

The Application of Chemistry to Industry

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In addressing an audience of scientific persons, it is not my intention to boast of the accomplishments of science in recent years. It is remarkable to what extent the general public has become interested in the scientific phases of our modern life. In the current number of the magazine *Fortune*, many pages are given to an excellent portrayal of the part that chemistry has played in industry and its prophecy of the part that it will play in future industry is even more remarkable. Quite recently large audiences greeted the polished secretary of the American Institute, Dr. Gerald Wendt, in his spectacular lecture, *Science on Parade*, delivered before Western audiences. Paul Muni of Hollywood has brought the life of Pasteur into a living knowledge of millions of people. It is my intention at this time to emphasize the mechanism or the ways and means by which chemistry is advancing our industrial well-being, and thus contributing to the comforts and the happiness of our people. It is difficult for those of us engaged in scientific work to evaluate the significance of many of the things we teach. We are like the traveller in the forest who is unaware of the glorious heights nearby from which a view of the world may be had. In order that we may gain perspective and thereby a better appreciation of the little menial tasks we do each day in the field of science, I would like to consider the background of chemistry rather than to guess its future: to analyze the forces that played back and forth and have brought chemistry to its present stage of activity in the world's affairs; and finally, to inquire into the effect it may have upon the social and economic conditions of the day.

As the writer in *Fortune* says: the activities of chemical industry can best be expressed by saying that it is engaged in making something into something else, not by altering shapes and sizes visible to the eye but by working with the unseen and unseeable materials of the chemist, viz: atoms and molecules. Using heat and pressure mainly it busies itself with making things that are new, things that are cheaper, things to make other things, things that the eye of the ultimate user seldom if ever falls upon.

Yet from undertakings so diversified chemical industry has had its origin. It goes back to the year 1791 and to a Frenchman named LeBlanc—Nicholas LeBlanc. He was not a great chemist; not a great research man or teacher, but rather a simple minded man who wanted to make some money. The French glass factories famed for their beautiful products the world over, were unable to get sea weed ashes from the Coasts of Spain on account of a military blockade by the English armies. The French Academy offered a prize of 12,000 francs for a process whereby the soda extracted from sea weed ashes could be made from salt, thus making the glass factories of France independent of Spain and the hindrance of British armies. Just how the French Academy hit upon salt as something to be used for making soda is remarkable inasmuch as at that time the element sodium was yet to be discovered. Perhaps it was intuition; perhaps it was due to the sea water of the French Coast; perhaps it was a stab in the dark; but anyhow, it was right because Nicholas LeBlanc treated salt with sulfuric acid, roasted the salt cake with charcoal and chalk and extracted the

"black ash" instead of the sea weed ash with water and obtained beautiful crystals of soda which he sold to the glass factories. Once LeBlanc had done it, it was as simple as that.

I am interested at this point in knowing what it was that enabled LeBlanc to do this. His contemporaries were much more brilliant than he. Lavoisier, the father of modern chemistry, was famous enough to be guillotined in 1794, even before the revolutionists had confiscated LeBlanc's factories and driven him to his death. Henry Cavendish and the great Joseph Priestley were his contemporaries—great figures in the unfolding movement of chemical knowledge, that characterized the beginnings of modern chemistry. Let us turn back now to those fascinating periods in which the strivings of chemistry took on an almost romantic phase but nevertheless comprised the periods that made it possible for LeBlanc to do what he did and that make it possible for us to do those things that now are so gloriously advertised.

I think there is a general understanding among readers that scientific chemistry is the successor of an ancient alchemy which sought to produce gold artificially and to explain its occurrence in the earth's crust. In China and also in India from remote times gold was valued as a magic medicine. In Egypt there were expert goldsmiths as early as 3000 B. C. and in the Euphrates valley skilled Sumerian metal workers practiced their craft some 500 years earlier still. Such processes as the weighing and fusion of gold in ancient Egypt were depicted on tomb walls dating back to 2500 B. C. The oldest map in the world which was drawn more than 3000 years ago depicts a gold mining region in the eastern desert of Egypt.

