Synthesis of some substituted biphenyls

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Synthesis
of some
Substituted Thio-phenols
and
Substituted Thio-naphthols
HISTORICAL INTRODUCTION
The exact mechanism of the stimulation of tissue or cell proliferation is a process that is not yet fully understood.

The skin, in so far as most people are concerned, is just a covering for the body. Very little attention is given it except for pursuits of artificial beauty. Yet, upon analysis, we find that the healthy epidermis is the first line of defence against the hordes of bacterial invaders with which we are in constant contact. If the pores are occluded by an impermeable covering, death results. If even the outermost stratum, the horny layer of the epidermis, is removed, a like termination follows. These two facts show the necessity of preserving the integrity of the skin if we would have the rest of the body in a state of perfect health.

Today, as is true thru the history of man, people are continually suffering wounds and various skin abrasions. The temporary disability caused by the wound itself is rather unimportant in most cases. The real discomfort comes when the sore refuses to heal causing partial invalidism for years. Also the unclosed wound furnished a favorable path of entrance for infecting organisms, which, if they multiply, may necessitate amputation or in many cases cause death.

The ancients appreciated the quick healing of
wounds, and had many ointments and salves which were supposed to be beneficial. The remedies were naturally occurring products and undoubtably showed their benefits by an antiseptic action. Disinfectants, however, in performing their beneficial action may even make healing much slower. Investigations, for the purpose of determining a means to stimulate tissue growth or healing of wounds have come about since the advent of the twentieth century.

One of the first examples of a tissue proliferant was given by Bramwell (Zentr. Biochem. Biophys. 12, 843; Brit. Med. J. (1912) 12; C.A. 6, 3128 (1912)). He reports that a crystalline substance from a plant, "symphytum officinale", having the empirical formula of allantoin actually excited the formation of tissue. He also reports that if taken internally, the compound acts as an analgesic. He offers no theory for the action produced.

Brailey (C.A. 7 2974 (1913); Trans. Ophth. Soc. United Kingdom 32, 43; Zentr. Biochem. Biophys. 15, 123) reports that allantoin acted as a cell proliferant in promoting granulation in ulcus corneae. As in the case given above, he offers no explanation for the effect observed.

Bell (C.A. 13, 2906 (1924); Lancet (1924).I, 267-76)
gives a report not concerning a stimulation of tissue or cell growth but a method of retardation. He found that the presence of the lead ion hinders the growth of tissue containing phosphatides. He suggests the retardation of growth to be due to chemical action between the lead ion and the phosphatides. Another and more probable way in which the lead ion can hinder the growth of tissue will be given later.

M. Popoff (C.A. 18, 993 (1924); J. physio. path. gen. 21, 482-92 (1923) suggests that a compound capable of stimulating cell function must possess the fundamental property of accelerating and increasing the oxidation processes of the living cell, and to possess this property they should themselves have a marked affinity for oxygen. He obtains results which he believes to be in keeping with his theory. Some of the chemicals which possess the stimulating power are carbon monoxide; carbon dioxide, to a lesser extent; magnesium and manganese salts which are enhanced by the addition of potassium or iron salts; arsenates; ethyl and methyl alcohol; glycerine and glycerophosphoric acid; aldehydes; methylal; formic acid but not the higher fatty acids; lactic and malic acids, but not tartaric to nearly as strong extent. The action of phenols increased with the number of OH groups.
He also obtained similar results with phenol, salicylic acid, and salol. Vanillic, gallic, and tannic acids (quinic acid less pronounced), as well as weak concentrations of ether, chloroform, chloral hydrate, strychnine and atropine. All gave a stimulating effect. He also reports that, if the absorbed oxygen is boiled out of the solutions containing the growth accelerating compound, the stimulative action is markedly decreased. He also points out that shaking up the solutions with oxygen before using will restore their full stimulative power.

Busy (C.A. 20, 3735 (1926); Micoplasma 5, 149-58, (1926) reports that the amount of free oxygen supplied to a cell by the interstitial fluid which bathes it, is the cause of cellular proliferation. The results of Busy tend to show that the observations of Popoff were due to the free oxygen dissolved in the solutions which he applied.

On the other hand, Popoff appeared to neglect the possibility of his compounds acting according to the Arndt-Schulze law. That is, narcotics or anaesthetics in small amounts show a stimulating effect on the cell. In greater concentrations the stimulative effect may be first noticed, but this action is followed by narcosis
or anaesthesia in which cellular proliferation has nearly stopped. In all probability, Popoff observed the stimulating effect, common to all narcotics in dilute solutions.

Later work on this subject is being done by Hammet and his associates. Their work deals with the healing activity of organic compounds containing the sulfhydryl group. An account of their work is given in "Synthetic Organic Chemicals" Vol. III No. 5, June 1930, published by the Eastman Kodak Co. Their results will be given here in part.

They first noticed the retardation of the growth of seedling roots by the presence of lead salts in solution. The lead salt decreased the reproduction by division. An investigation showed a lead containing product upon which an analysis indicated that it was a combination of the metal with an organic compound containing the sulfhydryl group. They gave glutathione as the possibility for this compound. They also noticed that the parts of the root, in which growth by cell division took place most rapidly, gave the strongest nitroprusside test for the sulfhydryl grouping. This tends to associate the sulfur containing organic compound with the growing process.

They confirmed the above supposition by showing
that a root tip when crushed or scratched with a needle immediately gave a distinct test with nitro prusside reagent. They also removed the stimulating compound from the root tips with 0.02 normal hydrochloric acid. The acid extract could then be used to accelerate the growth of other seedling roots. Further experiments showed that the sulfhydryl compounds were always present where the rapid production of new tissue was required.

They then began studying the effect of organic compounds containing the -SH group on the growth in length of seedling roots. Thioglycollic acid was used in very dilute solutions. Most of them having a sulfur content of about 0.01 milligram per hundred ml. In all cases the roots immersed in the sulfhydryl containing solution increased in length more rapidly than those in the control. The sodium and potassium salts of the acid showed the same effect. They also tried glycollic acid, but observed only normal activity. From this they concluded that the sulfhydryl group was the factor causing the acceleration in growth.

They also took roots, the growth of which had been retarded by treatment with lead salts, and found that if the roots were washed free of lead and then immersed in sulfhydryl solution, growth was stimulated. Cysteine
was also used, giving similar results while the closely related non sulfur containing amino acid, alanine, showed no such stimulation. Also cystine, the disulfide oxidation product of cysteine, showed similar stimulation. Microscopic examination showed that the increase in length of the roots was due to actual division of the cells and not to their elongation.

The same stimulation was noticed also when a simple form of animal life was treated with very dilute thioglycollic acid. Paramecium was the organism studied. This showed that stimulation of growth by the sulfhydryl group occurred in the lower forms of animal life as well as in plant life.

After the success with the paramecium, they tried white rats in order to see if the same principle could be applied to a more complex and highly developed species. The experiment is described in J. Exptl. Med. 50, 445-8 (1929). The rats were anesthetized and two small patches of skin removed from each. The wounds were covered with gauze and cotton and kept moist with the solution under investigation. In these experiments they used thioglucose in the hope that the glucose structure would provide a source of energy for the multiplying cells.

One of the dressings on each animal was saturated
every two or three hours with a 1:10,000 (based on sulfur content) thioglucose solution buffered to a pH of 6.8 with a phosphate mixture. The other dressing was kept moist with a similar glucose solution instead of thioglucose. At the end of 48 to 72 hours 80% of the rats showed a distinct acceleration in the healing of the side to which the thioglucose had been applied. The wounds which had been treated with the glucose solution showed but little evidence of healing.

Encouraged by the success in the healing of wounds in rats, Hammet and Reimann (Proc. Soc. Expt. Biol. Med. 27, 20-2 (1929); C.A. 24, 5310 (1930) tried using very dilute solutions of thioglucose on human patients. In one case a varicose ulcer, which had defied treatment for over 10 years, was treated with thioglucose. The section treated showed distinct signs of improvement in 24 hours; the surface had begun to granulate and cells had grown out from the edge of the healthy skin. Other cases showed a similar improvement, although it was found necessary to discontinue the thioglucose treatment after 24 to 48 hours as it stimulated not only the tissue cells, but also the bacteria.

To avoid this difficulty, they replaced the thioglucose with thioresol. This type of compound not only inhibited bacterial growth but it also showed
the same beneficial effect towards tissue growth as did the thioglucoae. In the case of thiocresol fresh solutions had to be used as the oxidized disulfide form slowed healing instead of hastening it.

The results obtained above tend to show the importance of the sulfhydryl group in hastening tissue growth. Such a theory not only accounts for many of the facts noted in cell division, but it has also predicted results in a very practical way.

The problem at present is to prepare some sulfhydryl containing compound, which not only acts as a stimulant to tissue growth, but also as an inhibitor of bacterial growth.

It is quite well established that the phenol coefficient of thiophenol is much greater than that of phenol itself. Consequently, if some substituted phenols could be found having a high phenol coefficient, the corresponding thio compounds should show at least as much, if not more toxicity.

In a pamphlet published by "Dr. F. Raschig G.m.b.H. Chemische Fabrik, Ludwigshafen, A. Rhein," the phenol coefficients of some substituted phenols were given. The coefficient of para-chlormetaresol(6-chlor-3-oxy-1-methyl benzol) was found to be 140 in water solution and 40 in soap solution. The organism used in deter-
mining the coefficient was Eberthella typhi. With the same organism the phenol of chloroxylenol (2-chlor-5-oxy-1,3-dimethyl benzol) was found to be 256 in water solution and 63 in soap solution. That of chlor-thymol (6-chlor-3-oxy-1-methyl-4isopropyl benzol) was found to be 343 in water solution and 110 in soap solution.

The relatively high phenol coefficients reported for these compounds made it desirable to prepare the corresponding thio derivatives. Although the exact properties of the thio compounds could not be predicted, they showed possibilities of very efficient action, both as germicide and tissue proliferant.

