

# Discussion of Misleading on the Interpretation of the Word “Catalysis, Catalyst”

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## Abstract

The main idea of this paper is what the resource of the serious error of the widely popular Chemical Reaction Mode catalysis Mechanism-CRMM is. The wrong definition of “catalysis, catalyst” by the catalytic academia boss leads to the wrong interpretation of “catalysis, catalyst” by linguists (Dictionary). The interpretation of “catalysis, catalyst” in a dictionary is misleading. The most fundamental reason for this error is that catalysis experts always believe that catalysts participate in chemical reactions. The result will appear as a series of impossible events. Such as catalysis cyclic reaction, opinions vary intermedium, catalysts repeated decomposition—formation, oxidation-reduction or life and death (enzyme), Sabatier’s principle and Boudart’s principle. The wrong theory leads the research and application of catalysts to the bottomless abyss, and industrial production suffers great losses. Electron Orbital Deformation-Recovery cyclic catalysis Mechanism-EODRM or Electron Cyclic Donate-Adopt catalysis Mechanism-ECDAM shows that the catalytic phenomenon is a physical phenomenon, not a chemical phenomenon, the catalyst does not participate in chemical reactions, only contact is the electron donate-adopt cycle, is the electron orbital deformation recovery cycle Chinese and foreign scholars should change the interpretation on the “catalysis, catalyst”, or add two new words: “contact and contactor”, it is to give up “catalysis, catalyst” altogether.

## Keywords

Catalysis, Catalyst, Sabatier Principle, Boudart Principle

## 1. Introduction

Catalysts are widely used in chemical production. However, the catalysis mechanism on the catalyst has always remained in the Chemical Reaction Model

Mechanism—CRMM. It has been more and more popular for more than 120 years and deep into middle school textbooks, it is deeply rooted in the catalytic academia. But the author thinks that the CRMM is contrary to the basic principle of thermodynamics. Therefore, the CRMM is an error. What is the cause of this result, whether it is the linguist or the catalysis expert. Although the author has written an article [1], it is fuzzy what the source is and there is no clear explanation. This article gives a positive explanation. The CRMM's serious mistakes were made by the big boys of catalytic academia. It is from the solidified idea of "take for granted".

The most basic cause is that the big guys think that "the catalyst will always participate in a chemical reaction, and it is a cyclic reaction". This view leads to a series of questions that completely contradict the basic principles of thermodynamics. Such as the Cyclic catalytic reaction, an intermediate catalyst will be repeating decomposition-generation, oxidation-reduction and life and death (enzyme), Sabatier's principle and Boudant's principle, etc.

## 2. "Contact" and "Catalysis"

In the textbooks of our fathers, you can see the word "contact", but you can't see the word "catalysis". "Catalysis" is a foreign word, it is a translation of "Catalysis, Catalyst" from west.

Different translations can be seen from the [English-Chinese Dictionary] published in different periods:

1) 1963, in the [English-Chinese Dictionary] compiled by Zheng Yili and others published by Beijing Times Press, The translation of these two words is as follows:

Catalysis: n. Contact reaction, contact action, Catalysis.

Catalyst: n. Contact agent, Catalyst.

2) In 1974, Shanghai Translation Publishing House, "New English-Chinese Dictionary" compilation group [New English-Chinese Dictionary] about the translation of these two words is:

Catalysis: n. Catalysis (action).

Contact agent (Old translation Contact).

3) In 2006, Shanghai Translation Publishing House, Zhou Jilian and other edited the [A NEW ENGLISH-ChINESE ADVANCED LEARNER'S DICTIONARY] about the translation of this word is:

Catalysis: n. Catalysis.

Catalyst: n. Catalyst.

It can be seen that the translation of "Catalysis, Catalyst" went from "Catalysis, Contact" to completely abandoning "Contact" and adopting "Catalysis, Catalyst" for over 40 years.

Taken literally, "Catalysis" has the meaning of a chemical reaction and it belongs to the realm of chemistry. "Contact", on the other hand, is just touch, it belongs to the realm of physics. It is obviously inappropriate to translate one

English into two different fields of meaning.

