10 cc. of the sulphuric acid.   Close X and heat to about 100° C. by means of the heating coil until the reaction is complete.   Let the apparatus stand until the absorption of other gases (sulphur dioxide, etc.) is complete and it has reached room temperature. Bring the gas in the apparatus to atmospheric pressure by means of the leveling tube E.   The gas reading in the eudiometer minus 10 cc. (for the added sulphuric acid) equals the volume of the evolved gas at the existing temperature and pressure.   The apparatus has been used in this laboratory with accurate results to estimate citric acid by the Spica method and for the estimation of amino acids by the Van Slyke method,[1] which depends on the evolution of nitrogen, by the action of nitrous acid on the amino acids. The apparatus is readily cleaned by taking it apart at the ground joint F.
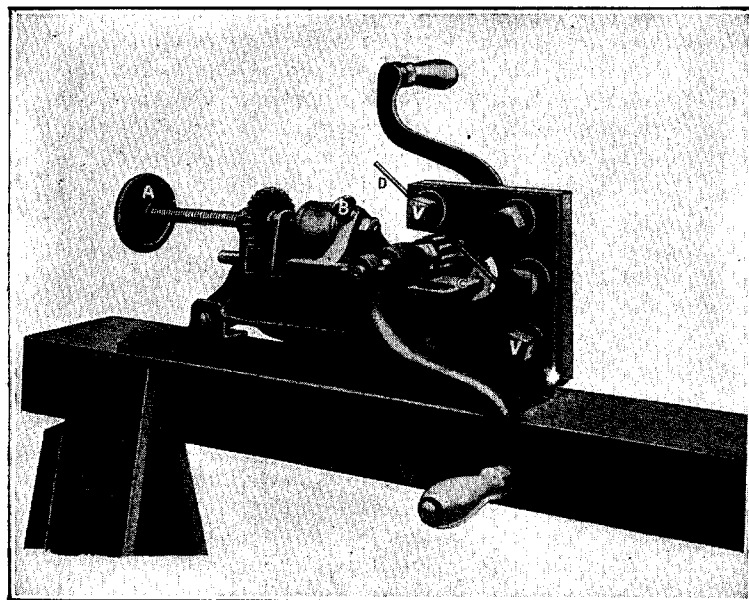
BUREAU OF CHEMISTRY,
WASHINGTON, D. C.

LABORATORY MILLING MACHINE FOR SAMPLING STEEL.

BY CHAS. MORRIS JOHNSON.

In certain kinds of steel the writer encountered much difficulty in getting samples of sufficiently

small mesh for the determination of carbon by the direct method described by him several years ago.

("The Chemical Analysis of Special Steels"—John Wiley & Sons, 1909.)

The trouble was confined to thin sheets, wire, hack saw steel, band saw steel, razor blades, resistance ribbon, nails and small samples of all kinds that are irregular in shape and difficult to hold in the drill press vise.

The machine shown in the illustration afforded a successful means of avoiding various time-consuming expedients.

The sample D of wire, for example, is held in the vise V-V.   The millings are taken up by means of a cutter, made of the best high-speed steel, and are caught on a piece of cardboard at C.

The automatic feeding device at A is hastened in its action by tightening the screw at B.

If desired, where a large number of samples are to be milled, a small motor can be used, and a pulley can be attached instead of one of the handles.

The milling cutters can be sharpened several times.

It is desirable, and well worth the small amount of time involved, to anneal all samples received, if they are not already in a softened state.   This operation can be done in a half hour's time by heating the sample to 800° C. (bright red), quenching at once in water and then holding at 620°–630° C., for 20 minutes (low red).   The annealing of 13 per cent. manganese steels has also been previously described in "Analysis of Special Steels, etc." together with the chemical tests for perfect annealing.

The millings obtained by this laboratory tool are not sifted, as they are just right for direct determination of carbon by combustion in oxygen.

If the sample submitted is sufficiently rigid, it does not need to be held by both ends, as in the case of the sample of wire.

This machine, as illustrated, has been in use in the writer's laboratory for a year. Since its introduction, the samplers no longer dread the appearance of wire and steel ribbon, this work being now a mere matter of easy routine.

The first cost was a bagatelle compared to the saving of labor in one month.   Several copies of this milling tool are now in use in other laboratories of this Company.

LABORATORY OF PARK WORKS,
CRUCIBLE STEEL COMPANY OF AMERICA,
PITTSBURGH.

ADDRESSES.

RECENT DEVELOPMENTS IN BAKELITE.[2]

BY L. H. BAEKELAND.

