The Chemical Research Laboratory

Department of Scientific and Industrial Research, Great Britain[1]

THE CHEMICAL RESEARCH LABORATORY is one of the stations of the Department of Scientific and Industrial Research and was founded in 1925. It is situated in the same grounds as the National Physical Laboratory at Teddington, which is within easy reach of London by train. The present main building was completed in 1933, and during 1946–47 extensive alterations were carried out to adapt the laboratory to new developments of the program and to make maximum use of the accommodation. A temporary building alongside, which provided for twenty workers, was added in 1947; another small building was completed during 1950.

The buildings have a total floor space of about 36,000 square feet, with about seventy rooms of various sizes. Several of these are devoted to special studies, such as large-scale operations, spectroscopy (from infrared to ultraviolet), radiometry, microanalysis, high-efficiency fractionation, electron diffraction, the "rotor" test for corrosion, microbiology, and the National Collection of Industrial Bacteria. The laboratory has a drawing office and workshops manned by an experienced staff, engaged on the design, construction, and maintenance of apparatus. A glass-working unit is available for the construction of special glass apparatus. In addition, there are administrative offices, a library, and stores.

The laboratory is under the executive control of a director who is responsible to the Secretary of DSIR. R. P. Linstead, C.B.E., F.R.S., was director from September 1945 to May 1949. Previous directors have been Sir Richard Threlfall, G.B.E., F.R.S. (1925–27); Sir Gilbert Morgan, O.B.E., F.R.S. (1927–38); and G. S. Whitby (1939–42). D. D. Pratt, O.B.E., acted as superintendent from 1942 to 1945 and is at present in charge of the laboratory.

The functions of the laboratory are: (*a*) to carry out objective, fundamental chemical research, including development work, insofar as this may be necessary to demonstrate the industrial value of any discoveries that may be made; and (*b*) to carry out appropriate chemical researches on request and to provide technical advice to other sections of the department, other government departments, and British industry.

These definitions clearly indicate that the work of the laboratory should be of two kinds: that undertaken as part of its own organized and approved program, and that carried out on request for other agencies. It is appropriate that the work of a national research establishment should have this dual nature, but it is important that a proper balance be preserved between the two aspects. Moreover, in view of the large amount of chemical research being carried out in other laboratories, careful selection of topics in the program of fundamental research is essential.

The general policy underlying the selection of topics is that the laboratory should study basic problems of chemistry and chemical technology that require the attack of a skilled team over a long period. Its work should not duplicate that going forward in universities and industry, although some duplication may on occasion be unavoidable.

Consideration of these factors led to the formulation of five main themes, which are particularly appropriate for inclusion in the program of the laboratory:

I. Researches leading to fundamental data of general value
II. New methods and techniques
III. The conservation of essential materials
IV. The utilization of indigenous raw materials, particularly those of low grade, including wastes
V. New materials and processes

Later, references will be made to these themes to show how they are being implemented in the present research work of the laboratory.

The program is reviewed by the Chemistry Research Board, appointed (1) to advise generally on research to be undertaken by the department's Chemical Research Organization; (2) to submit annual programs of research and to advise on the conduct of approved investigations; and (3) to submit annual reports. The present chairman of the board is E. L. Hirst, F.R.S. The members are men of wide knowledge and experience from universities and industrial organizations. Interested government departments are represented on the board by assessors. The approved program of the laboratory is circulated at intervals to industrial firms as a safeguard against duplication of work already proceeding within these organizations.

The total staff at present is 158, of whom 38 are scientific officers, and 59 experimental officers. Research work is organized in six main divisions.

Corrosion of Metals Group

The prevention of loss of metals by corrosion is a subject under Theme III eminently suitable for systematic long-term study under government auspices, and its many aspects have been studied at the laboratory since its foundation. The group consists of two sections dealing with immersed corrosion and atmospheric corrosion, respectively. (Underground micro-

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biological corrosion is investigated by the Microbiology Section and will be discussed later.)

