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The reaction of 1-benzensulfonyl-2-bromomethylethylenimine with benzene in the presence of aluminum chloride

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Thesis

THE REACTION OF 1-BENZENSULFONYL-
2-BROMOMETHYLETHYLENIMINE WITH
BENZENE IN THE PRESENCE OF ALUMINUM CHLORIDE

By

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INTRODUCTION

1-Benzensulfonyl-2-bromomethylethlenimine is a poly-functional and reactive compound. Its reactions are not well known, and could prove to be of theoretical as well as of preparative value.

It was the purpose of this work to investigate the course of the reaction of 1-benzensulfonyl-2-bromomethylethlenimine with benzene in the presence of aluminum chloride. This was done as part of a program of exploration of this compound.

In its original form, the problem was divided into three phases. The first phase was to be the search for conditions under which the reaction could be carried out so as to obtain maximum yields of isolable products. The second phase was to be concerned with the identification and proof of structure of the product or products from the reaction. The final phase was to be an investigation into possible reaction paths. It was hoped to present a plausible mechanism based on the results obtained in this phase of the work.

A major portion of the problem, as originally conceived, has been completed.
The chemistry of the three membered heterocyclic compounds is equivalent by and large to the chemistry of ethylene oxides and ethylenimines. Most of the work on these compounds is concerned with reactions involving ring opening. For this reason, and because the thesis work involved a ring opening process of an ethylenimine derivative, this section will be devoted to a brief survey of such reactions of ethylenimines and the related ethylene oxides.

The fact of strain inherent in these three membered ring compounds is strikingly brought out in their chemical behavior. The breaking of the carbon-oxygen or carbon-nitrogen bond occurs with a degree of ease unknown in analogous processes of ordinary ethers or amines. The high reactivity of the ring compounds should be related to the distorted bond angles, and thus to the energy rich condition in these compounds.

When ethylene oxide or ethylenimine is treated with hydrobromic acid, the ring is opened as follows:

1. $\text{CH}_2\text{CH}_2 + \text{HBr} \rightarrow \text{CH}_2\text{CH}_2 \rightarrow \text{CH}_2\text{CH}_2$

2. $\text{CH}_2\text{CH}_2 + \text{HBr} \rightarrow \text{CH}_2\text{CH}_2 \rightarrow \text{CH}_2\text{CH}_2$

The initial attack, in both the above reactions, is by a proton on the oxygen or nitrogen to form the appropriate
conjugate acid. This is followed by a nucleophilic displacement on one of the carbon atoms by the bromide ion to give the final product. Kinetic data of Bronsted, Kilpatrick, and Kilpatrick (1), who investigated the reaction of ethylene oxide with hydrobromic acid, show that, at substantial acid concentrations reaction by way of the conjugate acid of the oxide is much faster than by attack on the oxide itself. Similarly, the work of Freundlich and Neumann (8), shows that ethylenimine reacts with hydrobromic acid in a manner analogous to that of ethylene oxide. In both these cases a nucleophilic displacement mechanism of halide ion on a carbon atom is in agreement with the observed kinetics.

In reactions 1 and 2, there is no problem as to which carbon is attacked, because they are both symmetrically substituted. However, in dealing with an unsymmetrically substituted three membered ring compound, the problem as to where rupture of the ring takes place becomes more involved. In this respect, the chemistry of the ethylene oxides derivatives has been much more fully investigated than that of ethylenimines.

In the nucleophilic attack on a carbon atom of the epoxide ring of epichlorohydrin, the primary carbon atom was found to be considerably more reactive than the secondary. This is shown in reactions 3, 4, and 5.

\[ \text{ClCH}_2\text{CH} = \text{CH}_2 + \text{HBr} \rightarrow \text{ClCH}_2\text{CH} = \text{CH}_2 \]
4. \[ \text{ClCH}_2\text{CH}^\circ\text{CH}_2 + \text{CH}_2(\text{CO}_2\text{C}_6\text{H}_5)_2 \rightarrow \text{ClCH}_2\text{CH}^\circ\text{H} + \text{CH}_2\text{-CHCO}_2\text{C}_6\text{H}_5 \]

5. \[ \text{ClCH}_2\text{CH}^\circ\text{CH}_2 + \text{ROH} \xrightarrow{\text{H}_2\text{SO}_4} \text{ClCH}_2\text{CH}^\circ\text{OR} \]

In contrast, Nilsson and Smith (18), found that if isobutylene oxide is treated with hydrochloric acid, the attack is on the more highly substituted carbon, and the product is the tertiary halide. Similarly, Golumbic and Cottle (11), found that when styrene oxide is treated with hydrochloric acid, there is obtained the secondary and not the primary chloride. This is shown in reaction 6.

6. \[ \text{C}_6\text{H}_5\text{CH}^\circ\text{CH}_2 + \text{HCl} \rightarrow \text{C}_6\text{H}_5\text{CH}^\circ\text{H} \]

However, Russell and Vanderwerf (20), reported that when styrene oxide reacts with sodiomalonic ester, the displacement occurs on the less substituted carbon of the epoxide ring as shown in reaction 7.

7. \[ \text{C}_6\text{H}_5\text{CH}^\circ\text{CH}_2 + \text{CH}_2(\text{CO}_2\text{C}_6\text{H}_5)_2 \rightarrow \text{C}_6\text{H}_5\text{CH}^\circ\text{CH}_2\text{CH(CO}_2\text{C}_6\text{H}_5)_2 \]

Thus, it has been shown that one cannot predict a priori where attack will occur on unsymmetrically substituted ethylene oxide rings.

This same unpredictability also follows when ethylenimine derivatives are considered.

In analogy with reaction 3, Gensler (10), found that if 1-benzenesulfonyl-2-bromomethylethyleneimine is treated with hydrobromic acid, attack is on the less substituted carbon of
the ring, as shown in reaction 8.

\[
\begin{align*}
8. \quad & \text{CH}_2\text{CHCH}_2\text{Br} + \text{HBr} \rightarrow \text{CH}_2\text{-}\text{CH} - \text{CH}_2 \\
& \text{SO}_2\text{C}_6\text{H}_5 \quad \text{SO}_2\text{C}_6\text{H}_5
\end{align*}
\]

Gabriel and Ohle (9), reported the same mode of cleavage in the reaction of 2-methylethylenimine with hydrochloric acid.

In contrast to the above findings, Wolfheim (36), reported that the reaction of 2-phenylethylenimine with hydrochloric acid gave \(\beta\)-phenyl \(\beta\)-chloroethylamine. (Reaction 9).

\[
\begin{align*}
9. \quad & \text{C}_6\text{H}_5\text{CH} - \text{CH}_2 + \text{HCl} \rightarrow \text{C}_6\text{H}_5\text{CH} - \text{CH}_2 \\
& \text{H} \quad \text{Cl} \quad \text{NH}_2
\end{align*}
\]

Kharasch and Priestly (15), found that the p-toluenesulfonyl derivative of 2-phenylethylenimine reacted similarly with hydrobromic acid.

Evidently the aliphatic or aromatic nature of the group on the ring and the nature of the attacking species are important in determining the direction of ring cleavage. This effect is brought out in the comparison of the ring openings of epichlorohydrin (Reactions 3, 4, & 5) with that of styrene oxide (Reactions 6 & 7) as well as in the behavior of 1-benzenesulfonyl-2-bromomethylethylenimine (Reaction 8) as compared with that of 2-phenylethylenimine (Reaction 9).

Recently, Somerville and Spoerri (22a) (22b) investigated the reactions of butylene oxide, isobutylene oxide, and methyl styrene oxide with benzene in the presence of aluminum chloride. They found the reactions to be complicated in that not
only ring opening but also rearrangement occurs. For example, isobutylene oxide reacts to give neophyl alcohol, \( \text{\( \alpha, \alpha \)-dimethyl-dibenzyl} \) and meso-2, 3 diphenylbutane. The meso-2, 3 diphenylbutane is formed by a rearrangement of the \( \text{\( \alpha, \alpha \)-dimethyl-dibenzyl} \) under the experimental conditions used.

\[
\text{CH}_3\text{C} - \text{C} - \text{H}_2 \xrightarrow{\text{AlCl}_3} \text{C}_6\text{H}_5\text{CH}_3 + \text{C}_6\text{H}_5\text{CH}_3\text{C}_6\text{H}_5 + \text{C}_6\text{H}_5\text{CH}_3\text{C}_6\text{H}_5
\]

No work has been reported on the Friedel-Crafts reaction with epichlorohydrin.