My subject involves the use of two main raw materials, phenol or carbolic acid, which is found in

[1] *Ber. d. chem. Ges.,* [3] 43, 3170 (1910).
[2] Read at joint meeting of New England Section, Amer. Chem. Soc. and Soc. Chem. Industry, Boston, Nov. 10, 1911.

gas tar, and formaldehyde.   The latter is now manufactured by the oxidation of wood-alcohol.

I should state that the name of formaldehyde is used in a rather broad sense.   I never have seen real formaldehyde, CH_2O, and very few chemists have had occasion to examine it.   It is a gas which can be made to liquefy and solidify by the intense arti-

ficial cold attainable by means of liquid air.[1] Solidified CH_2O melts at —92° C. The commercial product, designated ordinarily under the name of formaldehyde, is a watery solution of formaldehyde, containing at the same time variable proportions of methylalcohol. In these solutions, formaldehyde is present partially as methylenglycol,

$$CH_2\begin{cases} OH \\ OH \end{cases},$$

and as methylal,
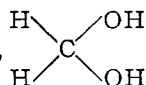
$$CH_2\begin{cases} O—CH_3 \\ O—CH_3 \end{cases},$$
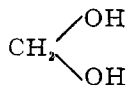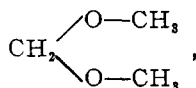
accompanied with variable amounts of several distinct polymers of formaldehyde, of polymers of methylenglycol, or polymers of partial anhydrides of methylenglycol, more or less directly related to paraform, trioxymethylen and similar substances.

The thermochemical researches of Delepine[2] had already shown, in watery solutions, the existence of stable hydrates, which are not decomposed by distillation, and the later work of Auerbach[3] leave no further doubt on the very complicated composition of so-called formaldehyde solutions. The latter are merely mixtures of various chemical compounds which ultimately react in the same way as CH_2O, and which, for practical purposes, are equivalents for each other in the chemical reactions where formaldehyde or methylen-compounds are used. The main point in all these reactions is that the group methylen $=CH_2$ should exist in a mobile condition. It matters little whether this group $=CH_2$ presents itself as true formaldehyde or oxymethylen,

$$\begin{matrix} H \\ H \end{matrix}\!\!\!>C=O,$$
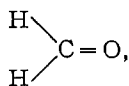
or as its hydrate as methylenglycol, $\begin{matrix} H \\ H \end{matrix}\!\!\!>C<\!\!\!\begin{matrix} OH \\ OH \end{matrix}$.

The same remark applies to its polymers, paraform, trioxymethylene, or other polymers of formaldehyde, or polymers of methylenglycol, or partial anhydrides thereof. All these substances can be substituted for each other, and the final result of the reaction can be made practically the same.
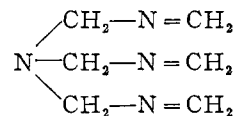
So well was this known that the early work of Ad. Baeyer and his pupils on condensation products of phenols and formaldehyde was carried out by means of the latter's methylen representatives: methylal, methylenacetate, methylenchlorid, or methyleniodid, for the simple reason that commercial formaldehyde was unavailable at that time.

Ammonia combines very easily with formaldehyde and forms hexamethylentetramin,[1]

$$N\begin{cases} CH_2—N=CH_2 \\ CH_2—N=CH_2 \\ CH_2—N=CH_2 \end{cases}$$

So eager is the tendency of combining with ammonia, that if formaldehyde, or any of its equivalent compounds, which keep the group CH_2 in mobile condition, is put in presence of an ammonium salt, like ammoniumchlorid, acid is expelled, and hexamethylentetramin is formed.[2]

Consequently, whenever an excess of formaldehyde or a formaldehyde compound is put in presence of ammonia or an ammonium salt, hexamethylentetramin is formed forthwith, so that mixtures of ammonia and formaldehyde, or hexamethylentetramin, are practically the same thing. On the other hand, hexamethylentetramin, in presence of acids, reliberates easily formaldehyde. There is nothing astonishing that in the condensation of phenols and formaldehyde we should be able to replace formaldehyde by other related compounds.

Let it then be understood that in the reaction I am about to explain, whenever I refer to formaldehyde, this broad denomination includes many substances which are practically equivalent in their chemical action to the orthodox, but elusive true formaldehyde, CH_2O.

When phenol is acted upon by means of formaldehyde, or its equivalents, a most varied set of reactions can occur; even by starting from the same raw materials, new substances may be produced which, according to conditions of operation, may vary considerably in appearance, as well as in chemical and physical properties.

