₁₃NO. Calculated, %: C 66.14, H 10.23, N 11.02.

1-Acetylpyrrolidine (6). Pyrrolidine [7.1 g (0.1 mol)] and VA [46.7 g (0.5 mol)] were obtained in a manner analogous to the previous example. Yield of 1-acetylpyrrolidine 9.0 g (80%), bp 80°C (3 mmHg), n_D^{20} 1.4740. IR spectrum, ν , cm⁻¹: 1640 (C=O). ¹H NMR spectra, δ , ppm (J , Hz): 1.78–1.88 (2H, CH₂), 1.88–1.99 m (2H, CH₂), 1.92 s (3H, CH₃), 3.30 t (2H, J 6.8, NCH₂), 3.41 t (2H, J 6.7, NCH₂). ¹³C NMR spectra, δ , ppm: 21.8 (CH₃), 24.0 (CH₂), 25.6 (CH₂), 47.7 (N-CH₂), 46.4 (N-CH₂), 166.9 (C=O). Found, %: C, 63.51; H, 9.96; N, 12.11. C₆H₁₁NO. Calculated, %: C 63.71, H 9.73, N 12.38.

4-Vinylmorpholine (7). Morpholine **1** (100 mL) from measuring point 2 and dimethyl sulfoxide from measuring point 3 containing 8–10% of potassium hydroxide (in terms of morpholine) were charged to the bottom of the reactor **1** with a volume of 300 mL. The mixture was heated to 100–125°C and acetylene was passed through it at a rate of 350–500 L/(L_{cat.sol} h). During the reaction at the top of the reactor, the leaving vapors [unreacted morpholine **1** and 4-vinylmorpholine **7** with excess acetylene stream were condensed through condensers **4** and **5**. The condensate discharged into the raw material

receiver **6**, and uncondensed gases, mainly acetylene, were released into atmosphere.

The yield and reaction conditions for the morpholine vinylation with acetylene are given in the table. Bp 103–110°C (680 mmHg), n_D^{20} 1.4965 [1]. IR spectrum, ν , cm⁻¹: 1100 (C–O–C), 1640 (C=O). ¹H NMR spectra, δ , ppm (J , Hz): 2.47 m (4H, O–CH₂), 3.66 m (4H, N–CH₂), 4.52 d (1H, J 15.6, =CH₂), 5.35 d (1H, J 8.8, =CH₂), 6.55 d.d (1H, J 15, 6.88 =CH).

CONCLUSIONS

It has been shown that earlier attempts to synthesize 4-vinylmorpholine without the use of acetylene have not been successful. Technologically more acceptable conditions for the vinylation of morpholine with acetylene at atmospheric pressure in a solution of dimethylsulfoxide in the presence of caustic potassium were developed.

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