No report has appeared in the literature on the Friedel-Crafts type of reaction with ethylenimine or its derivatives.

Excellent surveys of the reactions of both ethylene oxides and ethylenimines can be found in Elderfield's *Heterocyclic Compounds* (4).
DISCUSSION OF EXPERIMENTS

FRIEDEL-CRAFTS REACTION WITH 1-BENZENESULFONYL-2-BROMOMETHYL-ETHYLENIMINE

The starting material used in the present work was 1-benzenesulfonyl-2-bromomethylethenimine, a crystalline material with melting point of 89-90°. The compound was prepared by treating 1-amino 2,3-dibromopropane hydrobromide with benzenesulfonyl chloride and sodium hydroxide according to the method of Gensler (10).

1-Benzenesulfonyl-2-bromomethylethenimine was treated at 80° for three hours with benzene in the presence of a catalytic amount of aluminum chloride. All reactants were added in quick succession. A crystalline product with melting point 80-90° was obtained. Crystallization of this material from ethyl alcohol brought the melting point to 88-39.5° and a mixed melting point determination indicated that this material was the starting material. No other crystalline material could be isolated and the recovery of the starting material was 37.1%.

When the amount of aluminum chloride was increased to one mole, the other conditions being the same, starting material was recovered to the extent of 55.4%. The greater recovery in this experiment as compared to the previous one could be attributed to improved technique and greater familiarity with the isolation procedure.

An experiment was carried out using nitrobenzene as the solvent. The quantities used were one mole of 1-benzenesul-
fonyl-2-bromomethylethlenimine, one mole of aluminum chloride, and two moles of benzene. The reaction mixture was placed on the steam bath for three hours. Again little reaction if any, took place; starting material was recovered in 62.8% yield.

With two moles of aluminum chloride, one mole of 1-benzene-sulfonyl-2-bromomethylethlenimine, and excess benzene, the only product that could be isolated was benzenesulfonamide in 31% yield.

The optimum conditions for carrying out the reaction were found to be as follows: one mole of 1-benzenesulfonyl-2-bromomethylethlenimine, one and one-half moles of aluminum chloride with excess benzene, held at steam bath temperature for three hours. Under these conditions a crystalline product, with a melting point of 128.5-129°, was isolated in 30% yield. Carbon, hydrogen and nitrogen analytical values agreed with those calculated for a compound with the empirical formula C₇H₇NSO₂. Apparently the compound was the original ethlenimine derivative (C₇H₆NSO₂Br), plus benzene, and with a phenyl group in place of bromine. The material was soluble in ethyl alcohol, acetone, ethyl acetate, and acetic acid, but was insoluble in dilute aqueous sodium hydroxide. The last observation could be taken to indicate absence of sulfonamido hydrogen.

Several attempts were made to isolate further products from the tarry residue of the Friedel-Crafts reaction. No distillate was obtained from the residual oil at a pressure of 0.02mm with the bath temperature slowly increased to 100°.
At higher bath temperatures, decomposition took place. When the residual oil was treated in a sealed tube with concentrated hydrochloric acid, the reaction mixture charred completely. Oxidation of the residual oil with alkaline potassium permanganate furnished a small amount of benzoic acid.

STRUCTURE OF THE CRYSTALLINE FRIEDEL CRAFTS PRODUCT

If the Friedel-Crafts reaction of 1-benzenesulfonyl-2-bromomethylethylamine and benzene proceeded in a manner analogous to the addition of hydrogen bromide (Reaction 8), the product would be the benzenesulfonyl derivative of $\beta,\beta'$-diphenylisopropyramine as follows:

$$\begin{align*}
11. & \quad \text{C}_6\text{H}_5\text{C}_6\text{H}_4\text{Br} \quad \text{N} \\
& \quad \text{S}_\text{O}_2\text{C}_6\text{H}_5 + \text{C}_6\text{H}_6 \quad \xrightarrow{\text{AICI}_3} \quad \text{C}_6\text{H}_5\text{C}_6\text{H}_4\text{C}_6\text{H}_6 \quad \text{N} \\
& \quad \text{S}_\text{O}_2\text{C}_6\text{H}_5 \\
\end{align*}$$

To check this possibility $\beta,\beta'$-diphenylisopropyramine was prepared according to the method of Koelsch (16), and converted to the benzenesulfonyl derivative. This derivative was found to be a white crystalline material with melting point 107.5-108°. Thus, it was evident that the Friedel-Crafts product was not the $\beta,\beta'$-diphenylisopropyramine derivative.

Attention should be called to the fact that while the benzenesulfonyl derivatives of primary amines ordinarily are soluble in sodium hydroxide solution, the benzenesulfonyl derivative of authentic $\beta,\beta'$-diphenylisopropyramine was not soluble. This suggested the possibility that the unknown Friedel-Crafts product, though insoluble in sodium hydroxide solution, might be a derivative of a primary amine. Actually,
a literature search revealed other examples of primary amines whose benzenesulfonyl derivatives fail to dissolve in sodium hydroxide (3).

In an effort to establish identity of the Friedel-Crafts product, hydrolysis of the compound was investigated.

Optimum conditions for the hydrolysis involved treating the unknown material with concentrated hydrochloric acid in a sealed tube at 160° for two hours. A seventy-five per cent yield of the crude amine hydrochloride (m. p. 211-216°) was obtained. Several recrystallizations from absolute ethyl alcohol raised the melting point of the amine hydrochloride to 218.219.5°, and afforded sixty per cent of the pure material.

To insure that no rearrangement had taken place during the high temperature reaction, the benzenesulfonyl derivative of the amine hydrochloride was prepared. The derivative had a melting point of 128-129°. A mixed melting point with the original material showed no depression.

Other methods of hydrolysis were also attempted. Refluxing the Friedel-Crafts reaction product with concentrated hydrochloric acid or concentrated sulfuric acid resulted in no hydrolysis. Reductive cleavage using sodium and isoamyl alcohol according to the method of Howard and Marckwald (12) afforded a very small amount (less than 1%) of the free amine.

Attempts were made to remove the benzenesulfonyl group by reductive cleavage with lithium aluminum hydride although previous reports in the literature (Marvel and Caesar (17),
and Strating and Backer (23), indicated that the desired reaction does not occur.* In the earlier work the solvent used for the reaction was ethyl ether. It was thought that by using a solvent with a higher boiling point, the reaction might succeed with tetrahydrofuran (b. p. 65°) as the solvent, an exceedingly small amount of the amine was obtained. With dioxane (b. p. 101°) as solvent, a 10% yield of the amine was obtained. Another solvent used was n-butyl ether, but this called for some caution because the boiling point of n-butyl ether is 143°, which is above the reported thermal decomposition point (130°(2)) for lithium aluminum hydride. A test using a small amount of the lithium aluminum hydride in n-butyl ether was made, the temperature being raised slowly to 130°. The reaction proceeded without sign of vigorous decomposition and therefore a reduction was tried at 130° on the Friedel-Crafts product. A 16.4% yield of the amine was obtained.

The amine was isolated in every case as a carbon dioxide derivative. This was formed conveniently by exposing the free amine, a viscous liquid, to the air. The amine rapidly absorbed carbon dioxide to form a white solid with a melting point of 85-86°. Analytical figures for this material indicated a stoichiometric ratio of two moles of the amine to one mole carbon dioxide. A reasonable structure would correspond to that

*Field and Grunwald (5) reported without details the production of "small amounts of amine" from the lithium aluminum hydride reduction of N-(diethyl)-benzenesulfonamide.
of a substituted ammonium carbamate.

12. \( R-NH_2 + CO_2 \rightarrow R-NH \cdot CO_2^+ \cdot NH_3 - R \)

This conclusion is in agreement with the work of Frankel and Katchalski (7), and of Katchalski, Berliner-Klibanski, and Berger (14).

With two derivatives of the unknown Friedel-Crafts product available, the amine hydrochloride and the substituted ammonium carbamate, a thorough search of the literature was made of all the possible structural isomers of the free amine having the empirical formula \( C_{15}H_{17}N \). It was found that the hydrochloride of 3,3-diphenylpropylamine had a melting point of 218-219\(^\circ\). (25), in good agreement with the melting point of the amine hydrochloride derived from the original Friedel-Crafts product. Significantly, the 3,3-diphenylpropylamine was reported to be a viscous liquid which rapidly absorbed carbon dioxide from the air to form a solid. Unfortunately, no melting point was reported for the resulting solid.

