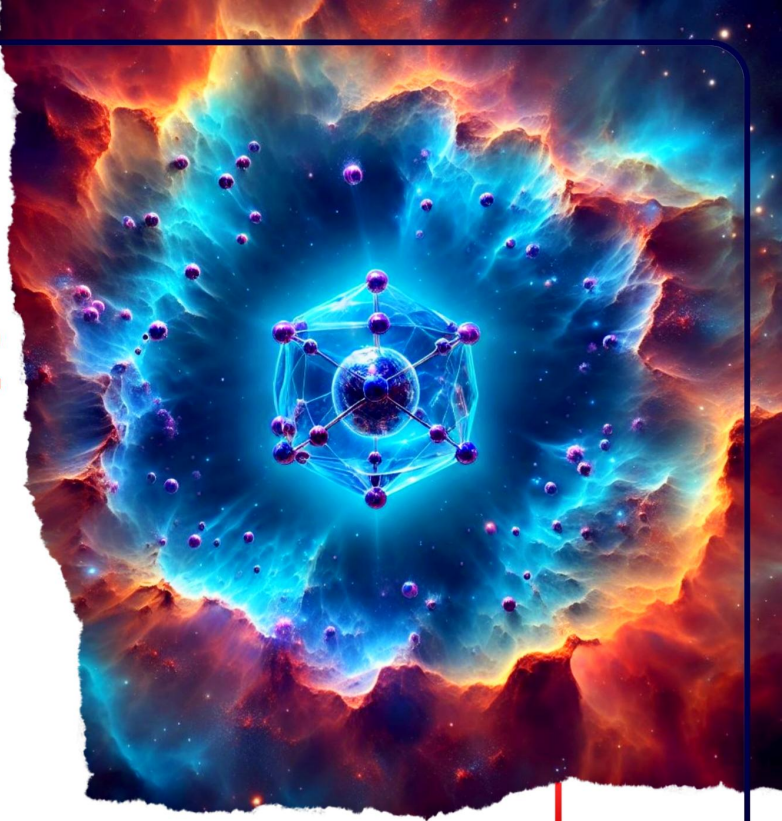


# History of Catalyst

A brief history of catalyst from the very beginning of the universe to the future of catalyst on earth



By:

- **Muhammed Abbas Abdulmaged**
- **Mahmoud Nori Alwan**

Supervised by:

**Dr. Anwar Qasim**

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# INTRODUCTION



One exciting subject related to catalysts is the role they play in the formation of complex organic molecules, which are the building blocks of life. This topic encompasses the study of interstellar chemistry, the conditions necessary for organic molecule formation in space, and the implications for the origins of life in the universe. Exploring how catalysts facilitate these processes can provide valuable insights into the potential for life beyond Earth and our understanding of the chemical evolution of the cosmos.





# Interstellar Clouds



Interstellar clouds, often referred to as molecular clouds, are vast regions of space where gas and dust coalesce under the influence of gravity. These clouds contain a variety of molecules, including simple compounds like hydrogen, helium, and carbon monoxide, as well as more complex molecules such as water and ammonia.



Within these molecular clouds, there are regions where temperatures and densities are conducive to chemical reactions. One significant process that occurs in these regions is the formation of complex organic molecules through reactions involving simpler precursor molecules.

Catalysts play a crucial role in these chemical reactions by lowering the activation energy required for the formation of specific products. In space, catalysts can be in the form of dust grains, ice particles, or even reactive surfaces on planetary bodies.



One example of a catalyst in space is the surface of cosmic dust grains. These grains provide a surface on which molecules can adsorb and react with one another. The surface chemistry of these grains can facilitate reactions that would otherwise be inefficient or improbable in the gas phase.

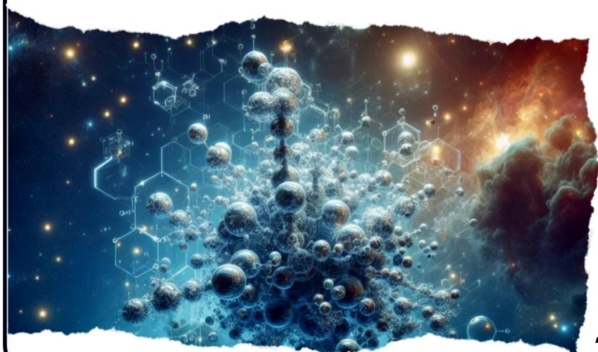
# Organic compounds



Another example is the presence of ices on the surfaces of dust grains or in the atmospheres of celestial bodies. These ices can act as catalysts by providing a medium for reactions to occur at lower temperatures than would be possible in the gas phase alone.

