Polymer (*Korea*) Published by The Polymer Society of Korea
Vol. 5, No. 6 1981.
Printed in the Republic of Korea

2-Methoxy-1, 3-oxazolidin-4-one의 합성에 관한 연구

김동영, 홍성일, 최남석*, 심정섭**

서울대학교 공과대학 섬유공학과
*럭키중앙연구소
**서울대학교 공과대학 공업화학과

(1981년 11월 12일 접수)

Synthesis and Characterization of 2-Methoxy-1, 3-oxazolidin-4-one

Dong-Yung Kim, Sung-Il Hong, Nam-Suk Choi* and Jyong-Sup Shim**

Dept. of Textile Eng., Seoul National Univ., Seoul 151.
**LUCKY Central Research Institute, Dae-Duk, Korea.*
***Dept. of Chemical Technology, Seoul National Univ., Seoul* 151.*

(Received November 12, 1981)

Abstract : 2-Methoxy-1, 3-oxazolidin-4-one was prepared by the reaction of glycolic amide with excess trimethyl orthoformate in the presence of acidic catalyst. Its structure was identified by IR and NMR spectral analysis. The ring-opening polymerization mas attempted with strong base via the activated monomer mechanism. It was however found that 2-methoxy-1, 3-oxazolidin-4-one was sensitive to strong base and decomposed thermally generating methanol. This was confirmed by DTA and TGA as well as actual trapping of methanol under high vacuum.

요약 : Glycolic Amide와 과량의 trimethyl orthoformate를 산촉매를 사용하여 100°C에서 6~7시간 반응시켜 2-methoxy-1, 3-oxazolidin-4-one을 합성하였다. (수율 약 40% ; m.p. 45~46°C)

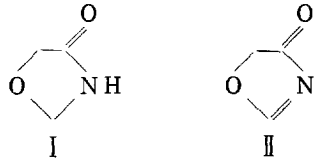
이 화합물의 구조를 IR과 NMR분석에 의하여 확인하였다. 특히 2-methoxy-1, 3-oxazolidin-4-one은 KOH, K_2CO_3, n-BuLi등의 강염기와 50~80°C에서 반응시켰을 때 쉽게 분해되는 경향이 있었으며 중합이 진행되지 않았다. 또 촉매없이 120°C이상의 온도에서는 methanol을 생성하며 분해반응을 일으켰다. 이에 관하여는 DTA, TGA 및 여러조건 아래에서 실제의 열분해 반응에 의해서 검토되었다.

I. INTRODUCTION

Polyamides of various kind have been synesized since Carother's earlier works on polycondensation. Recently, a high molecular weight polyamide of cyclic lactam, commonly known as Nylon 4, has been prepared from 2-pyrrolidone via ring-opening polymerization.[1]

Saegusa and co-workers have shown that 2-oxazoline, as a new type of 5-membered heterocyclic compound, can be successfully polymerized to give a high molecular weight linear polymer via cationic ring cleavage at the 1—5 bond followed by isomerization to amide.[2~5]

Two new types of 5-membered heterocyclic compounds containing an oxygen atom in addition to nitrogen are chosen for comparative studies for ring-opening polymerization for 2-pyrrolidone and 2-oxazoline. They are 1,3-oxazolidin-4-one (Ⅰ) and 2-oxazolin-4-one (Ⅱ), which have identical ring structures with 2-pyrrolidone and 2-oxazoline except that the carbon atoms at 4-position are replaced with oxygen atom in both compounds:



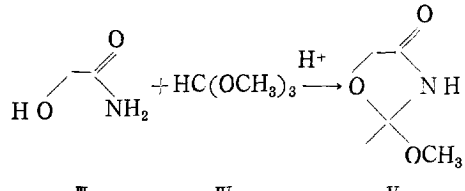
Ⅰ Ⅱ

The syntheses of 1,3-oxazolidin-4-one and 2-oxazolin-4-one have not been reported in the literature up to the present study. If they can be synthesized, 1,3-oxazolidin-4-one may be polymerized according to amide bond opening mechanism of lactams, while 2-oxazolin-4-one may be polymerized to give poly(N-formylglycine) according to isomerization polymerization mechanism.

