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## Transesterification of Methyl Methacrylate with Amino Alcohols. Preparation of a Primary Aminoalkyl Methacrylate and 2-Isopropenyl-4,4-dimethyloxazoline<sup>1</sup>

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Received March 17, 1958

The transesterification of 7-amino-3,7-dimethyloctanol (I) and methyl methacrylate, catalyzed by aluminum isopropoxide, gave 7-amino-3,7-dimethyloctyl methacrylate (II). The reaction of 2-amino-2-methylpropanol (III) with the ester, also catalyzed by heavy metal alkoxides, gave 2-isopropenyl-4,4-dimethyloxazoline (IV). The assigned structure was established by analyses, spectroscopy, and reduction to the 2-isopropyl analog (V) which was identical with an authentic sample. The oxazoline (IV) was also obtained by heating the methacrylic acid salt of III and by the acid-catalyzed cyclization of *N*-(1,1-dimethyl-2- $\beta$ -hydroxyethyl)methacrylamide (VI).

In a recent study of the reaction of 2-monoalkyl-aminoethanols with acrylic esters, the structure of the alkyl substituent was shown to be the factor which determined the nature of the product.<sup>2</sup> Usually, a complex mixture was obtained. Analyses of products indicated the predominance of amide formation, accompanied by transesterification of the hydroxyamide with methacrylate and addition of amine to the double bond. However, when the group in which the carbon atom bearing the nitrogen was fully substituted (*t*-butyl, 1,1,3,3-tetramethylbutyl), a clean transesterification occurred and the desired alkylaminoethyl methacrylates or acrylates were obtained in high yield.

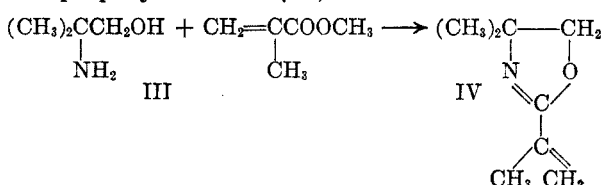
This selectivity which favors the transesterification reaction stems from the slowness with which trialkylcarbinamines enter into aminolysis of esters<sup>3</sup> or addition to the double bonds of acrylic esters.<sup>4</sup> In this transesterification, the resulting absence of interfering side reactions engendered by the amino function leads to a single reaction product.

In order to investigate further the scope of this selectivity, the transesterification of methyl methacrylate with aminoalcohols was extended to those compounds containing primary amino groups attached to a fully substituted carbon atom.

One such compound, whose functional groups are widely separated, is 7-amino-3,7-dimethyloctanol (I). The reaction of this alcohol with methyl methacrylate in the presence of aluminum isopropoxide gave a single product, the primary amino ester, 7-amino-3,7-dimethyloctyl methacrylate (II). This was a distillable, colorless oil with the correct analysis and neutralization equivalent. One mole of

hydrogen was absorbed in a quantitative hydrogenation in the presence of palladium. The infrared spectrum was very similar to that of *t*-butylaminoethyl methacrylate, but with an additional peak attributed to the primary amino group. It could be polymerized by heating with azo initiators to give a hard, clear, somewhat tacky polymer.

The application of this reaction to primary amino alcohols in which the functional groups were on proximate carbon atoms did not produce the expected amino esters, but instead led to new heterocyclic monomers. The main attention was given to the reaction of 2-amino-2-methylpropanol (III) with methyl methacrylate, from which 4,4-dimethyl-2-isopropenyloxazoline (IV) was obtained:



The catalysts used were aluminum isopropoxide, tetraalkyl titanates, and other alkoxides of metals of the middle groups in the periodic table. Since these materials should be destroyed by the presence of water, which would be one of the reaction products, it is considered that the intermediate aminoalkyl ester may have formed and then cyclized during the distillation. The crude product was obtained in about 65% yield and contained small amounts of water and starting amine. It could be purified by treatment with metallic sodium or isocyanates, followed by distillation.

The new olefinic oxazoline is a colorless liquid with a characteristic, pyridine-like odor, distillable under atmospheric pressure. It is partially miscible with water and soluble in typical organic solvents. Its composition was indicated by elemental analysis, neutral equivalent, and hydrogenation, in which one mole of hydrogen was absorbed. The reduction product, 4,4-dimethyl-2-isopropenyloxazoline (V), was identical with the product obtained by the reaction of isobutyric acid with the amino alcohol.

(1) Presented at the 2nd Delaware Valley Regional Meeting of the American Chemical Society, Philadelphia, Pa., February 5, 1958.

(2) H. J. Sims, P. L. de Benneville, and A. J. Kresge, *J. Org. Chem.*, **22**, 787 (1957).

