

with an internal diameter of 8 to 10 mm. was found to work very satisfactorily at rates of less than 500 cc. per minute. The tip of the inlet tube has an internal diameter of 1 to 2 mm. The size of the other parts

of the apparatus will depend primarily on the amount of reagent, and the duration of contact between gas and reagent, which is desired.

BUREAU OF STANDARDS, WASHINGTON, D. C.

ADDRESSES

SOME PROBLEMS OF CHEMICAL INDUSTRY¹

By RAYMOND F. BACON²

The industrial researcher, who deals with the processes of manufacture and the phenomena of reactions involved, is becoming less and less regarded as a burden unwarranted by returns. The aim of every industrial operation is toward perfection, both in process and the necessary mechanical equipment, and every new development in manufacturing creates new problems. It follows, then, that the greater the number of researches, the greater is the progress in a given field, and the greater becomes the number of new problems. Moreover, one can only conclude that, since perfection is but, after all, an ideal, no industrial field has been sufficiently investigated.

The thirst for distinction and wealth kindles the lamp of invention, and the light of the knowledge resulting from discoveries and improvements in manufacturing operations has so emboldened us that some industries now consider themselves capable of solving any problem. This has been shown in innumerable instances, but is particularly true of the great chemical industry, which, while its achievements have been stupendous, is nevertheless confronted with many problems of importance. With your permission, I shall restrict myself to recounting some of the problems which engage the attention of the present-day chemical industrialist—problems which he is capable of clearing up, provided the service of research is called to his aid, but which have so far remained unsolved. In collating these I have drawn from all available resources of information and from my own experience.

SOME METALLURGICAL PROBLEMS OF TODAY

While there may not be at the present time room for such abnormal discoveries in siderurgy as in the past, investigators are quietly and steadily augmenting our knowledge of iron and its alloys, and the value of such research work is generally recognized. Elaborate investigations are constantly being conducted by several manufacturers, especially by the United States Steel Corporation, which has to date expended over \$800,000 in studies on the electrothermic production of steel alone. However, metallurgical research laboratories are still comparatively uncommon. Very few iron furnaces or smelting plants are without a control laboratory, which has come about notwithstanding the opposition of "practical men," and the research laboratory will eventually win a similar victory. Such problems as the working-up of blast furnace slags by an economic process could probably be solved by systematic research.

The great problems at present in the metallurgy of zinc are in concentration of the ore and in the treatment of flotation concentrate. The latter produces the troubles that fine ore always does; it is difficult to roast, and the distillation of it is attended with troubles. Viewing the present status of the practice in zinc smelting, one is impressed by the high extraction results, the low fuel consumption made possible by regenerative gas-firing, and the reduction of labor involved in the art.

In copper metallurgy, the leaching of copper ores and electrolytic deposition for precipitating are receiving increased at-

¹ Author's abstract of an address delivered before the Chicago Section of the American Chemical Society on May 14, 1915. In Dr. Bacon's absence, this address was presented by Dr. S. R. Scholes, Assistant Director of the Mellon Institute.

² Director of the Mellon Institute of Industrial Research and School of Specific Industries of the University of Pittsburgh.

tention. With regard to chemical precipitation, it is desirable that this process be conducted in such a way as to regenerate the solution. In electrolytic copper refining, promising progress has been made in the treatment of anode slimes, and increasing attention is being paid to the recovery of by-products. Then, too, the progress in the development of flotation processes has been phenomenal, but still our knowledge regarding flotation is meager.

The search for platinum substitutes continues, and an economic method for rapidly separating the metals of the platinum group is also desired.

The brass industry has been carried on for more than a century in Connecticut and considerable study has been given the matter of zinc loss, but so far ones engaged in the industry have been unable to find any economic and entirely satisfactory method to overcome such loss. Moreover, no entirely satisfactory gas furnace has been designed for general brass rolling mill practice.