The reason on the change from “Contact” to “Catalysis” came from Western catalytic academics and linguists (dictionaries).

The definition of this “Catalysis, Catalyst” word in Western academia is as follows:

**a) Sabatiers principle (1902) [2] [3]**

Sabatier principle proposes the existence of an unstable intermediate compound formed between the catalyst surface and at least one of the reactants. This intermediate must be stable enough to be formed in sufficient quantities and labile enough to decompose to yield the final product or products.

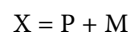
**b) Boudart principle (1992) [2] [4]**

Ninety years later, an American scholar M. Boudart redefined “catalysis, catalyst” like this:

The most fundamental principle in catalysis is that of the catalytic cycle, which may be based on a redefinition of a catalyst by Boudart: “A catalyst is a substance that transforms reactants into products, through an uninterrupted and repeated cycle of elementary steps in which the catalyst is changed through a sequence of reactive intermediates until the last step in the cycle regenerates the catalyst in its original form”.

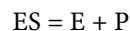
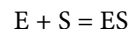
I call the principles of these two scholars the S-B principles. According to the S-B principle, the linguist (dictionary) was quite right to drop “Contact” and translate “Catalysis, Catalyst”. Unfortunately, it was the wrong way.

In the catalyst handbook [5], CRMM is expressed as follows:



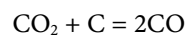
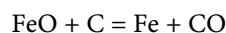
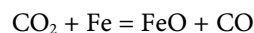
Above, R—reactant, M—catalyst, X—intermediate, P—product. The product (P) is not produced directly, but through an intermediate (X).

The catalytic action of biological enzymes is that enzymes participate in the reaction;



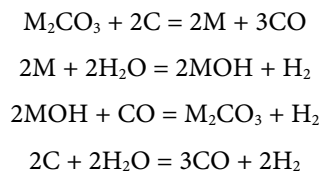
Above, S—reactants (proteins, starches, etc.), E—enzymes, ES—intermediates, P-products. This is the famous Michaelis-Menten mechanism proposed in 1913 [5] [6].

For Fe catalysts [4] [7], the catalytic process is described as follows:



The intermediate of the reaction is the FeO, and The Iron oxide is constantly reduced—oxidized, which is called “Oxygen Transfer Mechanism-OTM” in the literature.

For alkali metal carbonates [4] [8], the catalytic process is described as follows:



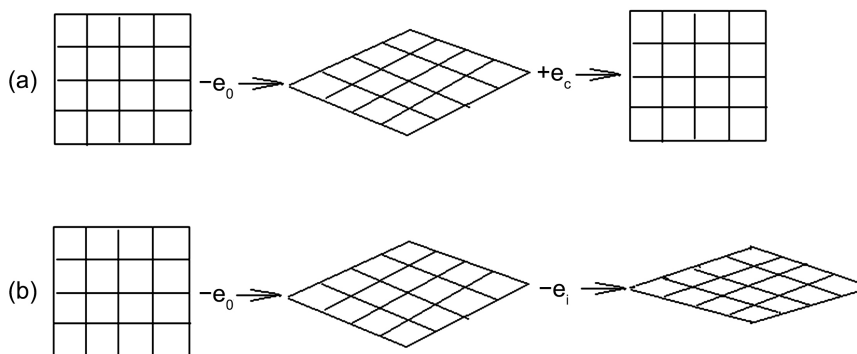
There are two intermediates in the reaction process, namely M and MOH. The catalyst ( $M_2CO_3$ ) continuously decomposes and generates a cyclic reaction.

The key points of CRMM are that the catalysts have to participate in the chemical reaction, and it is a cyclic reaction. There is an intermediate. The catalyst is continuously decomposed and regenerated.

After years of research [9], the author believes that Catalytic phenomenon is a physical phenomenon, not a chemical phenomenon, the catalyst does not participate in chemical reactions, only contact, is the electron donate-accept cycle, is the electron orbital repeated deformation-recovery. Electrocatalysis, photocatalysis, microwave catalysis, laser catalysis are all physical phenomena, but the energy levels are different. The selectivity of the catalyst is also related to the energy level.

