Heating was continued for two and one-half hours. Treatment of the viscous dark-brown product in the manner described above gave 4.25 g. (a yield of 22.5%) of β-resorcylamide, m. p. 228–229°.

**Methylurea and Resorcinol.**—The apparatus used was that described for the urea–resorcinol experiment. A mixture of 9.3 g. of methylurea, 15 g. of resorcinol, and 25 g. of anhydrous zinc chloride was heated at 128–132° for four hours, and the residue treated in the manner described above. A crystalline product weighing 5.44 g. was isolated. This melted at 228–229° and was identified as β-resorcylamide, the methyl group being apparently lost as methylamine during the condensation. The yield was 28.4%.

**Phenyl Isocyanate and Resorcinol.**—When 14.9 g. of phenyl isocyanate, 15 g. of resorcinol, and 25 g. of zinc chloride were heated at 128–132° for four hours, and the residue treated in the usual manner, a large crop of white crystals identified as the diphenyl-diurethan of resorcinol, m. p. 164°, was isolated. No other identifiable product was obtained.

**Urethan and Resorcinol.**—A mixture of 11.1 g. of urethan, 15 g. of resorcinol, and 25 g. of anhydrous zinc chloride was heated at 128–132° for four hours. The viscous clear red residue was treated in the usual manner, yielding 0.1 g. of β-resorcylamide, a yield of only 0.5% of the theoretical. A large amount of unreacted resorcinol was recovered from the mother liquors.

## Summary and Conclusions

1. When resorcinol and urea are allowed to react at 128–132° in the presence of anhydrous zinc chloride, β-resorcylamide is formed.

2. The evidence indicates that cyanic acid is an intermediate in this reaction.

3. Under the conditions employed the reaction is not general for the synthesis of benzamides.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY AND CHEMICAL ENGINEERING AT THE UNIVERSITY OF PENNSYLVANIA]

# α-Chloro-α-sulfonylamides

BY EUGENE BARR,[1] WM. M. ZIEGLER AND RALPH CONNOR

In continuing[2] the study of sulfones containing "positive halogen," α-chloro-α-sulfonylamides were selected to serve as examples of the activation of chlorine by sulfone groups in the alpha position. The chlorination of α-sulfonylamides in glacial acetic acid gave satisfactory yields of the desired products. Their structures seem established (1) by analogy with the corresponding

$$RSO_2CHR'CONH_2 \xrightarrow{Cl_2} RSO_2CClR'CONH_2$$

| | R = | R′ = |
|---|---|---|
| I | *p*-$CH_3C_6H_4$— | H— |
| II | *p*-$CH_3C_6H_4$— | Cl— |
| III | *p*-$CH_3C_6H_4$— | $C_2H_5$— |
| IV | *n*-$C_4H_9$— | Cl— |
| V | *n*-$C_4H_9$— | $CH_3$— |
| VI | *n*-$C_4H_9$— | $C_2H_5$— |

products from bromination,[2] (2) by the increased difficulty of chlorination of the butyramides[2] and (3) by the preparation of I by an alternative method which leaves no doubt that chlorine is attached to carbon.

The α-chloro-α-sulfonylamides were considerably more reactive than the corresponding α-bromo-α-sulfonylamides.[2] The former were in some cases dehalogenated by attempted recrystallization from dilute alcohol or water. One α,α-dichloro derivative (II) was converted to the monochloro product (I) by repeated recrystallization from alcohol containing water and repeated recrystallization of I from water gave α-*p*-tolylsulfonylacetamide. α-Chloro-α-*p*-tolylsulfonyl-*n*-butyramide (III) and II were decomposed by moisture in the atmosphere and could not be stored except under anhydrous conditions. Aside from this increased reactivity, the chloro compounds behaved like the bromo derivatives and reacted with hydrazine, hydriodic acid, piperidine and mercaptides to give nitrogen, iodine, piperidine hydrochloride and disulfides, respectively.

The less successful methods tested for the preparation of α-chloro-α-sulfonylamides are worthy of brief mention. The reaction of dichloroacetamide with sodium *p*-toluenesulfinate gave α-chloro-α-*p*-tolylsulfonylacetamide (I), but the yield was small and the product difficult to purify. While this is unsatisfactory as a preparative method, this experiment offers verification of the structure of the products obtained by direct chlorination.