There is ample evidence that the

Egyptians were remarkably skilled in various arts based upon chemical knowledge such as metallurgy, enameling, glass tinting, the extraction of plant oils and dyeing. For such reasons Egypt or Khem, the land of black soil, the Hebrew land of Ham, gave rise to practices variously known as the art of the dark country or the "black art." To Islam this black art became known as Al Khem and through Islam to the Western world as alchemy.

The fusion of Egyptian metallurgical and other arts with the mystical philosophies of the Greeks is often regarded as the true beginning of the science of chemistry which derives its name from the hieroglyphic name for Egypt, supposed to represent a heap of charcoal and a crocodile's tail, and is called chemi with the meaning, black—the black land.

The greatest contribution that Greek thought and Greek ideas rendered to mediaeval alchemy was the introduction of the Four Elements or simple bodies ascribed to Aristotle. Briefly, Aristotle's theory postulated four fundamental properties of bodies: these were hot and moist, with their contraries cold and dry. These qualities pointed to four material elements—earth, air, fire and water, of which all substances are composed. In accordance with the Greek philosophy one body can be transmuted into another by altering the proportions of the elements present. This transmutation was further correlated with the idea of a "prima materia" or primordial matter from which all things come and to which they all reverted. Aristotle called it a fifth element, quintessence. This was a spiritual element which when properly impressed upon any of the others would transmute and change them into any desired substance. It was this weird theory that gave the impetus that sent chemistry rolling down through the middle ages as the black

art of alchemy, the magic of transmutation.

The conclusion reached by an examination of the later writings of the Alexandrian alchemists leads us to believe that all of the Egyptian goldmaking and silversmithing consisted merely in impressing the colors of gold and silver upon the baser metals and that the alchemists of western Europe, by interpreting these terms too literally, were led away on a false trail.

Nevertheless, the ten centuries of alchemy were not useless. Its fundamental concept of transmutation and the hope of accelerating in the workshop the natural growth of a base metal even into a noble metal did not escape the avaricious notice of kings and rulers. With the intangible philosophy of Aristotle and Plato and the obscure reports of the Egyptian Black Art, the royal courts became the abode of the alchemists and magicians that roamed from place to place with the lure and promise of great riches to be gained by transmutation. As already described small pellets of gold and silver like bodies were made in these processes, but to do it on a large scale required the finding of the Philosopher's Stone or Elixir. It was sufficiently plausible and attractive to entice monarchs to finance and protect it within their royal enclosures for otherwise it would soon have ceased to exist from sheer hunger and exhaustion.

The golden age of alchemy reached its sublime heights in the fourteenth century. All of Europe was under the dormant hood of the Dark Ages, under the tyranny of absolute monarchs. No longer was the earth believed to be flat for men had sailed westward and discovered a new land in which was gold for the asking. Copernicus, the monk, was defying the church with his masterly arguments that the earth was not the center of the universe. England was

challenging Spain on the high seas. The printing press was invented. Leonardo da Vinci had given the world his masterpieces in both art and science. New masters appeared who refused to follow the myths of their predecessors.

Most notable among the rebelling scientists was Paracelsus who was born the year after America was discovered, the son of a physician and who early turned to medicine. He offended venerable professors, ridiculed ancient traditions and attempted to purge medicine of its witchcraft by throwing the books of old masters into the fire. No longer, he declared, would gout be cured by the playing of a flute or sciatica by the blowing of a trumpet. No longer would wearing a monkey's leg cure a monkey bite, or liverwort alleviate liver complaint, or feverwort, fever. To him the human body was a chemical plant to be treated with chemicals. "Seek remedies," he exhorted, "more potent medicines till you find one that will cure all disease." And thus began the crusade for the Elixir of Life that sent Ponce de Leon to the new world for the fabled Fountain of Youth. Now laboratories became not hiding places of secrets, but chambers of mercy and healing. The quest for gold was ended. The period of alchemy was succeeded by iatro or medical chemistry. For more than a century the quintessence of Aristotle appeared in a new guise as the search went on for the one great elixir guaranteed to cure all and sundry ills. Hopeless as the quest for the gold-making wand has this search proved to be, and in disillusion the early period of chemistry drew to a close about 1650 with but little advance in chemical art beyond that made by the Egyptians. Chemical theory following false gods had moved in circles about an imaginary point.