Researches on immersed corrosion include a study of the influence of surface finish on the corrosion rate of mild steel in aqueous solutions under conditions of rapid movement. The behavior of low-alloy steels in static and moving conditions is also being investigated. The high-speed rotor, developed by the laboratory, is used for assessing the value of pretreatment of steel pipes prior to painting, and for the evaluation of anticorrosive paints for underwater use in industrial and marine conditions. A new electrochemical technique has shown great promise in detecting the initial breakdown of paint coatings under immersed conditions. An improved technique for the removal and subsequent manipulation of surface oxide films has proved of great value in facilitating the chemical analysis and electron diffraction examination of these films. Researches during the war brought to light the valuable corrosion-inhibitive properties of sodium benzoate. Tests showed, however, that a concentration of sodium benzoate in distilled or tap water or in glycol solution failed to prevent corrosion of cast iron. Sodium nitrite, on the other hand, was found to be an effective inhibitor for cast iron, but has the serious disadvantage of attacking soldered joints. Further investigations have now shown that sodium benzoate with a smaller percentage of sodium nitrite in 20 per cent glycol solution adequately protects both cast iron components and soldered joints under the conditions that normally obtain in engine cooling systems. These findings are covered by Patent Application No. 10,471/49. Further studies are going forward on the mechanism of corrosion inhibition, together with a search for other inhibitors, including "vapor-phase" inhibitors.

The Atmospheric Corrosion Section deals with the application of sodium benzoate and the mixed inhibitor in nonimmersed conditions—e.g., prevention of corrosion of metal goods in transit or storage by inhibitive packages or coatings. Another subject is the development of an accelerated test for protective coatings on steel. In one test, which has also been applied to the examination of low-alloy steels, the specimens are subjected to a continuous cycle of spraying and drying, and in another test the specimens are suspended in a cylindrical glass vessel fitted with heating and cooling coils, so that there is a continuous deposition of moisture containing sulfur dioxide on the test surfaces.

Inorganic Group

Pure metals. A survey of coal and coal products of Britain as sources of gallium and germanium has been made, and numerous samples of coals from overseas have also been examined for the presence of minor metals. A process for the preparation of gallium from flue dusts (Theme IV) has been worked out, and a quantity of the pure metal isolated. Samples have been made available to various research laboratories for examination of its properties. Investigations on the purification of germanium are also in progress.

In 1948 the Chemistry Research Board set up a Pure Metals Committee to stimulate interest in, and to coordinate the preparation of, pure metals for research and development purposes. Considerable progress has been made in the formation of a stock collection of pure samples of those metals not readily available commercially.

A recent addition to the program is the conversion of phosphate rock into forms of fertilizer that are easily assimilated by plants. For this conversion new methods which require less sulfuric acid than is used at present in the fertilizer industry are being examined, so as to reduce the consumption of imported sulfur (Theme III). Preliminary experiments have been confined to wet methods of treating rock and, in particular, to the use of mixtures of nitric and sulfuric acids. Promising results have been obtained, and field trials are in progress.

The group is equipped with three spectrographs, and a microanalytical laboratory carries out the analyses needed by the laboratory.

Radiochemical Group

This group, which is engaged on a program of work for the Division of Atomic Energy, Ministry of Supply, comprises analytical and concentration studies on radioactive minerals and ores. Chemical, physical, and radiometric methods are employed in this work. An outstanding development is the application of methods (Theme II) based on solvent extraction in conjunction with the use of cellulose and other solid adsorbents, for preparing and analyzing inorganic substances, both qualitatively and quantitatively.

Organic Group

The group consists of three sections: Purification and Measurement, Organic Intermediates I, and Organic Intermediates II.

Precise data on the fundamental constants of pure chemicals are invaluable to the chemist in the study of possible chemical reactions and to the chemical engineer in designing plants. The work, which falls under Theme I, is of two kinds: (*a*) the preparation of pure compounds and (*b*) determination of the constants with great precision. The materials selected for initial study were the aromatic and heterocyclic substances present in coal tar fractions. Purification is affected by fractional distillation, using columns of 50 plates or better, and by fractional crystallization, together with chemical methods. Apparatus for direct recording of freezing point curves are available, capable of assessing purities of the order of 99.97 mol per cent. The constants to be determined include boiling and melting points, specific and latent heats, density, refractivity, and absorption spectra. Thermochemical data will be determined in collaboration with

the Physics Division, National Physical Laboratory.

The Organic Intermediates Section I is concerned with the chemistry of cyclic compounds, principally aromatic and heterocyclic. Coal tar constitutes a rich source of these compounds, and the investigations may be included as an example of the utilization of indigenous raw materials (Theme IV). Investigations have been made on acenaphthene, diphenylene oxide, and pyridine bases. Acenaphthene has been dehydrogenated in the vapor phase to give high yields of acenaphthylene, which polymerizes with other monomers to give interesting plastic materials. By hydrogenolysis of pyridine, products having some insecticidal activity have been isolated.