The development in engineering construction has arrived at a point where the use of special alloys for specific requirements requires more thorough investigation. The matter of corrosion has been one of a more or less mysterious nature; confusion has arisen on account of the names of alloys; the ideal alloy for condenser tubes has not been found; the failures of screens made from brass wire are well known, and we have yet to find an aluminum alloy that will resist alkalis. It is true that there is beginning to be a well-defined literature on the subject of alloys and that now one can sometimes very closely predict the properties of combinations of the more commonly known metals; but we have not begun to open up the possibilities of usefulness in the exploration of the alloy field, in which I include the so-called "dilute alloys"—cases wherein a very small amount of a metal alloyed with, say, iron or steel confers upon it some new or unusual properties.

SOME PROBLEMS OF INDUSTRIAL INORGANIC CHEMISTRY

Nitrous oxide is being successfully used in combination with oxygen for the production of anesthesia; but while there is a material available for the production of oxygen upon treatment with water ("oxone"), no substance which will yield nitrous oxide upon similar treatment is known. On account of the present large consumption of nitrous oxide, considerable study has been devoted to this problem.

New uses, ones such as would increase the demand, for the following products are required: Potassium hydroxide, chlorine, bleaching powder, bromine and bromides, calcium, silicon, selenium, tellurium, cobalt, uranium and molybdenum. Since sodium metantimonate is undesirable in enamels placed on cooking utensils, new uses for this and other antimony compounds are needed; attention may be directed to the fact that antimony lithopones, made by treating barium carbonate and antimony sulfite, offer, perhaps, a partial solution of this problem. It may be noted here that a large production of arsenic would follow a demand.

In the domain of ceramics, the subject of binders presents a field for research; to cite a simple instance, a binder for infusorial earth that is cheap and will stand a temperature of about 3,000° F. is being sought for by ones interested in the production of metallurgical brick.

Efforts to improve the quality of all varieties of clay goods, from ordinary brick to the highest-grade pottery, are constantly in progress by American clay-workers; this is evinced by the new

shades and texture of building brick, the new forms of hollow building tile or block, and the new effects in terra cotta that are being put on the market, and by a general improvement in the higher grades of pottery. Of interest in this connection is the realization of the value of American clays in glass-pot manufacture. Earthenware kilns designed in such a manner as to reduce the carrying of heavy weights, to do away with working in hot kilns, and to diminish the handling of dipped ware, would be very desirable, and some progress in tunnel kilns of this general type has been made in England.

It has been said that the technology of common earthenware, Rockingham ware, majolica, faience, and stoneware is comparatively simple; this is undoubtedly correct, viewing the pottery industry as it exists today, but it is also true that less advantage has been taken of scientific research in earthenware manufacture than in many other industries. A familiar problem is the nature of clay plasticity, which is quite open for study; the flowage behavior under pressure promises to be of value in this work.

There are many problems to be found in the glass industry; for example, the available results relating to the problem of strains in glass merely represent a beginning of the work necessary to a complete solution. However, the troubles of the glass manufacturer would vanish if the chemical constitution of glass were definitely determined, and if the ideal non-contaminating container (pot and tank) were found. A great problem in the glass industry is the better utilization of heat; only 5 per cent is actually utilized in making glass.

In the tinning industry electro-tinning has recently made important progress, although as yet no marked commercial success has been attained; and a beginning has been made toward coating black plates with aluminum by a cold, wet, electric process. Among the problems worthy of investigation in connection with the tinplate industry are the following:

- 1—Over and under black pickling, the influence of strength and temperature of the acid solution, and of time. Mention may be made here that the utilization of spent ferrous liquor obtained in pickling iron or steel, is receiving more and more attention.¹ Perhaps the acid and a paint pigment could be recovered from waste hydrochloric acid pickle liquor by a simple heat treatment in a suitable apparatus.

- 2—Effect of varying temperatures and time of annealing.

- 3—Light and heavy cold rolling.

- 4—Temperature effects in the tinning operations.

- 5—Differences from the tinplate-trade point of view between acid Bessemer steel, basic Bessemer steel, acid open-hearth steel, and basic open-hearth steel, and the comparative tin consumption of each kind.