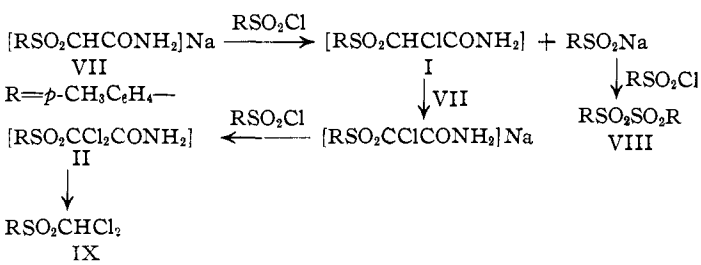
The reaction of mercaptides with dichloroacet-

(1) Röhm and Haas Research Assistant.

(2) For previous work see Ziegler and Connor, THIS JOURNAL, **62**, 1049 (1940); *ibid.*, **62**, 2596 (1940).

amide could not be interrupted; even with a large excess of the latter, the product was always the $\alpha,\alpha$-(bis-alkylthio)-amide.

The formation[3] of $\alpha$-chloroacetoacetic ester from the reaction of $\alpha$-toluenesulfonyl chloride with the sodium derivative of acetoacetic ester suggested that this reaction might be applied to the preparation of $\alpha$-chloro-$\alpha$-sulfonyl amides. The reaction of $p$-toluenesulfonyl chloride with the sodium derivative (VII) of $\alpha$-$p$-tolylsulfonylacetamide was carried out. The products isolated were di-$p$-tolyldisulfone (VIII) and $p$-tolylsulfonyldichloromethane (IX). It appears, therefore, that the reaction did not stop at the desired product but that the dichloro amide (II) was formed and gave IX by cleavage[4] of the $-CONH_2$ group.




The "positive" character of the chlorine in the $\alpha$-chloro-$\alpha$-sulfonylamides suggested that organic hypochlorites might be useful halogenating agents. With $t$-butyl hypochloride, however, no halogenation of $\alpha$-sulfonylamides was noted.

## Experimental Part

**Chlorination of $\alpha$-Sulfonylamides.**—Five hundredths mole of the $\alpha$-sulfonylamide[5] was added to a solution of the theoretical amount of chlorine in 50–100 ml. of glacial acetic acid. The reaction mixture stood at room temperature until the solution became colorless and the product was isolated as described below.

**$\alpha$-Chloro-$\alpha$-$p$-tolylsulfonylacetamide** (I).—After standing for one hour the reaction mixture was poured into 50 ml. of cold water and the white precipitate (8.0 g., 64%, m. p. 120–130°) removed by filtration. This product appeared to be a mixture of starting material, I and II. Two recrystallizations from alcohol and four from benzene gave 0.12 g. (1%) of pure product, m. p. 169–171° (cor.).

*Anal.* Calcd. for $C_9H_{10}O_3NSCl$: Cl, 14.4; N, 5.66. Found: Cl, 14.6, 14.3; N, 5.64, 5.63.

**$\alpha,\alpha$-Dichloro-$\alpha$-$p$-tolylsulfonylacetamide** (II).—After standing overnight the reaction mixture was distilled under reduced pressure until crystals began to appear. The solution was cooled in vacuum, filtered and dried overnight in a vacuum desiccator to give 7 g. (40%) of a white solid, m. p. 127–130°. Crystallization from chloroform gave a final melting point of 131–133° (cor.). An additional amount of II was obtained by concentration of the glacial acetic and reaction mixture. Repeated recrystallization from dilute alcohol gave I, m. p. 166–171°.

*Anal.* Calcd. for $C_9H_9O_3NSCl_2$: Cl, 25.2; N, 4.96. Found: Cl, 25.3, 25.1; N, 4.94, 4.90.

**$\alpha$-Chloro-$\alpha$-$p$-tolylsulfonyl-$n$-butyramide** (III).—After standing a day and a half, most of the acetic acid was removed from the reaction mixture by distillation under reduced pressure. The residue was dissolved in 25 ml. of hot carbon tetrachloride and chilled. The crude product, m. p. 50–54°, weighed 7 g. (51%). Two recrystallizations from carbon tetrachloride gave 4.5 g. (33%) of pure product, m. p. 58–60° (cor.). This compound reacts with atmospheric moisture and must be stored in a vacuum desiccator.

*Anal.* Calcd. for $C_{11}H_{14}O_3NSCl$: Cl, 12.9; N, 5.07. Found: Cl, 13.0, 13.2; N, 4.77, 4.87.