The main investigation of the Organic Intermediates II Section is the study of the specialized techniques (Theme II) required for the synthesis of isotopically labeled compounds. The work is confined to research on preparative methods and does not include larger-scale production. Earlier the section carried out investigations on the preparation of organosilicon compounds.

High Polymers and Plastics Section. The work of this section is devoted mainly to the study of ion exchange and allied properties of high polymers, including an investigation of the effect of polymer structure on the equilibria and kinetics of ion exchange, the development of improved exchangers, and an examination of the application of ion-exchange resins in chromatographic separations and other fields. A new research has begun on the relationship between the properties and chain length of carefully fractionated linear polymers, with the immediate object of finding improved methods of determining molecular weight distribution (Theme V).

Microbiology Section. Originally the effort of this section was devoted to the study of sulfate-reducing bacteria and their various activities as they affect industry. A study of their fundamental properties is in progress, including investigations of their isolation in pure culture, growth (heterotrophic and autotrophic), inhibition, morphology, and enzymic constitution. The most important economic activity of these organisms is their participation in the external corrosion of ferrous pipes in water-logged neutral clay soils, and many inquiries for advice on this problem are dealt with by the laboratory. Sulfate-reducing bacteria also sometimes play a part in the internal corrosion of water mains. Other deleterious activities being studied include the pollution of water in gas holders, coal mines, open pools, and oil wells. Recently the scope of the work has been widened to include sulfide-oxidizing bacteria and the production of sulfur by bacterial action; natural deposits of sulfur produced in this way have been examined.

The section is also responsible for the maintenance of the National Collection of bacteria of industrial importance. This duty was taken over in January 1950, and already a large number of cultures have been sent out to meet requests from many countries.

So far attention has been mainly focused on the program work but, as previously stated, the laboratory also performs the duty of carrying out work on request by other organizations. The main items within this category are: the large program on behalf of the Division of Atomic Energy, Ministry of Supply, a study of the corrosion of boiler tubes on behalf of the British Shipbuilding Research Association, the preparation and supply of pure hydrocarbons as spectrographic standards, the study of preparative methods for compounds containing tracer elements, and the National Collection of Industrial Bacteria.

In conclusion, some of the past achievements of the laboratory may be stated briefly. These include:

a) The discovery of the anodic oxidation of aluminum and alloys as a method of protection;

b) The development of the C. R. L. rotor test for accelerated corrosion in immersed conditions;

c) The discovery of ion-exchange resins;

d) Research on the composition of tars obtained by the low-temperature carbonization of coal, and utilization of various products, notably tar acids;

e) Research on high-pressure reactions leading to the formation of aliphatic alcohols and acids;

f) The development up to a pilot plant stage of a method for the production of food yeast from molasses;

g) The production from indigenous material of a cheap and effective foaming agent for combating petrol fires;

h) Researches on chemotherapeutically active materials of the phenanthridine series which led to the discovery of C.R.L. 1553 (dimidium bromide), which has been widely used against trypanosome diseases of cattle in Africa.

Subjects of agricultural interest have been the production of sheep dips containing DDT, and sprays for killing potato haulms; a short-term investigation for the Board of Trade to provide a means of preventing the caking of fertilizers.

The results of the laboratory's researches are communicated to British industry and published in the usual scientific journals. In some cases special reports are issued through H.M. Stationery Office. Reviews of the work of the laboratory for the period ending December 31, 1934, for the triennial period ending December 31, 1937, and for the years 1938–46 have been published. Since 1946, annual reports, entitled *Chemistry Research,* have been issued through H.M. Stationery Office for the years 1947, 1948, and 1949.

Active steps are taken to maintain and improve external relations with industry, particularly by exchange of visits and by communications through research and industrial associations.

During the period of the Festival of Britain (May–September, 1951), the Department of Scientific and Industrial Research is arranging for small parties of scientists and technologists from overseas to visit the Chemical Research Laboratory. Accommodation for such parties is limited, and applications to join them should be made as early as possible to the Secretary, Department of Scientific and Industrial Research, Charles House, 5–11, Regent St., London, S.W.1. (The envelope should be marked "Festival Visits".) Applicants should state the time during which they expect to be in this country.