Since the mantle industry cannot absorb more thorium (about 300 tons of thorium nitrate are consumed annually), and much larger quantities of mesothorium than 6 grams (present available supply, under normal conditions, from 3300 tons of monazite sand) will probably be required for therapeutic purposes, the extraction of larger quantities of mesothorium depends upon profitable utilization of cerium (over 1,000 tons of ceria are obtained annually in the mantle industry, and only 3 tons are required in the manufacture of mantles). Of 1,000 tons of ceria, 200 tons are normally used in the manufacture of pyrophoric alloys, 300 tons are used in the form of fluoride for impregnating arc-light carbons, and the dyeing and photographic industries take small amounts. New uses are consequently wanted for cerium compounds, which might be used, for instance, in the weighting of silk.

Chemistry is a very important factor, indeed, in the fertilizer

industry, and it will, of course, carry out the work ahead. Some of the problems are:

- 1—Rendering available the phosphoric acid in refractory minerals by, say, electrochemical means of a suitable nature.

- 2—Recovery by economical processes of potash from feldspar, alunite, leucite, and beet-sugar molasses. In the case of the production from minerals, the cost of treating feldspars has so far been prohibitive; electrothermic processes will undoubtedly be eventually used. It may also be possible to recover thus the potash contained in the raw materials used in the cement industry, and some progress has, in fact, been made in the solution of this problem. My own opinion is that the successful potash recovery process will be one in which the principal product will be one other than potash and the latter will be a by-product.

SOME PROBLEMS OF INDUSTRIAL ORGANIC CHEMISTRY

In the wood distillation industry, new uses, immune from the competition of denatured alcohol, are anxiously desired for methyl alcohol. A more rational utilization of wood-tar is also essential for the future of this industry; there is no reason why valuable by-products other than creosote and shingle stains might not be obtained from hardwood tar. In this connection an economic (direct, if possible) process for manufacturing acetaldehyde (for use as an acetylene solvent) from acetate of lime, would undoubtedly attract the producers of the latter, as would also important new uses for acetone. It is rather surprising that the manufacture of acetic acid from acetate of lime has been neglected in the United States. Hardwoods abound on the Pacific coast and can be distilled with profit, providing markets for the charcoal and calcium acetate can be created.

Commercially operable processes for the manufacture of charcoal, cellulose, gas, glucose, or ethyl alcohol from wood waste, are occasionally inquired for. A number of methods have been devised, but economies must be developed.

It may be mentioned in this place that pinene has been shown to be the chief source of isoprene in turpentine. A process for economically increasing the yield of pinene in the distillation of long-leaf pine, would possess commercial value, both from a synthetic rubber and from a turpentine standpoint.

There are many chemical problems in paper making. What, for instance, is the influence of chemicals on the "beating" process? The bleaching problem has also been very little studied; it is unknown, for example, what is the exact nature of the substances removed from the pulp by bleaching or in what form they are eliminated. Then, too, the problem of sizing is full of unsolved points; the fixation of the loading materials is a physico-chemical problem which should repay systematic investigation, and the question of new sizing agents awaits solution. Other of the many problems are the following: What are the chemical causes of the loss of resistance to ink after storage, particularly in the case of engine-sized paper? What are the chemical relations of the dyestuff towards the mineral loading materials in pulp-dyeing?¹ And then there is the problem of the clarification of the machine waste waters and the recovery of by-products therefrom. In spite of the fact that a tremendous amount of work has been done on the problem of the waste liquor from sulfite pulp mills, it still remains for the most part unsolved.

On account of the war, now would be a most opportune time to lay the foundation for an artificial silk industry in this country.

The manufacturers of the chlorides of carbon would be interested in new commercial uses for carbon tetrachloride, dichloromethane, and hexachlorethane. An economic commercial process for chlorinating natural gas rich in methane would be

¹ Of a similar nature is the problem of the economic utilization of mine water, which resolves itself into the ascertainment of either (1) a cheap process of precipitating the dissolved matter, including any free acid, or (2) a suitable process for purifying the water.

¹ Three theories have been advanced to account for the fixing of dyes by fillers. Results favor the absorption theories of Pelet and Rohland rather than the chemical combination theory of Suida, but discrepancies have been observed in all cases.

attractive; a number of such processes have been worked out, but apparently these leave something to be desired.

