THE CHEMIST IN PUBLIC SERVICE

BY W. C. DUMAS

THE goal of science is clear; it is nothing short of the complete interpretation of the universe."

The material prosperity of a nation is determined by the manner in which resources are utilized, by the efficiency of its industries in methods of production and utilization of its wastes. The proper efficiency in methods of production and manufacture can be obtained only by an intelligent scheme of working and a familiarity with raw materials. The manufacturer must know how to produce the best with least waste. Herein lies our future commercial salvation; for the great natural resources are becoming exhausted, and the producer must turn to the chemist and scientific worker in order to find out how he can save. There must in the future be a closer alliance between the so called practical man and the scientific worker.

Science has solved many problems; but many more remain to be solved if industrial efficiency is brought up to its proper level. Day by day there is lost to this world untold million in money and an appalling number of human lives. We hear of the snapping of steel rails, the failure of bridges; our boilers corrode; ninety per cent. of the potential energy of our coal is lost through the stack and by radiation; energy is dissipated by noise and friction. Our rivers are pouring into the sea wealth from the waste of great cities, and our great peat bogs, numbering many square miles and holding vast stores of energy, still lie practically untouched. Trolley wires snap, our railway ties last scarcely five years, our roadbeds are torn up by heavy traffic, paint needs frequent renewing, and our books are far from indestructible. Yearly the lumber industry wastes the equivalent of three hundred thousand acres of forest in sawdust and scraps; the paper industry literally pours money into the rivers; and beehive coke ovens obtain only coke, wasting sixty-five to eighty per cent. of the coal into the air. We have piles of wealth in our culm banks, in our low grade iron ores and our lean gold and silver ores. We have great deposits of iron ore worthless on account of its high content of titanium, and our sulphuric acid plants throw away thousands of dollars' worth of iron in their wastes from pyrites burning.

We import from Spain annually two and a half million dollars' worth of forty-six to fifty per cent. pyrites ore, costing the manufacturer practically eight dollars a ton, while our great deposits of thirty-five to thirty-eight per cent. pyrites lie practically untouched, because no way has yet been found to burn ore of such low sulphur content profitably. We also import from Germany yearly three and a half million dollars' worth of potash salts, an important constituent of plant food. There are millions of tons of potash locked up in our insoluble silicates of potash, the feldspars; but we haven't succeeded as yet in profitably extracting it for the fertilizer trade.

Is this not a field for the research worker? Does the world not need his help? Few realize what the chemist has done or what he can do. Every advance in utilizing waste, every problem solved, makes for better living. The chemist is usually quiet and unassuming, and for that reason seldom, as a class, do chemists get the credit due to them.

"The key of Progress is hidden in a question mark." In order to be able to do a thing successfully or to use a material to its greatest advantage, everything it is possible to know must be known about that material. Water has been used from times far remote; but even water could not be used to its greatest good for the human race until the properties of steam were fully understood, until steam was recognized as obeying the gaseous laws enunciated by the chemists Boyle, Avogadro, and Gay Lussac, and until Watt had applied the expansive power of steam to the steam engine.

What They Have Already Done

IN passing, let us glance at some of the wonders achieved by the chemist and his brother, the physicist. Let us turn from the rather discouraging things to be done to some of the magnificent things already accomplished.

Black coal and its sticky, jetty tar have literally been changed into hues of the rainbow. Formerly immense areas in India were given over to indigo culture; but now India imports indigo made synthetically from coal tar products, and great tracts of land have been opened to cultivation for something else. As soon as chemists, working laboriously to determine the structure of the molecule of these various dyes, had solved that seeming intangible problem, the world had another source of wealth opened up to it in coal tars and their derivatives.

He has given to us for our pleasure and use a marvelous series of beautiful dyes built up out of the unlovely black of coal tar. Few have any conception of the painful steps by which the chemist has claimed these triumphs in the making of colors. For example, he knows that by the introduction of different chemical groups or units, so to speak, into such substances as rosalinine or pararosaniline (whose compositions he has accurately determined) dyes of other colors are formed. He knows that the general effect of the introduction of methyl groups is to form dyes of violet colors, and that as the number of these methyl groups increases the product has a deeper blue tint. He knows what dye will suit certain fabrics; he knows that benzidine dyes have a peculiar power of uniting with cotton. He calls this series substantive dyes. They bear euphonious names, such as congo red and chrysamine. He divides his dyes into series,—tri-phenyl-methane dyes, benzidine dyes, etc. The dye chemist deals with complexity itself, and with names that are staggering in their length and sound. The dye crystal violet or hexatetra-methyl-pararosaniline, is made by the action of para-tetra-methyl-diamino-benzophenone on dimethyl aniline in the presence of dehydrating agents. The beautiful dye fluorescein and the delicate rose pink dye eosin, as well as the yellow alizarin, the sulphur dyes, and hundreds of others of all tints and suitable to every kind of fabric, are all products of the chemist's brain.

Ultramarine, formerly obtained from the natural mineral lapis lazuli, and worth its weight in gold, is now made by purely artificial processes from kaolin, sodium sulphate, sodium carbonate, sulphur, and rosin, and sells for only a few cents a pound.