(3) L. M. Arnett, J. G. Miller, and A. R. Day, *J. Am. Chem. Soc.*, **72**, 5635 (1950).

(4) L. S. Luskin, M. J. Culver, G. E. Gantert, W. E. Craig, and R. S. Cook, *J. Am. Chem. Soc.*, **78**, 4042 (1956).

Each preparation of V gave the same picrate, which differed from the picrate of the olefinic oxazoline IV. The infrared spectra of both samples of V were superimposable and showed only one band at 1665  $\text{cm.}^{-1}$ , attributed to the imine group.

The oxazoline IV showed two bands at 1658 and 1613  $\text{cm.}^{-1}$ . These values are similar to the positions of the bands of  $\alpha,\beta$ -unsaturated Schiff bases,<sup>5</sup> while the position of the single absorption band of the reduced oxazoline V is similar to the imine band of ordinary Schiff bases.<sup>6</sup> The data do not permit distinction in the assignment of imine and olefin to the two peaks of the oxazoline IV.

The conjugated structure was further indicated by the ultraviolet absorption spectrum in iso-octane (point of inflection at 225  $\mu\text{m}$ ,  $\log \epsilon = 3.79$ ). By contrast, the reduced oxazoline (V) showed only end absorption.

The oxazoline IV was obtained by two other methods. 2-Alkyloxazolines have been prepared in poor yields by heating ethanolamine salts of carboxylic acids above 250°. These drastic conditions would not be desirable in the preparation of the new oxazoline. However, the salt of 2-amino-2-methylpropanol with methacrylic acid was rapidly dehydrated at 190° to give the oxazoline in 43% yield. Similar low temperatures sufficed in the preparation of the reduced oxazoline V from the amino alcohol and isobutyric acid. The olefinic oxazoline was contaminated by a small amount of an unknown impurity. This was indicated by a shoulder at 1662  $\text{cm.}^{-1}$  in the infrared spectrum, which was otherwise similar to that of the transesterification product. The contaminant might be 2-ethyl-4,4-dimethyloxazoline resulting from acid-catalyzed cleavage of the methylene group.

The dehydration of *N*-(1,1-dimethyl-2-hydroxyethyl)methacrylamide (VI), obtained by the reaction of the amino alcohol with methacryloyl chloride, was also studied. The intermediate amide was a viscous, colorless oil, distillable at low pressures. Its preparation required the addition of the chloride to an excess of amine; the reverse procedure gave a mixture of the hydroxyamide VI with its methacrylate ester.

When the pure amide VI was heated under atmospheric pressure at 175–180°, water and the oxazoline IV co-distilled. This amide is therefore another possible intermediate in the formation of the oxazoline in the transesterification method. The reaction was accelerated by the addition of a few drops of sulfuric acid. The acid-catalyzed cyclization gave the product in 60% yield and in a state of high purity, as indicated by the infrared spectrum.

The pyrolysis of the isomeric amide, *N*-(2-hy-

droxy-2-methyl)propylmethacrylamide (VIII), gave a small amount of distillate, but most of the product was a polymeric residue. This result further established the structural features needed for easy preparation of an oxazoline.

4,4-Dimethyl-4-isopropenyloxazoline was polymerized in bulk or in solution by heating in the presence of azo initiators. The resulting polymer was hard, clear resin, with inverse solubility in water, that is, soluble in the cold, precipitated by heating. Its infrared spectrum showed a single band at 1660  $\text{cm.}^{-1}$  indicating the survival of the oxazoline ring.

#### EXPERIMENTAL<sup>8</sup>

*7-Amino-3,7-dimethyloctyl methacrylate* (II). A mixture of 7-amino-3,7-dimethyloctanol<sup>9</sup> (57.6 g., 0.33 mole), methyl methacrylate (66.6 g., 0.67 mole), aluminum isopropoxide (2 g.), and di- $\beta$ -naphthol (7.2 g.) was heated under a Vigreux column, 20 cm. long, and total reflux distillation head for 10 hr. Distillate (23 g.) was collected, about half between 65 and 70°, and the remainder as the temperature slowly rose to 98°. After removal of excess methyl methacrylate, the crude product (74 g., 92%), b.p. 119–146° (0.9 mm.), was obtained. Redistillation gave pure II, b.p. 115–120° (0.8 mm.),  $n_D^{25}$  1.4570,  $d_4^{25}$  0.9215, strong infrared peaks at 1724 (ester), 1641 (C = C) and 1565  $\text{cm.}^{-1}$  ( $\text{NH}_2$ ).

*Anal.* Calcd. for  $\text{C}_{14}\text{H}_{28}\text{NO}_2$ : N, 5.8; neut. and hydrogenation equiv., 241. Found: N, 5.7; neut. equiv. 250; hydrogenation equiv. 255.