Among other problems awaiting technical solution are: the production of oxalic acid by the electrolytic oxidation of cellulose; the production of acetaldehyde and acetic acid from acetylene; the device of ways and means to use the lower grades of gasoline in internal combustion motors; an economic process for removing resin from fir and other wood in pulp making; the production of permanent light shades on glove leather; more efficient processes for depilating, disinfecting, deliming, softening, and waterproofing skins and hides, and for brightening tanned skins; and the utilization of the fibrous wastes in several industries, especially the million bushels of envelopes decorticated from buckwheat annually. Novel processes for the refining or bleaching of vegetable oils, especially of cottonseed and soy-bean oils, always interest the refiners of these. And finally it may be mentioned here that the wine growers of California and New York now have the opportunity to produce argol, and thus begin the manufacture of tartaric acid.

As instances of some desirable commercial syntheses, mention may be made of the fact that processes are wanted for the synthesis of acetylene, formaldehyde, amyl alcohol, tartaric and citric acids, sanguinarine, hydrastine, and nicotine.

In the explosives industry, the manufacturers of nitroglycerine hope that in synthetic glycol may be found the solution of their bondage to the fluctuation of the corn and cottonseed crops. The production of glycerine depends considerably on the abundance or otherwise of pork and of cottonseed oil, and the former depends largely on the corn supply.

In depolymerizing heavy hydrocarbon oils, hydrogenation with platinum black could be accomplished if an antidote could be found for the poisonous effect of sulfur compounds. Oil refiners are endeavoring to find methods to convert every pound of gas oil into more valuable products, especially motor fuel.¹ Through the application of physicochemical principles to the "cracking" of oil, a better control of and greater flexibility in the resultant end products can be expected. This means that if gas manufacturers are to continue the use of petroleum in carbureting water gas, they must resort to one of two alternatives:

1—Greatly increase the yield of gaseous hydrocarbons from a given amount of oil; or

2—Perfect methods of using the millions of barrels of fuel oil which are at present considered unfit for carbureting water gas.

Much also remains to be done in the field of concentration, pressure and contact-surface changes with respect to illuminating and heating gas.

Sugar manufacturers do not work up their by-products; for example, they do not can molasses or manufacture alcohol from it. Molasses is a suitable source of alcohol; the by-products are yeast, fusel oil, and carbon dioxide. There is little coöperation among sugar manufacturers to improve methods. No limits have been scientifically set for moisture content and degree of infection of sugar, the two greatest points in grading sugars for storage, and the cause and prevention of infection require study along broad lines. Then, too, much remains to be learned concerning bone-black. A satisfactory drying process must be found to render the mud from sugar refineries available for use as a fertilizer; and sugar-beet wastes could furnish about 15,000 tons of potash annually.

In the rubber industry there are four leading groups of problems: quality of natural raw rubber; synthetic rubber; vulcanization; and regeneration. The viscosity of Hevea latex diminishes upon dilution with water in such a manner as to suggest that it is an emulsion rather than a suspension. Since, however, rubber is an emulsoid colloid, and consequently always

a liquid, we are not able, in this way, to draw any conclusion as to the state of polymerization in the latex. The nature of coagulation has not been fully explained, although it is of absolutely vital importance as regards the quality of the rubber produced. No chemical explanation can at present be given to account for the differences in quality between Para and Plantation rubber. Research is also required to determine the nature of the factors affecting the quality of raw rubber and its velocity of vulcanization. It is important to have a raw rubber which shall vulcanize at a constant speed, and, if possible, of guaranteeing this by careful tests before buying. Rubber from which the resins or proteins have been removed will not vulcanize as readily as ordinary technically pure rubber, and the conclusion has been drawn that synthetic rubber will be bad on the ground of its being too pure. The rubber manufacturer will not, however, be in any way embarrassed on that account and will be able to add as much resin as is needed, consistent, of course, with specific work. With regard to the regeneration of waste vulcanized rubber, so far it has not proved possible to obtain from waste vulcanized rubber a product like new rubber and containing no sulfur. The combined sulfur is bound with extraordinary strength. What can be accomplished is to remove the free sulfur, some or all of the mineral fillers, and the fibrous materials, and the reclaimed rubber thus obtained by many processes is a valuable adjunct in cheap mixings.