With this view in mind, the mercaptans, given later, were prepared.
EXPERIMENTAL
Fifty grams of Eastman Kodak Co. C.P. o-toluidine was treated with a solution of 24.9 ml. of C.P. H₂SO₄ (sp. gr. 1.84) in 75 ml. of distilled water. The acid was added to the water and the solution cooled. The amine was put in a pyrex evaporating dish and the aqueous solution of the acid added to it slowly. The water was then removed by heating on an electric hot plate. The water came off at 100-105°C. The temperature was then slowly raised to 225°C. At this temperature the amine sulfate appeared to change to the sulfonic acid. The mass was pasty before this temperature was reached, but at this temperature the mass became solid. The solid was heated for 30 minutes more. The material began to char on the bottom of the dish, so heating was discontinued. The solid was then dissolved in 20% sodium hydroxide. The unreacted o-toluidine was extracted with ether. The water solution was treated with Norite and filtered. The water solution was made slightly acid with dilute H₂SO₄. No acid separated out. The solution was then saturated with NaCl. No acid or sodium salt of the acid was precipitated. The failure
of the reaction was probably due to insufficient heating.

After the failure to prepare the toluidine sulfonic acid by the above procedure, the method given on page 219 of "Laboratory Experiments in Organic Chemistry" by Adams and Johnson--Macmillan 1931, was tried. The following amounts and procedure were used.

Fifty ml. of C.P. Eastman Kodak Co. o-toluidine were placed in a 200 ml. round bottom flask. To this, 78.5 ml. of concentrated sulfuric acid was added. The acid must be added slowly and the flask kept cool.

An air cooled reflux condenser was then attached and the mixture was heated on an oil bath for 5 hours at 180-190°C. To test for completion of the reaction one or two drops of the reaction mixture were added to 5-6 ml. of dilute sodium hydroxide (10%). No oily drops of o-toluidine separated out, so the heating was discontinued. In the case of o-toluidine 5 hours heating gave a complete reaction.

The mixture was then removed from the oil bath and allowed to cool to room temperature. When the mixture was cool, it was poured over 200 grams of finely crushed ice. It was necessary to put some ice in the flask to partially dissolve the material as it solidified on cooling. The solid material was thoroughly broken up. The material was then filtered with
suction and pressed as dry as possible.

The reaction:

\[
\text{CH}_2\text{NH}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CH}_3\text{NH}_2 + \text{H}_2\text{O}
\]

The sulfonic acid was used without further purification.

The next step of the synthesis involves the replacement of the amino group with chlorine by means of the Sandmeyer reaction. The procedure used follows very closely that found in "Laboratory Experiments in Organic Chemistry", by Adams and Johnson—Macmillan 1931, page 253-4.

The following method and amounts were used. Preparation of the cuprous chloride solution:—125 grams of powdered copper sulfate crystals \((\text{CuSO}_4 \cdot \text{5H}_2\text{O})\) and 35 grams of pure sodium chloride were placed in a liter pyrex Erlenmeyer flask. 400 ml. of distilled water was added to this, and the mixture heated to boiling on an electric hot plate. While this solution was heating, a solution of 27 grams of sodium bisulfite and 18 grams of sodium hydroxide in 200 ml. of distilled water was prepared. The bisulfite solution was added slowly and with shaking to the hot copper
sulfate, sodium chloride solution. The mixture was then cooled to room temperature by means of running water. The precipitated cuprous chloride was washed with water by decantation three times. The precipitate was then dissolved in 135 ml. of concentrated hydrochloric acid and 50 ml. of water. The cuprous chloride did not dissolve completely so concentrated hydrochloric acid was added until solution was complete. The flask was corked and set in a salt ice mixture to cool.

Diazotization of the amino sulfonic acid:--
The crude wet crystals from the sulfonation reaction were suspended in a mixture of 50 ml. of water and 140 ml. of concentrated hydrochloric acid. The mixture was contained in an 800 ml. pyrex beaker. The mixture was then set in a cooling bath of ice and technical concentrated hydrochloric acid. A mechanical stirrer was then placed in the beaker and the material stirred vigorously until the temperature of the mixture (in the beaker, not in the bath) reached 0°C. Then 40-50 grams of finely crushed ice were added. The temperature immediately dropped to -10°C. While the mixture was cooling a solution of sodium nitrite, 28 grams in 80 ml. of water, was prepared. When the temperature of the mixture reached -10°C, the sodium
nitrite solution was added slowly. The stirrer was kept running all thru the reaction, and the sodium nitrite was added thru a separatory funnel, the stem of which extended about 3 cm. below the surface of the liquid in the beaker. The nitrite solution was added until the mixture gave a positive test for nitrous acid, with starch-potassium iodide paper. During the course of the reaction, the temperature was kept below 0°C. by the addition of small quantities of crushed ice.

When the solution gave a positive test for nitrous acid, it was poured into the cuprous chloride solution which had been previously cooled to 0°C. The diazonium solution was added to the cuprous chloride solution slowly and with agitation. After all the diazonium solution had been added, the mixture was kept cool for 10-15 minutes more. It was then allowed to slowly warm to room temperature. It was shaken frequently to prevent foaming as much as possible. In this way the decomposition of the double salt, of the diazonium chloride, was accomplished with no loss thru foaming. The mixture was finally placed in a water bath at room temperature. The temperature of the bath was then slowly raised until it boiled. The solution was then cooled to room temperature and an equal volume
of a saturated solution of sodium chloride added. The sodium salt of the sulfonic acid separated out in white shining plates, which are characteristic of this type of compound. The crystals were filtered with suction and washed with 40-50 ml. of saturated sodium chloride solution. The filtrate was then evaporated to half its volume, and cooled. A small additional amount of the sodium salt of the acid separated out. This was filtered off and added to that obtained above. The sodium salt of the acid was then dried in an oven at 110°C for 3 hours.

The reactions:

\[
\begin{align*}
\text{CH}_3\text{NH}_2\cdot\text{HCl} + \text{HONO} \xrightarrow{\text{HCl}} &\rightarrow \text{CH}_3\text{N=N-Cl} \\
\text{HO-SO-} \text{N=N-Cl} \xrightarrow{\text{CuCl (Heat, HCl)}} &\rightarrow \text{CH}_2\text{Cl + N}_2 \\
\text{HO-SO-} \text{Cl} \xrightarrow{\text{NaCl (excess)}} &\rightarrow \text{NaO-SO-} \text{Cl} + \text{HCl}
\end{align*}
\]
The dry salt was then treated with $\text{POX}^*$ according to the method given in "Organic Synthesis" Vol.I p.21.

Forty-six grams of the dry salt, which had been ground in a mortar, and 25 grams of finely ground phosphorous pentachloride ($\text{PCl}_5$) were put in a 200 ml. round bottom flask. The materials were then thoroughly mixed by rotating the flask and contents. The mixture was then heated at 170-180°C for 15 hours on an oil bath. Every 3 or 4 hours during the heating, the flask was removed from the oil bath, cooled for about 15 minutes and then thoroughly mixed by shaking. At the end of the 15 hour heating period, the contents of the flask was poured over 250 grams of finely cracked ice. The material was allowed to stand in the ice for about an hour. This treatment decomposed any unreacted phosphorous pentachloride or phosphorous oxychloride ($\text{POCl}_3$).

The sulfonyl chloride was then filtered with suction. It was in the form of a brown amorphous precipitate.

The reaction:—

\[
\text{PCl}_5 + 3 \text{NaO-SO}_{2} \rightarrow 3 \text{Cl-SO}_{2} + 2\text{NaCl} + \text{NaPO}_3
\]
A small portion of the sulfonyl chloride was purified by crystallization from ligroin. Two crystallizations gave a white compound melting at 63.5-34.0°C. This melting point corresponds quite closely with those found by Wynne. (Reference: J. Chem. Soc. 61, 1040, 1074).

In one article he gave the melting point of the compound as 60°C, and in the other article as 65°C.

The remainder of the crude sulfonyl chloride was then reduced according to the method given in "Organic Synthesis" Vol. I page 71-72.

Six hundred and fifty ml. of 25% sulfuric acid were put in a 2-liter pyrex beaker. The beaker was then set in a cooling mixture of ice and technical concentrated hydrochloric acid. When the temperature of the sulfuric acid reached -4°C, a mechanical stirrer was started. The amorphous sulfonyl chloride was then added slowly keeping the temperature below 0°C at all times. 65 grams of zinc dust was added as rapidly as possible and yet keeping the temperature below 0°C. After all the zinc dust had been added, the mixture was kept at 0°C and stirred constantly for 1½ hours. The material was removed from the cooling bath and poured into a 2-liter pyrex round bottom flask. A reflux condenser was attached and the flask allowed
to warm to room temperature. The reaction between the zinc and the acid was still very slow so the material was heated on a steam bath. Hydrogen was liberated rapidly at first but soon subsided. The mixture was then heated over a Bunsen burner for six hours. A downward condenser was then attached and steam was passed into the mixture. The material was very sparingly volatile in steam, and in all about 0.1 ml. came over with a liter of water. Upon cooling the reduction flask, a quantity of crystals separated. These were filtered off with suction.

The reaction:

\[
\begin{align*}
\text{CH}_3\text{Cl} & \xrightarrow{\text{CH}_3\text{H}_2\text{SO}_4 + \text{Zn}} \text{CH}_3\text{Cl + HCl} \\
\text{Cl-S} & \text{Cl}
\end{align*}
\]

At first these crystals were thought to be the mercaptan. They could not be recrystallized from benzene as they were too soluble. They were then crystallized from 95% ethyl alcohol, and dried in vacuum over phosphorous pentoxide. This product gave a melting point of 64.5-65°C. corr. However, the crystals were not soluble in dilute (10%) potassium hydroxide. This fact excluded the possibility of their being the desired mercaptan. The failure of the experiment was thought to be in the preparation of the sulfonyl.
chloride and subsequent reduction. With this in view another procedure was tried for the production of the sulfonyl chloride and its reduction.

In this procedure double quantities were used. The sulfonation of the amine and the Sandmeyer reaction were run in the same manner. However, the quantities of all reagents were doubled.