Nevertheless the awakening was soon to come. The greater actors with their

lines well learned were waiting in the wings to make their entrances. The prelude was over. Chemistry with its transforming power advanced boldly on to the stage to take its place with the world's great forces. The drama of modern chemistry is still on the stage. The older actors give way to the younger, but who pay tribute to the older, ever.

In a recent address to the graduating class of Stevens Institute, Professor Lawrence of the University of California described his work that deals with the artificial radioactivity of common table salt. After calling attention to the fact that there are scientific cycles just as there are business cycles, he says: "We are now on the threshold of a new era fraught with potentialities for the future—the new era of the atomic nucleus. The new frontier lies within the hearts of atoms and we are in a position to attack the problem the ancient alchemists set for themselves. Indeed their dreams have already been surpassed, for they sought ways of turning base metal into gold, while the modern scientist is now making something vastly more precious and useful—the artificial radioactive substances."

The demonstrations which Professor Lawrence has been giving in his public lectures with ordinary table salt made artificially radioactive has amazed even his colleagues. The important contributions to medical science that are in prospect make us think that perhaps salt has at last regained its savour and that quite properly only the outstanding persons may be called "the salt of the earth." No greater proof of the continuity of science is needed perhaps than to point to the healing activated salt of Lawrence, to the beginnings of chemical industry by LeBlanc and to the allegorical use of salt by the Great Teacher to typify that which is noblest and best in all human life.

There is another great tribute that

modern science is paying to the alchemy of antiquity. It is the recognition of the four elements of Aristotle as the source of all wealth. This earth consists of rock and soil, air and water, and it receives its energy from the sun. From these we get our living. In them is contained all our wealth. Chemistry simply describes how these four components of nature may be transformed from their existing forms into others which we may desire or enjoy much more than their natural state. From ordinary air we extract small traces of a substance, neon, which we use to influence the transfer of millions of dollars from one pocket to another in so-called advertising signs. In the water of the oceans there is enough gold in solution to provide a \$1,000,000 for every inhabitant of the globe. The energy of the sun lifts the water from the ocean in the form of vapor which floats to the mountain tops where it falls as snow and is stored for a season until the energy of the sun again changes it to water, which in falling from the high land to the low land, may be converted into the hydroelectric power which lights our homes, cooks our meals, carries our messages to the ends of the earth, and performs a multitude of tasks that once were the burdens of human slaves. We have learned even how to convert this energy into matter or commodities that may be packed in barrels and sold in the markets of the world. From water, air and electricity we can now make chemical compounds for use as explosives, dyes, and fertilizers.

Air, earth, water and sunshine are the four horsemen of a chemical revolution that has promise not only of increased comforts for our daily lives, but holds forth much for a greater stability in our social and economic conditions. It is in the alleviation of unfavorable conditions in industry and agriculture that a new movement has

called science into service in behalf of mankind. This movement is known under the name of Chemurgy—a newly coined word made up of the Egyptian chemi and the Greek word, ergon, meaning work. Chemurgy, therefore, means the work of chemistry, and in its specialized meaning it deals with the application of chemistry to the annual crops as raw materials in industry.