The earlier investigators, like Ad. Baeyer and others,[3] were especially on the lookout for substances of definite chemical constitution, which could be easily isolated, crystallized and purified for the development of their purely scientific work; if they obtained non-crystalline bodies, of resinous appearance, this was merely considered as a drawback, and constituted an unpleasant obstacle in their theoretical research work. Their resins did not seem to attract much of their attention, and the study of the resinous products was soon abandoned in favor of the crystalline bodies which could be obtained. Under the circumstances, it is quite natural that no special effort had been made to produce these resinous bodies, under such conditions that they could be used for definite technical purposes.

When in 1891 formaldehyde had become a relatively inexpensive article of commerce, Kleeberg[4] took up this matter anew, and found that by bringing together a mixture of formaldehyde solution, phenol and hydrochloric acid, a violent reaction ensues,

[1] Raikov, Chem. Ztg., 26, 135; 12; 11 (1901). Kekule, Ber., 25, 2435. Harries, Ber., 34, 635.

[2] Compt. rend., 124, 1454; Bull. soc. chim., 17, 849.

[3] F. Auerbach, also Auerbach and Barschall, Arb. kais. Gesundh., Band XXII, Heft 3 and Band XXVII, Heft 1, Verlag Julius Springer, Berlin.

[1] See Wohl, Ber., 19, 1892. Tollens, Ber., 17, 653. Carl Goldschmidt, page 29. Bonn, Verlag von Friedrich Cohn, 1903.

[2] See Cambier, Brochet, Compt. rend., 120, 557.

[3] Ber., 5, 1095; 19, 3004 and 3009; 25, 3477; 27, 2411.

[4] Ann., 263, 283.

and the whole mass changes to an amorphous, hard, resinous body, of irregular shape, a mixture of various heterogeneous substances, including remnants of the reacting materials. He was confronted by the fact that trying to purify this substance, or to establish a constant composition, was a rather thankless job, especially so as the biggest part is insoluble and not amenable to the usual methods of purification; after giving a limited attention to this subject, he pursued his work along the line of other condensation products, which can be obtained in crystalline form.

Afterwards, various attempts were made by Smith, Luft, Blumer, Story, DeLaire and others, to try to modify this reaction, so as to produce more definite bodies than those obtained by Kleeberg.[1] Their efforts were directed towards moderating the reaction by limiting the temperatures, or by diluting the reacting materials in suitable solvents. It was thus found that, according to circumstances, resins could be obtained which are soluble in alcohol and similar solvents, and which can be heated and melted, and which under treatment of heat remain indefinitely fusible, and behave much like shellac or similar natural resins. For that reason, they are called shellac-substitutes, and I have published a special paper on this subject,[2] in which I designate these artificial soluble and fusible resins, under the general name of Novolak.

Under other conditions, entirely different bodies are obtained which, although resinous in appearance, can no longer be considered as true resins, and lack the chemical characteristics of resins. They are infusible and insoluble. However, the preparation of these infusible substances involved several objectionable conditions, which made them of little, if any, practical value. All this is described in my former publications on this subject.[3]

I undertook a systematic study to establish the chemical constitution and the relation which exists between these infusible bodies, the fusible, soluble, resinous condensation products, and the substances from which they are derived. I was able to dissect this perplexing reaction in several distinct transition stages, which can be produced at will. It seemed at first that the formation of these very dissembling bodies was simply a matter of relative proportions of reacting materials, or of quantity of condensing agents, but I became convinced that this is not so simple and that the reaction involved several, until then unobserved or neglected, phenomena which have a paramount bearing on the results.

By conducting the process in several stages, and more particularly by effecting the synthesis from different starting points, I succeeded in gaining enough insight into the problem that I could devise some sure practical methods for obtaining new results. Since then, several years of uninterrupted hard work have enabled me to devise various technical applications, with most of which you are already acquainted. One of my first problems was to determine why

different experimenters had obtained such dissimilar. results when starting from almost identical products. For instance, Lederer[1] and Manasse[2] by acting with one molecule of CH_2O on one molecule of C_6H_5OH, in presence of one molecule of NaOH, then acidulating, obtained ortho- and paraoxybenzylalcohol,

$$C_6H_5OH + CH_2O = H_2O +$$
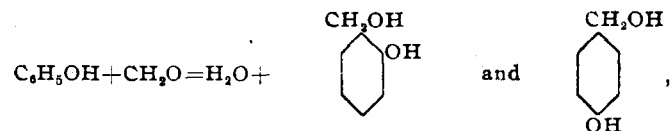
which is a nicely crystalline, water-soluble body, known also as saligenin, very different from the resinous amorphous condensation products. Saligenin had formerly been prepared from its glucoside, salicin, which was extracted from the willow tree.