The sulfonyl chloride was prepared according to the method given in "Die Praxis des Organischen Chemikers" by L. Gattermann and revised by Heinrich Wieland.

Twenty-five grams of finely divided dry sodium salt of the sulfonic acid were placed in a 200 ml. round bottom pyrex flask. 40 grams of finely divided phosphorous pentachloride was then put into the flask. The contents of the flask were then thoroughly mixed with a stirring rod. An air cooled reflux condenser was attached and the flask heated for 30-45 minutes on a briskly boiling water bath. After heating, the material was allowed to cool to room temperature, and then was poured over 250 grams of crushed ice. The material was allowed to remain in the ice and water for one hour. In this manner the phosphorous oxychlorides were decomposed.
The reaction:—

\[
\begin{align*}
\text{CH}_3 & \quad \text{Cl} \quad + \quad \text{PCl}_5 \quad \rightarrow \quad \text{Cl} = \quad \text{S}_\text{O} \quad + \quad \text{NaCl} + \text{POCl}_3 \\
\text{NaO} & \quad \text{O} \\
\text{O} & \quad \text{O} \\
\end{align*}
\]

The sulfonyl chloride was then extracted with 3-100 ml. portions of benzene. About half of the benzene was then distilled off leaving the sulfonyl chloride in about 150 ml. of benzene. The benzene solution was then put in a 1-liter round bottom pyrex flask, and 35 grams of zinc dust added. A reflux condenser was attached and the flask set on a steam bath. 300 ml. of 25% sulfuric acid was then added in small amounts thru the condenser. The addition was accomplished in the course of 3 hours. During this time the mixture was kept slowly refluxing. After the addition was complete, the heating was continued for 2 hours more.

The reaction:—

\[
\begin{align*}
\text{Cl} = \quad \text{S}_\text{O} & \quad \text{Cl} \quad + \quad \text{H}_2\text{SO}_4 \quad \rightarrow \quad \text{HS} \\
\text{Cl} & \quad \text{Cl} \quad + \quad \text{HCl} + 2\text{H}_2\text{O} \\
\end{align*}
\]

The reaction mixture was then cooled. Upon cooling zinc sulfate (ZnSO\textsubscript{4}) separated out. This material was
filtered off with suction, and the residue washed with benzene. The water portion of the filtrate was then extracted with three 100 ml. portions of benzene. The benzene was then distilled off until the final volume was about 30 ml. This residue was then placed in a beaker, and the remainder of the benzene removed in a vacuum dessicator. Upon removal of the benzene, crystals separated out. A small amount of these were recrystallized from dilute ethyl alcohol. They were dried in a vacuum dessicator over phosphorous pentoxide. The crystals gave a melting point of 64.5-65°C. corr. This melting point corresponds exactly with that of the compound obtained from the previous reduction. The crystals from the second reduction were not soluble in dilute (10%) potassium hydroxide, so they could not be the mercaptan. A quantitative analysis was run on the compound, and this showed the presence of sulfur and chlorine.

Knowing the tendency of mercaptans to oxidize to the corresponding disulfide, the crystals obtained from the two reductions were believed to be the disulfide from the desired mercaptan. This also accounts for the presence of chlorine and sulfur which was found in the quantitative analysis. The failure to isolate
the mercaptan was now believed to be in the final purification.

With this view in mind, the compound, thought to be the disulfide, was dissolved in 150 ml. of benzene. The solution was then put in a 1-liter pyrex round bottom flask, and 10 grams of zinc dust was added. A reflux condenser was attached and the flask set on a steam bath. The solution was refluxed slowly and 150 ml. of 25% sulfuric acid was added slowly thru the condenser. The addition took about 2 hours. The mixture was refluxed for 1 hour more and then allowed to cool. The excess zinc and zinc sulfate were then removed by filtering with suction. The benzene solution was separated from the water in a separatory funnel.

The reactions:

\[
\begin{align*}
\text{Cl} & \quad \text{CH}_3 \\
\text{S-S} & \quad \text{Cl} \\
2\text{H(Zn+H}_2\text{SO}_4) & \rightarrow 2\text{H}_2\text{S} \\
\text{Cl} & \quad \text{CH}_3
\end{align*}
\]

The water layer was then extracted once with a 100 ml. portion of benzene. The benzene was then distilled off until the final volume was about 30 ml. About half of this solution was put into a 25 ml. Claisen flask with a fractionating side arm. The last traces of benzene were removed from this under reduced pressure. The
The remaining benzene solution was then put in the flask and the benzene removed as above. The pressure was then lowered to 26 mm., and the material distilled on an oil bath. Nearly all of the material came over between 122-123°C. at 26 mm. pressure with a bath temperature of 160-165°C. and was a clear colorless oil. It gave a clear solution with dilute (10%) potassium hydroxide. Upon adding hydrochloric acid the solution turned milky. The odor of the mercaptan was not very pronounced. The low vapor pressure at room temperature was probably the cause of this. However, the slight odor and behavior towards acid and alkali showed the compound to be a mercaptan.

Some of the sulfonyl chloride isolated earlier in the synthesis, was now treated with dilute ammonium hydroxide (NH₄OH). The solution was heated at 70-80°C. for 2 hours. The white crystalline sulfone amide was filtered off and recrystallized from dilute ethyl alcohol. This was dried in a vacuum desiccator over phosphorous pentoxide. The pure product gave a melting point of 127.5-128°C. corr. Wynne reports 128°C. as the melting point. (Reference: J. Chem Soc. 61, 1040 (1892))
The reaction:

\[ \text{Cl} \overset{\text{CH}_3}{\text{O}} - \text{Cl} + 2\text{NH}_4\text{OH} \rightarrow \text{Cl} \overset{\text{CH}_3}{\text{O}} - \text{NH}_4 + \text{NH}_4\text{Cl} \]

The mercaptan had a density of 1.2217 20/4, and an index of refraction, using sodium light, of 1.59675 at 20°C.

The mercaptan was then analyzed for sulfur by the Carius method.

Results:

<table>
<thead>
<tr>
<th>Sulfur Content</th>
<th>Calc.</th>
<th>Found</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20.09%</td>
<td>20.17%</td>
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</table>

The mercury salt of the mercaptan was then made in the following manner. 8 drops of the mercaptan was dissolved in 2 ml. of 95% ethyl alcohol. An excess of a saturated solution of mercuric chloride (HgCl₂) in 95% ethyl alcohol was then added to the solution of the mercaptan. The salt precipitated in a mass of fine white crystals that gave the appearance of being gelatinous. They filtered off readily with suction and were recrystallized from 95% ethyl alcohol. Upon drying in a vacuum dessicator over phosphorus pentoxide, the crystals gave a melting point of 193-194°C, corr.
The reaction:

\[ \text{HgCl}_2 \rightarrow \text{Cl} \rightarrow \text{Cl} + \text{HCl} \]
Preparation of

This mercaptan was prepared by a method quite similar to that used in the previous preparation. 25 ml. of Eastman Kodak Co. C.P. 2,6-dimethyl, 1-amino benzene was placed in a 200 ml. round bottom flask. To this, 40 ml. of concentrated sulfuric acid was added. The acid had to be added slowly and the flask kept cool or the amine would char. An air cooled condenser was then attached and the mixture was heated on an oil bath for 6 hours at 180-190°C. At the end of this time, test samples showed complete sulfonation. This amine showed a greater tendency to char than did the o-toluidine.

The mixture was removed from the oil bath and allowed to cool to room temperature. When cool, the mixture was poured over 150 grams of finely crushed ice. As in the previous synthesis, it was necessary to put some ice in the flask to partially dissolve the material as it had solidified on cooling. All the solid was broken up as fine as possible with a stirring rod in order to remove as much of the excess
sulfuric acid as possible. The solid amino sulfonic acid was then filtered with suction and pressed as dry as possible.

The reaction:

\[
\begin{align*}
\text{CH}_3\text{NH}_2\text{CH}_3 + \text{H}_2\text{SO}_4 & \rightarrow \text{CH}_3\text{NH}_2\text{CH}_3 + \text{H}_2\text{O} \\
\end{align*}
\]

A Sandmeyer reaction was then run, using the crude sulfonic acid crystals. Preparation of the cuprous chloride solution: 63 grams of powdered copper sulfate crystals (CuSO\(_4\)·5H\(_2\)O) and 18 grams of pure sodium chloride were placed in a 1-liter pyrex Erlenmeyer flask. 200 ml. of distilled water were added to this and the solution heated to boiling. While boiling, a solution of 14 grams of sodium bisulfite and 10 grams of sodium hydroxide in 100 ml. of distilled water, was added slowly and with shaking. The solution was then cooled to room temperature by means of running water. The precipitated cuprous chloride was washed with water by decantation three times. The precipitate was then dissolved in 100 ml. of concentrated hydrochloric acid and 30 ml. of water. The flask was corked and set in a salt ice mixture to cool.

Diazotization of the Amino Sulfonic Acid:

The crude wet crystals from the sulfonation reaction
were suspended in a mixture of 100 ml. of concentrated hydrochloric acid and 40 ml. of water. The mixture was contained in an 800 ml. pyrex beaker. This was set in a cooling bath of crushed ice and technical concentrated hydrochloric acid. A mechanical stirrer was started and the mixture agitated vigorously until the temperature (in the beaker) reached 0°C. 40-50 grams of crushed ice was then added. The temperature immediately dropped to -10°C. Upon reaching this temperature, a solution of sodium nitrite (28 grams NaNO₂ in 80 ml. of water) was added slowly and with constant agitation of the mixture in the beaker. The nitrite solution was added thru a separatory funnel, the stem of which dipped about 3 cm. below the surface of the liquid in the beaker. The nitrite solution was added until the mixture gave a positive test for nitrous acid with starch-potassium iodide paper. During the course of the reaction, the temperature was kept below 0°C, by the addition of small quantities of crushed ice.