**$\alpha,\alpha$-Dichloro-$\alpha$-$n$-butylsulfonylacetamide** (IV).—After the reaction mixture had stood for two days, the acetic acid was removed by distillation under reduced pressure. The residue was crystallized from 25 ml. of carbon tetrachloride, giving 6.5 g. (53%), m. p. 88–89°. Recrystallization from carbon tetrachloride gave 6.0 g. (49%) of pure IV, m. p. 89–90° (cor.).

*Anal.* Calcd. for $C_6H_{11}O_3NSCl_2$: Cl, 28.6; N, 5.65. Found: Cl, 28.6, 28.5; N, 5.50, 5.45.

**$\alpha$-Chloro-$\alpha$-$n$-butylsulfonylpropionamide** (V).—After the reaction mixture had stood for two days, the acetic acid was removed by distillation under reduced pressure. Crystallization from 25 ml. of carbon tetrachloride gave 6.3 g. (55%) of pure V, m. p. 65–66° (cor.).

*Anal.* Calcd. for $C_7H_{14}O_3NSCl$: Cl, 15.6; N, 6.14. Found: Cl, 15.5, 15.4; N, 6.14, 6.26.

**$\alpha$-Chloro-$\alpha$-$n$-butylsulfonyl-$n$-butyramide** (VI).—After standing for one and one-half days the reaction mixture was poured into 50 ml. of benzene. The volume of this mixture was concentrated to about 20 ml. and the residue poured upon crushed ice. The oil was separated and the aqueous layer extracted twice with ether. The oil was combined with the ethereal extracts and the solution washed with dilute sodium bicarbonate solution and water. After drying over sodium sulfate the ether was evaporated and the residue crystallized from absolute alcohol. The crude product, 7.5 g., 62%, m. p. 55–57°, was recrystallized twice from carbon tetrachloride. The yield of pure VI was 4.2 g. (35%), m. p. 58–59° (cor.).

*Anal.* Calcd. for $C_8H_{16}O_3NSCl$: Cl, 14.7; N, 5.78. Found: Cl, 14.9, 14.7; N, 5.60, 5.63.

**Reaction of Sodium $p$-Toluenesulfinate with Dichloroacetamide.**—Ten grams (0.078 mole) of dichloroacetamide and 19 g. (0.083 mole) of sodium $p$-toluenesulfinate dihydrate were mixed with 75 ml. of dioxane and heated on a water-bath for twelve hours. After cooling and filtering, the dioxane was evaporated, the product mixed

(3) Kohler and MacDonald, *Am. Chem. J.*, **22**, 225 (1898).

(4) The influence of bromine upon the cleavage of the $-CONH_2$ group has already been noted.[2]

(5) Prepared by the methods described by d'Ouville and Connor, THIS JOURNAL, **60**, 33 (1938), and Pomerantz and Connor, *ibid.*, **61**, 3386 (1939).

with 75 ml. of water and heated to 90°. The solution was chilled and the solid recrystallized from water. The yield of α-chloro-α-*p*-tolylsulfonylacetamide (I) was 1 g. (4.4%), m. p. 162–165°. Repeated recrystallizations from water and alcohol gave α-*p*-tolylsulfonylacetamide.

**Reaction of Sodium *n*-Butyl Mercaptide with Dichloroacetamide.**—To 10.7 ml. (9 g., 0.10 mole) of *n*-butyl mercaptan was added a sodium ethoxide solution prepared by dissolving 2.3 g. (0.10 gram atom) of sodium in 60 ml. of absolute alcohol. This was added dropwise, at room temperature, to a well stirred solution of 20 g. (0.15 mole) of dichloroacetamide in 150 ml. of absolute alcohol. After the addition the mixture was stirred up for two hours and then allowed to stand for three days. The alcohol was evaporated and the material poured on ice. After several recrystallizations from a mixture of ligroin (b. p. 70–90°) and ether, the product melted at 78–80°. The compound was identified as (bis-*n*-butylthio)-acetamide by oxidation with 15 ml. of 30% hydrogen peroxide in 30 ml. of acetic acid-acetic anhydride mixture (1:1). The oxidation product was shown to be bis-*n*-butylsulfonylacetamide[5] by mixed melting point. The over-all yield was 27% based on the mercaptan.