Then again, DeLaire,[3] operating under rather similar conditions, using about the same proportions of alkali, phenol and formaldehyde, then acidulating, and heating afterwards, obtained fusible soluble resins of totally different character than oxybenzylalcohol. These resins are identical with the soluble fusible resins which he and others obtained by heating directly acids with a mixture of formaldehyde and phenols, but they are totally different from the infusible, insoluble mass Kleeberg and others obtained by heating hydrochloric acid with the same mixture of phenol and formaldehyde. At that time, those results seemed rather irreconcilable with each other, and it very often happened that two operators, starting from the same mixtures, obtained totally different products by simply changing somewhat their way of working. Some workers in this line seemed to pin their faith to the fusible, soluble resins, or Novolak, and used every means to exclude the disturbing insoluble bodies which tended to form. Others again tried to utilize the infusible bodies. It soon became evident to me that the bodies of the latter kind prepared up till then had not attained their full best qualities because they were produced at too low a temperature in presence of acids and in admixture with solvents or with an excess of phenol.

I found that decidedly higher temperatures than those preconised for these products were very desirable, not only for improving the end product but more especially for insuring rapid formation and rapid molding. But when I tried to employ high temperatures, I was immediately confronted, like my predecessors, with the same difficulties; namely, high temperatures bring about violent uncontrollable reactions, accompanied with self-heating and with the evolution of gaseous products, which render the mass porous. This was the very reason why those who had preceded me had carefully recommended in all their descriptions, not to use temperatures exceeding 50 to 80° C., or at the utmost, 100° C.; even then, they were compelled to use solvents or,

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[1] See Baekeland, This Journal, **1**, No. 3, March, 1909, published by the American Chemical Society, Easton, Pa.
[2] See Baekeland, This Journal, **1**, No. 8, August, 1909.
[3] See Baekeland, *Ibid.*, **1**, No. 3, March, 1909, **1**, No. 8, August, 1909.

[1] *J. prakt. Chem.*, [2] **50**, 224.
[2] *Ber.*, **1984**, 2409–11; D. R. P., Baeyer, 85,588; U. S. P., Manasse, 526,786, 1894.
[3] French Patent, No. 361,539.

in some cases, an excess of phenolic body so as to moderate the reaction by these diluents.

I became aware of the fact that the disturbing emission of gaseous products, whenever the reaction is carried out at too high a temperature, has the characteristics of chemical dissociation. Its disturbing action could be moderated by introducing a solvent, for instance, an excess of phenol, in which the gaseous products could provisionally accumulate until they established a dissociation equilibrium. But I concluded that the easiest and most practical way to prevent gaseous dissociation, and the resulting porosity of the mass, was to exert a suitable counter-pressure. This allows us to use as high a temperature as we may desire, by increasing the counter-pressure accordingly. This can be done in several ways, either by heating in a closed vessel in which the pressure raises by itself, or better in a vessel in which air or another gas is pumped, under pressure, before the heating begins. One of the most practical ways, and specially suitable for molding, is the use of a heated hydraulic press.

Permit me to say here that before I took up this subject, no other methods for molding infusible condensation products of phenols and formaldehyde had been suggested than so-called cast-molding, consisting in pouring the original mass in a mold and heating moderately without pressure until solidification sets in.

The technical problem was advanced further by utilizing the following observation:

If formaldehyde and phenols are heated in presence of an acid condensing agent, an insoluble body *may or may not* be the result. This does not depend on the amount of acid nor whether the reaction is allowed to proceed violently, or slowly; neither does it depend on the amount of formaldehyde which has been used; but it all depends on the amount of formaldehyde which has really entered into reaction. For instance, if the reaction be carried out in presence of an acid condensing agent, with an amount of phenol exceeding 15 molecules of phenol for 14 molecules of formaldehyde, a fusible, soluble resin of the Novolak type is most likely to form. The same thing occurs even if large amounts of formaldehyde are used, but if for some reason or another, enough formaldehyde is volatilized, or otherwise lost during the reaction.