When the solution gave a positive test for nitrous acid, it was poured into the cuprous chloride solution which had been previously cooled to 0°C. The diazonium solution was added to the cuprous chloride solution slowly and with constant agitation. After all the diazonium solution had been added, the mixture was kept
cool for 10-15 minutes more. It was allowed to slowly warm to room temperature, with frequent shaking to prevent foaming as much as possible. In this was the decomposition, of the double salt of the diazonium chloride with the cuprous chloride, was accomplished with no less thru foaming. The flask was then set in a water bath at room temperature and then slowly heated until the temperature reached 100°C. The solution was then removed from the bath and cooled to room temperature. An equal volume of saturated sodium chloride solution was added. The sodium salt of the sulfonic acid separated out in white shining plates characteristic of this type of compound. The solution was then evaporated to half its volume. Upon cooling, a small quantity of sulfonic acid crystals separated out. These were added to those obtained above, and the entire quantity dried in an electric oven for three hours at 110°C.

The reaction:

\[
\begin{align*}
\text{CH}_3\text{O}\text{SO}_3\text{N}_2\text{H}_2 + \text{HONO} & \xrightarrow{\text{HCl}} \text{CH}_3\text{N}_2\text{Cl}\text{SO}_3\text{H} \\
\text{CH}_3\text{O}\text{SO}_3\text{N}_2\text{Cl} & \xrightarrow{\text{Heat}} \text{CH}_3\text{O}\text{SO}_3\text{H} + \text{Cl} + \text{N}_2
\end{align*}
\]
The dry salt was then treated with PCl₅ according to the method given in "Die Praxis des organisch-chen Chemikers" by L. Gattermann and revised by Henrich Wieland.

Twenty-five grams of finely divided dry sodium salt of the sulfonic acid was placed in a 200 ml. round bottom flask. 40 grams of finely ground phosphorous pentachloride (PCl₅) was then put into the flask and the contents thoroughly mixed with a stirring rod. An air cooled reflux condenser was attached and the flask heated for 30-45 minutes on a briskly boiling water bath. After heating, the material was allowed to cool to room temperature, and then was poured over 250 grams of finely crushed ice. The material was allowed to remain in the ice and water for one hour. In this manner the phosphorous oxychlorides were decomposed.
The sulfonyl chloride was then extracted with 3-100 ml. portions of benzene. About half of the benzene was then distilled off leaving the sulfonyl chloride in about 150 ml. of benzene.

Five ml. of this benzene solution were evaporated to dryness. The chloride crystallized out easily. It was purified by recrystallization from ligroin (boiling point 60-90°C.) and gave white crystals. The crystals were put on a porous plate and dried in a vacuum. They gave a melting point of 120.5-121°C. corr.

The remainder of the purified sulfonyl chloride was then treated with dilute ammonium hydroxide. The mixture was heated on a steam bath for 1 hour. The sulfone amide was filtered off with suction and recrystallized from dilute alcohol. The crystals were white and upon drying in a vacuum dessicator gave a melting point of 204-5°C.

The reaction:

\[
\text{CH}_3\text{Cl} + 2\text{NH}_4\text{OH} \rightarrow \text{CH}_3\text{Cl} + \text{NH}_4\text{Cl} + 2\text{H}_2\text{O}
\]

The remainder of the benzene solution of the crude sulfonyl chloride was then put in a 1-liter round bottom pyrex flask and 35 grams of zinc dust added. A reflux condenser was attached and the flask set on a steam bath.
300 ml. of 25% sulfuric acid was then added in small amounts thru the condenser. The addition was accomplished during the course of 3 hours. During this time the mixture was kept slowly refluxing. After the addition was complete the heating was continued for 2 hours more.

The reaction:

\[
\begin{array}{c}
\text{CH}_3 \\
\text{Cl} \\
\text{CH}_3
\end{array}
\xrightarrow{\text{CH}_3(\text{Zn+H}_2\text{SO}_4)}
\begin{array}{c}
\text{Cl} \\
\text{HS} \\
\text{CH}_3
\end{array}
\xrightarrow{\text{HCl+2H}_2\text{O}}
\begin{array}{c}
\text{CH}_3 \\
\text{Cl} \\
\text{CH}_3
\end{array}
\]

The reaction mixture was then cooled. Upon cooling zinc sulfate crystals separated out. This material was filtered off with suction and the residue washed with benzene. The water portion of the filtrate was then extracted with 3-100 ml. portions of benzene. All the benzene extracts were combined and the benzene distilled off until the final volume was about 30 ml. About half of this solution was put in a 25 ml. Claissen flask with a fractionating side arm. The benzene was distilled from this portion and the remainder of the solution of the mercaptan added. The benzene was removed from this, the last traces coming off under reduced pressure. The pressure was finally reduced to 27 mm. Upon heating, no mercaptan distilled over.
The temperature of the oil bath was raised to 250°C. About that temperature a few white crystals were noted in the side arm of the flask. The bath was removed and the flask allowed to cool. Upon removing the stoppers, a very pronounced odor of sulfur dioxide was noticed. Also the material in the flask had charred, and was a tarry black mass. The crystals deposited in the side arm were insoluble in dilute (10%) potassium hydroxide. They were probably the disulfide but were not present in sufficient quantity to be of value.

Undoubtedly the mercaptan was oxidized to the disulfide by the traces of sulfuric acid present. The presence of sulfur dioxide in the distilling flask confirms this opinion. In future experiments it was decided to use hydrochloric acid instead of sulfuric in the reduction process.

A second 25 gram portion of the amine was obtained and treated in exactly the same manner up to the reduction.

The benzene solution of the sulfonyl chloride, obtained in the second run, was put in a 1-liter pyrex round bottom flask and 35 grams of zinc dust added. A reflux condenser was attached and the flask set on a steam bath. The solution was refluxed slowly and 200 ml. of concentrated
hydrochloric acid was added slowly thru the condenser. The addition took about two hours. The mixture was refluxed for one hour more and then allowed to stand over night. The excess zinc and precipitated zinc chloride was filtered off with suction. The benzene solution was separated from the water layer in a separatory funnel. The water layer was extracted with 2-100 ml. portions of benzene.

The reaction:

\[ \text{CH}_3 \overset{\text{H} \text{Zn} + \text{HCl}}{\longrightarrow} \text{HS} \]

The benzene was then distilled off until the final volume was about 30 ml. About half of this solution was put into a 25 ml. Claisen flask with a fractionating side arm. The benzene was distilled from this portion and the remainder of the solution of the mercaptan added. The benzene was then removed from the entire amount, the last traces coming off under reduced pressure. The pressure was finally lowered to 29 mm, and the temperature of the oil bath raised to 190-200°C. The mercaptan came over as a clear colorless oil at 141-2°C. corr. The compound gave a clear solution with dilute (10%)
potassium hydroxide. Upon adding hydrochloric acid, the solution turned milky. The odor of the mercaptan, as was true of the one previously prepared, was not very pronounced. The low vapor pressure at room temperature was probably the cause of this. As in the case of the previous compound, the slight odor and behavior towards acid and alkali showed the compound to be a mercaptan.

The oil had a density of 1.1906 20°/4° and an index of refraction, using sodium light, of 1.59115 at 20°C.

The mercaptan was analyzed for sulfur by the Carius method.

Results:--

<table>
<thead>
<tr>
<th></th>
<th>Calc.</th>
<th>Found</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur content</td>
<td>18.57%</td>
<td>18.62%</td>
</tr>
</tbody>
</table>

A residue remained in the distilling flask after the distillation. This was dissolved with benzene. Upon evaporation of the benzene, some yellow crystals separated out. These were recrystallized from dilute alcohol and gave white crystals. After drying in a vacuum dessicator over phosphorous pentoxide (P₂O₅), they gave a melting point of 124-5°C, corr. A qualitative analysis showed the presence of chlorine and sulfur.

The reaction:

\[
\begin{array}{c}
\text{HS} \quad \text{Cl} \quad \text{CH}_3 \\
\text{CH}_3 \\
\end{array} \quad \xrightarrow{\text{O_2}} \quad \begin{array}{c}
\text{Cl} \\
\text{CH}_3 \\
\text{S=S} \\
\text{CH}_3 \quad \text{Cl} \\
\text{CH}_3 \\
\end{array}
\]
The mercury salt of the mercaptan was then made in the following manner. 2 drops of the mercaptan was dissolved in 2 ml. of 95% ethyl alcohol. An excess of a saturated solution of mercuric chloride in 95% ethyl alcohol was then added to the solution of the mercaptan. The salt precipitated in a mass of fine white crystals that gave the appearance of being gelatinous. They filtered readily with suction and were recrystallized from 95% ethyl alcohol. After drying in a vacuum desiccator over phosphorus pentoxide, an attempt was made to determine the melting point. They melted at about 240-5°C, with decomposition. The high melting point and accompanying decomposition made the mercury salt of little value as a derivative.

The reaction:—

\[
\text{HSCH}_3 + \text{HgCl}_2 \rightarrow \text{ClCH}_3 \quad + \text{HCl}
\]
Preparation of mercaptan followed the same procedure used in the preparation of the former two.

Twenty-five ml. of Eastman Kodak Co. C.P. 3-6 dimethyl 1-amino benzene was placed in a 200 ml. round bottom pyrex flask. To this 40 ml. of concentrated sulfuric acid was added. The acid was added slowly and the flask kept cool to prevent charring the amine. An air cooled condenser was then attached and the mixture heated on an oil bath for 6 hours at 180-190°C.

The mixture was removed from the oil bath and allowed to cool to room temperature. It was poured into water and instead of giving crystals gave a black mass of tar. The odor of sulfur dioxide was very pronounced. A water extract of the tar was treated with a saturated solution of picric acid, in hopes of isolating the amino sulfonic acid picrate. No picrate was isolated.

The presence of the sulfur dioxide showed that there had been some oxidation. The formation of the tar also was a good indication of the same thing.
conclusion was that the amine must be quite sensitive to oxidation, and had to be protected before sulfonation could be successfully carried out. A procedure, which will be given later, for the sulfonation of the acetyl derivative of the same amine was found. It was then decided to try this method for the preparation of the sulfonic acid.