The 3,3-diphenylpropylamine and its derivatives were prepared as follows:
Cinnamic acid was treated with benzene and aluminum chloride to give \( \beta, \beta \)-diphenylpropionic acid according to the method of Vorlander, Rack and Leister (25). On treating \( \beta, \beta \)-diphenylpropionic acid with thionyl chloride, the acid chloride was obtained, and this with ammonium hydroxide was converted to the amide, a known compound, melting at 123-124\(^0\). Using lithium aluminum hydride the amide was reduced to the desired amine in 32.4\% yield. The hydrochloride of 3,3-diphenylpropylamine was prepared by bubbling dry hydrochloric acid through an ether solution of the amine. The amine hydrochloride precipitated in white crystalline form with m. p. 218-219\(^0\). When a small amount of the 3,3-diphenylpropylamine was exposed to the air, it rapidly absorbed carbon dioxide to form a white solid having m. p. 85-86\(^0\).

A mixed melting point of the amine hydrochloride obtained from the Friedel-Crafts product with authentic 3,3-diphenylpropylamine hydrochloride showed no depression. A mixed melting point of the ammonium carbamate obtained from the Friedel-Crafts product with the carbamate from authentic 3,3-diphenylpropylamine showed no depression. Further, the benzenesulfonyl derivative of the authentic 3,3-diphenylpropylamine was prepared (not previously reported), and the melting point found to be 128-129\(^0\). A mixed melting point of this benzenesulfonyl derivative with the original Friedel-Crafts product showed no depression. The two materials were thus considered to be identical and the structure of the Friedel-Crafts product demonstrated.
It was established then, that with one mole of 1-benzenesulfonyl-2-bromomethylethylidenimine, one and one-half moles of aluminum chloride and excess benzene, the following reaction occurs to an extent of at least 30%:

\[
\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{C}_6\text{H}_5 + \text{C}_6\text{H}_6 + \text{AlCl}_3 \rightarrow \text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{NHSO}_2\text{C}_6\text{H}_5
\]

**REACTION PATH**

In an attempt to offer a plausible mechanism for the above reaction, several compounds, which could either by intermediates or products transformed into the N-(3,3-diphenylpropyl)-benzenesulfonamide by rearrangement under the experimental conditions used, were prepared.

It was thought that perhaps N(\(\beta'\beta\))-diphenylisopropyl)-benzenesulfonamide was the first formed product and then rearranged under the experimental conditions to the N-(3,3-diphenylpropyl)-benzenesulfonamide. However, when N-(\(\beta'\beta\))-diphenylisopropyl)-benzenesulfonamide was treated with benzene and aluminum chloride under conditions comparable to the original Friedel-Crafts reaction, no products were isolated, and starting material was recovered in over 70% yield.

Several possible compounds could be formed as intermediates in the original Friedel-Crafts reaction. Three compounds, which were taken as likely to be formed, were prepared.

The first possible intermediate investigated was N-(benzenesulfonyl)-cinnamylamine.
Cinnamylamine had been prepared from cinnamyl chloride in low yield by Posner (19), by application of the Gabriel synthesis. Modification of the reaction, by using dimethylformamide as solvent, (21), afforded a 71.9% yield of the cinnamylamine (as the hydrochloride.). The benzenesulfonyl derivative of cinnamylamine was prepared in the usual manner. When N-(benzenesulfonyl)-cinnamylamine was treated with benzene and aluminum chloride under conditions corresponding to that of the original Friedel-Craft reaction, the only product isolated was benzenesulfonamide in 40% yield.

The last two compounds investigated as possible intermediates, were 1-bromo-2-benzenesulfonyamido-3-phenylpropane and 1-benzenesulfonyl-2-benzylethyleneimine. These compounds were prepared as follows:
dl-Phenylalanine was converted to its ethyl ester. Following the directions of Karrer, Portmann and Suter (13), the ethyl ester of dl-phenylalanine was converted with lithium aluminum hydride to dl-phenylalaninol. Treatment of dl-phenylalaninol with concentrated hydrobromic acid in a sealed tube yielded 2-amino-1-bromo-3-phenylpropane hydrobromide. When 2-amino-1-bromo-3-phenylpropane hydrobromide was treated with benzenesulfonyl chloride and sodium hydroxide, 1-benzenesulfonyl-2-benzylethlenimine was formed. The 1-bromo-2-benzenesulfonamido-3-phenylpropane was obtained by treating 2-amino-1-bromo-3-phenylpropane hydrobromide with benzenesulfonyl chloride and sodium carbonate.

It was demonstrated that if 1-benzenesulfonyl-2-benzylethlenimine was refluxed with concentrated hydrobromic acid, the product was 1-bromo-2-benzenesulfonamido-3-phenylpropane. Also, that sodium hydroxide converted 1-bromo-2-benzenesulfonamido-3-phenylpropane to 1-benzenesulfonyl-2-benzylethlenimine.
Reaction Path in the Conversion of 1-benzenesulfonyl-2-bromo-
methylethlenimine to N-(3,3-diphenylpropyl)-benzenesulfonamide.

The site of the primary reaction of the ethlenimine
derivative may be at the carbon-to-bromine link or at one of
the ring carbon-to-nitrogen links.

If it is assumed that simple alkylation of benzene occurs,
without rearrangement at the bromomethyl grouping, the first
formed product would be 1-benzenesulfonyl-2-benzylethlenimine.

Speculation as to subsequent steps leads to the possibil-
ities described in the following equations:
Under the influence of aluminum chloride, the ethylenimine ring could open with formation of compounds B, C, or D. The formation of compounds A or B will necessitate a rearrangement in order to reach the observed product E. A rearrangement mechanism involving carbonium ions could be written for the conversion of D to E; and, although more complicated and less reasonable, a reaction path could be devised also for the conversion of B to E. If the cinnamyl derivative, C, is formed from the ethylenimine, the subsequent step (addition of benzene to the styrene system) is acceptable.

That none of these possibilities describe the course of events in the Friedel-Crafts reaction is demonstrated by tests made on compounds, A, B, and C. In the presence of benzene and aluminum chloride and under the same condition as those used in the production of compound E from \(1\)-benzenesulfonyl-2-bromo-methyleneimine, none of these compounds afforded compound E. An oil from which no crystalline material could be isolated was obtained from ethylenimine derivative A. Benzenesulfonylamide was the only isolable product from C. Starting material was recovered in the reaction with B. The 2, 3-diphenylpropyl derivative, D, was not prepared and was not tested.

Judging from these experiments, reaction at the carbon-to-bromine link as the first step of the Friedel-Crafts reaction is excluded.

Possible action first at the heterocyclic ring of the original starting material and then at other sites may be
described by the following equations which do not exhaust all the possibilities:

The only test of these processes was made with compound H. This compound under the original Friedel-Crafts conditions was largely recovered.

For future work it is recommended that the bromoallyl derivative F be prepared and tested. The reaction from the starting material to F is reasonable, as are the subsequent steps F to G to E. The sequences G to C to E is inadmissible as the result of the direct test of compound C described before.

It should be realized that if the bromoallyl derivative F is actually the intermediate in the reaction leading to compound E, the allylic carbon-to-nitrogen link in F, in contrast to the corresponding link in cinnamyl derivative C, must be resistant to cleavage to benzenesulfonamide.
The results in the Friedel-Crafts reaction depend on the amount of the aluminum chloride used. The presence of catalytic amounts or one mole lead to appreciable recovery of unreacted starting material, and no other pure product. Two moles of aluminum chloride results in the liberation of benzensulfonamide. One and one-half moles of aluminum chloride results in the formation of E. If it is proved that compound F is an intermediate this difference in behavior with different amounts of aluminum chloride may be rationalized by assuming two competing actions of F. One leads to compound G; the other to benzensulfonamide. The observation may then be explained if the reactions leading to compound G (and so to E) does not increase in rate with an increase in the amount of aluminum chloride present as rapidly as the reaction leading to benzensulfonamide.