I found that these uncertainties do not exist if, instead of an acid condensing agent, we use a small amount of a base. Bases had been used before but in much larger proportions, by which they form substances entirely different from those I have in view. Relatively small amounts of ammonia, alkalies, amines or other basic substances, added to a mixture of phenols and formaldehyde, enabled me in every case, after heating, to produce insoluble, infusible end products, regardless whether the amount of phenol is or is not in excess. With the use of small amounts of basic condensing agents, there is no longer any doubt as to the result, and the reaction becomes so easy to control as to lend itself to the

most varied industrial applications. By the use of bases the initial reaction can easily be interrupted at will, so as to obtain stable intermediate products, which simplify the whole process so as to make it a practical industrial operation. Furthermore, the presence of these small quantities of bases in the initial condensation product accelerates, at relatively low temperatures, the final hardening by polymerization. This beneficial accelerating action is so pronounced that, with some precautions, the process of hardening can be carried out in a much shorter time, and without the use of any counterpressure; for instance, by starting at relatively moderate temperatures, say about 80° C., and as soon as the mass begins to harden by raising the temperature with increasing rapidity to 110° C. and over. For very thin layers, this precaution of gradual heating can even be omitted, and the maximum temperature can be applied at once, without any danger of blisters or porosity.

However, in most cases it is decidedly more practical to heat directly at maximum temperature, under suitably increased pressure. In this way, hardening and moulding can be accomplished in as short a time as one to five minutes, according to the thickness or the size of the object. My published patents contain a description of these processes, and I shall limit myself to the following brief description:

About molecular proportions of phenol and formaldehyde are boiled in presence of suitable amounts of ammonia, or sodium hydroxide. This gives an initial product which is called A, and which can be purchased in the trade either in liquid, or in solid condition. A is the immediate and first result of the condensation reaction, whereby formaldehyde in reacting upon phenol increases the carbon nucleus of its molecule, this phenomenon being accompanied by a corresponding chemical elimination of water. This A, our initial condensation product, is soluble in alcohol, acetone and similar solvents. Certain varieties of A can be kept indefinitely, or at least for a long time, without alteration. A is characterized by the very distinct property that when it is further heated, it will ultimately be transformed into a final infusible, insoluble substance, of great hardness, called Bakelite "C," and this is the final product at which we aim in the whole process.

Solid A, on account of its physical appearance and its solubility in alcohol or acetone, might easily be mistaken for one of the permanently fusible, soluble resins of the Novolak type. But such a mistake is impossible if we bear in mind that Solid A, when heated, although it may melt for awhile, soon becomes hard, infusible and insoluble by polymerization. Novolak, on the contrary, if heated, simply melts and sets again by cooling, but it does not harden to an infusible, insoluble body by simple application of heat.

In my former publications[1] I have described also an intermediate product, B, the existence of which is of considerable importance for certain industrial

[1] Baekeland, *loc. cit.*

applications, because, although being infusible and insoluble, it nevertheless, possesses the property of softening if heated, and of welding and molding under the combined action of heat and pressure.

There are several other ways of obtaining "C," for instance, Lebach (Knoll & Co.) uses a base as a condensing agent, and mixes the so obtained "A" with a strong acid, and heats at a moderate temperature.[1]

"C" can also be produced by heating oxybenzyl alcohol with CH_2O, or its equivalents.[2] Or instead of starting from oxybenzyl alcohol, we may start from Novolak, and heat it with CH_2O, or equivalent substances.[3] DeLaire[4] has already shown that the fusible soluble resins are anhydrides of phenol alcohols. This can easily be demonstrated by heating, preferably *in vacuo*, oxybenzyl alcohol in a test tube at 160-170° C. Heating oxybenzyl alcohol, in presence of acid solutions, favorizes considerably the formation of these anhydrides, or saliretins, sáligenosaligenin, and similar products.[5] I believe this explains to us why bodies of the Novolak type are more easily engendered in presence of acid condensing agents, provided the CH_2O be not used in excess.

The intervention of condensing agents for the formation of fusible, soluble resins of the Novolak type is not indispensable. This has been shown as far back as 1905 by Story,[6] who, by simply boiling an excess of phenol with formaldehyde *without any condensing agent*, and evaporating afterwards, has obtained a soluble, fusible resin of the Novolak type. Lately, Aylsworth[7] has confirmed this method in a somewhat more complicated way. All these fusible resins are simply anhydrides of the corresponding phenol alcohols. Their fusibility and solubility are augmented by the presence of small amounts of phenolic bodies. In my former publication "On Fusible, Soluble Resinous Condensation Products of Phenols and Formaldehyde,"[8] I considered these bodies as definite compounds of saliretin products, with a small excess of phenol. More recent work on the same subject, the details of which are not yet ready for publication, compels me to abandon this interpretation. We have to deal here simply with physical mixtures in the form of colloidal solid solutions of saliretin products with very small quantities of phenols. These small amounts of phenol are retained stubbornly by the phenol alcohol anhydrides or saliretin products forming therewith a solid solution; this accounts for the difficulty of their complete removal.