Twenty-five grams of Eastman Kodak Co. C.P. 3,6 dimethyl 1-amino benzene was put in a 200 ml. pyrex round bottom flask. To this was added 24 grams of acetic anhydride and 17.2 grams of fused sodium acetate. A water cooled reflux condenser was then attached and the mixture refluxed on an asbestos center wire gauze for 3 hours. At the end of this time it was poured while hot into 400 ml. of distilled water. During the course of the addition the water was agitated violently by means of a mechanical stirrer. The acylated amine separated out in a mass of small crystals. The crystals were so fine that they would not be noticed without close examination. The acetyl compound was allowed to remain in the water for about 2 hours. The period of standing afforded time for cooling and for the sodium acetate to diffuse out of the solid. The acetyl compound was filtered off with suction, and dried in an
oven at 100-5°C for 3 hours.

The reaction:

\[
\text{CH}_3 \text{N} \text{H}_2 + \text{CH}_3-\text{O} \rightarrow \text{CH}_3 \text{COONa}
\]

The acylated amine was sulfonated in the manner used by Junghahn. (Reference: Ber. 35, 1364-5 (1900).) The dry acetyl compound was ground very fine by means of a mortar and pestle. 130 grams of 20% fuming sulfuric acid was put in a 250 ml. pyrex Erlenmeyer flask. To this the dry acetyl p-xylidine was added at such a rate that the temperature of the acid was kept at 35-40°C. 40 grams of the dry powder was added to the acid. The addition required about 3 hours. The procedure, which was being followed, advised heating the mixture at 40°C on a water bath until a test sample in sodium hydroxide gave a clear solution. In this preparation the mixture was allowed to stand in the rubber stoppered flask overnight. A test sample of the mixture treated in this manner gave a clear solution with sodium hydroxide (6N).

The sulfuric acid mixture was slowly poured over 400 grams of finely crushed ice contained in a 2-liter pyrex beaker. During the course of the addition, the
ice was agitated with a stirring rod. After addition was complete and all the ice in the beaker had melted, the beaker was set in a cooling mixture of finely crushed ice and technical concentrated hydrochloric acid. The sulfonic acid separated out in a thick mass of crystals. These were filtered off with suction and pressed dry. The crystals were nearly white in color, as there was practically no charring during the course of the reaction.

The reaction:

\[
\begin{array}{c}
\text{CH}_3 & \text{H-O-CH}_3 \\
\text{CH}_3 & \text{N-O-CH}_3
\end{array} \xrightarrow{\text{H}_2\text{SO}_4, \text{SO}_3} \begin{array}{c}
\text{H}_2\text{O} \\
\text{H-O-SO}_3 \text{H}_2\text{O} \\
\text{H}_2\text{O}
\end{array}
\]

The wet sulfonic acid crystals were then put in a 500 ml. pyrex round bottom flask. 250 ml. of concentrated hydrochloric acid was added and a water cooled reflux condenser attached. The mixture was refluxed for 3 hours over an asbestos center wire gauze. During the first half hour of boiling the crystals went in solution. The solution remained clear for about 15 minutes. Then crystals began separating out and by the end of 2 hours of refluxing, they were so thick that boiling was difficult. The mixture was refluxed for another hour to insure completion of the reaction.
The reaction:--

\[
\begin{align*}
\text{HO-SO}_3\text{CH}_3 + \text{H}_2\text{O} & \xrightarrow{\text{HCl}} \text{HO-SO}_3\text{CH}_3 + \text{CH}_3\text{COOH} \\
\text{O-SO}_3\text{CH}_3 + \text{NH}_2 \text{CH}_3 & \xrightarrow{\text{HCl}} \text{O-SO}_3\text{CH}_3 + \text{CH}_3\text{COOH}
\end{align*}
\]

After hydrolysis was complete, the material was poured into an 800 ml. pyrex beaker. The flask was then washed with 50 ml. of concentrated hydrochloric acid, and this added to the material already in the beaker. The beaker was set in a cooling mixture of finely crushed ice and technical concentrated hydrochloric acid.

While the above material was cooling, a solution of cuprous chloride in concentrated hydrochloric acid was prepared. 63 grams of powdered copper sulfate crystals and 18 grams of pure sodium chloride were placed in a 1-liter pyrex Erlenmeyer flask. 200 ml. of distilled water was added to this and the solution heated to boiling. While boiling, a solution of 14 grams of sodium bisulfite and 10 grams of sodium hydroxide in 100 ml. of distilled water, was added slowly and with shaking. The solution was then cooled to room temperature by means of running water. The precipitated cuprous chloride was washed with water by decantation.
three times. The remaining precipitate was dissolved in 120 ml. of concentrated hydrochloric acid. The flask was corked and set in a salt and ice mixture to cool.

A mechanical stirrer was then put in the beaker containing the cold solution of the amino sulfonic acid. The mixture was agitated and further cooled until the temperature reached 0°C. 40-50 grams of finely crushed ice was added and the temperature immediately dropped to -10°C. Upon reaching this temperature, a solution of sodium nitrite (23 grams NaNO₂ in 80 ml. of water) was slowly added thru a separatory funnel, the stem of which dipped about 3 cm. below the surface of the liquid in the beaker. During the addition of the nitrite solution, the solution in the beaker was agitated constantly. It was kept below 0°C. by adding small quantities of crushed ice. The nitrite solution was added until the solution gave a positive test for nitrous acid with starch-potassium iodide paper.

When the solution gave a positive test for nitrous acid, it was poured into the cuprous chloride solution which had been previously cooled to 0°C. The diazonium solution was added to the cuprous chloride solution slowly and with constant agitation. After all the diazonium solution had been added, the mixture was kept cool for 10-15 minutes more. It was then allowed to
slowly warm to room temperature. In this way the decomposition of the double salt of the diazonium chloride with the cuprous chloride was accomplished with no loss thru foaming. The flask was then set in a water bath at room temperature and slowly heated until the temperature reached 100°C. The solution was then removed from the bath and cooled to room temperature. Upon cooling to room temperature crystals separated from the solution. The solution was further cooled in a salt-ice mixture. The crystals were filtered with suction and washed with 25 ml. of saturated sodium chloride solution. The crystals proved to be the sulfonic acid and was probably thrown out of the solution by the high concentration of hydrochloric acid. When the filtrate was treated with an equal volume of saturated sodium chloride solution, no crystals separated out. The solution was then evaporated to about five-eights of its original volume. About 2 grams of the sodium salt of the sulfonic acid separated. This was filtered with suction and added to the sulfonic acid which had separated out before. The entire quantity of sulfonic acid and its sodium salt was then dried in an electric over for 3 hours at 110-115°C.
The reactions:

\[
\begin{align*}
\text{CH}_3\text{N}^+\text{H}^- + \text{HONO} &\rightarrow \text{CH}_3\text{N}=\text{N}=\text{Cl}^- + \text{H}_2\text{O} \\
\text{HO-SO} &\rightarrow \text{HO-SO} + \text{Cl}^- + \text{N}_2
\end{align*}
\]

The dry salt was then treated with \( \text{PCl}_5 \) according to the method given in "Die Praxis des organischen Chemikers" by L. Gattermann and revised by Henrich Wieland.

Twenty-five grams of finely divided dry sulfonic acid crystals were placed in a 200 ml. pyrex round bottom flask. 40 grams of finely ground phosphorous pentachloride was then put into the flask. The reaction started immediately. An air cooled condenser was attached and after the reaction had subsided, the mixture in the flask was heated for 30-40 minutes on a briskly boiling water bath. After heating, the material was allowed to cool to room temperature and then poured over 250 grams of finely crushed ice. The material was allowed to remain in the ice and water for 1 hour to decompose any excess phosphorous pentachloride and the
phosphorous oxychloride formed in the reaction.

The reaction:

\[
\begin{align*}
\text{CH}_3 & \quad \text{Cl} \quad + \quad \text{PCl}_3 \\
\text{HO-} & \quad \text{SO}_2 \quad \text{CH}_3 \quad \text{Cl} \quad + \quad \text{HCl} \quad + \quad \text{POCl}_3 \\
\end{align*}
\]

The sulfonyl chloride was then extracted with 3-100 ml. portions of benzene. About half of the benzene was removed by distillation leaving the sulfonyl chloride in about 150 ml.

Five ml. of this benzene solution was evaporated to dryness. The sulfonyl chloride did not crystallize very readily. However, it did recrystallize fairly well from ligroin (b. pt. 80-90°C.). The crystals were dried over phosphorous pentoxide under reduced pressure. They melted at 49.0-49.5°C. corr. The literature reports 50°C as the melting point.

The remainder of the sulfonyl chloride crystals was then treated with dilute ammonium hydroxide. The mixture was heated on a steam bath for an hour. The mixture was cooled and the sulfone amide filtered off with suction. Upon recrystallizing from dilute ethyl alcohol and drying over phosphorous pentoxide under reduced pressure, the amide melted at 189-190°C. corr.
The reaction:

\[
\text{Cl-SO}_2\text{Cl} + 2\text{NH}_4\text{OH} \rightarrow \text{Cl-SO}_2\text{NH}_2\text{Cl} + 2\text{H}_2\text{O}
\]

The remainder of the benzene solution of the sulfonyl chloride was then put in a 1-liter pyrex round bottom flask. 35 grams of zinc dust was added slowly and with shaking. A reflux condenser was attached and the flask set on a steam bath. The solution was refluxed slowly and 200 ml. of concentrated hydrochloric acid added thru the condenser in 10-15 ml. portions. The addition took about 2 hours. The mixture was allowed to remain over night. The following morning 50 ml. of concentrated hydrochloric acid was added and the mixture refluxed for about an hour. It was allowed to cool to room temperature. The excess zinc and the precipitated zinc chloride was filtered off with suction. The benzene solution was separated from the aqueous layer in a separatory funnel. The water layer was extracted with 3-75 ml. portions of benzene.
The benzene was then distilled off until the final volume was about 50 ml. This was placed in a pyrex evaporating dish and set in a desiccator over finely shaved paraffin. The paraffin shavings were renewed about every six hours. The material was treated in the above manner for about 36 hours. The residue was then placed in a vacuum desiccator over finely shaved paraffin and more benzene removed by reducing the pressure. The rapid evaporation of the benzene under the reduced pressure cooled the solution enough to cause the mercaptan to crystallize out. The crystals were filtered with suction and dried on a porous plate under reduced pressure over finely shaved paraffin. The residue was placed over paraffin again and more benzene removed. A second crop of crystals was obtained in this manner. The filtrate was then evaporated to dryness over paraffin under reduced pressure. The third crop thus obtained was colored and not very pure.