Compared with CRMM and EODRM or ECDAM, the former is that the catalyst participate in the chemical reaction, and it is a cyclic reaction. The latter is the catalyst does not participate in the chemical reaction, just contact. The former is a chemical phenomenon, the latter is a physical phenomenon.

**Figure 1** is a schematic.



**Schematic diagram 1.** Electron orbital deformation-recovery diagram of catalysis and poisoning.  $-e$ —take away electrons by nitrogen or oxygen from iron or carbon;  $+e$ —the added electron from the cocatalyst or catalyst.

“ $-e$ ” in **Schematic Diagram 1** indicates that when the suspended electrons on the surface of the carbon particle (**matrix**) or catalyst iron particle (**matrix**) are taken away by oxygen or nitrogen, the carbon or iron matrix tries to regain the take away electrons in order to maintain the original low-energy state electron orbital, and the electron orbital and lattice in matrix must be deformed. The electrons suspended on the surface of carbon are not free, and their move causes the deformation of the electron orbitals in the carbon or iron matrix, but does

not reach the degree of lattice reconstruction. When this kind of electron pulling occurs, there are two possibilities. One is to transport electrons to the carbon or iron matrix, restore the deformed electron orbitals, reduce the fracture energy of the bond, and speed up the reaction, which is the catalyst (a). The other is to further rob the electrons in the carbon or iron matrix, resulting in further deformation of the deformed electron orbitals, resulting in higher bond breaking energy and slower reaction speed, which is the poison agent (b). Thence; Naturally, two important conclusions are drawn, that is, there is a boundary between catalyst and poison agent, and the activity of catalyst or poison agent is closely related to the electronegativity difference.

### 3. Many Difficulties Encountered to CRMM

#### 3.1. Cyclic Reactions Involving Catalysts Are Unlikely to Occur

The S-B principle defines that; “The most fundament principle in Catalysis is catalytic cycle. The catalyst participating in the chemical reaction is constantly decomposition-generation or oxidation-reduction cycle reaction during the catalytic process, and finally regenerates the same catalyst as the original.”

A professor at Shanghai University asserts that all catalysts have to meet this principle, and those that do not meet this principle are not catalysts. Be visible; the catalytic academia boss regards this “principle” as a classic, as if this principle provides a theoretical basis for the study of catalysts. The author asserts that if this “principle” is followed, I am afraid that a catalyst that meets this principle will never be found.

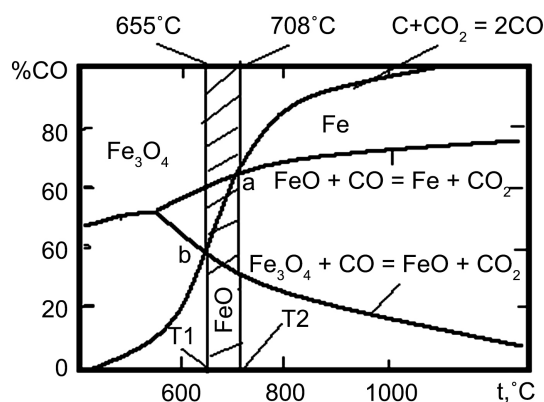


Figure 1. Iron-carbon-oxygen reaction equilibrium diagram [10].

For carbon gasification reaction, iron is a catalyst, we have proved this many times by experiments... According to the S-B principle, iron must undergo an oxidation-reduction cycle in order to have catalytic activity. Figure 1 is an iron-carbon-oxygen reaction equilibrium diagram. As can be seen from the figure, the  $C + CO_2 = 2CO$  reaction equilibrium curve and  $FeO + CO = Fe + CO_2$  reaction equilibrium curve intersect at  $708^\circ C$ . There is only one point in the figure that meets the requirement of the oxidation-reduction cycle reaction, that is,