This makes the chemistry of this whole subject

1 See U. S. P., Lebach, 965,823.

2 See Baekeland, THIS JOURNAL, 1, No. 3, March, 1909.

3 See Baekeland, "On Soluble, Fusible, Resinous Condensation Products of Phenols and Formaldehyde," THIS JOURNAL, 1, No. 8, Aug., 1909; Belgian Pat., 213,576, February 15, 1909.

4 See British Patent, 15,517, 1905.

5 Beilstein, *Organ. Chemie*, 2, 1109 (1896). R. Piria, *Ann. Chem.*, 48, 75; 56, 37; 81, 245; 96, 357. *Moitessier Jahresbericht*, 1886, 676; K. Kraut, *Ann. Chem.*, 156, 123. Gerhardt, *Ann. Chim. Phys.*, [3] 7, 215. F. Beilstein and F. Seelheim, *Ann. Chem.*, 117, 83. C. Schotten, *Ber.*, 1878, 784.

6 D. R. P., 308,449.

7 Belgian Patent, 232,899.

8 THIS JOURNAL, 1, No. 8, August, 1909.

extremely simple. The fusible, soluble resins of the Novolak type are merely the old known saligeno saligenins, saliretins, or anhydrides of phenol alcohols, containing in some cases, in solid solution, a smaller or larger amount of phenols.

If then we take into consideration that I succeeded in making C by heating six molecules of oxybenzyl alcohol with at least one molecule CH_2O or its equivalent, and that the same result is attained by heating Novolak or other anhydrides of phenol alcohols with the requied amount of formaldehyde, the explanation of a heretofore rather perplexing set of reactions becomes exceedingly simple.

Instead of directly preparing Solid A by starting with phenol and formaldehyde and a base, we can make it in two steps: first, prepare Novolak or any other saliretin products and then melt and mix it with the polymers of formaldehyde, and thus obtain a variety of Solid A, practically identical to the Solid A obtained by direct action of phenol and formaldehyde in presence of a base. This Solid A, by further action of heat, will then change into hard infusible, insoluble "C."

The similarity of the Solid A thus prepared is even greater if, instead of using formaldehyde, we use a mixture of formaldehyde and ammonia, so as to accelerate the hardening process. In place of this mixture of formaldehyde and ammonia, we can use its preformed and direct equivalent, hexamethylentetramin. However, in the latter case the amount of ammonia introduced into the mixture, with the required amounts of CH_2 group, becomes much larger than strictly necessary, and on account of this as soon as the final hardening sets in this excess of ammonia is liberated.

If the temperature of such a hexamethylentetramin mixture be raised above 110° C., self-heating starts in, and the whole mass raises like a sponge, while hardening: this on account of the sudden liberation of ammonia vapors. This phenomenon which I show you here is in direct contradiction with the statement of Mr. Aylsworth.[1] It is quite true that my method of using counterpressure in a hydraulic press, or otherwise, can easily be called into service here, so as to allow the use of the high temperature at which rapid molding and hardening becomes possible. In this respect, small amounts of fixed alkalies, like caustic soda, have decided advantages over ammonia, or hexamethylentetramin, in as far as they do not exaggerate the tendency of forming gaseous products by the elimination of NH_3, which causes foaming and porosity during the application of heat in the hardening process.

The properties of Bakelite, its chemical constitution, and some of its industrial applications, have been so often described that I will dispense with a general repetition thereof. The fact that it only chars at relatively high temperatures, its infusibility, its hardness, and tenacity, its resistance to physical and to most chemical agents, and its ease of manipulation explain sufficiently its uses in the arts.

1 See Belgian Patent, Aylsworth, 232,899, February 11, 1910.

In my former publication on the subject, I have insisted, in order to better differentiate its properties from those of hard rubber and celluloid, that it lacks the flexibility of the two latter products, but I have found since then that my statements have been taken too absolutely, instead of in a comparative sense. Here is, for instance, a thin plate of Bakelite, which is flexible enough for many purposes, and which is, furthermore, quite strong, but you will notice that if I bend it in an exaggerated manner it suddenly will snap off and break in many small pieces. It resembles in this respect a thin plate of glass, but it is not so fragile and is more flexible. Thrown on a hard surface, it will not break as easily as glass and will rebound. Nevertheless, it cannot stand the seemingly endless bending of the very flexible varieties of celluloid. There is no difficulty whatever, by the introduction of some substances which produce colloidal solid solutions, to make Bakelite so soft and flexible that a rod thereof can be twisted around one's finger; but in introducing these extra matters, many of the other excellent qualities of Bakelite are sacrificed to a considerable extent; for those applications where great flexibility is required, rubber and celluloid answer, incomparably better, the purpose.