The Residual Oil formed in the Friedel-Crafts Reaction

Speculation as to the nature of the oily base—insoluble, non-volatile product(s) obtained in large amounts must take into account the following facts:

1. Test for halogen by sodium fusion was negative.
2. Oxidation leads to benzoic acid (20% weight yield)
3. No evidence for the presence of phthalic acid, isophthalic and terephthalic was obtained.
4. No benzensulfonamide was isolated from the experiment using one and one-half moles aluminum chloride. Tests for nitrogen and sulfur were positive.
5. No unsaturation by bromine test was observed.

Two possible structures which are in agreement with the observed facts are as follows:

\[
\begin{align*}
&\left[ \begin{array}{c}
& \text{C}_6\text{H}_5 \\
& \text{C}_6\text{H}_5
\\
& \text{C}_6\text{H}_5 \\
& \text{S}_\text{O}_2\text{C}_6\text{H}_5
\end{array} \right] \\
&\left[ \begin{array}{c}
-\text{CH} - \text{CH} - \\
\text{C}_6\text{H}_5 \\
\text{N} - \\
\text{S}_\text{O}_2\text{C}_6\text{H}_5
\end{array} \right]^\text{n}
\end{align*}
\]

It may be calculated that either of these two possibilities should yield benzoic acid on oxidation to the extent of 45%. The yield of benzoic acid actually found was 20%. Thus, either there is present material that does not have the carbon-to-benzene bond, or the yield from the oxidation is far from quantitative. No choice between the two alternatives is possible at this time.

**Ring opening of substituted Ethylenimines**

In the preparation of 1-benzenesulfonyl-2-benzylethyleneimine and 1-brome 2-benzenesulfonamide 3-phenylpropane, a significant series of reactions were recorded.

\[
\begin{align*}
&\text{C}_6\text{H}_5\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{Br} \quad \text{C}_6\text{H}_5\text{C}_6\text{H}_5\text{SO}_2\text{Cl} \\
&\text{N}_2\text{H}_4\text{O} \quad 2 \quad \text{NaOH} \\
&\text{C}_6\text{H}_5\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{Br} \quad \text{C}_6\text{H}_5\text{C}_6\text{H}_5\text{CH}_2\text{CH}_2\text{Br} \\
&\text{N}_2\text{H}_4\text{O} \quad \text{NaOH} \quad \text{HBr} \quad \text{NaOH}
\end{align*}
\]

When 1-benzenesulfonyl-2-benzylethyleneimine was refluxed with 48% hydrobromic acid, the ring was opened and substitution took place at the methylene carbon of the ring rather than the methine carbon atom. This result added support to the generalization that when the single substituent group on the ethylen-
imine ring was of aliphatic nature, attack by a nucleophilic agent such as the bromide ion took place on the less substituted carbon of the ring.
EXPERIMENTAL

Experiment I: Reaction of 1-Benzene sulfonfonyl-2-Bromomethyl-ethylenimine and Benzene in the presence of a catalytic amount of Aluminum Chloride

In a 300-ml. ground glass flask fitted with a stirrer and moisture-protected condenser was placed 8.9g (0.0322 mole) of 1-benzenesulfonfonyl-2-bromomethyl ethylenimine and 112 ml. (1.288 mole) of dry benzene. The aluminum chloride 0.43g (0.00322 mole) was then added in one portion. The mixture was refluxed on the steam bath for three hours. No acid gases were evolved during the reaction. After three hours, the mixture was poured into a beaker containing 200 ml. of water and 20 ml. of concentrated hydrochloric acid. This mixture was extracted with three-100 ml. portions of ether. The ether extract was washed several times with small volumes of water and then dried over magnesium sulfate.

All solvent was removed (finally at 100° under water pump vacuum) leaving a residue of 9.3g of colorless oil, which solidified to a crystalline mass. A small amount was pressed on clay giving a waxy solid with m. p. 60-85°. The crystalline mass was recrystallized from 40 ml. of 95% ethyl alcohol. Upon cooling, white crystals were obtained weighing 3.3 g. m. p. 88.5-90°. A mixed melting point with starting material gave m. p. 88.5-90°. This represented a 37.1% recovery of the starting material.
Experiment 2: Reaction of 1-Benzencesulfonyl-2-Bromomethyl-ethylenimine with Benzene in the presence of one mole of Aluminum Chloride.

The conditions and the quantities used in this reaction were the same as Experiment 1, except that the amount of aluminum chloride was increased to give a 1:1 molar ratio with the 1-benzenesulfonyl-2-bromomethylethylenimine.

From the reaction there was obtained 5.36 g. of material having m. p. 88-90°. One recrystallization from 15 ml. of alcohol furnished 4.35 g. The melting point alone or mixed with starting material was 88.5-90°. The recovery was calculated to be 55.3%.
Experiment 3: Reaction of 1-Benzencesulfonyl-2-Bromomethyl-ethylenimine with two moles of Benzene, one mole of Aluminum Chloride, using Nitrobenzene as the solvent.

To 75 ml. of dried nitrobenzene in a 3-necked ground glass flask fitted with a stirrer and a moisture-protected condenser, was added 4.26 g. (0.0119 mole) of 1-benzencesulfonyl-2-bromomethylethylenimine, 2.08 ml. (0.0238 mole) of benzene and 1.58g. (0.0119 mole) of aluminum chloride. The reaction was placed on the steam bath for three hours. The solution took on a dark amber color, but no acid gases were evolved during the reaction as shown by test with wet litmus paper. The solution was poured into a beaker containing 200 g. of ice-water and 5 ml. of conc. hydrochloric acid. The nitrobenzene was removed by steam distillation and the water-oil residue that remained was extracted with three-100 ml. portions of ether. The ether was washed with water and dried over magnesium sulfate. All solvent was removed and the residual oil dissolved in 20 ml. of ethyl alcohol and cooled. There was obtained 3.16 g. of material with m. p. 78-82°. One recrystallization from 10 ml. of alcohol gave 2.68 g. of material m. p. 88.5-89.5°. A mixed melting point with starting material gave m. p. 88.5-89.5°. The recovery of starting material was 62.8%.
Experiment 4: Reaction of one mole of 1-Benzenesulfonyl-2-Bromomethyleneimine, one and one-half moles of Aluminum Chloride with excess Benzene.

In a 300 ml. 3-necked ground glass flask fitted with a stirrer and moisture protected condenser, was placed 7.04 g. (0.0255 mole) of 1-benzenesulfonyl-2-bromomethyleneimine, 100 ml. (1.141 moles) of dry benzene, and 5.1 g (0.0382 mole) of aluminum chloride. The reaction was placed on the steam bath; after one hour a litmus test for acid gases was positive. The color of the solution was red-amber. After refluxing for three hours, the reaction mixture was poured into a beaker containing 200 g. of ice-water and 25 ml. of concentrated hydrochloric acid. The amber color was discharged to a white color. This aqueous acid solution was thoroughly extracted with ether, the ether washed with water and then dried over magnesium sulfate. The solution was concentrated down to a volume of approximately 20 ml. of viscous oil, and 30 ml. of alcohol was added. Upon cooling down in an ice-water bath, there was obtained 1.81 g. of material with m. p. 125-130°. The solids were removed by filtration and the filtrate placed in a refrigerator overnight. There was obtained an additional 1.60 g. of material with m. p. 124-130°. Both solid fractions were crystallized from ethyl alcohol and yielded 2.69 g. of material with m. p. 128-129.° in 30.05% yield. The ethyl alcohol was then removed by distillation under reduced pressure and there remained 4.81 g. of residual oil which had a tarry odor.
The residual oil could not be crystallized from alcohol.

A sodium fusion was carried out on the above crystalline material. A positive test was obtained for nitrogen and sulfur; a negative test for bromine.

The material was soluble in ethyl alcohol, acetone, ethyl acetate and acetic acid, but insoluble in sodium hydroxide solution.

Analysis: Calculated for C_{11}H_{12}NSO: C, 71.77; H, 6.02; N, 3.99. Found C, 72.08; H, 6.06; N, 3.83

All analysis were performed by Carol Fitz,


All melting points are uncorrected.
Experiment 4-1: Preparation of $\beta,\beta'$-Diphenyl Isopropylamine.

The above compound was prepared according to a modified procedure of Koelsch (16).

To a 300-ml three-necked flask fitted with a dropping funnel, thermometer and downward directed condenser was added 26.2 g. (0.86 mole) of 28% aqueous ammonia and 22 g. (0.86 mole) of 90% formic acid. The temperature was slowly raised to 160$^\circ$ to distil out the water. Dibenzyl ketone 1.78 g. (0.172 mole) was then added in one portion. The temperature was then raised to 175$^\circ$ and maintained there for eight hours. If during the reaction any of the ketone distilled over, it was returned to the flask at intervals.