**Reaction of Sodium *p*-Thiocresolate with Dichloroacetamide.**—The above experiment was carried out as described for *n*-butylmercaptan using 12.5 g. (0.1 mole) of *p*-thiocresol. The resulting product, m. p. 172–173°, was proved by mixed melting point to be α,α-(bis-*p*-tolylthio)-acetamide.[5] The yield was 88% based on the *p*-thiocresol.

**Reaction of α-*p*-Tolylsulfonylacetamide with *t*-Butyl Hypochlorite.**—Tertiary butyl hypochlorite was prepared by the method of Taylor, MacMullen and Gammel.[6] To 10.7 g. (0.05 mole) of α-*p*-tolylsulfonylacetamide was added 100 ml. of carbon tetrachloride containing 0.05 mole of *t*-butyl hypochlorite. After heating the mixture for sixty hours on a water-bath 80% of unreacted amide was recovered.

(6) Taylor, MacMullen and Gammel, THIS JOURNAL, **47**, 395 (1925).

**Reaction of the Sodium Derivative of α-*p*-Tolylsulfonylacetamide with *p*-Toluenesulfonyl Chloride.**—To 2.3 g. (0.1 gram atom) of sodium shot in 225 ml. of benzene was added 7.5 ml. (0.13 mole) of absolute alcohol. The mixture was refluxed until the sodium had dissolved, 21.3 g. (0.1 mole) of α-*p*-tolylsulfonylacetamide added and the mixture refluxed for fifteen minutes. The condenser was set for a downward distillation and 75 ml. of benzene removed. The last portion of the distillate gave a negative test for alcohol with dichromate. To the resulting residue 19.6 g. (0.1 mole) of *p*-toluenesulfonyl chloride in benzene solution was added dropwise with stirring. The material was refluxed for two hours with stirring and was then neutral to moist litmus. The hot solution was filtered and the residue washed with hot benzene. The combined benzene solutions were evaporated to 50 ml., chilled and filtered. The crystals (6 g.) were extracted with hot alcohol and this extract gave after recrystallization 2.5 g. (21% based on the chloride) of a product m. p. 111–112°. This was shown by mixed melting point to be *p*-tolylsulfonyldichloromethane, which is reported[7] to melt at 114°.

The residue from the alcohol extraction was recrystallized from benzene. There was isolated 1 g. (6%) of di-*p*-tolyldisulfone, m. p. 203–205° (dec.). The benzene-insoluble portion of the reaction mixture was crystallized from 5% sodium carbonate solution and gave 11.1 g. (52%) of recovered α-*p*-tolylsulfonylacetamide.

## Summary

α-Chloro-α-sulfonylamides have been prepared by the chlorination of α-sulfonylamides in glacial acetic acid. These products contain "positive" chlorine and are considerably more reactive than the α-bromo-α-sulfonylamides previously described.

(7) Otto, *J. prakt. Chem.*, [2] **40**, 526 (1889).

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[CONTRIBUTION FROM THE ANIMAL CHEMISTRY AND NUTRITION SUBSECTION OF IOWA STATE COLLEGE]

# The Structure of "7-Dehydrocholestene Isomer"[1]

BY J. C. ECK AND E. W. HOLLINGSWORTH

In a previous paper[2] the crystalline product (m. p. 84–85°, $(\alpha)^{28}D$ + 45.77°), obtained by the action of quinoline on 5,6-dibromocholestane (cholestene dibromide), was considered to be $\Delta^{4,6}$-cholestadiene in a pure condition since the physical properties could not be changed by attempted further purification. However, from more recent research, a considerable accumulation of evidence has been obtained to indicate that no structure other than $\Delta^{4,6}$-cholestadiene could account for the reactions of "7-dehydrocholestene isomer" (m. p. 90–91°, $(\alpha)^{24}D$ + 4.27°). A Wolff–Kishner reduction of the semicarbazone of $\Delta^{4,6}$-cholestadieneone-3, which has been studied by Petrow,[3] yielded a crystalline product (m. p. 82.5–84°, $(\alpha)^{26}D$ − 38.1°) which would also be expected to have the structure of $\Delta^{4,6}$-cholestadiene. As a result of this investigation, it has been found that the 5,6-dibromocholestane-quinoline product is an inseparable

(1) Journal Paper No. J-793 of the Iowa Agricultural Experiment Station, Project No. 506.

(2) Eck, Van Peursem and Hollingsworth, THIS JOURNAL, **61**, 171 (1939).

(3) V. A. Petrow, private communications.