I found that we can enormously increase the practical uses of Bakelite by incorporating it with structural fillers, like fibrous or cellular bodies. The beneficial action of the latter is remarkable, and seems to consist mainly in modifying the shattering wave which develops whenever an object made of Bakelite is submitted to a violent shock. Some substances, like rubber or celluloid, are weakened if they are mixed with large amounts of fibrous materials. But Bakelite is strengthened by fibrous materials, on account of its low flexibility and other specific properties, probably also by the fact that its fusible parent "A" impregnates homogeneously any fibrous or cellular materials with which it is incorporated, instead of remaining on the surface like rubber or celluloid. It produces, with fibrous fillers, compositions which are strikingly much stronger and less breakable than if it be used alone or in conjunction with structureless fillers. This valuable property has been put to excellent advantage in the manufacture of many molded and impregnated articles where Bakelite is used in smaller proportions as a binder for fibrous bodies. This is best illustrated by some of the molded solid buttons, insulators, phonograph records, brush-backs, magneto distributors, knife-handles, pressed plates, and other manufactured objects you see here before you, many of which have been molded in the hot hydraulic press, without any after-treatment. Some of these articles have been molded and finished in a few minutes' time; others of large size require some longer heating.

Here is a third rail, insulator block, molded from a mixture of asbestos fiber and Bakelite. From its excellent appearance, you would never imagine that it has had two years of strenuous service for heavy passenger traffic on the third rail system of the New York Central lines, exposed to rain and sun and all the extreme conditions of our variable climate.

Molded compositions of ordinary asbestos and Bakelite, containing less than one-third of Bakelite, have shown on the Riehlé testing machine tensile strengths as high as 4490 lbs. per square inch, and by selecting carefully the fibrous material still better results can be obtained.

The following electric tests will give a general idea of the dielectric value of Bakelite and some of its composition:

Composition. Different varieties of transparent "C" made specially for electrical purposes by hardening liquid "A" on a glass plate in a stove:	Thickness testing piece in millimeters.	Punctured at	Volts per millimeter, at puncture. Tested with a 50 kilowatt transformer, raising voltage gradually so that puncture occurs within 20 to 30 seconds.
Sample 1...............	1.78		17,400
Sample 2...............	2.18		14,200
Sample 3...............	2.60		13,400
Sample 4...............	0.43	16,750	38,800
Sample 5...............	0.9	23,300	28,000
Sample 6...............	0.95	25,600	26,900
Molded composition:			
70 Asbestos...........	8		
30 Bakelite...........	8		8,500
Molded composition wood flour and Bakelite.....	7.9		11,000
Impregnated blotting paper, hardened in a hot hydraulic press....	3.66	102,000	27,880
Pressed paper impregnated with Bakelite...	1.6	53,700	33,500

Some other tests (Electrical Testing Laboratories of N. Y.) have shown an unusually high specific inductive capacity, which makes the material very suitable for electrical condensers.

Pressed paper, impregnated with Bakelite, has been recommended in Germany for the manufacture of electrostatic machines. Its value for this purpose may reside in the fact that it withstands rather well the action of ozone, which is not the case with resins, or with hard rubber. In fact, hard rubber is known to coat itself by and by with an extremely thin film of sulphuric acid, due to slow oxidation of the sulphur. This sulphuric layer, although microscopically thin, causes considerable disturbances for some electrical applications. The impregnation of electric coils with Bakelite is now regularly practised on an industrial scale by several electric manufacturing companies. Its advantages for this purpose are obvious on account of the fact that in case of an increase of temperature, through overload or otherwise, the impregnating material cannot melt; but there is another important factor, namely, this substance, notwithstanding its good electric insulating properties, is a better conductor of heat than the resinous materials or varnishes generally used for the impregnation of dynamos or motors, so that the generated heat is better conveyed to the outside. At any rate, it has been observed that coils impregnated with Bakelite heat up much less than others impregnated with resinous bodies.

Bakelite has rendered excellent service as a glue;

one of its latest applications on a commercial scale is shown by these brushes, of which the bristles are held together with this binding material, which is indifferent to any of the solvents used in paints, varnishes, paint removers and to soap or hot water. It is cheaper and easier to apply than rubber, which has lately been used extensively in the United States for the same purpose. Furthermore, the hardening can be conducted at temperatures so low that white bristles are not discolored.