When II was heated with 1% by weight of dimethyl azoisobutyrate at 70° for about 16 hr., a clear, somewhat tacky polymer was obtained.

*4,4-Dimethyl-2-isopropenyloxazoline* (IV). *a. Transesterification of methyl methacrylate with 2-amino-2-methylpropanol* (III). A mixture of III (89 g., 1 mole), methyl methacrylate (220 g., 2.2 moles), and di- $\beta$ -naphthol (10 g.) was heated under a short column (Cannon packing) and reflux head for 1 hr. to remove a small amount of water. Tetraisopropyl titanate (1 g.) was then added and distillation was continued for 15 hr. More catalyst was added after 4 and 11 hr. The pot temperature was carefully adjusted to keep the overhead temperature below 70° as long as possible. From the refractive indices of the distillates, the total collection of methanol was about 81% of the calculated amount. Distillation then gave 59 g. of recovered methyl methacrylate, 19.5 g. and 82.3 g. of product cuts, b.p. 61–56° (22 mm.) and 56–88° (21 mm.), respectively, 7.3 g. of higher boiling liquid, b.p. 83–103° (20 mm.) and 22 g. of residue.

The crude product fractions were combined and treated with ethyl isocyanate (25 g.) in pentane (200 cc.) to remove unreacted III and water. Two layers formed. The upper layer was distilled twice to give 52.3 g. of pure IV, b.p. 62–63° (30 mm.), while the lower layer gave 11 g., b.p. 65–66° (36 mm.); the total yield was 45%,  $n_D^{25}$  1.4535–1.4540,  $d_4^{25}$  0.9181, neut. equiv. calcd., 139; found, 142.

In a run of similar size, the pot temperature was held below 110° by operation at 400 mm. The yield of crude IV was then 89.5 g., b.p. 59–62° (34 mm.), which, after drying over sodium, was redistilled to give a 60% yield of pure IV, b.p. 149°.

(8) The assistance of A. J. McFaul and Rita Cerruti in the performance of some of the experimental work, James D. Stroupe and Helen Miklas for determination and interpretation of some of the infrared data, and C. W. Nash for analyses is gratefully acknowledged.

(9) R. A. LaForge, C. R. Whitehead, R. B. Keller, and C. B. Hummel, *J. Org. Chem.*, **17**, 457 (1952).

(5) E. P. Goldberg and H. R. Nace, *J. Am. Chem. Soc.*, **75**, 3646 (1953); **77**, 359 (1955).

(6) W. D. Emmons, *J. Am. Chem. Soc.*, **79**, 5739 (1957); M. Carmack and L. S. Luskin, unpublished data.

(7) H. Wenker, *J. Am. Chem. Soc.*, **57**, 1079 (1935).

*Anal.* Calcd. for  $C_8H_{13}NO$ : N, 10.1; neut. and hydrog. equiv., 139. Found: N, 10.0; neut. equiv., 142; hydrog. equiv., 153.

The solubility of IV in water at 25° was found to be 9.15%, while the solubility of water in IV at 25° was 10.2%.

Infrared analysis showed two strong peaks at 1658 and 1613  $cm^{-1}$ . The ultraviolet absorption spectrum of a solution in isooctane showed a point of inflection at 225  $m\mu$  ( $\log \epsilon = 3.79$ ).

*4,4-Dimethyl-2-isopropenyloxazoline picrate.* A slight excess of a saturated aqueous solution of sodium picrate was added to a solution of IV (1.39 g., 0.01 mole) in 0.5N hydrochloric acid (20 ml.). The colorless needles were collected and dried at 50°, 2.6 g., m.p. 115–116°.

*Anal.* Calcd. for  $C_{14}H_{16}N_4O_8$ : C, 45.7; H, 4.4; N, 15.2. Found: C, 45.5; H, 4.4; N, 15.1.

*4,4-Dimethyl-2-isopropenyloxazoline (V). a. By Hydrogenation of 4,4-dimethyl-2-isopropenyloxazoline.* IV (28 g., 0.2 mole) was shaken for 48 hr. with Adams catalyst and hydrogen under 50 lbs. pressure in a Parr hydrogenation apparatus. After addition of fresh catalyst, shaking was continued for 24 hr. Distillation of the filtered oil gave 17.4 g. (62%), b.p. 50–52° (29 mm.). After drying over sodium, it was redistilled, b.p. 56° (35 mm.),  $n_D^{25}$  1.4218,  $d_4^{25}$  0.8797; strong infrared absorption at 1665  $cm^{-1}$  ( $C=N$ ), with a very weak peak at 1612  $cm^{-1}$  indicating some residual unreduced IV.

*Anal.* Calcd. for  $C_8H_{13}NO$ : N, 9.95; neut. equiv., 141. Found: N, 9.75; neut. equiv., 141.