the gas phase composition in the figure is 65% CO, 35% CO<sub>2</sub>, and the air pressure is 1 atmosphere. Once it is to leave this point, the iron cannot undergo the oxidation-reduction cycle reaction. Above 708°C, the stable phase is iron, the FeO is unstable, and the FeO will be reduced by carbon. Below 708°C, FeO is a stable phase, Fe is unstable, and Fe is oxidized to FeO. Factors affecting the chemical reaction equilibrium in addition to temperature, as well as pressure and the form of carbon, if according to the S-B principle, only at 708°C, 1 atm. of pressure, carbon in the form of graphite can meet the requirements of the oxidation-reduction cycle reaction, to have catalytic activity, leaving this condition, the cyclic reaction is impossible to occur, iron will lose catalytic activity. In fact, iron has catalytic activity in a wide temperature range (600°C - 1000°C).

For carbon gasification reaction, alkali metal salt, alkali earth metal salt, transition metals, noble metals, etc., all have catalytic activity, but the activity size is different. Under the same reaction conditions (such as carburizing box, 940°C), so many salts and metals cannot be able to decompose-generation, or oxidation-reduction cyclic reaction. The cyclic reaction not only fails to show that many catalysts have catalytic activity under the same reaction condition, but also fails to show that the same catalyst has catalytic activity over a wide temperature range. Therefore, according to the S-B “principle”, it can never be found one catalyst.

Besides, the decomposition pressure (equilibrium pressure) of metal oxides has an exponential relationship with temperature, and each metal oxide has a decomposition pressure curve, which is different. Metal and metal oxide can coexist only on the decomposition pressure curve ( $2\text{MeO} = 2\text{Me} + \text{O}_2$ ), and away from this point (temperature, pressure, gas phase composition), Me and MeO cannot coexist. Under certain reaction conditions, it is impossible for many metals or salts with catalytic activity to undergo the cycle reaction of generate and decomposition, and it is impossible to have catalytic activity in a wide temperature range.

According to our determination, in the carburizing box, the catalyst barium carbonate, BaCO<sub>3</sub> and BaO can coexist only at 1048°C, leaving this point, the decomposition-formation cyclic reaction is impossible. The actual production temperature is about 940°C, barium carbonate has catalytic activity.

Let me take another popular example. Housewives know that salt has catalytic activity, and a dying coal stove can be saved by sprinkling a handful of salt into it. NaCl is a very stable compound, and it is impossible to undergo decomposition-generation reaction in coal furnaces.

### 3.2. Intermediate Is Impossible to Appear

- The S-B principle asserts that the most fundamental principle in catalysis is the catalytic cycle, and this cycle is the cycle in which the catalyst participates in and in order to maintain this cycle, an Intermediate is necessarily needed. The catalyst must form an intermediate with the reactants that is stable, has a

certain amount, and is easily decomposed. The catalyst must be continuously decomposed-generated, and from literature can see many, each says his own, this view is completely contrary to the basic principles of thermodynamics.

For example, the barium carbonate catalysts can be seen to appear Barium metal (Ba), Barium oxide (BaO) intermediate. Iron catalyst has FeO, carbonate catalyst has Me and MeOH, precious metal catalyst has PtO and so on, Each speaking his own way. The author does not want to make one explanation one by one, only to say the FeO intermediate.

In industrial production, the iron oxide powder and reducing agent carbon powder in the reaction tank are stacked in layers. tens of kilograms of iron oxide has reduced to sponge iron ingots by carbon, the Iron catalyst in the carbon powder layer cannot undergo an oxidation-reduction cycle. It would be fanciful to say that the iron catalyst in the carbon powder layer repeatedly occurs in the oxidation-reduction cycle.

Moreover, for platinum catalyst, due to the very high decomposition pressure of platinum oxide, it can only exist in the metal state in nature. In a strong reducing atmosphere, it can only appear in the metal state, and it is absolutely impossible to occur oxidation-reduction cycle reaction.

These two examples demonstrate that there can be no intermediate.

### **3.3. Using TOF to Define Catalyst Activity Size and Catalyst Life Is out of Thin Air**

It can be seen from the literature that catalytic experts use the number of “cyclic reactions” per unit time, “TOF”, to define the activity size of the catalyst, and the total number of cyclic reactions before the catalyst failure to indicate the catalyst life. Since the catalyst participating in the cyclic catalytic reaction does not exist, the intermediate cannot appear, the use of TOF is obviously out of thin air. It is a pity that the catalytic experts have deceived their readers.