A small portion of the first crop of crystals was recrystallized from dilute alcohol. 4 or 5 drops of
concentrated hydrochloric acid was added to each 100 ml. of alcohol used in order to assure its being acidic, mercaptans being much more stable towards oxidation in acid medium. The crystals obtained from the alcohol were nearly white and after drying under reduced pressure over phosphorous pentoxide, they gave a melting point of 91.5-92.5°C. corr.

The crystals were soluble in dilute (10%) potassium hydroxide. Upon neutralization of the potassium hydroxide with hydrochloric acid, the mercaptan was thrown out of solution. This property confirms the compound as being the mercaptan and not the disulfide.

The third crop of crystals of the mercaptan was too impure to be of use without recrystallization. They were oxidized to the disulfide by allowing an ammoniacal solution of the mercaptan to set in contact with air for about two days. The disulfide was then dissolved in chloroform. The chloroform was removed until the solution was nearly saturated. Then an amount of 95% ethyl alcohol, equal to twice the volume of the chloroform solution, was added. The disulfide crystallized out in nearly white crystals. They were dried under reduced pressure over phosphorous pentoxide, and gave a melting point of 102-3°C. corr.
The reaction:

\[
\begin{align*}
2 \text{HSCH}_3 & \overset{0}{\underset{\text{NH}_4\text{OH}}{\longrightarrow}} \text{ClCH}_3 \text{S-SCH}_3 \text{Cl} + \text{H}_2\text{O} \\
\end{align*}
\]

No mercury salt of the mercaptan was prepared as they melt too high to be of value as a derivative.

The mercaptan was analyzed for sulfur by the Carius method.

Results:

<table>
<thead>
<tr>
<th>Sulfur Content</th>
<th>Calc.</th>
<th>Found</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18.57%</td>
<td>18.67%</td>
</tr>
</tbody>
</table>
The first attempt to prepare the compound followed the same procedure used in the preparation of the first two.

Twenty-five ml. of Eastman Kodak Co. 2-amino cymene was placed in a 200 ml. pyrex round bottom flask. To this 40 ml. of concentrated sulfuric acid was added. The acid was added slowly and the flask kept cool to prevent charring of the amine. An air cooled reflux condenser was attached and the mixture heated on an oil bath for 6 hours at 180-190°C.

The mixture was removed from the oil bath and allowed to cool to room temperature. Upon pouring over 250 grams of crushed ice, a tar separated out instead of crystals. The odor of sulfur dioxide was very pronounced. The tar was extracted with water. This extract was treated with picric acid in an attempt to isolate the amino sulfonic acid as the picrate. No picrate was isolated.

The tar was then placed in alkali and the mixture distilled with steam. About 18 ml. of the amine distilled over. The amine was separated from the water
and saved for further use.

In the above sulfonation the presence of the sulfur dioxide indicated oxidation of the amine. The baking process was then tried. In this process there was not an excess of sulfuric acid as was used in the former procedure.

Three ml. of the 2-amino cymene was put in a 50 ml. pyrex beaker. An equivalent amount of 20% sulfuric acid was added from a burette. The amine sulfate was then heated in an electric oven at 250-280°C. for 10 hours. The material in the beaker, after receiving this treatment had the appearance of being carbon. Upon further analysis, it was found to be insoluble in both alkali and acid.

After the failure of this method to sulfonate the amine, it was decided to use the method of Junghahn (Reference: Ber. 33, 1334-5 (1900) for the sulfonation of the acetyl derivative of the amine.

The amine was acylated in the following manner. 25 grams of Eastman Kodak Co. C.P. 2-amino cymene was put in a 200 ml. pyrex round bottom flask. To this was added 24 grams of acetic anhydride and 17.2 grams of fused sodium acetate. A water cooled reflux condenser was attached and the mixture refluxed on an asbestos center wire gauze for 4 hours. At the end of this time
the mixture was poured, while hot, into 400 ml. of distilled water. During the addition the water was agitated violently by means of a mechanical stirrer. The material did not form a solid but separated out as an oil. After cooling and with continued stirring the oil solidified forming lumps of various sizes. This material was filtered off with suction. It could not be dried in an oven as it melted too low. Consequently, it was broken up as finely as possible and dried for 18 hours over phosphorous pentoxide under reduced pressure.

The reaction:

\[
\begin{align*}
\text{CH}_3 \quad \text{NH}_2 \\
\text{CH}_3 - \text{C}-\text{CH}_3 \\
\text{H}_3\text{C}-\text{C}-\text{CH}_3
\end{align*}
\quad + \quad \begin{align*}
\text{CH}_3\text{C}=\text{O} \\
\text{CH}_3\text{C}=\text{O}
\end{align*}
\quad \xrightarrow{\text{CH}_3\text{COONa}}
\begin{align*}
\text{CH}_3 \\
\text{H}_3\text{C}-\text{C}-\text{CH}_3 \\
\text{H}_3\text{C}-\text{C}-\text{CH}_3
\end{align*}
\]

The acetyl compound after drying over phosphorous pentoxide did not seem to harden, but acquired the consistency of very hard grease. It was not as hard as paraffin, but was more solid than vaseline.

The acylated amine was then sulfonated in the following manner: 130 grams of 20% fuming sulfuric acid was put in a 250 ml. pyrex Erlenmeyer flask. The acylated amine was added to this in small pieces at such a rate that the temperature was kept at 35-40°C. The material
was kept at this temperature for about an hour after the addition was complete and then allowed to set over night at room temperature. The next morning the sulfuric acid mixture was slowly poured over 400 grams of finely crushed ice which was contained in a 2-liter pyrex beaker. During the course of the addition, the ice was agitated with a stirring rod. After all the mixture had been added and all the ice had melted, the beaker was set in a cooling bath of finely crushed ice and technical concentrated hydrochloric acid. A tarry mass separated out. Upon further cooling the tar thickened up but showed no tendency to crystallize.

It did not prove to be soluble in 6N sodium hydroxide.

The fact that it was insoluble in hydroxide tended to indicate incompleation of the sulfonation reaction.

The 18 grams of 2-amino cymene recovered in an earlier experiment was then converted to the acetyl derivative in the same manner as before. Corresponding amounts were used. The reaction went in the same manner as the one previous, and the same type of product isolated. This was dried over phosphorous pentoxide under reduced pressure.

The dried compound was now added to 90 grams of 20% fuming sulfuric acid. The material was added in
small pieces and at such a rate that the temperature was kept at 35-40°C. This time, instead of allowing the mixture to stand over night, it was heated on a water bath at 70-80° for 4 hours. The heating was discontinued because of charring. After cooling to room temperature the mixture was poured over 400 grams of crushed ice. This time a tar separated out, much like that in the former case except that it was much blacker and more thick.

The supply of the amine being used up, the preparation of the mercaptan was abandoned. The purity of the amine was rather doubtful, since it gave an oil on acylation. Also the tar formed by oxidation was in such abundance that it probably kept any sulfonic acid, that was formed, suspended in it.
Preparation of \[ \text{SH} \]

Twenty grams of Eastman Kodak Co. C.P. \( b \)-naphthalene sulfonyl chloride was put in a 1-liter pyrex round bottom flask. 200 ml. of pure benzene was added and a water cooled reflux condenser attached. The flask was put on a steam bath and heated gently until the sulfonyl chloride dissolved. The mixture was then removed from the steam bath and allowed to cool to room temperature.

40 grams of zinc dust was added in 5-8 gram portions. The contents of the flask being mixed after each addition. After all the zinc had been added, the water cooled reflux condenser was again attached and the flask set on a steam bath. The mixture was allowed to reflux slowly for about 10 minutes and then 200 ml. of concentrated hydrochloric acid was added thru the condenser. The acid was added in 10-20 ml. portions. The addition required about an hour. The mixture was refluxed for another hour and was then allowed to stand over night.

The next day the mixture was refluxed for about 30 minutes more. After cooling to room temperature, the precipitated zinc chloride and excess zinc was
filtered off with suction.

The benzene layer was separated from the water in a separatory funnel. The water layer was then extracted once with a 100 ml. portion of benzene. The benzene was then distilled off on a steam bath until the final volume was approximately 50 ml. The remaining benzene solution was placed in a pyrex evaporating dish and the benzene removed in a vacuum dessicator over finely shaved paraffin. The benzene was removed until the material in the evaporating dish was a solid mass of crystals.

The crystals were then dissolved in about 250 ml. of ligroin (b.pt. 60-90°C). Ligroin proved a very good solvent to remove any color. The tar and most of the coloring matter being insoluble. The ligroin solution was then treated with 2-3 grams of Norite and filtered. The ligroin was evaporated to about 50 ml. The evaporating dish containing the solution was put in a vacuum dessicator over finely shaved paraffin. The remaining ligroin was removed by reducing the pressure. Three crops of crystals were obtained. These were filtered off with suction and placed on watch glasses. The crystals were allowed to remain in a dessicator over finely shaved paraffin for several days. The long standing was necessary for complete
removal of ligroin from the crystals. Ligroin was a very good solvent except for the fact that it was extremely difficult to free the crystals of it. The crystals melted at 30-31°C, corr. The melting point given in the Chemical Rubber Handbook is 81°C.

The reaction:

A small quantity of the mercaptan was oxidized to the disulfide. This upon recrystallization from chloroform and alcohol gave a melting point of 138-9°C, corr. The literature gives 139° as the melting point.

The reaction:
Preparation of \( \text{Cl} \)

In this preparation the starting material was Eastman Kodak Co., technical grade of 2-amino, 1-naphthalene sulfonic acid. Since the material was already sulfonated, the first step in the procedure was to replace the amino group with chlorine by means of the Sandmeyer reaction.

