To: Mrs. Strebeck
From: Grant Reddoch
Re: Definition of a Catalyst
Date: January 14, 2015

Catalysts: The Keys to Reaction Efficiency

Purpose

This memo will define the word "catalyst" as used in the field of chemistry. The definition will include historical uses of "catalyst," what purpose catalysts typically serve, and general types of catalysts.

What is a Catalyst?

A catalyst is a molecule (a connected unit of two or more atoms of the same or different elements) that reduces the amount of energy needed for a chemical reaction to take place. Figure 1 shows the amount of energy needed with and without a catalyst for a general reaction. The most unique attribute of a catalyst is that it has the same structure and qualities before and after the reaction it aids ("catalyst, n."). Throughout the reaction, the catalyst undergoes "catalytic action," or catalysis, with the reagents (molecules that are permanently changing in the reaction) to form intermediate chemicals, which lead to the desired products. The catalyst is completely regenerated, structurally and chemically, by the end of the reaction ("Catalyst," Encyclopedia Britannica).

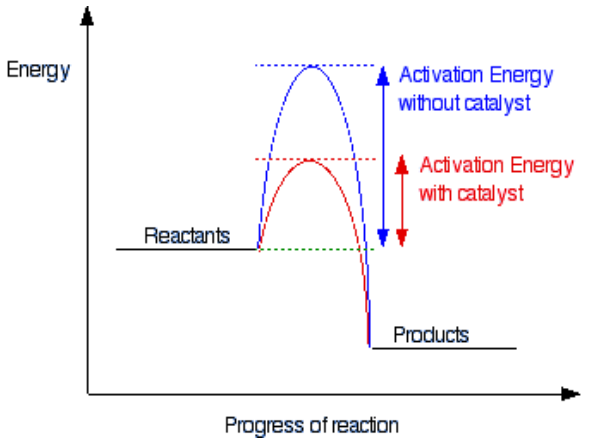


Figure. 1: A Graph of energy versus time needed for a reaction with and without a catalyst

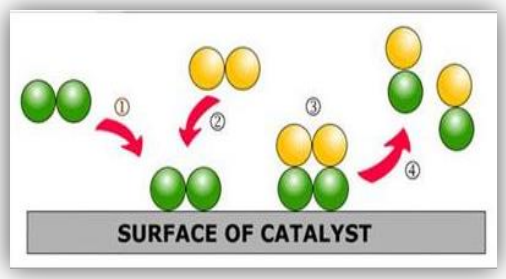


Figure 2: General Reaction of fluid chemical with a surface catalyst. The green atoms would be hydrogen, the yellow atoms would oil molecules.

Origin of the word "Catalyst"

"Catalyst" was first used in 1902, according to the Oxford English Dictionary, in defining that a reaction must be possible without a catalyst; the catalyst only reduces, or increases the energy being used when present with the reactants. If the reaction was not possible without the catalyst, the molecule being referred to as such would not be a catalyst. In 1920, the word appeared in a description of the hydrogenation (addition of hydrogen atoms) of oils to make margarine. As Figure 2 shows, nickel is the catalyst in this reaction, carrying hydrogens for the oil molecules to collect as they come into contact with the nickel catalyst. Once the hydrogens have been

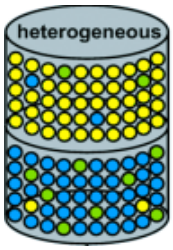
taken, the nickel is left unchanged. The Oxford English Dictionary also notes that a catalyst can be considered "negative" if it slows the reaction which it is present in.

Why use a Catalyst?

Many chemical reactions, especially in organic chemistry (the study of carbon-containing molecules and the reactions they participate in), can lead to identical end products. Two given reactions may require vastly different amounts of energy, time, and initial reactants to achieve the same product. When reactants and time are precious, such as in industrial settings, catalysts enable more product to be created with limited amounts of starting chemicals and in a limited time span. In the field of Chemical Engineering, catalysts can make enormous increases in profit possible, even after paying for the catalyst.

Types of Catalysts

Fig. 3: The reactants (fluid) are above the catalyst (solid)



Like any other chemical compound, catalysts can exist as solids, liquids, or gases. This depends on the pressure and temperature of the environment they are in. A widely accepted system separates catalysts into the categories of "homogenous" and "heterogeneous." A homogenous catalyst is one that occurs in the same state as the other chemicals that are participating in a reaction (see Figure 4). Heterogeneous catalysts exist in a different state than the other chemicals participating in a reaction, as in Figure 3 ("Catalysis," 3). In the example of using nickel as a catalyst for hydrogenation, nickel is a heterogeneous catalyst, as it is solid while the chemicals being reacted are fluids (liquid or gas). A desired quality when producing solid catalysts is maximized surface area on the catalyst so that more reactant can come into contact with it. A special category of biological catalysts are enzymes.

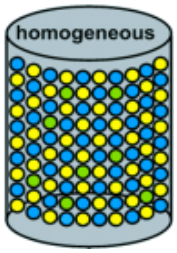


Fig. 4: Reactants and catalyst are fluids, mixed together

Conclusion

Catalysts are a great tool for many chemists, chemical engineers, and members of other chemical related fields. They can dynamically change the difficulty with which a reaction can be carried out. Because catalysis is so diverse, it is a wide-reaching field of research. The field of catalytic research is still growing at a fast pace, and it is vital to the chemical production industry.

Sources:

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