The reaction mixture was cooled and the product precipitated to afford 37.8 g. of material with m. p. 90-93$^\circ$. One crystallization from benzene-ligroin yielded 35.5 g. of the formyl derivative with m. p. 92-93$^\circ$ in 86.8% yield.

To a 200-ml flask, fitted with a condenser was added 18.81 g. (0.0785 mole) of the above formyl derivative, 19 ml. of sulfuric acid, 19 ml. of water and 50 ml. of alcohol. The solution was refluxed for two hours. After steam distilling, the solution was cooled and made basic with 20% sodium hydroxide and 13.5 g. of the $\beta,\beta'$-diphenyl isopropylamine precipitated. The pure product had m. p. 47-48$^\circ$ and was obtained in 82.1% yield.
Experiment 4-2: Preparation of Benzenesulfonyl derivative of \( \beta,\beta' \)-Diphenyl Isopropylamine.

To 10 g. (0.0474 mole) of \( \beta,\beta' \)-diphenyl isopropylamine in a 200 ml. flask was added 50 cc. of 30% sodium hydroxide solution and 8.8 g. (0.05 mole) of benzenesulfonyl chloride. The mixture was stirred vigorously. The flask became quite warm and after a few minutes it was cooled in an ice-water bath. The material was insoluble in the sodium hydroxide solution. Upon filtering, there was obtained 16.1 g. of material with m. p. 107.5-108° in 97% yield.

Further recrystallizations from absolute ethyl alcohol did not change the melting point.

Analysis: Calculated for \( \text{C}_{14} \text{H}_{14} \text{NSO}_3 \): C, 71.77; H, 6.02; Found: C, 71.53; H, 6.08.
Experiment 5: Sealed tube hydrolysis of unknown material from Experiment 4, using concentrated Hydrochloric Acid.

To a 50 ml. tube was added 3.36 g. (0.0094 mole) of the unknown product from Experiment 4, and 10 ml. of concentrated hydrochloric acid. The tube was sealed and heated at 160° for two hours. The tube was cooled and opened (some charring took place). The crude product was obtained by filtration and yielded 1.78 g. of light brown crystals with m. p. 211-216°. Crystallization of the crude product from absolute ethyl alcohol yielded 1.41 g. (60.5%) of white crystals with m. p. 218-219.5°.

To insure that no rearrangement had occurred during the sealed tube reaction, the benzenesulfonyl derivative was prepared from the above amine hydrochloride. To 5 ml. of water was added 0.2 g. of the amine hydrochloride, and the resulting solution made basic by the addition of sodium hydroxide solution. Benzenesulfonyl chloride (0.5 ml) was added and the mixture vigorously shaken. The mixture was cooled, the solids were filtered, air dried, and gave m. p. 128-129°. A mixed melting point with some of the original product from Experiment 4, gave m. p. 128-129.5°.
Experiment 5-1: Attempted hydrolysis of unknown material from Experiment 4, by refluxing with concentrated Sulfuric Acid.

To a 50 ml. flask fitted with a condenser was added 2.63 g. (0.0074 mole) of the product from Experiment 4, 10 ml. of ethyl alcohol and 6 ml. of 50% sulfuric acid. The solution was refluxed for a period of twenty-four hours. Upon cooling, a crystalline material was obtained. This material, dried in the air, weighed 2.4 g. and had m. p. 125-128°. It was crystallized from 10 ml. of ethyl alcohol to yield 2.1 g. of material with m. p. 128-129°. A mixed melting point with the starting material gave m. p. 128-129°. The recovery of the starting material was 79.8%.

Experiment 5-2: Attempted hydrolysis of unknown material from Experiment 4, by refluxing with concentrated Hydrochloric Acid.

This experiment was carried out using the exact quantities as in Experiment 5. Starting material was recovered as evidenced by mixed melting point of 128-129° in 92% yield.
Experiment 5-3: Attempted reduction of unknown material from Experiment 4, using Sodium and Isoamyl Alcohol.

This experiment was carried out according to the procedure of Howard and Marckwald (10).

In a 200-ml. flask fitted with a condenser was placed 3.0 g. (0.0085 mole) of material from Experiment 4, and 50 ml. of isoamyl alcohol (dried over calcium hydride). The metallic sodium 1.15 g. (0.05 mole) was added in small pieces and the reaction mixture then refluxed for one hour. The reaction mixture was cooled and made basic with sodium hydroxide solution. Two layers formed and were separated. The lower aqueous basic layer was thoroughly extracted with three-100 ml. portions of ether. This ether extract was combined with the upper layer, washed with water, and dried over magnesium sulfate.

To isolate any free amine, the ether solution was extracted with three-50 ml. portions of dilute hydrochloric acid. This acid extract was made basic by adding sodium hydroxide solution and extracted with ether. The ether extract was washed with water, dried, (over magnesium sulfate) and then distilled, leaving a heavy colorless oil. This oil when exposed to the air rapidly absorbed carbon dioxide to form 0.01 g. of a white solid with m. p. 85-86°. Calculated on the basis of an amine carbamate the yield was 0.4%.

The ether solution, which remained after the acid extraction, was concentrated to a volume of 50 ml. and upon
cooling yielded 2.41 g. of material with m. p. 128-129°. A mixed melting point with starting material gave m. p. 128-129°. The recovery of starting material was 80%.

The previously obtained white solid, m. p. 85-86° was sent in for analysis without further purification.

Analysis: Calculated for C₃₁H₆₄N₂O₂: C, 79.9; H, 7.3

Found: C, 79.7; H, 7.5
Experiment 5-4: Attempted reduction of unknown material from Experiment 4, using Lithium Aluminum Hydride with Tetrahydrofuran as solvent.

In a 200 ml. three-necked flask fitted with a condenser and stirrer was placed 2 g. (0.0056 mole) of unknown material from Experiment 4, 60 ml. of tetrahydrofuran and 1.5 g. (0.00396 mole) of lithium aluminum hydride. The reaction mixture was refluxed for one hour, cooled, and water added dropwise to destroy the excess lithium aluminum hydride. The mixture was made basic by adding 20 ml. of 40% sodium hydroxide solution and then thoroughly extracted with ether in three 100 ml. portions.

To isolate any free amine, the ether extract was itself extracted with three-50 ml. portions of dilute hydrochloric acid. This acid extract was made basic by adding excess sodium hydroxide solution and then extracted with ether. After the ether extract was washed with water and dried over magnesium sulfate, the ether was distilled, leaving a small amount of colorless oil. Upon exposure to air, the oil absorbed carbon dioxide to form 0.01g. (.08%) of a white solid with m. p. 85-86°.

The ether that remained following the acid extraction was concentrated to a small volume, cooled, and afforded 1.2 g. (60%) of material with m. p. 128-129°. A mixed melting point with starting material gave m. p. 128-129°.
Experiment 5-5: Attempted reduction of unknown material from Experiment 4, using Lithium Aluminum Hydride with Dioxane as solvent.

To a 300 ml. flask fitted with a stirrer, condenser, and dropping funnel was added 0.1 g. (0.00028 mole) of unknown material from Experiment 4, 100 ml. of dioxane and 1.5 g. (0.039 mole) of lithium aluminum hydride. After refluxing for two hours, the reaction mixture was cooled and dilute hydrochloric acid added dropwise. The reaction mixture was steam distilled to remove the dioxane, cooled, and made basic by the addition of sodium hydroxide solution. This basic mixture was extracted thoroughly with ether.

To isolate any amine, the ether extract was extracted with three-50 ml. portions of dilute hydrochloric acid. Acid extract was made basic with excess sodium hydroxide solution and extracted with ether. This ether extract was washed with water, dried over magnesium sulfate, and then distilled from a steam bath to yield a colorless oil. Upon exposure to air, the oil absorbed carbon dioxide to form 0.008 g. (10.1%) of the amine carbamate; m. p. 84-85.5°.

A mixed melting point with starting material gave m. p. 128-129°. The recovery of the starting material was 70%.
Experiment 5-6: Attempted reduction of unknown material from Experiment 4, using Lithium Aluminum Hydride with n-Butyl Ether as Solvent.