The cuprous chloride solution was prepared in a manner similar to those given before. 63 grams of copper sulfate (CuSO₄·5H₂O) crystals were used. The precipitated cuprous chloride was dissolved in 135 ml. of concentrated hydrochloric acid and 25 ml. of distilled water. The flask containing the solution was then corked and set in a salt-ice bath to cool.

Diazotization of the amino sulfonic acid: 150 ml. of concentrated hydrochloric acid was put in a 1-liter pyrex beaker. A mechanical stirrer was installed and while the acid was being thoroughly agitated, 25 grams of the amino naphthalene sulfonic acid was added. The mixture was set in a cooling bath of finely crushed ice and technical concentrated hydrochloric acid. The material was stirred vigorously until the temperature
in the beaker reached 0°C. Upon addition of 40-50 grams of crushed ice the temperature dropped to -8°C. A solution of sodium nitrite (8 grams NaNO₂ in 25 ml. of H₂O) was then added very slowly and with constant agitation of the mixture in the beaker. The nitrite solution was added thru a separatory funnel, the stem of which dipped about 3 cm. below the surface of the liquid in the beaker. Naphthalene amino compounds do not react as fast with nitrous acid as the benzene compounds. Consequently the nitrite solution was added much slower and over a longer period of time than was necessary for the benzene compounds used in previous experiments. The nitrite solution was added until the mixture gave a positive test for nitrous acid with starch-potassium iodide paper. During the course of the reaction the temperature was kept below 0°C, by the addition of small quantities of crushed ice.

When the solution gave a positive test for nitrous acid, it was poured into the cuprous chloride solution which had been previously cooled to 0°C. The diazonium solution was added to the cuprous chloride solution slowly and with constant agitation. After all the diazonium solution had been added to the cuprous chloride solution, the mixture was kept cool for 10-15 minutes more. It was then allowed to slowly warm to room tempera-
ture, with frequent shaking to prevent foaming as much as possible. After remaining at room temperature for about half an hour, the flask was set on a steam heated hot plate. It was allowed to remain on the hot plate until the temperature of the solution in the flask reached 80°C. Upon cooling to room temperature no chlor sulfonic acid separated out. The material was then put in a beaker and set on a steam hot plate. When it had evaporated to about half its original volume, the solution was put in an Erlenmeyer flask, stoppered, and set in the refrigerator. After standing at a low temperature over night, the sulfonic acid separated out. The crystals were filtered off with suction, and washed with a small quantity of a saturated sodium chloride solution. The crystals were dried in an electric oven for 4 hours at 110-115°C.

The reaction:

\[
\text{SO}_2\text{OH} + \text{HONO} \xrightarrow{\text{HCl}} \text{SO}_2\text{OH} \quad N=N=\text{Cl}
\]
The dry sulfonic acid was then treated with phosphorous pentachloride according to the method given in "Die Praxis des organischen Chemikers" by L. Gattermann and revised by Heinrich Wieland.

Twenty-four grams of finely divided dry sulfonic acid was placed in a 200 ml pyrex round bottom flask. 35 grams of finely ground phosphorous pentachloride was put into the flask. The reaction started immediately. An air cooled reflux condenser was attached and after the reaction had subsided, the mixture in the flask was heated for 1½ hours on a boiling water bath. The contents of the flask were allowed to cool to room temperature, and then poured over 250 grams of finely crushed ice. The material was allowed to remain in the ice and water for 1 hour to decompose any excess phosphorous pentachloride and the phosphorous oxychloride formed in the reaction.
The reaction: 

\[
\begin{align*}
\text{SO}_2\text{OH} & \quad \text{Cl} + \text{PCl}_3 \\
\rightarrow & \\
\text{SO}_2\text{Cl} & \quad \text{Cl} + \text{PCl}_3
\end{align*}
\]

The sulfonyl chloride was extracted with 3-75 ml. portions of benzene. The sulfonyl chloride in the 225 ml. of benzene was then put in a 1-liter pyrex round bottom flask. The chloride was reported in the literature so it was not isolated in this preparation. 35 grams of zinc dust was added to the benzene solution of the sulfonyl chloride. A water cooled reflux condenser was attached and the flask set on a steam bath. The solution was refluxed slowly and 200 ml. of concentrated hydrochloric acid added thru the condenser in 10-15 ml. portions. The addition took about 2 hours. The mixture was refluxed for an hour longer and then cooled to room temperature. The excess zinc and the precipitated zinc chloride was filtered off with suction. The benzene solution was separated from the aqueous layer in a separatory funnel. The water was extracted with 2-75 ml. portions of benzene.
The reaction:--

\[
\begin{align*}
\text{SO}_2\text{Cl} & \quad \text{SH(Zn+HCl)} \\
\text{Cl} & \quad \text{Cl}
\end{align*}
\]

The benzene was then distilled off until the final volume was about 50 ml. This was placed in a pyrex evaporating dish and set in a dessicator over finely shaved paraffin. The paraffin shavings were renewed about every six hours. This treatment was continued for 56 hours. The residue was then placed in a vacuum dessicator over finely shaved paraffin and the remaining benzene removed under reduced pressure.

The mercaptan was then dissolved in 95% alcohol, treated with Norite and filtered. The alcohol solution was then concentrated and diluted with water, while hot, until it started to appear cloudy. Upon cooling crystals of the mercaptan separated out. These were filtered off with suction and dried under reduced pressure over phosphorous pentoxide. The remaining alcohol solution was treated in the same manner and a second crop of crystals obtained. A third crop was also obtained but these were too impure to be of use. They were saved, however, for later conversion to the disulfide.

A small quantity of the first crop of crystals
were recrystallized from alcohol. Upon drying under reduced pressure over phosphorous pentoxide they gave a melting point of 65.5-66.5°C, corr.

The remainder of the purified mercaptan was analyzed for sulfur according to the method of Carius.

Results:

<table>
<thead>
<tr>
<th>Sulfur content</th>
<th>Calc.</th>
<th>Found</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16.47%</td>
<td>16.58%</td>
</tr>
</tbody>
</table>

The disulfide was made by allowing an ammoniacal solution to set in the air for 2 days. The ammonia was then evaporated off on a steam hot plate. The disulfide was recrystallized from chloroform and alcohol. The crystals gave a melting point of 133-4°C, corr.

The reaction:

\[
2 \text{SHCl} + 0 \text{NH}_4\text{OH} \rightarrow \text{S---S}
\]
In this preparation the starting material was Eastman Kodak Co. C.P. 1-naphthylamine, 4-sulfonic acid. Since the material was already sulfonated, the first step in the procedure was to replace the amino group with chlorine by means of the Sandmeyer reaction.

The cuprous chloride solution was prepared in a manner similar to those given before. 63 grams of copper sulfate \((\text{CuSO}_4 \cdot 5\text{H}_2\text{O})\) crystals were used. The precipitated cuprous chloride was dissolved in 125 ml. of concentrated hydrochloric acid. The flask containing the solution was then corked and set in a salt-ice mixture to cool.

Diazotization of the amino sulfonic acid: 150 ml. of concentrated hydrochloric acid was put in a 1-liter pyrex beaker. A mechanical stirrer was installed and while the acid was being thoroughly agitated, 25 grams of the amino naphthalene sulfonic acid was added. The mixture was set in a cooling bath of finely crushed ice and technical concentrated hydrochloric acid. The material was stirred vigorously until the temperature in the beaker reached 0°C. Upon addition of 50-60 grams
ice the temperature dropped to -10°C. A solution of sodium nitrite (8 grams NaNO₂ in 25 ml. of H₂O) was then added very slowly and with constant agitation of the mixture in the beaker. The nitrite solution was added thru a separatory funnel, the stem of which 'dipped about 3 cm. below the surface of the liquid in the beaker. As was the case with the naphthalene amino compound used previously, the nitrous acid did not react very fast with the amino group. Consequently the solution was added much slower and over a longer period of time than was necessary for the benzene compounds used in the previous experiments. The nitrite solution was added until the mixture gave a positive test for nitrous acid with starch-potassium iodide paper. During the course of the reaction the temperature was kept below 0°C, by the addition of small quantities of crushed ice.

When the solution gave a positive test for nitrous acid, it was poured into the cuprous chloride solution which had been previously cooled to 0°C. The diazonium solution was added to the cuprous chloride solution, slowly and with constant agitation. After all the diazonium solution had been added to the cuprous chloride solution, the mixture was kept cool for about 10 minutes longer. It was then allowed to slowly warm to room
temperature, with frequent shaking to prevent foaming as much as possible. After remaining at room temperature for about half an hour the flask was set on a steam heated hot plate. It was allowed to remain on the hot plate until the temperature of the solution in the flask reached 80°C. Upon cooling to room temperature, sulfonic acid crystals separated out. They were undoubtedly thrown out of solution by the large concentration of hydrochloric acid. The sulfonic acid crystals were filtered off with suction, washed with 20 ml. of a saturated sodium chloride solution, and dried in an electric oven for 3 hours at 110-120°C.

The reactions:

\[
\begin{align*}
\text{NH}_2 & \quad \overset{\text{HONO, HCl}}{\rightarrow} \quad \text{N N-Cl} \\
\text{SO}_2\text{OH} & \quad \text{SO}_2\text{OH} \\
\end{align*}
\]

\[
\begin{align*}
\text{N N-Cl} & \quad \overset{\text{CuCl, HCl, Heat}}{\rightarrow} \quad \text{Cl} \\
\text{SO}_2\text{OH} & \quad \text{SO}_2\text{OH} \\
\end{align*}
\]

The dry sulfonic acid crystals were then treated with phosphorous pentachloride according to the directions given in "Die Praxis des organischen Chemikers"
by L. Gattermann and revised by Heinrich Wieland.

Twenty-eight grams of finely divided dry sulfonic acid was placed in a 200 ml. pyrex round bottom flask. 35 grams of finely ground phosphorous pentachloride was put in the flask and the contents well mixed. The reaction was quite slow in starting, so an air cooled reflux condenser was attached and the mixture heated for two hours on a boiling water bath. The contents of the flask were allowed to cool to room temperature, and then poured over 250 grams of finely crushed ice. The material was allowed to remain in the ice and water for 1½ hours to decompose any excess phosphorous pentachloride and the phosphorous oxychloride formed in the reaction.