Certain problems connected with the coal-tar industry are as follows:

1—The devising of a practical distillation method for increasing the yield of coal tar light oil (at present the yield is never over 4 per cent and averages about 2 per cent).

2—New uses for hard coal tar pitch—ones other than as a briquette binder. This investigation would have for its object the extension of the demand for this constituent of tar.

3—A commercially successful, economic method of dehydrating tar. While the water may be reduced to less than 0.5 per cent by heating the tar continuously in thin films under a partial vacuum (this plan is most in favor), it is said that any improvement in this troublesome and expensive step would be welcome.

4—An investigation to find special fields for the use of water gas tar and its products, especially the pitch (which shows, to a much higher degree than coal tar pitch, the properties of brittleness and susceptibility to temperature changes) and oils (which have not given the great value for timber preservation characteristic of the coal tar oils).

5—New uses for anthracene (other than as a basis for alizarine, etc.) in this country. The object would be the finding of such uses as would make the production of anthracene profitable.

6—The chlorination of naphthalene. The wax products obtainable thereby possess dielectric properties and promise to develop an important field. An investigation of the methods of preparing these, their properties and commercial values, along broad lines, would undoubtedly lead to important technical results.

Owing to the great number of existing technicochemical problems, I have restricted myself in the choice of the ones cited and in general have refrained from even a cursory discussion thereof. I have endeavored, however, within the brief period of thirty minutes, to show that many various problems await solution and that a number of branches of chemical industry invite research.

It was for the purpose of aiding manufacturers in solving just such problems as have been mentioned that the Mellon Institute of Industrial Research was founded. I now invite you to make a visit of inspection to the new home of this representation of an alliance between industry and learning which has been gratifyingly successful, in order that you may see what we are accomplishing in obviating difficulties in manufacture, in utilizing wastes, in improving and cheapening manufactured

¹ The success which has attended scientific progress in refining petroleum is the cause of the high cost of gas oil. It must soon render necessary extensive scientific research in the gas industry.

products, in finding new uses for products, and in searching for new and useful products, for twenty-five American industrialists.

[Dr. Scholes gave here a brief discourse on the work of the Mellon Institute of Industrial Research (see THIS JOURNAL, 7, 343-7), illustrating its activities by means of sixty lantern slides.]

MELLON INSTITUTE OF INDUSTRIAL RESEARCH
PITTSBURGH

THE BRITISH NATIONAL DYE SCHEME

By D. GEDDES ANDERSON

Received April 6, 1915

Towards the end of the first month of the war, the British Board of Trade appointed a committee, with Lord Moulton as president, to consider and advise as to the best means of obtaining for the use of British industry sufficient supplies of chemical products, colors and dyestuffs of kinds hitherto imported from countries with which at present a state of war existed. It was brought out that British industries use annually dyes to the value of nearly \$13,000,000, and of this total about \$10,000,000 came from Germany, about \$850,000 from Switzerland, and only about \$1,000,000 were of British home production. It was further estimated that an adequate supply of dyestuffs was essential to an industry with a turnover of \$10,000,000 per annum, and that 1,500,000 employees were directly or indirectly interested.

The first proposal of the Government was to subsidize the establishment of a British dye industry by the creation of a new joint stock company to increase the output of existing dye works. The company was to have a working capital of \$26,000,000, of which \$15,000,000 was to have been subscribed by the public (principally the dye-users), and \$11,000,000 by the Government in the shape of a loan bearing interest at 4 per cent, repayable in 25 years. The Government was to have two nominees on the Board of the company with a right of veto on three points: (1) That the concern should remain permanently under British control; (2) that no arrangement should be made with any foreign producers as to keeping up the price or delimiting the area of activity; (3) a right by veto over all contracts so that no large consumers should be given an advantage in price over the small consumer.

Users of dyes were also asked to bind themselves to take their requirements from this company for a period of five years after the war.