To a 250 ml. flask was added 0.63 g. (0.00179 mole) of unknown material from Experiment 4, 100 ml. of n-butyl ether (b. p. 141-143°), and 1.0 g. of lithium aluminum hydride. The temperature of the flask was raised slowly to 130° and maintained there for two hours. The reaction mixture was cooled, water added dropwise, and the mixture made basic by the addition of sodium hydroxide solution.

The free amine was obtained in the same manner as described for Experiment 5-5; and upon exposure to air absorbed carbon dioxide to yield 0.13 g. (16.4%) of the amine carbamate; m. p. 85-86°.

Upon distilling of the ether as described in Experiment 5-5 there was obtained 0.24 g. of material; m. p. 128-129° in 38% yield. A mixed melting point with starting material gave m. p. 128-129°.
Experiment 6: Preparation of $\beta,\beta$-Diphenyl Propionic Acid.

This material was prepared according to a modified procedure of Vorlander, Rack and Leister (25).

In a three-necked 500 ml. flask fitted with a stirrer and condenser was placed 15.0 g. (0.101 mole) of cinnamic acid, 190 ml. of dry benzene and 25.0 g. (0.187 mole) of anhydrous aluminum chloride. The reaction mixture was refluxed on the steam bath for thirty-six hours. After cooling the mixture, it was poured into a beaker containing 200 g. of ice-water and 35 ml. of concentrated hydrochloric acid. This mixture was extracted with ether, the ether washed with water and dried over magnesium sulfate. The ether extract, after concentration to a small volume, was cooled, and yielded 18.6 g. of white crystalline material; m. p. 149-152°. One crystallization from benzene-ligroin afforded 17.1 g. (75%) of pure $\beta,\beta$-diphenyl propionic acid; m. p. 151-152°. The yield of pure product (m. p. 152°) previously reported was 90%.
Experiment 7: Preparation of $\beta,\beta$-Diphenyl Propionamide

In a 50 ml. flask fitted with a condenser, was placed 5.0 g. (0.022 mole) of $\beta,\beta$-diphenyl propionic acid and 5.0 g. (0.042 mole) of thionyl chloride. The reaction mixture was allowed to stand overnight. The excess thionyl chloride was removed by means of water vacuum and 15 ml. of dry benzene added to the residual oil. This mixture was added slowly to an excess of concentrated ammonium hydroxide and yielded 4.1 g. of the crude product with m. p. 122-124°. One crystallization from benzene afforded 3.7 g. (75.5%) of $\beta,\beta$-diphenyl propionamide, m. p. 123-124°. The previously reported melting point (25) was 123-124°.
Experiment 8: Preparation of 3,3-Diphenyl Propylamine Hydrochloride.

In a 300 ml. flask was placed 3.0 g. (0.0133 mole) of o,p'-diphenyl propionamide, 100 ml. of dry ether and 1.5 g. (0.039 mole) of lithium aluminum hydride. The reaction mixture was refluxed on the steam bath for three hours. Upon cooling the mixture, water was added dropwise and the mixture made basic by the addition of 50 ml. of 40% sodium hydroxide solution. The mixture was thoroughly extracted with ether and the ether extract washed with water and dried over magnesium sulfate. Dry hydrochloric acid was bubbled through the ether solution and yielded crystalline solids. The solids were removed by filtration, air dried, and weighed 1.16 g. having m. p. 214-218°.

One crystallization from 50 ml. of absolute ethyl furnished 1.07 g. (32.4%) of pure 3,3-diphenyl propylamine hydrochloride having m. p. 218-219°.
Experiment 9: Preparation of the Benzenesulfonyl derivative of 3,3-Diphenyl Propylamine.

To a vigorously stirred solution of 0.1 g (0.0004 mole) of 3,3-diphenyl propylamine hydrochloride in 5 ml. of water was added 0.6 ml. (0.0047 mole) of benzenesulfonyl chloride followed immediately by 5 ml. of a 40% sodium hydroxide solution. After the mixture had been stirred for thirty minutes at room temperature, it was filtered and the solids washed and pressed on the funnel. This material, dried in the air, weighed 0.12 g (85%) and had m.p. 127-129°. It was crystallized from 3 ml. of absolute ethyl alcohol to yield 0.089 g. (64%) of 3,3-diphenyl propyl benzenesulfonamide, m.p. 128-129°.
Experiment 10: Preparation of 3,3-Diphenyl Propylamine Carbamate.

To 5 ml. of water was added 0.2 g of 3,3 diphenyl propylamine hydrochloride and the solution made basic by the addition of 5 ml. of 40% sodium hydroxide solution. This basic mixture was thoroughly extracted with ether, the ether washed with water and dried over magnesium sulfate. All solvent was removed by distillation leaving a small amount of colorless liquid. After exposure to the air, this liquid changed to a white solid having m. p. 85-86°.
Experiment 11: Proof of structure of unknown material from Experiment 4.

A mixed melting point with the amine hydrochloride obtained from Experiment 5, and authentic 3,3 diphenyl propylamine hydrochloride gave m. p. 218-219°.

A mixed melting point with the unknown material from Experiment 4, and authentic 3,3 diphenyl propyl benzenesulfonamide gave m. p. 128-129°.

A mixed melting point with the substituted amine carbamate obtained from Experiment 5-4, and authentic 3,3 diphenyl propylamine carbamate gave m. p. 85-86°.
Experiment 12: Attempts at isolation of further products from tarry residue obtained in Experiment 4.

A vacuum distillation was tried on 15 g. of the tarry oil using a Vigreux column. The temperature of the flask was slowly raised to 100° with the pressure maintained at 0.02 mm. No distillate was obtained and the oil turned dark brown. When the temperature was increased to 200°, decomposition began as evidenced by an increase in the pressure. Several other attempts were made to distill the oil, but with no success.

Five grams of the oil were treated with 5 ml. of concentrated hydrochloric acid in a sealed tube at 110° for two hours. A large amount of charring occurred and no products could be isolated from the reaction.
Experiment 12-1: Oxidation of residual oil from Experiment 4.

In a 300-ml. flask was placed 1.5 g. of the oil, 50 ml. of water, and 5 ml. of 10% sodium hydroxide solution. An aqueous solution of potassium permanganate, 2.6g. in 75 ml. of water, was added dropwise over a period of two hours. The temperature was kept at 50°. Gaseous sulfur dioxide was bubbled through the mixture to dissolve the manganese dioxide and a colorless solution was obtained. This solution was cooled and thoroughly extracted with ether. This ether extract was itself extracted with dilute sodium hydroxide solution. This latter extract was acidified with dilute hydrochloric acid and the solution cooled. There was obtained 0.3 g. of material having m. p. 120-121°. A mixed melting point with an authentic sample of benzoic acid gave m. p. 120-122°.
Experiment 13: Reaction of one mole of 1-Benzenesulfonyl-2-Bromomethylethyleneimine with Benzene and two moles of Aluminum chloride.

To a 200 ml. flask was added 34 ml. of benzene and 6.36 g. (0.0478 mole) of aluminum chloride. The flask was placed on the steam bath and a solution of 50 ml. of benzene and 6.60 g. (0.0239 mole) of 1-benzenesulfonyl-2-bromomethylethyleneimine added dropwise over a period of one hour. Acid gases were evolved after five minutes. The product was isolated exactly as done in Experiment 4. There was obtained 1.63 g. of material having m. p. 140-148° and 3.10 g. of residual oil. Crystallization of the solids from 10 ml. of benzene yielded 1.47 g. of pure product with m. p. 149-150°.

A sodium fusion carried out on the above crystals gave a positive test for sulfur and nitrogen and a negative test for bromine. The analytical figures obtained suggested that it might be benzenesulfonamide. A mixed melting point with an authentic sample of benzenesulfonamide and the above product gave m. p. 149-150°. The yield of benzenesulfonamide was calculated to be 31.0%.

Analysis: Calculated for C₆H₇NSO₂: C, 45.86; H, 4.49; N, 8.92

Found: C, 45.60; H, 4.65; N, 8.90
Experiment 14: Reaction of N-(β,β'-diphenylisopropyl)-benzene-sulfonamide with Benzene and Aluminum Chloride.