*b. From 2-amino-2-methylpropanol and isobutyric acid.* III (89 g., 1 mole) was added to isobutyric acid (89 g., 1 mole). The salt was heated under a distillation head for 5 hr. At first, only water was obtained, but as the overhead temperature increased from 106 to 142°, a two-phased distillate was formed. The separated wet product layer (112 g.) was dried over sodium and distilled, 93 g. (66%), b.p. 50–53° (28 mm.),  $n_D^{25}$  1.4210,  $d_4^{25}$  0.8770; infrared absorption at 1665  $cm^{-1}$ ; ultraviolet end absorption below 245  $m\mu$ .

*Anal.* Found: N, 9.87.

The picrates of each preparation were obtained as above, m.p. and mixture m.p., 190–191°.

*Anal.* Calcd. for  $C_{14}H_{16}N_4O_8$ : C, 45.4; H, 4.9; N, 15.1. Found: C, 45.4; H, 4.8; N, 15.0.

*4,4-Dimethyl-2-isopropenyloxazoline (IV). b. From 2-amino-2-methylpropanol and methacrylic acid.* This reaction was carried out in a manner similar to the preparation of V on a 1-mole scale to give 60 g. (43%) of IV, b.p. 64–67° (35 mm.),  $n_D^{25}$  1.4492, neut. equiv. 143. The product thus obtained seemed to be less pure than obtained by other methods, since the infrared spectrum had a shoulder at 1665  $cm^{-1}$ . No attempt was made to identify the contami-

nant. The yield of IV was not improved by the addition of a few drops of sulfuric acid.

*N-(1,1-Dimethyl-2-β-hydroxyethyl) methacrylamide (VI).* A solution of methacryloyl chloride (104.5 g., 1 mole) in benzene (50 ml.) was added to a stirred solution of III (185 g., 2.1 moles) in benzene (100 ml.) at 10–15° in 2.5 hr. Stirring was continued for 3 hr. and the mixture was refrigerated overnight. It was then filtered and the solids washed with benzene. The combined filtrates were evaporated to give a pale yellow residual oil (169 g.) which was distilled in the presence of *p*-hydroxydiphenylamine. The yield of viscous amide was 140 g. (89%), b.p. 97° (0.15 mm.),  $n_D^{25}$  1.4785, infrared peaks at 1660 and 1621  $cm^{-1}$ .

*Anal.* Calcd. for  $C_8H_{15}NO_2$ : N, 8.9. Found: N, 8.9.

*4,4-Dimethyl-2-isopropenyloxazoline (IV). c. By dehydration of 1,1-dimethyl-2-hydroxyethylmethacrylamide (VI).* VI (32 g., 0.2 mole) was heated at 175–180° for 4 hr. Water and IV co-distilled. The crude product was separated and weighed 24.3 g. (86%),  $n_D^{25}$  1.4545.

In the presence of a few drops of concentrated sulfuric acid, the distillation was completed in 1.5 hr. at 180–190°. The yield of IV was 24.5 g. (87%),  $n_D^{25}$  1.4543. After drying over sodium, redistillation gave a 67% yield of pure oxazoline. The infrared spectrum of this material was identical with the product obtained by transesterification.

*N-(2-Hydroxy-2-methylpropyl) methacrylamide (VII)* was prepared by the reaction of 1-amino-2-methylpropanol-2<sup>10</sup> with methacryloyl chloride as above. The product was largely insoluble in benzene and was recovered from the solids by solution in 100 ml. of water and extraction with two 50-ml. portions of chloroform. Evaporation of the extract, finally under reduced pressure, gave 34.5 g. (75%) of a crystalline solid, m.p. 70–75°, to which a small amount of polymerization inhibitor was added. The solid could not be distilled.

*Anal.* Calcd. for  $C_8H_{15}NO_2$ : N, 8.9. Found: N, 8.6.

When the hydroxyamide VII (33 g., 0.2 mole) was heated with 5 drops of concentrated sulfuric acid at 180–250°, only 2.5 g. of water and 1.5 g. of an oil,  $n_D^{25}$  1.4532, was obtained. The oil was not examined further. The remainder of the material (27 g.) in the pot had resinified.

*Polymerization of 4,4-dimethyl-4-isopropenyloxazoline.* IV (1 g.) containing 0.01 g. of dimethylazoisobutyrate was heated at 75° for 24 hr. There was formed a hard, clear, colorless polymer which was soluble in water and benzene. The benzene solution was poured into 200 ml. of pentane to give a dry fluffy powder. Infrared examination of the benzene solution showed an imine peak at 1660  $cm^{-1}$ .

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(10) T. L. Cairns and J. H. Fletcher, *J. Am. Chem. Soc.*, **63**, 1034 (1941).