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Brief Literature Review on Ethylene

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Abstract: This review focuses on ethylene, a compound of paramount importance in the chemical industry, aiming to comprehensively explore recent advancements in both theoretical and practical aspects, revealing the intrinsic connections between its chemical properties and industrial applications. The definition and significance of ethylene are clarified, laying a theoretical foundation for subsequent studies. Following this, the review traces the research journey of ethylene by scholars both domestically and internationally, outlines the evolution of the field, and highlights gaps and challenges in the existing research.

Keywords: Ethylene; Chemical Raw Material; Plant Hormone; Production Technology; Research Progress.

1. Ethylene Uses and Background

1.1. Molecular Structure

Molecular formula: C2H4
Simple structure: CH2=CH2

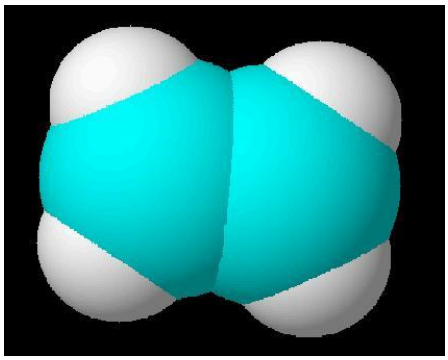

Fig 1. Molecular scale model of ethylene

Ethylene is bound by 4 hydrogen atoms, and the carbon atoms are connected by double bonds. The two carbon atoms and four hydrogen atoms in the ethylene molecule are all in the same plane. The bond Angle between them is about 120 degrees.

1.2. Ethylene Use

1.2.1. Industrial Field

One of the most basic raw materials for petrochemical industry. In terms of synthetic materials, it is widely used in the production of polyethylene, vinyl chloride and polyvinyl chloride, ethylbenzene, styrene and polystyrene, ethylene-propylene rubber, etc. In organic synthesis, widely used in the synthesis of ethanol, ethylene oxide and ethylene glycol, acetaldehyde, acetic acid, propionic aldehyde and propionic acid and its derivatives, and other basic raw material for organic synthesis; After halogenation, can produce chloroethylene, chloroethane, bromoethane; Oligomerization can produce α-olefins, and then produce higher alcohols, alkylbenzene, etc.

It is mainly used as the standard gas of analytical instruments in petrochemical enterprises;

Ethylene is used as an environmentally friendly ripening gas for navel orange, tangerine, banana and other fruits;

Vinyl used in medicine, high and new material.

1.2.2. Use of Ethylene in Ecological Field

Vinyl "triple response" (triple response of ethylene) : (1) inhibit the growth of stem elongation; (2) promote the stem and root thickening; (3) promote the transverse growth of stem. Treatment of etiolated seedling stems with ethylene made stems thicker and petioles grow upward. Because ethylene can promote the synthesis of RNA and protein, and can increase the permeability of cell membrane in higher plants and accelerate respiration, so when the ethylene content in the fruit increases, the synthesized auxin can be decomposed by enzymes in the plant body or external light, further promoting the transformation of organic matter and accelerating ripening. Commonly used ethephon solution soak not fully ripe tomatoes, apples, pears, bananas and persimmon fruit can significantly promote the mature. Ethylene also have promoted organ prolapse and aging. Ethylene plays an important role in the shedding of flowers, leaves, and fruits. Ethylene can also promote the flowering and differentiation of female flowers in some plants (such as melons), and promote the discharge of milk from rubber trees and sumac trees. Ethylene can also induce cuttings the formation of adventitious roots, promote root growth and differentiation, breaking seed and bud dormancy, inducing the secretion of secondary substances, etc.

1.2.3. Ethylene in Agriculture

Ethylene is a plant endogenous hormone. All parts of higher plants, such as leaves, stems, roots, flowers, fruits, tubers, seeds and seedlings, can produce ethylene under certain conditions. It is the smallest molecule in plant hormones, and its physiological function is mainly to promote the expansion of fruits and cells. The grain mature, promote the leaf, flower, fruit, also have induction of flower bud differentiation, break the dormancy and promote germination, flowering, organ prolapse, dwarf plant and promote adventitious root formation, and so on. Ethylene is gas, difficult to application in the field until the developed ethrel, to provide agricultural practical ethylene plant growth regulator. The main products are ethephon, vinyl silicon, ethylenedioxime, meconidazole, defoliate phosphine, cycloheximide (cycloheximide), they can release ethylene, or promote plant production of ethylene plant growth regulators, so collectively called ethylene releasing agents. The most commonly used at home and abroad is ethethel, which is

widely used in ripening fruits, defoliation of cotton before harvesting, promoting boll cracking and boll boll, stimulating rubber milk secretion, rice dwarf, increasing melon female flowers and promoting pineapple flowering, etc.