Some derivatives of the parent compounds mentioned above have been reported. For instance, 2-methyl-1,3-oxazolin-4-one in the form of HBr salt was prepared from the reaction of acetamide with bromoacetyl bromide in benzene.[6]

2-Methoxy-1,3-oxazolidin-4-one(Ⅴ) was prepared by Compernolle and coworkers for the first time in 1975.[7] They prepared it by the photolytic ring expansion of 2,4-azetidindione.

As will be shown in the present work, we were able to prepare it by the reaction of glycolic amide (Ⅲ) with excess trimethyl orthoformate (Ⅳ) in the presence of acidic catalyst. Orthoesters have often been used in the syntheses of heterocyclic compounds having bifunctional end groups with active hydrogens.



Ⅲ Ⅳ Ⅴ

2-Methoxy-1,3-oxazolidin-4-one was sensitive to strong base and decomposed thermally generating methanol. This was confirmed by DTA and TGA as well as actual trapping of methanol under high vacuum.

The purposes of present study are: (1) to prepare 2-methoxy-1,3-oxazolidin-4-one: (2) to investigate the possibility to synthesizing unsubstituted 2-oxazolin-4-one: (3) to investigate the ring-opening polymerization of 2-methoxy-1,3-oxazolidin-4-one.

Ⅱ. EXPERIMENTAL

Ⅱ-1. Reagents

Glycolic amide(m.p. 120°C) was prepared from glycolic acid by two step reaction. Ethyl glycolate(b.p. 59~61°C, 13mmHg) was prepared according to the simple esterification procedure followed by amidation with ammonia. Extra pure grade of reagents were used for trimethyl orthoformate and other without further purification.

Ⅱ-2. Preparation of 2-Methoxy-1,3-oxazolidin-4-one

A mixture of 75g(1mol) of glycolic amide and 318.4g(3mol) of trimethyl orthoformate

containing 0.98g(1mol%) of conc. sulfuric acid as catalyst was added to the 500-ml. round bottom flask equipped with simple distillation apparatus. The mixture was heated for 6 to 7 hours and the bath temp. was kept below 100°C. Methanol was distilled off during the entire course of the reaction.

At the end of reaction, the reaction mixture was cooled, neutralized with sodium carbonate or sodium bicarbonate, and filtered off. Excess trimethyl orthoformate was removed under reduced pressure. A dark brown syrup was obtained. The brown syrup was extracted with ether several times or by use of liquid-liquid extractor overnight, and then the extracted carefully without heating under the reduced pressure. White solid was precipitated. The resulting white precipitate was recrystallized from the mixture of ethyl ether and a small amount of ethyl acetate at −5°C. The structure of product was confirmed by IR and NMR. Yield ca. 40% ; m.p. 45∼46°C.

Ⅱ-3. Spectrophotometry

The Infrared Spectrophotometer(Perkin-Elmer Model 735B) was used for the IR spectral analysis. The Nuclear Magnetic Resonance Spectrophotometer(Varian EM-360, 60 MHz) was used for the NMR analysis. DMSO-d_6 was used as a solvent.

Ⅱ-4. Thermal Analysis

The TRACOR R L STONE Thermal Analyzer was used for the differential thermal analysis (DTA), and the CHAN RG Electrobalance for the thermogravimetric analysis (TGA). Both experiments were carried out under nitrogen atmosphere with heating rate of 5°C/min. for DTA and 8°C/min. for TGA, respectively.

Ⅲ. RESULTS & DISCUSSION

Ⅲ-1. Cyclization with Orthoesters

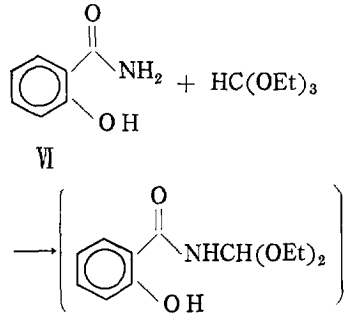
Orthoesters have been used in many cyclization reactions in the presence of acid catalyst. For the ring closure reactions, the starting materials must have two functional groups such as hydroxyl, amine, or amide groups etc., which contain active hydrogens.