The types of organic molecules that form in these environments depend on factors such as temperature, pressure, and the availability of precursor molecules. Some of the molecules that have been detected in interstellar space include simple organic compounds like formaldehyde and methanol, as well as more complex molecules like amino acids and polycyclic aromatic hydrocarbons (PAHs).

**Studying the formation of these molecules and the role of catalysts in space chemistry can provide valuable insights into the conditions necessary for the emergence of life in the universe. It also helps scientists understand the chemical evolution of planetary systems and the potential for habitability on other worlds. Additionally, this research has implications for astrobiology, the study of the origins and evolution of life in the universe.**



# Methanol



## 1- Background:

- Interstellar clouds are vast regions of space where gas and dust coalesce under the influence of gravity.

- These clouds contain a variety of molecules, including simple compounds like hydrogen (H<sub>2</sub>), helium (He), and carbon monoxide (CO), as well as more complex molecules.

## 2- Formation of Methanol:

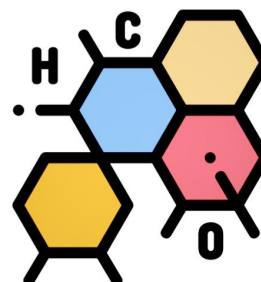
- Methanol (CH<sub>3</sub>OH) is a simple organic molecule composed of one carbon atom (C), four hydrogen atoms (H), and one oxygen atom (O).

- In interstellar clouds, methanol can form through a series of chemical reactions involving precursor molecules such as carbon monoxide (CO) and hydrogen (H<sub>2</sub>).

- One of the key reactions involved in the formation of methanol is the hydrogenation of carbon monoxide:



- This reaction proceeds via several intermediate steps, with the involvement of various reactive species.





# Methanol

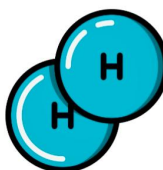
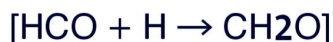
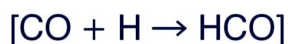


## 3- Role of Catalysts:

- Catalysts in space, such as dust grains or ices, provide surfaces where chemical reactions can occur more efficiently.
- The surface chemistry of these catalysts facilitates the adsorption of reactant molecules and lowers the activation energy barrier for the formation of products.
- In the case of methanol formation, dust grains or ices act as catalysts by providing surfaces for the adsorption of carbon monoxide (CO) and hydrogen (H<sub>2</sub>) molecules, enhancing the likelihood of reaction.

## 4- Detailed Mechanism:

- On the surface of dust grains or ices, carbon monoxide (CO) molecules can adsorb and react with hydrogen (H<sub>2</sub>) molecules.
- The hydrogenation of carbon monoxide proceeds through several steps, including the formation of formyl (HCO) and methoxy (CH<sub>3</sub>O) radicals:



- Finally, the addition of another hydrogen atom leads to the formation of methanol:  $[\text{CH}_3\text{O} + \text{H} \rightarrow \text{CH}_3\text{OH}]$
- These reactions occur more readily on the surfaces of dust grains or ices due to the presence of catalytic sites.

# Comparison



**Without Catalyst:** Methanol formation proceeds slowly, primarily through gas-phase reactions with high activation energy barriers. Yields of methanol are limited, and the process may take **Hundreds of millions** of years to produce significant quantities. **if at all.**

**With Catalyst:** Methanol formation is accelerated by surface reactions facilitated by catalysts. The presence of catalysts enables more efficient pathways for methanol synthesis, resulting in **higher yields** over shorter timescales, potentially on the order of **thousands of years** depending on local conditions.

Overall, the presence of catalysts significantly influences the efficiency and timescale of methanol formation in interstellar space. By enhancing reaction rates and facilitating surface chemistry, catalysts play a crucial role in driving the synthesis of complex organic molecules essential for the chemical evolution of the cosmos.





Now let's move on to modern day.

On December 31, 2007, China introduced a "plastic limit" system, whereby malls and stores are not allowed to provide consumers with free plastic bags, mainly because environmental problems caused by discarded plastic bags may It caught people's attention

Can biodegradable plastic really decompose automatically?





# Plastic



The so-called biodegradable plastic, we say firmly, is the plastic that contains large plastic particles that can decomposes into small molecules easily in the natural environment. However, most of this commercial plastic is biodegradable Mixed in certain proportions with starch and cellulose, such as polyethylene. Since starch and cellulose are highly degradable, the plastic will disintegrate quickly in the natural environment. At this time, although the plastic fragments are not visible, the polyethylene particles have not decomposed. Moreover, to maintain the strength and transparency of the plastic, the amount of starch or cellulose added is small, so this method partially mitigates the environmental risk.



# Plastic waste



For plastic waste.

