Can Ni-Based Catalysts Enable Reliable Ammonia Cracking?

The search for sustainable energy solutions is necessary to protect the planet from greenhouse gases and pollution. Hydrogen is one solution for consideration. It has the capability to create electricity, without forming any harmful by-products, and store energy. Estimates have been made that by 2030, the need for clean hydrogen will rise to about 30%. Therefore, it is important to find innovative techniques to contain this gas. That way it can maintain its energy while being moved to different locations. Enter ammonia cracking. Ammonia contains hydrogen, thus ammonia cracking can be utilized to split the elements of ammonia apart, providing access to the hydrogen. Essentially, ammonia acts as a container for the hydrogen, offering an easy means of transporting it, as ammonia is simpler than hydrogen to liquify and contain. Nickel (NI)-based catalysts can be used to support the ammonia cracking process. They offer robust levels of catalytic activity to ensure the ammonia can be divided effectively, particularly if applied at temperatures between 700 – 950°C. Read on to discover how Ni-based catalysts can be applied to optimize ammonia cracking.

The Promise of Ammonia as a Hydrogen Carrier

Ammonia (NH_3) is a molecule with a high hydrogen density. This makes it an attractive candidate for hydrogen storage and transportation. The cracking of ammonia is a process that involves breaking down NH_3 into nitrogen (N_2) and hydrogen (H_2). It is crucial for utilizing ammonia in hydrogen fuel cells and other applications. However, achieving efficient ammonia cracking requires effective catalysts that can operate at lower temperatures while maintaining high conversion rates.

Ni-Based Catalysts: An Overview

Nickel-based catalysts are favored in the industrial sector because of their relatively low cost and satisfactory catalytic performance. Ni catalysts work by adsorbing ammonia onto their surface. This can facilitate the separation of N-H bonds and eventually desorb hydrogen and nitrogen gases. The key challenge lies in optimizing these metal catalysts. That way their efficiency and longevity can be enhanced while the operational temperature is minimized.

Recent Advances in Ni-Based Catalysts

Recent studies have shown significant progress in improving Ni-based catalysts for ammonia cracking. Researchers are focusing on several strategies to enhance catalytic performance:

1. **Support Materials:** The use of various support materials can significantly influence the activity and stability of Ni catalysts. These materials include alumina (Al_2O_3), magnesium oxide (MgO), and silicon dioxide (SiO_2). Supports provide a high surface area and can affect the dispersion of Ni particles, thus improving catalytic efficiency. For instance, Ni supported on Al_2O_3 has demonstrated high activity and stability. These properties are due to the strong metal-support interaction.

2. **Promoters and Dopants:** Adding promoters, like alkali or alkaline earth metals, can enhance the performance of Ni-based catalysts. For example, the incorporation of

potassium (K) or calcium (Ca) can modify the electronic properties of Ni. This can lead to improved ammonia adsorption and bond cleavage.

3. **Nanostructuring:** Advances in nanotechnology have enabled the development of Ni-based catalysts with controlled particle sizes and shapes. Nanostructured Ni catalysts offer a higher surface area and more active sites. These can lower the activation energy required for ammonia cracking. Nanostructuring can also help in achieving better thermal stability and resistance to sintering.

Challenges and Future Directions

Despite these advancements, several challenges remain in the development of Ni-based catalysts for ammonia cracking:

1. **Deactivation and Sintering:** Ni catalysts are prone to deactivation due to sintering. This is where Ni particles agglomerate at high temperatures, leading to a loss of active surface area. Researchers are exploring methods to stabilize Ni particles and prevent sintering. Examples of these methods include alloying with other metals or using robust support materials.

2. **Selectivity and By-Products:** Ensuring high selectivity towards hydrogen production without the formation of unwanted by-products is critical. Contaminants such as carbon monoxide (CO) can poison downstream hydrogen applications like fuel cells. Therefore, the development of Ni-based catalysts that can selectively produce hydrogen with minimal by-products is an ongoing research focus.

3. **Scalability and Cost:** Ni is relatively inexpensive compared to noble metals like platinum. However the overall cost and scalability of producing highly efficient Ni-based catalysts must be considered. Scaling up laboratory successes to industrial applications requires a thorough understanding of the synthesis processes and long-term stability under real-world conditions.

Solutions for Ni-based Catalyst Production

Ni-based catalysts hold significant promise for enabling reliable and efficient ammonia cracking, a crucial step towards harnessing ammonia as a sustainable hydrogen carrier. Advances in support materials, promoters, and nanostructuring have led to the improved catalytic performance of NI-based catalysts. However, challenges such as catalyst deactivation, selectivity, and scalability need to be addressed. That way the power of Ni-based catalysts in industrial applications can be fully utilized.

Enhancing the Capabilities of Ammonia Cracking Through an Ni-Based Catalyst

The success of a Ni-based catalyst in facilitating ammonia cracking depends on how well it has been optimized. A variety of methods exist to improve the performance of a Ni-based catalyst, from applying alkaline promoters to control the size of Ni particles, and thus its capacity to separate the elements of ammonia, to including other oxides and metals to enhance its overall catalytic capabilities. With that said, another way of increasing the abilities of a Ni-based catalyst for ammonia cracking is through its surface area. By utilizing an increased surface area, coupled with smaller particles of Ni, there is an opportunity to improve the activity of the catalyst.

We, Nikalyte, have the Nikalyte NL-UHV available to support catalysis development. It can be used for nanoparticle deposition, meaning it has the ability to create functionalised surfaces, and thus can be applied to manage the stability and surface characteristics of a Ni-based catalyst. Apply the Nikalyte NL-UHV to the formation of your Ni-based catalysts and watch their potential soar. We are ready to utilize our knowledge of nanoparticles to ensure your catalyst can make an impact, whether that be in relation to the production of hydrogen or a different application. Speak with our specialists now to get started and find the right equipment for you to enhance your Ni-based catalyst.