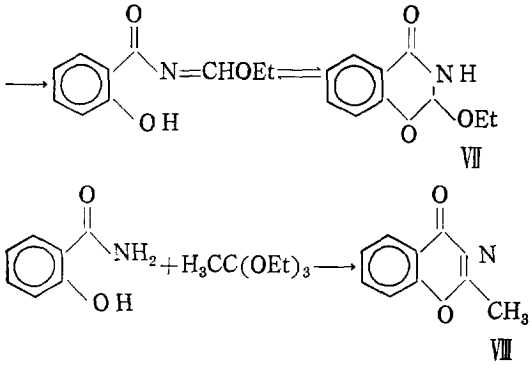
Baganz[8] prepared 2-methoxy-1,3-dioxolane from the reaction of ethylene glycol and excess trimethyl orthoformate.

It was also reported by Kröger et al[9] that 1,4-dimethyl-1,2,4-triazolone-(5) could be synthesized from the reaction of 2,4-dimethylsemicabazide with triethyl orthoformate. In this case the double bond between carbon and nitrogen was formed as a result of elimination of three mols of ethanol.

There are some exception to above ring closure reactions as reported by Irie et al. for the reaction of salicylamide (Ⅵ) and orthoesters.[10] They demonstrated that the major product of reaction between salicyl amide and orthoacetate was clearly 3-methyl-4H,1,3-benzoxazolin-4-one(Ⅷ) but in case of reaction between salicyl amide and orthoformate, in stead of orthoacetate, the major product was Ⅶ. The authors suggested the different reaction mechanisms for the reaction with orthoacetate and orthoformate.

In the present study we tried to obtain unsub-





stituted 2-oxazolin-4-one from the reaction of trimethyl orthofomate with glycolic amide in the presence of acid catalyst, but we could only obtain 2-methoxy-1, 3-oxazolidin-4-one similar to the Irie's result.

Ⅲ-2. Reaction Conditions on the Syntheses

It was very difficult to optimize or follow the reaction kinetics because of the poor solubility of glycolic amide in organic solvents. All attempts to carry out the reaction in organic solvent systems were unsuccessful. Therefore, the reaction was carried out in excess trimethyl orthoformate below 100°C.

The reaction temperature was carefully controlled so as not to exceed 100°C in order to prevent the loss of trimethyl orthoformate at its boilling point (101~102°C). It was also confirmed that the product, 2-methoxy-1, 3-oxazolidin-4-one, showed that endency to decompose over 100°C during the reaction. This will be discussed in detail later.

In order to obtain the crystals of 2-methoxy-1, 3-oxazolidin-4-one, it was important to keep the solution at low temp., e.g. in a refregerator, due to its low melting point and good solubility in common organic solvents. The product was obtained in the form of melt at room temperature. Therefore, it was necessary to remove impurities by repeated washing followed by careful recrystallization.

Ⅲ-3. Spectroscopic Analysis

IR spectrum of 2-methoxy-1, 3-oxazolidin-4-one is shown in Fig.1. Strong amide I band at 1, 720cm^{-1} is a suggestion of cyclic structure of the reaction produc. Amide Ⅱ band is shifted to lower frequency ot 1, 450cm^{-1}. In general, amide Ⅱ band in open chain secondary amide, which is due to mainly N—H mixed with C—N, represents transamide structure. In the present case, amide Ⅱ band appears to be weak and shifted to a lower frequency in cis-amide region(e.g. small ring lactams).[11,12]

In Fig.2., NMR spectrum of 2-methoxy-1, 3-oxazolidin-4-one is shown. All peaks are singlet δ9.3(1H, >NH) ; δ6.0(1H, >CH), δ4.15(2H, $>CH_2$) ; δ3.25(3H, $-OCH_3$).

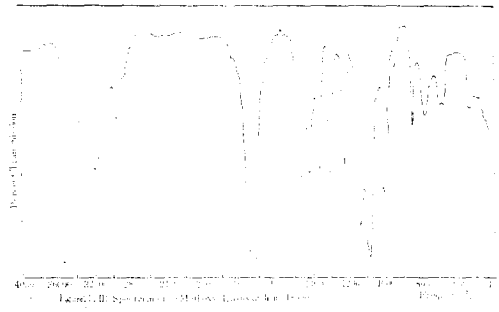


Fig. 1. IP Spectrum of 2-methoxy-1, 3-oxazolidin-4-one.