To solve this problem radically, the microplastic particles themselves must decompose, and this decomposition must occur Under natural conditions such as light and microorganisms. These organisms, mainly enzymes, can break down microplastic particles. Some enzymes can break carbon-oxygen and carbon-nitrogen bonds in organic molecules, so if the main chain of microplastics contains an oxygen or a nitrogen atom, they can easily be broken down by microorganisms. However, if the main chain is composed entirely of carbon atoms, it is very difficult to separate it because the carbon-carbon bond is very good, and we cannot obtain iodegradation. Because there are no enzymes that can break the carbon- carbon bond and thus plastic materials such as polyester, polyurethane, polyamide are biodegradable under the same conditions, and materials such as polyethylene, polypropylene and polystyrene are difficult to degrade.



# Polylactic acid

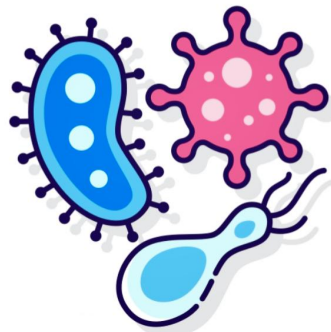


Some plastics, such as polyester, which are usually made from a single caprolactone, are biodegradable, but they are slower. If we want to speed up the decomposition, the caprolactone and the polyether must be polymerized together during manufacturing because The anhydricity of plastic can accelerate it biodegradation.

Polylactic acid is a decomposing plastic that deserves attention.

It uses corn, cane sugar, and some other plants as raw materials, extracts starch from them, hydrolyzes it with enzymes to form barley sugar or dextrose, then presents it to microorganisms for consumption and fermentation, which produces lactic acid. The lactic acid then polymerizes, producing polylactic acid

The biggest advantage of plastics made from sulfuric acid is that they are easily decomposed under natural conditions, and the last products of their decomposition are carbon dioxide and water. In addition, the raw materials are taken from plants (i.e. they are renewable resources) and we get rid of dependence on oil. Although polylactic acid plastic is ideal, its use has not expanded due to its high prices.





# Fertilizer Production



## Unveiling the Role of Catalysts in Fertilizer Production

### Introduction:

- Fertilizers are vital for agricultural productivity, ensuring abundant yields to feed our growing population. Catalysts, often unseen heroes, significantly influence the efficiency and sustainability of fertilizer synthesis.

### Understanding Fertilizer Production:

- Fertilizers are compounds rich in essential nutrients like nitrogen, phosphorus, and potassium, crucial for plant growth.
- The Haber-Bosch process, a landmark in industrial chemistry, synthesizes ammonia ( $\text{NH}_3$ ), a key component of nitrogen-based fertilizers, by combining nitrogen from the air and hydrogen from natural gas under high pressure and temperature.
- The synthesis of phosphoric acid, another essential fertilizer ingredient, involves complex chemical reactions using phosphate rock.



# Fertilizer Production



## The Catalytic Influence:

- Catalysts are substances that accelerate chemical reactions by lowering the activation energy required for the reaction to occur, thus increasing reaction rates.
- In ammonia synthesis, iron-based catalysts, often promoted with potassium oxide or other compounds, facilitate the conversion of nitrogen and hydrogen into ammonia.
- Similarly, catalysts like vanadium oxide are employed in the oxidation of ammonia to nitric oxide (NO), a precursor in the synthesis of nitric acid, a crucial step in manufacturing nitrogen-based fertilizers.
- Phosphoric acid production utilizes catalysts such as silica-alumina or zeolites to enhance the efficiency of phosphate rock digestion and subsequent reactions.

## Advantages of Catalyst Employment:

- Improved Reaction Efficiency: Catalysts enable higher yields of desired products while minimizing unwanted by-products, enhancing overall process efficiency.
- Energy Savings: By lowering the energy barrier for reactions, catalysts allow fertilizer synthesis to occur at lower temperatures and pressures, reducing energy consumption and operational costs.
- Environmental Benefits: Efficient fertilizer production through catalysis helps minimize waste generation and energy consumption, contributing to sustainability goals.

# Fertilizer Production



## Challenges and Innovations:

- **Catalyst Stability:** Maintaining catalyst activity and selectivity over extended periods is crucial for continuous production. Ongoing research focuses on developing more robust catalysts with enhanced stability.
- **Sustainability:** The quest for greener processes drives the exploration of eco-friendly catalysts and novel reaction pathways to minimize environmental impact.
- **Process Optimization:** Continuous improvement efforts aim to optimize catalyst formulations and reaction conditions to maximize productivity and minimize resource utilization.



## Conclusion:

- In conclusion, catalysts are indispensable allies in the journey towards sustainable and efficient fertilizer production.
- By catalyzing essential reactions with precision and efficiency, these agents contribute significantly to global food security and environmental sustainability.
- As we continue to advance our understanding of catalysis and explore innovative solutions, the future of fertilizer production shines brighter, promising a greener and more productive agricultural landscape.