In a 100 ml. flask, fitted with a stirrer and moisture-protected condenser, was placed 0.97 g. (0.0027 mole) of N-(β,β'-diphenylisopropyl)-benzenesulfonamide, 30 ml. of benzene and 0.56 g. (0.004 mole) of aluminum chloride. The reaction mixture was placed on the steam bath for three hours. After cooling, the mixture was poured into a beaker containing 50 ml. of ice-water and 5 ml. of concentrated hydrochloric acid. Two layers formed and were separated. The lower aqueous layer was extracted with ether; the ether extract was combined with the benzene layer and dried over magnesium sulfate. All solvent was removed by distillation, leaving a colorless, heavy oil. This oil was dissolved in 10 ml. of alcohol and upon cooling, yielded 0.71 g. of material having m. p. 105-108°. Recrystallization from 5 ml. of alcohol furnished 0.61 g. (72%) of pure material having m. p. 107-108°. A mixed melting point with starting material gave 107-108°.
Experiment 15: Preparation of N-Cinnamyl Phthalimide.

This material was prepared according to a modified procedure of Posner (19), using the modification of Sheehan and Bolhofer (21).

Potassium phthalimide 7.40 g. (0.04 mole) was added to a solution of 5.69 g. (0.037 mole) of cinnamyl chloride in 40 ml. of dimethylformamide. The reaction was slightly exothermic, the temperature rising to 38° in ten minutes. Stirring was continued for one hour, and the temperature dropped slowly to 25°. After the addition of 40 ml. of chloroform, the mixture was poured into 100 ml. of water. The aqueous phase was separated and extracted with two 10-ml. portions of chloroform. The combined chloroform extract was washed with 20 ml. of 0.2N sodium hydroxide (to remove unreacted phthalimide) and 20 ml. of water. After drying (sodium sulfate), the chloroform was removed. The crystalline residue was triturated with 40 ml. of ether, and 8.31 g. (85.4%) of N-cinnamyl phthalimide was collected by filtration; m. p. 153-153.5°.
Experiment 15-1: Hydrolysis of N-Cinnamyl Phthalimide by treatment with Hydrazine Hydrate.

A mixture of 4.00 g. of N-Cinnamyl phthalimide (0.0151 mole) 50 ml. of methanol and 1.8 ml. of an 85% aqueous hydrazine hydrate solution (0.03 mole) was heated under reflux for one hour. After cooling, 25 ml. of concentrated hydrochloric acid was added, and the mixture was heated under reflux for thirty minutes. After cooling to 0°C, crystalline phthalalhydrazide was removed by filtration. The filtrate was concentrated to a volume of 40 ml. and then cooled in an ice-water bath. After cooling at approximately 0°C for two hours, 2.31 g (m. p. 205-209°C, yield 90.4%) of cinnamyl amine hydrochloride was obtained. One crystallization from absolute alcohol gave 1.84 g. (m. p. 209-219°C, yield 71.9%) of pure cinnamylamine hydrochloride.
Experiment 15-2: Preparation of the Benzenesulfonyl derivative of Cinnamylamine.

A small amount, 0.5g. (0.00294 mole), of the cinnamylamine hydrochloride was dissolved in 5 ml. of water and the solution made strongly basic by the addition of sodium hydroxide. To this basic solution was added 2 ml. of benzenesulfonyl chloride, and the mixture shaken vigorously. The mixture was then cooled and the resulting crystalline solid material removed by filtration. This material 0.78 g. had m. p. 88-90°. One crystallization from 3 ml. of ethyl alcohol gave 0.71 g. (88.7%) of a crystalline solid; m. p. 89-90°.

Analysis: Calculated for C_{15}H_{13}NSO: C, 65.90; H, 5.53
Found: C, 65.70; H, 5.50
Experiment 16: Preparation of dl-Phenylalaninol

To a vigorously stirred solution of 2.61 g (0.069 mole) of lithium aluminum hydride in 100 ml. of ether was added a solution of 0.66 g (0.0345 mole) of the ethyl ester of dl-phenylalanine in 50 ml. of ether. The mixture was stirred an additional fifteen minutes, cooled, and water added dropwise to destroy the unused lithium aluminum hydride. To the mixture was added 20 ml. of 40% sodium hydroxide solution and the mixture thoroughly extracted with ether. This ether extract was concentrated to a small volume, cooled, and after scratching yielded 2.61 g (51.5%) of the dl-phenylalaninol having m. p. 67-68°. Two further crystallizations from ether did not change the melting point. Karrer, Portmann and Suter (13) reported a 75% yield of dl-phenylalaninol with m. p. 67-68°.
Experiment 16-1: Preparation of dl-Phenylalaninol Hydrobromide.

A stirred mixture of 25 ml. of 48% hydrobromic acid and 1.0g (0.0066 mole) of dl-phenylalaninol was left at room temperature for one hour. The reaction mixture was taken to dryness under reduced pressures on the steam-bath. This crude crystalline material was crystallized from absolute ethyl alcohol and afforded 1.21g (79%) of pure product having m. p. 148-149°.

Calculated for C₉H₇NO Br: C, 46.5; H, 5.6

Found C, 46.3; H, 5.3
Experiment 16-2: **Preparation** of 2-Amino-1-bromo-3-phenyl propane hydrobromide.

In a Carius tube was placed 1.0 g (0.0066 mole) of dl-phenylalaninol and 25 ml. of 48% hydrobromic acid. The tube was heated at 170-175° for five hours. The resulting dark-colored mixture, in which some carbonized material was present, was diluted with 100 ml. of water and treated with decolorizing carbon (Nuchar) to obtain a water-white solution. This was taken to dryness under reduced pressures on the steam-bath and a crystalline residue was obtained. The crude product was crystallized from absolute alcohol and furnished 1.27 g. (68%) of product having m. p. 173-176°.

Recrystallization from 3 ml. of absolute alcohol yielded 0.97 g. (49%) of pure product and had m. p. 174-175°.

**Analysis:** Calc. for C₁₅H₁₀NBr₂: C, 36.8; H, 4.43
  Found: C, 36.7; H, 4.4

Experiment 16-3: When the above reaction was carried out at 100°, the only product that could be isolated was the hydrobromide of the starting material dl-phenylalaninol m. p. 148-149°. The mixed melting point with the pure product was 148-149°.
Experiment 17: Preparation of 1-Benzencesulfonyl-2-benzylethyleneimine.

A. To a vigorously stirred solution of 1.5 g. (0.0050 mole) of 2-amino-1-bromo-3-phenylpropane hydrobromide in 10 ml. of water was added 0.78 ml. (0.006 mole) of benzenesulfonyl chloride followed immediately by a solution of 1.0 g. (0.0025 mole) of sodium hydroxide in 10 ml. of water. After the mixture had been stirred for forty minutes at room temperature, the solids were collected, washed with water and finally air-dried. The crude product weighed 1.22 g. (89%) and had m. p. 54-56°C. It was dissolved in ether, the ether washed with several portions of water and then dried over sodium sulfate. The ether was distilled from a steam bath and the residual oil crystallized from ethyl alcohol. There was obtained 1.03 g. (75%) of pure product having m. p. 55-56°C.

Analysis: Calculated for C₁₅ H₁₅ NSO₂: C, 65.9; H, 5.53
          Found:  C, 65.7; H, 5.6; Ash, 0.3%

B. In a 50 ml. flask was placed 0.5 g. (0.0014 mole) of 1-bromo 2-benzenesulfonamido 3-phenylpropane. To this was added a solution of 0.4 g. (0.01 mole) of sodium hydroxide in 10 ml. of water. The mixture was shaken for fifteen minutes. The crude crystalline product, which weighed 0.36 g. (95%), m. p. 53-55°C, was crystallized from 5 ml. of ethyl alcohol and afforded 0.31 g. (81%) of pure product having m. p. 55-56°C. A mixed melting point with the 1-benzencesulfonyl-2-benzylethlenimine prepared in Method A gave 55-56°C.
Experiment 17-1: Reaction of 1-Benzenesulfonyl-2-benzylethylenimine with Benzene in the presence of Aluminum Chloride.