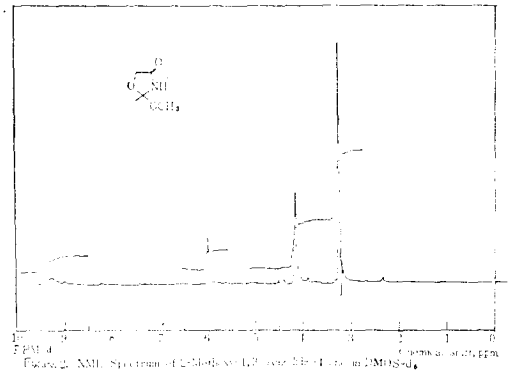


Fig. 2. NMR Spectrum of 2-methoxy-1, 3-oxazolidi-4-none in DMSO-d_6.

Ⅲ-4. Thermal Analysis

Fig.3 and 4 show the DTA and the TGA, respectively, for 2-methoxy-1, 3-oxazolidin-4-one run in nitrogen atmosphere. In the DTA curve, there were three endotherms and large exthotherm at higher temp. range. The first sharp endotherm peak at 46°C region corresponds the melting. The broad peak of the second endotherm at 100°C region seems to result from

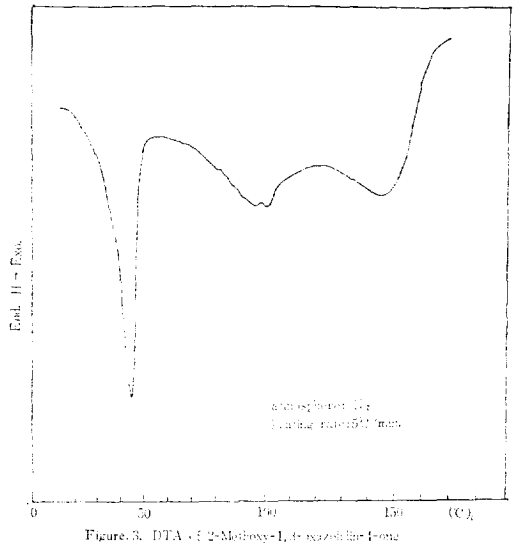


Figure. 3. DTA of 2-Methoxy-1, 3-oxazolidin-4-one

Fig. 3. DTA of 2-methoxy-1, 3-oxazolidin-4-one.

the evaporation of moisture entrapped in crystals.

The third endotherm. which overlaps with the second one may be due to the decomposition to volatile materilas.

When the pyrolysis of 2-methoxy-1, 3-oxazolidin-4-one was carried out at 120~140°C under high vacuum, methanol was entrapped in dry-ice/acetone trap. The elimination of methanol (volatile component) also evident from the TGA curve as shown in Fig.5. It is also evident from Fig.5 that the moisture is lost initially at 100°C, and a large and rapid weight loss is observed at 120°C.

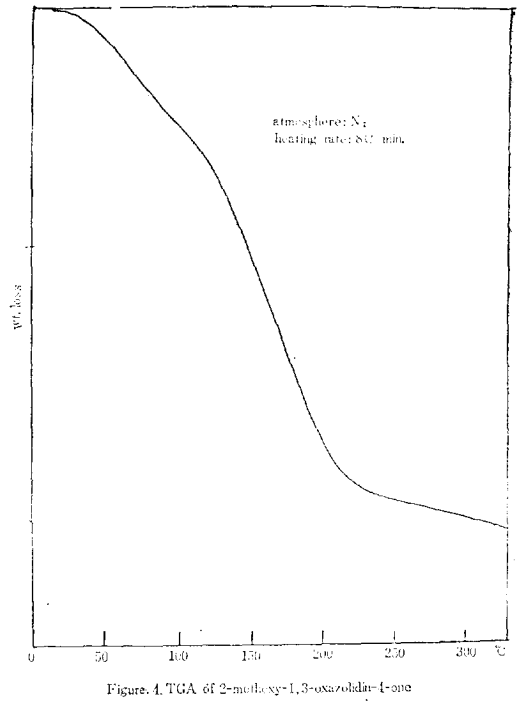


Figure. 4. TGA of 2-methoxy-1, 3-oxazolidin-4-one

Fig. 4. TGA of 2-methoxy-1, 3-oxazolidin-4-one.

