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## Catalysis

THE phenomenon of catalysis was discovered well over a century ago and has ever since intrigued the chemist. Even though the manufacture of most industrial chemicals and of practically all petroleum products involves the use of catalysts, elementary textbooks usually dismiss catalysis by defining it as the acceleration of a chemical reaction by a substance which itself does not change significantly.

The Gordon Research Conferences of the AAAS have devoted one week to the elucidation of catalysis every year since 1940. The points brought out in the conference held last June gave reason to expect that some of the mystery surrounding catalysis may soon clear away.

Up to recent years, the catalyst has been considered as an unspecific adsorbent which holds the reactants in a favorable geometric position so as to permit the reaction to occur. Thus the catalyst was pictured as a kind of jig, but insufficient attention was given to the interaction between the catalyst and the reactant.

Papers by H. S. Taylor, Weyl, and Hulburt showed that, according to recent work, notably by Garner, Dowden, and others, the chemisorption and the catalytic activation of the reactants can be correlated with the electron-donating and -accepting properties of the catalyst. On this basis, the catalytic activity of the transition metals for hydrogenation can be ascribed to their partly empty d-shells and their capacity of temporarily accommodating the electrons of the reactants in these shells and of rearranging them to form the new compounds. The same consideration holds also for a large number of oxide catalysts, which are semiconductors because of the presence of lattice defects caused either by impurities or by partial oxidation or reduction. Again, the transfer of electrons between reactants and oxide, and the mobility of the electron within the semiconducting oxide catalysts, are necessary conditions for catalytic action.

According to this concept, the catalyst can be compared to an electronic switchboard in its action, and a

good example for this mechanism is the isomerization of hydrocarbons by catalysts containing silica, alumina, and nickel (Ciapetta). In this instance, the carbon skeleton is rearranged by switching carbon-carbon bonds within the individual molecules in a manner similar to the way a train is switched from one track to another.

Papers by Simard, Kirkpatrick, Hofer, Anderson, Selwood, and Eckstrom dealt with the changes that occur in the composition of the catalyst as a consequence of the reaction catalyzed. Some of these, as, for example, color changes of the vanadium pentoxide catalysts used in catalytic oxidation of hydrocarbons, are obvious, whereas others require delicate magnetic, electrical, optical, or x-ray diffraction methods for detection. These changes may lead to the formation of common or unusual compounds, or may result in novel material otherwise not formed. They show distinctly that the catalyst does participate in the reaction it accelerates, and will eventually offer a clue to its mode of action.

Fries and Eischens reported on progress made in catalytic research by the use of isotopic tracers. By this technique it is possible to trace the fate of a given type of molecule, or even a given part of certain molecules, in the bewildering variety of chemical reactions, or to follow the exchange or displacement of labeled molecules on the surface of the catalyst. Further possible application of the radioactive isotopes is the study of the diffusion processes within the solid catalyst.

Besides the significant technical advances made in the field of catalysis, the conference revealed that industrial firms are conscious of the necessity of fundamental research in catalysis and contribute generously to this type of activity. It is to be hoped that industry's share in basic studies will keep on increasing and will bring us closer to the solution of the puzzle.

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