Among ethylene plant growth regulators, some varieties can regulate plant growth by inhibiting ethylene synthesis in plants, which are called ethylene synthesis inhibitors

1.3. The Research Background and Research Significance

Ethylene, as a bright star in the chemical industry, its importance is self-evident. It is not only the basic raw material of the petrochemical industry, widely used in the production of plastics, synthetic fibers, rubber and organic chemical products, but also in the field of plant physiology, as a key plant hormone, regulating the ripening and aging of fruits. The intersections of the industrial chemical and biological sciences, the research and application of ethylene show infinite potential and challenge.

From the perspective of the chemical ethylene production and application technology development, is directly related to the nation's energy security and economic competition. As global consciousness of environmental protection has increased, and the exploration of the renewable energy, ethylene production technology is experiencing from the traditional oil cracking to substitute the transition of the way more environmental protection, economy, such as ethanol dehydration to ethylene, the rise of emerging technology of methane to ethylene. These technical break through, not only can reduce dependence on fossil energy, also can promote the efficient utilization of resources, to realize the green transformation of the chemical industry.

In the field of biological sciences, ethylene biosynthesis and signal transduction mechanism research, to understand the plant growth and development, ripe and responses of plants to adversity, is of important value. Through in-depth analysis of ethylene molecule regulation network, scientists have developed a new type plant growth regulator, optimize the environment of crop growth, increase yield and quality. In addition, the mechanism of ethylene with other plant hormones, provide a new perspective for plant hormone regulation, help to design more accurate agriculture management strategy, to cope with the challenge of global food security.

However, the research and application of ethylene still face many challenges. From the perspective of the industrial production improve ethylene yield and purity, reducing energy consumption and environmental pollution, is a key problem to be solved. In the biological sciences, ethylene signal transduction mechanism of concrete, and its role in the plants to process, it remains to be further revealed.

2. Research Status at Home and Abroad

In the global chemical industry and plant physiology, driven by the research and development of ethylene showed an unprecedented vigor and potential. In-depth exploration of ethylene at home and abroad scholars, not only reveals its chemical properties and industrial application prospects, more analytical its complicated mechanism in plant growth and development. This chapter aims to carding the research status of this field, so as to provide comprehensive and in-depth for subsequent research perspective.

From the perspective of the chemical industry, the production technology of ethylene has always been the focus of research. Ma Ying etc[2] in the research, this paper discusses the application of ethylene in the chemical synthesis, not only also revealed its role in plant stress responses, especially on cadmium pollution prevention and control of the preliminary theoretical basis. This finding not only enriches the industrial production theory of ethylene, but also provides a new research direction for environmental protection and plant stress physiology.

In the field of biological sciences, ethylene biosynthesis and signal transduction mechanism research has made significant progress. The work of Xiao-Hong Kou and Yunbo Luo revealed the importance of polygalacturonase (PG) in fruit ripening and its extensive involvement in multiple processes of plant development. They showed that PG gene accumulation at specific sites during fruit ripening, such as carpel to pericarp tissue and pericarp cell wall, is closely related to ethylene regulated ripening process. This finding provides a new insight into the mechanism of ethylene in plant physiological processes.

Scholars at home and abroad for ethylene in the application of different preparation processes are also discussed extensively. The emergence of new processes such as ethanol dehydration to ethylene and methane to ethylene not only reflects the pursuit of efficiency and environmental protection in the chemical industry, but also provides the possibility for the efficient utilization of resources and the green transformation of the chemical industry. However, ethylene production and application technology still face many challenges, such as raising the yield and purity, reducing energy consumption and environmental pollution, etc., still need to be continuous technical innovation and optimization.

The research and application of ethylene is at the intersection of interdisciplinary cooperation and technological innovation. From chemical production to biological science, ethylene research not only promotes technological progress in related fields, but also promotes a deeper understanding of plant physiological regulation and environmental protection. In the future, with the discovery of new catalysts, the optimization of process processes and the progress of biotechnology, the production and application of ethylene will be more efficient and environmentally friendly, making an important contribution to the sustainable development of human society. The importance of interdisciplinary collaboration is self-evident, chemical engineers, biologists and environmental scientists and experts in the field of joint participation, will open a new road of research in the field of ethylene, jointly cope with challenges, and promote scientific development.