To a 200-ml. flask was added 1.60 g. (0.0058 mole) of 1-benzenesulfonyl-2-benzylethylenimine, 40 ml. of benzene and 0.81 g. (0.0061 mole) of aluminum chloride. The reaction mixture was placed on the steam bath for three hours. The reaction product was isolated as in Experiment 13-1. There was obtained 1.09 g. of a heavy, viscous oil which could not be crystallized from ethyl alcohol, benzene, carbon tetrachloride, acetone, or ethyl ether.
Experiment 18: Preparation of 1-Bromo-2-benzenesulfonamido-3-phenylpropane

**Method A:** To a vigorously stirred solution of 1.0 g. (0.0051 mole) of 2-amino-1-bromo-3-phenylpropane hydrobromide in 10 ml. of water was added 0.78 ml. (0.006 mole) of benzenesulfonyl chloride followed immediately by a solution of 0.86 g. (0.010 mole) of sodium carbonate in 10 ml. of water. After the mixture had been stirred for one hour at room temperature, the mixture was extracted with ether to remove the oily product. The ether extract was washed thoroughly with water, dried over magnesium sulfate and then distilled from a steam bath. The oil obtained, which weighed 1.30 g. (72%), was dissolved in ethyl alcohol and upon cooling in an ice-water bath afforded 1.03 g. (57%) of product having m. p. 22-23°.

**Method B:** A mixture of 10 ml. of 48% hydrobromic acid and 0.4 g. (0.00146 mole) of 1-benzenesulfonyl-2-benzylethyl-enimine was heated on the steam bath for one hour. After the addition of 20 ml. of water, the reaction mixture was cooled in an ice-bath and then thoroughly extracted with ether. This ether extract was dried over sodium sulfate, and distilled from a steam bath leaving 0.44 g. (84%) of crude product. This material was crystallized from ethyl alcohol at 15° and yielded 0.34 g. (65%) of pure white crystals melting at 22-23°. A mixed melting point of the product from Method A and Method B gave 22-23°.

**Analysis:** Calculated for C₁₅H₁₆NSO₂Br; C, 50.8; H, 4.5

**Found:** C, 50.6; H, 4.6
Experiment 18-1: Reaction of 1-Bromo-2-benzenesulfonamido-3-phenylpropane with Benzene in the presence of Aluminum Chloride.

To a 200-ml. flask was added 1.48 g. (0.0041 mole) of 1-bromo-2-benzenesulfonamido-3-phenylpropane, 40 ml. of benzene and 1.29 g. (0.0097 mole) of aluminum chloride. The reaction mixture was placed on the steam bath and refluxed for three hours. The reaction mixture was added to a beaker containing 100 ml. of ice-water and 10 ml. of concentrated hydrochloric acid. The upper benzene layer was separated and the lower aqueous layer thoroughly extracted with ether. The ether and benzene layers were combined and dried over sodium sulfate. All solvent was removed by vacuum distillation and the residual oil crystallized from 5 ml. of 95% ethyl alcohol. There was obtained 1.21 g. (75%) of material having m. p. 22-23°. A mixed melting point with starting material gave m. p. 22-23°.
SUMMARY

The reaction of 1-benzenesulfonyl-2-bromomethylethyleneimine with benzene in the presence of aluminum chloride was investigated. It was found that when a catalytic amount of aluminum chloride was used, no product could be isolated and the starting material was recovered. The optimum conditions for the reaction leading to the product described below involved the use of one mole of 1-benzenesulfonyl-2-bromomethylethyleneimine, one and one-half moles of aluminum chloride and excess benzene. The reaction mixture was placed on a steam bath for three hours. Under these conditions, a crystalline product was isolated in 30% yield, and its structure established as N-(3,3-diphenylpropyl)-benzenesulfonamide.

\[ \text{CH}_2\text{CHCH}_2\text{Br} + C_6H_5 \rightarrow A1Cl_3 \rightarrow C_6H_5\text{CHCH}_2\text{CH}_2\text{NHSO}_4\text{C}_6H_5 \]

From the previous reaction there was also obtained a heavy viscous oil. Although this oil was submitted to further treatments such as low pressure distillation and hydrolysis with hydrochloric acid, no pure product could be isolated. An alkaline potassium permanganate oxidation did yield a small amount of benzoic acid.

During the proof of structure of the N-(3,3-diphenylpropyl)-benzenesulfonamide, it was found desirable to obtain the amine hydrochloride or free amine. The only satisfactory method for hydrolyzing the benzenesulfonyl derivative was treatment of the benzenesulfonyl derivative with concentrated hydrochloric acid
in a sealed tube. Reductive cleavage of the benzenesulfonyl group with sodium in isoamyl alcohol, and with lithium aluminum hydride proved to be possible, but furnished the desired product in impractical yields. Of the three solvents (tetrahydrofuran, dioxane and n-butyl ether) used with lithium aluminum hydride, n-butyl ether at 130° resulted in the highest yield, 16.4%. It was found that the 3,3-diphenylpropylamine, which was an oil, rapidly absorbed carbon dioxide from the air to form a substituted ammonium carbamate.

A preliminary study of the mechanism was undertaken. Four compounds were prepared which might either be intermediates or products transformed into the N-(3,3-diphenylpropyl)-benzenesulfonamide under the experimental conditions used. These compounds were N-(benzenesulfonyl)-cinnamylamine, N-(β,β'-diphenylisopropyl)-benzenesulfonamide, 1-benzenesulfonyl-2-benzylethlenimine and 1-bromo-2-benzenesulfonamido 3-phenylpropane. Both cinnamylamine and β,β'-diphenylisopropylamine had been prepared previously although their benzenesulfonyl derivatives were not reported; 1-benzenesulfonyl-2-benzylethlenimine and 1-bromo 2-benzenesulfonamido 3-phenylpropane are new compounds.

When the above prepared compounds were allowed to react with benzene and aluminum chloride under exactly the same conditions as reaction 1, results described in the following equations were obtained:

2· \( \text{C}_6\text{H}_5\text{CH}=\text{CHCH}_2\text{NHSO}_2\text{C}_6\text{H}_5 + \text{C}_6\text{H}_6 \xrightarrow{\text{AlCl}_3} \text{C}_6\text{H}_5\text{SO}_2\text{NH}_2 \) (40%)
3. \[ C_6H_5CH_2CH_2CH \cdot CH_2C_6H_5 - N^{+}H \] \[ SO_{2}C_6H_5 \] + \[ C_6H_6 \] AlCl_3 \[ \rightarrow \] Starting Material (72%) 

4. \[ C_6H_5CH_2CH - CH_2 \] \[ N \] \[ SO_{2}C_6H_5 \] + \[ C_6H_6 \] AlCl_3 \[ \rightarrow \] Intractable Oil 

5. \[ C_6H_5CH_2CH_2CH_2Br \] \[ N \] \[ SO_{2}C_6H_5 \] + \[ C_6H_6 \] AlCl_3 \[ \rightarrow \] Starting Material (75%) 

It is the view of the author that before a mechanism for reaction 1 can be offered, more information is needed on the Friedel-Crafts reaction with other ethylenimine derivatives.

Speculation on the course of reaction 1, in the light of these experiments, suggests that a path which might be tested proceeds by way of initial ring opening to yield N-(bromoallyl) benzenesulfonamide. This compound could react to yield N-(3-bromo-3-phenyl-propyl)-benzenesulfonamide, which by alkylation of a second benzene molecule would furnish the observed product.

6. \[ \text{CH}_3 - \text{CHCH}_2\text{Br} \] \[ N \] \[ SO_{2}C_6H_5 \] + \[ C_6H_6 \] AlCl_3 \[ \rightarrow \] \[ \text{BrCH} = \text{CHCH}_2\text{NH}SO_{2}C_6H_5 \]

\[ \Downarrow \]

\[ C_6H_5\text{CHCH}_2\text{CH}_2\text{NH}SO_{2}C_6H_5 \]

\[ \Downarrow \]

\[ C_6H_5\text{CHCH}_2\text{CH}_2\text{NH}SO_{2}C_6H_5 \]
In the preparation of 1-benzenesulfonfyl-2-benzylethyleneimine and 1-bromo 2-benzenesulfonamido 3-phenylpropane, a significant series of reactions were recorded.

\[ \text{C}_6\text{H}_5\text{CH}_2\text{CHCH}_2\text{Br} \xrightarrow{\text{I. C}_6\text{H}_5\text{SO}_2\text{Cl}} \xrightarrow{2. \text{NaOH}} \text{C}_6\text{H}_5\text{CH}_2\text{CH} - \text{C}_6\text{H}_5 \]

When 1-benzenesulfonfyl-2-benzylethyleneimine was refluxed with 48% hydrobromic acid, the ring was opened and substitution took place at the methylene carbon of the ring rather than the methine carbon atom. This result added support to the generalization that when the single substituent group on the ethyleneimine ring was of aliphatic nature, attack by a nucleophilic agent such as the bromide ion took place on the less substituted carbon of the ring.
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