As stated above, the definition by the S-B principle of the “catalysis, catalyst” is incorrectness. Therefore, The interpretation of “catalysis, catalyst” by S-B principle has been misled.

## **4. The Harm Caused by Catalysis’s Misdirection**

Due to a misinterpretation of the word “Catalysis catalyst”, the result was confusion in catalysis research and application. For this reason, the author wrote an article: [Some Problems in the research and production of heterogeneous catalysis] [11].

Several examples are given in the article, such as, the poisoning problem of alumina in iron base ammonia synthesis catalyst. The poisoning of Cordierite ceramic honeycomb supports in automobile exhaust gas purification catalyst. The poisoning of carbon support material in ruthenium ammonia synthesis catalyst and the CRMM has existence question.

This paper supplements two points to explain the problems in the research of

catalysts.

1) M. Boudart [12] studied the catalytic effect of Pt on the reactions of  $C + CO_2 = 2CO$  and  $C + H_2O = CO + H_2$  [3]. Finally, he used the Oxygen Transfer Mechanism (OTM) to explain the catalysis of Pt, that is, the oxidation and reduction reaction of Pt continuously occurs during the catalytic process. The intermediate is the oxide of Pt. On this point, it has been explained before, and will not be repeated here.

A danger signal can be seen from the literature, some people in the catalytic academia believe that the basic principles of thermodynamics can not guide the research of catalysts, so there are many different intermediate compounds that deviate from the basic principles of thermodynamics. Catalyst research is getting more and more outrageous. This is where the misinterpretation of “Catalysis, catalyst” word lead us.

2) Mckee. W [13], who used Controlled Atmosphere Electron Microscopy (CAEM) to study alkali metal oxides and salts, alkaline earth metal oxides and salts, transition metals and oxides, noble metals and other catalysts on the four reactions of  $C + O_2$ ,  $C + CO_2$ ,  $C + H_2O$ , and  $C + H_2$  was studied by referring to 152 literatures and writing 118 pages of articles. In the end, he thought

“Although it is not yet possible to explain all the observed catalytic effects within one all-encompassing, mechanistic framework, on balance specific oxidation-reduction cycles have been conspicuously successful in interpreting the effects of alkali-metal salts, transition metals and oxides, and the noble metals in the various types of carbon gasification reactions. however, many details of the complex catalytic phenomena still remain obscure and await elucidation by carefully designed experimental and theoretical investigation.”

Here he still adopts the Oxygen Transfer Mechanism-OTM. The special oxidation-reduction cycle, but exactly how special it is, it does not say.

Mr. M. Boudart and D. Mckee were both famous American scientists.

From these two examples, it can be seen that scientists have spent a lot of effort trying to solve this mystery, but the result is helpless and end up with nothing definite. The research to catalyst falls into a bottomless pit.

## 5. Conclusions

The author believes that CRMM is deeply rooted in the catalytic academia and popular for more than 120 years. The fundamental reason is that catalytic experts always believe that catalysts participate in chemical reactions.

The inevitable result of participating in the chemical reaction is to appear a series of trouble. For example, the S-B principle, the most fundamental principle in catalysis is the catalytic cycle, the catalyst repeatedly decomposing-generate or oxidation-reduction. As a result, many intermediate compounds appear, each in its own way, completely contrary to the basic principles of thermodynamics,

such as, the metal Ba, BaO, PtO, MeOH, FeO etc.

The author believes that Chinese and foreign scholars must abandon the inherent idea that catalysts participate in chemical reactions.

The definition of word “catalysis, catalyst” in a dictionary should be changed to “contact, contact agent”, or create a new word to avoid misdirection.

The use of CRMM in middle school textbooks to explain the catalytic role of enzymes should be deleted to avoid delaying future generations.

The author’s knowledge is limited, inappropriate place, ask experts to criticize and correct.

### Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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