3. The Research Methods

In exploring the theoretical and applied research methods of ethylene, we need to consider its research characteristics and needs in the chemical and biological sciences. This chapter will focus on the key links such as experimental design, data analysis, model construction, and interdisciplinary cooperation, in order to provide a systematic and standardized research paradigm for ethylene related research.

3.1. Experimental Design and Operation

Experimental design is the basis of scientific exploration, especially in the study of complex systems, such as ethylene

biosynthesis and industrial production. In the field of chemical industry, the experimental design should focus on the screening of catalysts, the optimization of reaction conditions, and the separation and purification of products. Ma Ying waiting[2] in the studies of the effect of ethylene plant resistance to cadmium, through accurate control Cd squared $^{+}$ concentration, ethylene on methionine adenosine transferase (MAT) activity, the influence of revealing the underlying mechanisms in the ethylene plant stress response in. This kind of experimental design emphasizes the importance of environmental control and process monitoring, and provides a direct basis for in-depth understanding of the role of ethylene under different environmental stresses.

3.2. Data Analysis and Model Building

Data analysis is a bridge connecting experiment and theory. Through statistical analysis, stoichiometry, machine learning and other methods, we can reveal the underlying rules and causal relationships in complex systems. In the industrial production of ethylene, data analysis is used to optimize process parameters and improve yield and economic efficiency. In the field of biological sciences, the construction of molecular regulatory network models, such as the link between ethylene signal transduction and fruit ripening, is the key to understand the biological functions of ethylene. Based on gene expression data, physiological indexes and comprehensive analysis of environmental factors, it is possible to build a more sophisticated model, is used to predict and control the role of ethylene in plant growth and development.

3.3. Interdisciplinary Collaboration

The leap forward nature of ethylene research determines the diversity and complexity of its research methods. The participation of chemical engineers, biologists, environmental scientists and materials scientists is the key to ensure the innovation and depth of ethylene research. Interdisciplinary cooperation not only promotes the integration of theory and technology, but also promotes the optimal allocation of resources and the innovation of experimental design. For example, through the combination of chemical engineering and biotechnology, can develop the new type catalyst, improve the production efficiency of ethylene. The cooperation between biological science and material science may lead to new applications of ethylene in biomaterials and environmental remediation.

4. Discussion

Catalyst and process optimization are key to improving ethylene production efficiency. The development of new catalyst, such as metal complex, the structure of the porous materials and nanometer catalyst, not only can improve the reaction selectivity and yield, also can reduce energy consumption and environmental pollution. In terms of process optimization, through simulation and computing technology, such as molecular dynamics and density functional theory, can be a deep understanding on the surface of the catalyst reaction mechanism and provide theoretical guidance for catalyst design and process improvement. For example, the application of transition metals and their composites in ethylene oxidation and polymerization shows the significant role of catalyst innovation in improving ethylene conversion and product purity.

Exploring the mechanism of ethylene in plant physiology revealed a complex network involving fruit ripening, stress response, and plant growth and development. Ethylene is not only a key regulator of fruit ripening, but also involved in the response of plants to drought, saline-alkali stress, flower bud formation, root development and other growth and development processes. Based on ethylene receptor, signal transduction proteins and in-depth study of the downstream genes, we gradually reveal the fine structure and function of ethylene regulation network. In addition, ethylene and other plant hormones, such as auxin, gibberellin interactions, constitutes the complex regulation network of plant growth and development, provides a new perspective for understanding plant life activities.

Interdisciplinary cooperation is an accelerator to promote the research and application of ethylene. The close collaboration between chemical engineers and biologists not only accelerates the discovery and validation of novel catalysts, but also promotes a deeper understanding of ethylene biosynthesis and signal transduction mechanisms. Using metabolic engineering and synthetic biology technology, for example, can be optimized ethylene synthesis methods of microorganism, the efficient production of bio-based ethylene. The participation of environmental scientists and material scientists further expands the application potential of ethylene in the field of environmental remediation and functional materials, and provides innovative solutions to solve environmental problems.

5. Conclusion

In the future, ethylene research will be more efficient, environmentally friendly, and intelligent. Continuous innovation of catalysts and optimization of process flow will make ethylene production more green and economical. Advances in biotechnology, especially breakthroughs in gene editing and synthetic biology, will promote the application of ethylene in bio-based materials and pharmaceuticals. The deepening of interdisciplinary cooperation will promote the integration of theory and technology, and open up a new way for the future development of ethylene research. In summary, the research in the field of ethylene not only shows the power of science and technology, but also reflects the wisdom and courage of interdisciplinary scholars to jointly meet challenges and promote social progress.

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