The application of chemistry is not a spontaneous affair. It does not naturally occur. It is at this point that our modern methods of instruction and research step on the stage. The reactions of the LeBlanc soda process had been known for a long time but he was the first person that with deliberate intention and for a practical end changed salt into soda, with his eye not only on chemistry but on economics as well. And he accomplished much more than he expected. Chlorine products and cheaper sulfuric acid resulted. Instead of making soda for the glass industry, another new industry with cheap alkali now was established for something that hitherto had been a luxury enjoyed only by the rich—this product was soap. Thus LeBlanc was responsible for a cleaner world, and through the use of cheap soda in the textile industry, a whiter world.

There are other considerations in the application of chemistry to industry—those of obsolescence of industrial upsets. LeBlanc's large scale manufacture of soda diminished the use of perfumes and incense and of any other business that prospered because of a lack of soap. Finally LeBlanc's soda process was flung on the rubbish pile for the cheaper methods now used and, most amazing of all, we now have soapless soaps which require no alkali at all in their manufacture.

What I have tried to develop in this discourse is patience in the study and understanding of chemistry—a regard

for the toil and labours of that great host of men and women whose work is enshrined in the literature of our science and to which we may turn for almost every condition of perplexity that may be encountered. This is the work of the colleges and universities.

My second objective was to show the necessity of direction. We cannot have a French Academy or a British fleet to bring about the application of chemical knowledge in the affairs of our daily lives. It is significant that spontaneous movements such as Chemurgy, and legislative bodies such as state planning boards, and philanthropic institutions such as the Mellon Institute have sprung into existence and are marshaling the academic facts of science into the channels where they will feed the social and economic necessities of the day.

In the Pacific Northwest we have need for the pioneering of science in behalf of our industrial development. The application of chemistry to our forest resources is urgent. The utilization of trees has thus far been mechanical consisting of the reduction of trees to logs by logging and to boards by sawmills. These industries utilize roughly about one third of the tree as it stands in the forest, the other two-thirds consisting of logging and sawmill waste. The chemical utilization of wood offers a more efficient method in the use of wood. By mechanical reduction to chips and the use of chemical reactions for pulp manufacture the loss is reduced to 50 per cent consisting largely of lignin, the chemistry of which is still unknown. Fundamental research into the nature of the lignin molecules is under way in this and other countries and must be awaited for more complete utilization of the wood used in the pulp industry. Other chemical reactions applied to wood as a raw material are promising, resulting in the production

of plastics for structural and housing purposes as well as the production of carbohydrates convertible into fuel for automotive transportation and other uses.

The development of hydroelectric power offers an opportunity for the application of the energy of falling bodies of water into commodities. From water, air and electricity ammonia and nitric acid may be obtained in forms convenient for packaging and marketing in other parts of the country or the world. Electrochemical industries manufacturing phosphates, carbides, light metals, fertilizers find an attractive habitat in this region. Acres now idle beckon to the migration of peoples from the drought sections and the marginal lands and assure us a population ample to consume the products made by chemical processes.

In the western part of this State are coal deposits of large magnitude which are but slightly utilized as fuel due to the greater convenience of oil as a heating agent for homes. When chemistry is applied to the coal industry this picture changes completely. When coal is heated under pressure in the presence of hydrogen and a solvent it is possible

to change the solid organic matter of coal to a liquid and pump it 500 miles or more in pipe lines as fuel for steam engines or in the cylinders of Diesels or for use in house heating. Coal hydrogenation due to the abundance of petroleum resources has made but little headway in this country, but in Germany, England and Japan the process has already begun.

In summarizing this discussion, I have borrowed freely from the history of chemistry and of science to show how essential is the teaching and learning of the facts of science; our indebtedness to that vast literature recording the patient labors of the scientific workers of the past; the great need of intelligent direction of the facts of chemistry and of science so that they may be marshalled into a line of duty for service in industry. When this is done, there comes back to us a multitude of things which transform the conditions under which we live; that add to our social and economic stability; and constitute an enlightenment of modern life attainable in no other way.

[In the preparation of this address the author is especially indebted to Read: Prelude to Chemistry; MacMillan (1937), and French: The Drama of Chemistry; University Society Inc. (1937).]