Ⅲ-5. Polymerization

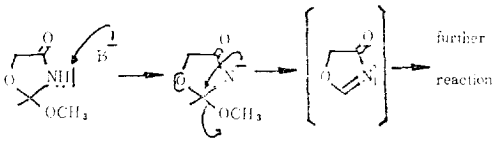
Attemptions were made to polymerize 2-methoxy-1, 3-oxazolidin-4-one using several different methods. Strong bases were used as catalysts. In all cases, however, the ring-opening polymerization with base catalysts were unsuccessful due to the intramolecular side reaction.

It was found that the reactions with base such as potassium hydroxide, potassium carbonate, n-butyl lithium (15% solution in hexane), etc., under inert atmosphere has led to almost instant decomposition of the monomer presumably due to the instability of the resulting active anion.

When the same reaction was carried out under high vacuum at 50~60°C with K_2CO_3 or n-BuLi, the reaction mixture solidified attaining slight yellowish color after 1 hour, but decomposed eventually after prolonged reaction time. The removal of methanol was observed under

the high vacuum.

These results indicate the formation of a transient active molecule, 2-oxazoiln-4-one from the starting material. The plausible mechanism for the reaction is shown in Scheme 1. These results are in good agreement with the pyrolysis experiment of 2-methoxy-1, 3-oxazolidin-4-one as described in Ⅲ-4.



Scheme 1.

In conclusion, the preliminary study of reaction of 2-methoxy-1, 3-oxazolidin-4-one with strong bases resulted in formation, a transient compound, of 2-oxazolin-4-one, the compound that we have originally sought after. It will undoubtly require further study for isolation and characterrization of 2-oxazolin-4-one as well as the planned syntheses of polyglycine via N-formyl glycine route.

Ⅳ. CONCLUSION

2-methoxy-1, 3-oxazolidin-4-one was prepared from the reaction of glycolic amide with excess trimethyl orthoformate in the presence of acid catalyst. Yield ca. 40% ; m.p. 45~46°C.

This compound was sensitive to strong base and decomposed thermally generating methanol. This was confirmed by DTA and TGA as well as actual trapping of methanol under high vacuum.

This result along with other experimental evidence indicate that 2-oxazolin-4-one might be formed by generating one mol of methanol from the 2-methoxy-1, 3-oxazolidin-4-one. But it could not be identfied in this work.

Ⅴ. REFERENCES

1. W.O. Ney, W.R. Nummy, and C.E. Barnes' *U.S. Pat.* 2, 638, 463(1953)
2. T. Saegusa, H. Ikeda, and H. Fujii, *Polym. J.*, 3, 35(1972)
3. *Ibid.*, 3, 176(1972)
4. *Ibid.*, **4**, 87(1973)
5. T. Saegusa, H. Ikeda and H. Fujii, *Macromol.*, **6**, 315(1973)
6. I.V. Smolanka, S.M. Khripak and V.I. Staninets, *Ukr. Khim. Zh.*, **30**, 265(1964) ; *Chem. Abstr.*, 60 : 14490g
7. F. Compernolle, J. Schytyser, and F.C. Schryver, *Org. Mass Spectrum.*, **10**, 74(1975) ; *Chem. Abstr.*, 83 : 271103t
8. H. Baganz und L. Damsche, *Chem. Ber.*, **91**, 650(1958)
9. C.F. Kroger, P. Selditz, und M. Mutscher, *Chem. Ber.*, **98**, 3034(1958)
10. T. Irie, E. Kurosawa, and T. Hanada, *J. Chem. Soc. Japan*, **79**, 1410(1958)
11. R. Juisgen und H. Waltz, *Chem. Ber.*, **89**, 2616(1956)
12. I. Suzuke, Bull. *Chem. Soc. Japan*, **35**, 540 (1962)