Let me draw also your attention to these samples of fancy articles, like cigar holders and pipe stems, made of "C," perfectly transparent. Some have the color of amber; others are as colorless as glass. You will notice that they are entirely devoid of odor or taste, even if you rub them. If I insist on this point, it is merely to eliminate an erroneous impression, which has gained some ground, that Bakelite has a particular smell. If there was any smell at all, it would only show that the transformation in C had not yet been complete.

As chemists, you are undoubtedly more interested in the application of Bakelite for laboratory work, or for chemical engineering purposes. Time forbids me to take up the subject in detail. But I may state that a dilute alcoholic solution of "A" finds many uses in the laboratory. Dipping or spraying of metallic objects in or with a solution of the kind, followed by treating in a stove at a temperature of about 120° C. or above, provides them rapidly with a hard protective coating. The time of hardening varies from one minute to half an hour or more, according to the available temperature. If blisters are caused, this indicates that the solution is too thick. This gives us a very economical means for transforming an ordinary sheet-iron-kitchen-gas-oven, which can be purchased at any hardware store for one to two dollars, into a very efficient substitute for the expensive copper drying stove.

Leaks or cracks in glass apparatus can easily be made tight by the skilful application of this solution. In certain cases, asbestos paper or tape, used in conjunction with varnish or Liquid A, will prove an excellent reinforcement.

There is a special variety of Liquid A, which can easily be mixed with asbestos fiber, or clay, or silex powder or baryta, so as to make a very soft dough-like-mass.

If I apply this soft mass to a hot steam pipe, it will stiffen rapidly, until it becomes as hard as stone. By the fact that it contains a base hardening agent, the hardening can take place easily at temperatures as low as 75° C., although higher temperatures will give quicker results. This makes an excellent mixture for spreading on the surface of cast iron pipes or other parts of machinery which have to be protected against the corrosive action of some chemicals. Here is, for instance, a part of an iron casting, the inside of which has thus been protected by applying this paste as a $1/_4$-inch inside lining. These protected iron castings have been used in a large electrolytic plant, where they have been submitted for more than a

year, day and night, continuously to contact with rapidly moving hot brine and hot chlorine, at temperatures of about 70° C. For such purposes it is always better to apply the material abundantly, because it is very difficult to spread a thin film of any material so uniformly that there should not exist some unprotected places where corrosion can occur.

For certain chemical uses like digesters, the possibility of chemical corrosion is augmented by mechanical abrasion, due to the friction of moving liquids or solids. For such purposes, there exists a simple and efficient way for lining the vessel with acid-proof bricks, held together with Bakelite cement. This is accomplished in a somewhat similar way as porcelain-lined ball mills are made, with that difference that the walls of the vessel ought to be first lined with a thin sheet of asbestos paper, impregnated with liquid A; on this the brick lining is inserted and fastened with liquid A or better with a cement made with liquid A and some inert filling materials, like clay, baryta, or powdered silex, or asbestos. This liquid mixture is easily applied, and then a suitable heater, for instance a gas-stove, is introduced in the vessel, so as to raise the temperature of the lining to at least 80° C., or higher, until the polymerization into C has taken place.

Whenever asbestos is used as a filling material, it should not be forgotten that Canadian asbestos is easily attacked by acids. Amphibole asbestos is considerably more resistant to acids; unfortunately, it lacks strength and fibrous qualities. Green Cape asbestos resists acids well and has a good strong fiber, but is more expensive.

THE "KAISER WILHELM INSTITUT FUER PHYSIKALISCHE CHEMIE UND ELEKTROCHEMIE" IN DAHLEM NEAR BERLIN.

By WILLIAM D. HARKINS.

On October 1st Professor F. Haber began his work as Director of the new Kaiser-Wilhelm Institute für physikalische Chemie und Elektrochemie at Dahlem near Berlin. The buildings of the Institute, work upon which was begun during the present summer, are being erected by the Prussian government working in conjunction with the "Koppel-Stiftung for the purpose of improving the intellectual relations of Germany with other lands."

The "Koppel-Stiftung" which was founded in Berlin some years ago by Geheimer Kommerzienrat Leopold Koppel, and which until now has maintained the German School of Medicine in Shanghai and the American Institute in Berlin, will provide the funds for the erection of the new Institute and will also give thirty-five thousand marks annually for its maintenance during a period of ten years. The Prussian government has provided the site which is situated at the terminus of the new underground railway from the center of Berlin to Dahlem, and