One of the Wonderful Triumphs

ALL vegetation upon which our lives depend must have nitrogen for its nourishment. Over each acre of land on this earth there is thirty-four thousand tons of nitrogen. When the natural deposits of nitrates for our fertilizers began to wane, chemistry rose equal to the occasion and combined this inert nitrogen of the atmosphere by an electrolytic process with oxygen and calcium, forming calcium nitrate and calcium cyanamide, substances suitable for plant food and plant nutrition.

Science deals with the ultimate constituents of our universe, their combinations and changes. It deals with life. It knows that nitrogen is one of the most important as well as the most expensive elements of plant food. This achievement is one of the most useful as well as most wonderful triumphs of chemist and engineer. The chemist has made nitrogen serve mankind in many useful and harmful ways. He has combined it into compounds of tremendous explosive power,—guncotton, nitroglycerin, lyddite, cordite, and many other explosives. By studying the instability of nitrogen compounds, he has made possible its application in warfare and in peace. He has made the sweetest of perfumes out of the proper combination of this element. Again, the same element of the perfumes, nitrogen, has been made into most deadly poisons and into substances of most revolting odors. The scientist now knows a large part of the romance of nitrogen,—its entrance into the composition of delicate perfumes, of nauseous gases, beautiful hues in dyes, healing medicines, deadly poisons, explosives, in cyanides, in protoplasm of our bodies, in nutritive foods, and in the plasma of our blood.

When we eat meats in the magnificent dining rooms of our great restaurants and hotels, we seldom think how science has been at work here too, in order to give us the best that the world affords, brought maybe long distances from other parts of the world. Studies into the composition of flesh, its methods of analysis, and the processes of its decay, have made it possible to preserve by refrigeration for years at a time the products of our abattoirs and slaughter houses. Analyses of these frozen meats show that they have not changed in composition, but are practically the same as when slaughtered. Again, the thing that has made refrigeration possible is understanding of the laws of heat and its absence, cold.

The slaughter house wastes nothing, and with the aid of the chemist everything is disposed of, nothing being thrown away. Hides are sent to tanneries, grease is used in the manufacture of soap and candles, blood is made into blood albumen or sold for fertilizer, scraps are worked into tankage or potassium cyanide, horns and hoofs into jelly, buttons, and glue, and the bones themselves into boneblack to be used in sugar refining.

The man of science serves the public in more ways than by mere introduction of new processes. Often he improves existing processes and applies existing principles in other directions, thus enriching the community and bettering humanity. As an example of this, we may consider the development of the internal combustion engine, the common gasolene engine of our motor cars. The power derived from this class of engine is dependent on the explosion of gaseous mixtures of air and combustible vapors. If the ratio of one of these constituents to the other is too great, the force of the explosion will be materially lessened. If there be too much air, the resulting power will be decreased; and if too much vapor is present, the power will also be lessened. So the engineer, taking the results of the scientist's efforts, has improved the efficiency of our internal combustion engines by a study of the most powerful explosive mixtures of vapor and air.

Aëroplanes and Metallurgy

THE advent of the aëroplane, demanding motors giving a unit of power for the least possible weight, has been responsible for some remarkable improvements in motors; so that now it is nothing uncommon to hear of an engine developing a horsepower for every three or four pounds of weight. They are veritable centers of force. If it had not been for the marvelous development in the manufacture of fine steels and their alloys, with special properties for standing successive strains and stresses of explosion and elongation, and at the same time combining marvelous strength and comparative lightness, these powerful motors would not have been possible.

Chemistry has played and is now playing a major rôle in metallurgy. Iron and steel industries rest mainly on chemistry, and are under control of the chemist at every step. The production of steel by the Bessemer process depends on the combustion of carbon and silicon, maintaining the mass in molten condition. By utilization of waste furnace gases for raising steam and to preheat the blast going into the furnace, the amount of coal to produce one ton of pig iron is now only one-fourth of what it formerly was.

The chemist has studied the rarer elements, titanium, tungsten, and molybdenum, and their effects on steel, so that the steelmaker can now make any kind of steel for any special purpose. If it must stand strains, he adds the proper element; if the finished product must bear the heavy traffic of railroads, he makes it more dense by the subtraction of certain elements and the addition of others. There is nothing haphazard about it. In 1907 our production of pig iron was twenty-six million tons, worth five hundred and thirty million dollars.

This age of electricity has made heavy demands on the copper deposits of the world, and now aluminum has stepped in partially to displace copper in conductors for conveyance of power to throbbing factories and teeming cities. Niagara distributes its power through aluminum alloy cables. Aluminum is cheap and its sources practically inexhaustible, and its alloys are now widely used in automobile castings, airship construction, in cooking utensils, and for welding. Copper and aluminum bear electric currents, and in its turn electricity is now made to extract and refine these two metals. In 1907 there was produced four hundred and thirty-five thousand tons of copper, valued at a hundred and seventy-four million dollars, and seventy per cent. of this amount was refined electrolytically.

Chemistry also disposes of much of the wastes that the steelmaker and smelter find such nuisances. Blast furnace slag finds uses in cement and concrete, is spun