This scheme did not prove acceptable to those interested. The directors of the influential Bradford Dyers' Association in a letter to the Board of Trade summarized the main objections as follows:

"(1) The failure of the Government to take their fair share of responsibility, and merely subscribing for debentures, wholly or mainly secured.

"(2) The stipulation by the Government, extraordinary and novel on the part of debenture holders, that they should not only nominate two directors, but that in these nominees should be vested impracticable and dangerous rights of veto.

"(3) The stringency and impracticability of the agreement for the supply of colors, the agreement being also exclusive in regard to existing makers and effectively preventing the establishment of new ventures.

"(4) The lack of advantages to the investing consumer.

"(5) The power of veto by the Government nominees and encroachment on the businesses of manufacturers of produce other than dyes and colors, by which proviso the 'working up' of by-products would be restricted and the most economic production of the staple articles rendered impossible.

"(6) The lack of information as to the intended acquisition by the proposed company and the basis as well as apprehension of the type of director possibly constituting the Board."

This letter went on to state what in the opinion of the directors

were the main objects in any movement for procuring and maintaining supplies of aniline colors, namely:

"(1) The immediate increase of the British production.

"(2) The immediate increase of supplies from Switzerland.

"(3) The establishment in this country of the color-making industry on an adequate scale and on permanent and progressive lines. The attainment of the first and second of these essentials should be governed wholly by urgency. The third should be approached with the least disturbance to ordinary business procedure and conditions. It must be borne in mind that existing plants, supplemented by the maximum supplies which can be reasonably expected from Switzerland, fall woefully short of the requirements of the dependent trades. Consequently even at otherwise unreasonable cost, every possible and immediate step should be taken to increase production—by temporary extensions, by emergency production, by rapid installation of equipment for the production of intermediaries without consideration, if it means delay of the possibility of subsequent removal or concentration of equipment so provided.

"These objects can be attained only by liberal and continued outlay. If the requisite funds are to be either wholly or partly provided from private sources the invitation to subscribe must carry with it some of the assurances usually required by investors. Here we may concede a difference between the interested and the ordinary subscriber. To the former an indirect inducement may appeal; to the latter a direct attraction is essential. To the one the depreciation or loss of his investment may not mean so much if in the process he has obtained all necessary supplies on competitive terms. To the other, direct inducements must be offered by way of security of capital and prospective returns, or by reasonable security and relatively higher returns. But, owing to the inevitable losses on establishment, especially under emergency conditions, owing to the possible initial mistakes in staffing and organization, owing to the likelihood of the re-entrance of German competition in all its ruthlessness before the new conditions have been successfully established and organized, the British efforts must contemplate and prepare for initial losses probably heavy in the earliest years. It is, therefore, difficult to believe that, without special inducements, capital would be attracted.

"The circumstances, the urgency, and the magnitude of the situation call for Government aid, and in some other and more effective form than that merely of lenders on first charge security. Such aid may be applied by any of the following means:

"(1) Protective tariffs; (2) grants in aid; (3) lending schemes. Although aware that, owing to the exceptional circumstances, many who have hitherto resolutely opposed any system of protection are convinced that this form of assistance is the likeliest to be effective and to attract capital, we feel and recognize the obvious objections to advancing it. As between the remaining two courses we prefer a system of grants in aid, and beg to submit for consideration a suggested method by which such a system may be established and worked, namely: (I) That a Commission should be established to administer a fund for the objects as stated hereafter, and raised on the lines indicated. The number of the Commission should be small, and the members certainly active and experienced. (II) That the Government should make an immediate grant in aid up to, say, \$2,500,000, to be administered by the Commission on the lines of the suggestions in clause 4, more particularly to objects *a* to *c* inclusive. (III) That the Government should for ten years make an annual grant of equal amount to that voluntarily raised by the trades interested, such sums to be administered by the Commission, with more particular regard to objects *d* and *e* of clause IV. (IV) That the objects of the Commission should be (a) immediately to stimulate the maximum of effort by the British color-makers to increase their production of colors by way (1) of plant extensions; (2) coördination of production and