The reactions—

\[
\text{Cl} \quad \text{SO}_2\text{OH} \quad + \quad \text{PCl}_5 \rightarrow \quad \text{Cl} \quad \text{SO}_2\text{Cl} + \text{POCl}_3 + \text{HCl}
\]

The sulfonyl chloride was extracted with 2-100 ml. portions of benzene. The 200 ml. of benzene containing the sulfonyl chloride was put in a 1-liter pyrex round bottom flask. The chloride was reported in the literature so it was not isolated in this preparation.
35 grams of zinc dust was added to the benzene solution. A water cooled reflux condenser was attached and the flask set on a steam bath. The solution was refluxed slowly and 200 ml. of concentrated hydrochloric acid added thru the condenser in 10-20 ml. portions. The addition took about 2 hours. The mixture was allowed to stand for 2 days at room temperature. The long period of standing does not help the reaction. In this case it was impossible to isolate the mercaptan as soon as the reduction was complete. At the end of this time 5 grams more of zinc dust and 50 ml. of concentrated hydrochloric acid were added and the mixture refluxed for about 1 1/2 hours. The extra amount of zinc and acid was added to reduce any mercaptan which might have oxidized on the long standing. The mixture was then cooled to room temperature, and the excess zinc and precipitated zinc chloride filtered off with suction. The benzene solution was separated from the aqueous layer in a separatory funnel and the water layer extracted with 2-50 ml. portions of benzene.

The reactions:

\[
\begin{align*}
\text{Cl} & \quad + \quad 6\text{H(Zn+HCl)} \rightarrow \quad \text{Cl} \\
\text{SO}_2\text{Cl} & \quad + \quad \text{HCl} + 2\text{H}_2\text{O}
\end{align*}
\]
The benzene was then distilled off. In the distillation the flask was overheated. The material decomposed giving a tar which was dark green in color. It was soluble in benzene solution. The benzene solution was treated with zinc and hydrochloric acid in an attempt to reduce any oxidized material. The charring must have gone too far, for the reduction did not change the material.

The second trial was carried out in the same manner as the first. Except that the long standing during the reduction was omitted.

In this case the benzene was carefully distilled until the final volume was about 50 ml. This was placed in a pyrex evaporating dish and set in a vacuum dessicator over finely shaved paraffin. The benzene was removed under reduced pressure. After all the benzene had been removed, a small portion of the crystals were dissolved in chloroform, and the chloroform evaporated until the solution was nearly saturated. A volume of 95% ethyl alcohol equal to twice the volume of the chloroform solution, was then added to the chloroform solution. Crystals separated out but they were insoluble in dilute (10%) potassium hydroxide. Some of the impure crystals were then tried for solubility in potas-
sium hydroxide. They were found to be only slightly soluble. About 10\% being the mercaptan and the remaining 90\% was thought to be the disulfide. Either the compound had not been completely reduced or the mercaptan had been oxidized during the evaporation of the benzene.

All the material was then dissolved in about 150 ml. of chloroform. This solution was put in a 500 ml. pyrex round bottom flask and 10 grams of zinc dust added. A water cooled reflux condenser was attached and the flask set on a steam bath. 100 ml. of concentrated hydrochloric acid was added in 10-20 ml. portions, thru the condenser, while the material was being slowly refluxed. The addition required about an hour and the material was refluxed for 2 hours after the addition was complete. The mixture was then cooled to room temperature and about 30 ml. of the chloroform solution withdrawn by means of a pipette. The chloroform solution was extracted with 35 ml. of an 8.5 sodium hydroxide solution, which contained about half a gram of hydroquinone per 100 ml. of solution. The hydroquinone was added in an attempt to prevent oxidation of the mercaptan as much as possible. The alkaline solution was then treated with 1 gram of Norite and filtered with suction. The filtrate was then made acid with hydrochloric acid. The mercaptan was thrown
out of solution and upon cooling formed very fine crystals. These were filtered off with suction and dried over phosphorous pentoxide under reduced pressure. The crystals were found to melt at 45-80°C. corr. The literature (Richter's Lexikon) gives the melting point as 43-4°C. Since the melting point of the material obtained by this procedure melted higher than that given in the literature, it was decided to purify the compound more in an attempt to obtain a sharper melting point.

The mercaptan obtained above was again dissolved in 8% sodium hydroxide containing hydroquinone. This time the solution was treated with "Kieselguhr" as Norite did not seem to be very efficient in removing the color. The material was then filtered with suction. The filtrate was acidified with hydrochloric acid and cooled. The mercaptan was filtered off with suction and again dried over phosphorous pentoxide under reduced pressure. This material gave a melting point of 49-50.5°C corr. Solubility in 10% potassium hydroxide showed the material to be about 98-99% mercaptan.

The material was again recrystallized in the same manner. However, when the "Kieselguhr" was being filtered off, hydrochloric acid was placed in the suction flask in order that the alkali would be immediately
neutralized and not allow the unstable alkaline solution of the mercaptan to remain in contact with the air any longer than possible. Upon cooling, the mercaptan settled out in small crystals. The crystals were dried in the same manner as given above. The material melted quite sharply at 50-51°C, corr. Solubility in alkali showed the material to be about 100% mercaptan.

The remainder of the chloroform solution of the mercaptan was separated from the water layer and extracted with 2-75 ml. portions of 8% sodium hydroxide containing hydroquinone. A third extraction was tried but no mercaptan was present in it. The alkaline extractions containing the mercaptan were then treated with about 5 grams of "Kieselguhr" and filtered with suction. In this case the filtrate dropped into hydrochloric acid which was contained in the suction flask. The acid solution was cooled in ice water and the mercaptan filtered off. The crystals were of sufficient purity for the use for which they were made.

Before the final reduction in chloroform, a small amount of the disulfide was recrystallized from chloroform and alcohol. After drying over phosphorous pentoxide under reduced pressure the disulfide gave a melting point of 124-5°C, corr.
SUMMARY
Resumé of Synthetic Compounds Prepared

**Empirical Formula**: $C_7H_3O_2Cl_2S$
- Melting point (obs.): 63.5-64°C
- Melting point (lit.): 60-65°C

**Empirical Formula**: $C_7H_3O_2NCI_3$
- Melting point (obs.): 127.5-128°C
- Melting point (lit.): 128°C

**Empirical Formula**: $C_7H_7Cl_3S$
- Boiling point (obs.): 122-3°/26mm
- Boiling point (lit.): none

**Empirical Formula**: $C_1_4H_1_2Cl_2S_2$
- Melting point (obs.): 64.5-65°C
- Melting point (lit.): none

**Empirical Formula**: $C_7HgCl_2SHg$
- Melting point (obs.): 193-4°C
- Melting point (lit.): none
**Empirical Formula**: $\text{C}_8\text{H}_9\text{O}_2\text{Cl}_2\text{S}$  
Melting point (obs.) $120.5-21^\circ\text{C}$  
Melting point (lit.) none

**Empirical Formula**: $\text{C}_8\text{H}_{10}\text{O}_2\text{NCl}_2\text{S}$  
Melting point (obs.) $204-5^\circ\text{C}$  
Melting point (lit.) none

**Empirical Formula**: $\text{C}_6\text{H}_9\text{Cl}_2\text{S}$  
Boiling point (obs.) $141-2^\circ/29\text{mm.}$  
Boiling point (lit.) none

**Empirical Formula**: $\text{C}_{16}\text{H}_{16}\text{Cl}_2\text{S}_2$  
Melting point (obs.) $124-5^\circ\text{C}$  
Melting point (lit.) none

**Empirical Formula**: $\text{C}_8\text{H}_9\text{Cl}_2\text{SHg}$  
Melting point (obs.) $240-5^\circ\text{C}$  
Melting point (lit.) none

**Empirical Formula**: $\text{C}_8\text{H}_9\text{O}_2\text{Cl}_2\text{S}$  
Melting point (obs.) $49-49.5^\circ\text{C}$  
Melting point (lit.) $50^\circ\text{C}$
Empirical Formula \( \text{C}_8\text{H}_{10}\text{O}_2\text{NCI}_8 \)
Melting point (obs.) 189-90°C
Melting point (lit.) none

Empirical Formula \( \text{C}_8\text{H}_9\text{Cl}_8 \)
Melting point (obs.) 91.5-92.5°C
Melting point (lit.) none

Empirical Formula \( \text{C}_{16}\text{H}_{16}\text{Cl}_2\text{S}_2 \)
Melting point (obs.) 102-3°C
Melting point (lit.) none

Empirical Formula \( \text{C}_{10}\text{H}_8\text{S} \)
Melting point (obs.) 80.81°C
Melting point (lit.) 81°C

Empirical Formula \( \text{C}_{20}\text{H}_4\text{S}_2 \)
Melting point (obs.) 138-9°C
Melting point (lit.) 139°C

Empirical Formula \( \text{C}_{10}\text{H}_8\text{O}_2\text{Cl}_8 \)
Melting point (obs.) not isolated
Melting point (lit.) 76°C
Empirical Formula $C_{10}H_7ClS$
Melting point (obs.) $65.5-66.5^\circ C$
Melting point (lit.) none

Empirical Formula $C_{20}H_{12}Cl_2S_2$
Melting point (obs.) $133.4^\circ C$
Melting point (lit.) none

Empirical Formula $C_{10}H_6O_2Cl_2S$
Melting point (obs.) not isolated
Melting point (lit.) $95^\circ C$

Empirical Formula $C_{10}H_7ClS$
Melting point (obs.) $50-1^\circ C$
Melting point (lit.) $43-44^\circ C$
$49-50^\circ C$

Empirical Formula $C_{20}H_{12}Cl_2S_2$
Melting point (obs.) $124-5^\circ C$
Melting point (lit.) $121-2^\circ C$

The compound is referred to C. 100, II, 352 (1929), but no physical properties are given.