

Participation of nano-sized iron in aqueous-based chemical reactions and renewable gas production

レレボヒレ, モケテ

<https://hdl.handle.net/2324/5068257>

出版情報 : Kyushu University, 2022, 博士 (工学), 課程博士
バージョン :
権利関係 :



氏 名 : Relebohile Mokete

Name

論 文 名 : Participation of nano-sized iron in aqueous-based chemical reactions and renewable gas production (水溶液中の化学反応及び再生可能気体燃料生成に対するナノサイズ鉄粒子の影響に関する研究)

Title

区 分 : 甲

Category

論 文 内 容 の 要 旨

Thesis Summary

This research work is a combination of nanoparticles' application and renewable energy generation. Until now, research strives to find affordable, effective and efficient materials that can be applied for environmental remediation and renewable energy production. The objectives of this research were to compare the reactivity of NZVI-based nanoparticles in various conditions and to observe NZVI participation in renewable energy generation. Also, the novel Polymer Electrolyte Membranes (PEMs) were fabricated in this study and their role in H₂ generation via electrolysis was observed. Again, renewable energy was generated in the form of biogas. The outstanding point of the research work is that all the materials used for PEM fabrication (e.g biomass) are readily available hence their functional groups help to aid the proton conductivity of the PEMs. As a result, the PEMs formed are affordable and effective for H₂ production from electrolysis thus they can be used as alternatives for the costly and commercially scarce Nafion membrane. A typical example of an effective nanoparticle is NZVI which undergoes a series of reactions in water with altered conditions therefore it presents a good tool for highly reactive material that can remove the contaminants as well as produce H₂ gas. NZVI has a spherical, chainlike morphology due to high surface magnetic and electrostatic interactions within the nanoparticles. As well, the structure of NZVI which is divided into a shell and a core allows it to donate electrons and have a strong reducing power for contaminants. Also, the processes that are involved during the reaction of NZVI include dissolution and precipitation, therefore, the reactivity of NZVI in water evolves over time and it is affected by time. The surface modification of the NZVI using the bimetal approach is also effective in environmental remediation. The bimetal can either influence the reactivity of NZVI positively or negatively, but they are mostly known to enhance the reactivity. Furthermore, the reaction conditions within which NZVI or NIBP are introduced affect its reactivity, and such include pH, oxygen supply, temperature, dosage, and interferences. The acidic pH, increased dosage, and continuous oxygen supply generally favor the NZVI dissolution. Another way in which H₂ can be obtained as a renewable gas is via the process of electrolysis which simply involves the water splitting under the electric potential influence into O₂ and H₂. To improve the conductivity, the electrolysis of saltwater has also proven to be a good way to generate H₂ and it is applicable in desalination systems. The PEMs play an important role of proton exchange during electrolysis, therefore, they were successfully fabricated in this study using materials such as biomass, activated carbon, and nanoparticles and they had a significant proton conductivity although it was lower than that of the commercially available membrane of Nafion that is commonly used. The biomass fillers improved the H₂ generation and all the

PEMs with filler materials showed better H_2 production than SSA thus proving that the filler plays a significant role in improving electrolysis. Also, due to its good adsorption properties, carbon black (CB) nanofluid led to the highest generation of current thus proving that CB improves the electrochemical conductivity most. Furthermore, methane gas is another biogas that can be obtained through the anaerobic digestion (AD) process which is based on the organic matter degradation by microorganisms. Additives can also be used to improve the biogas and methane gas generation so in this study, NZVI and ZnO improved gas production. However, the Volatile Fatty Acids (VFAs) that are produced accumulate in the system and affect the AD process negatively. Along with VFAs, ammonia and H_2S can also accumulate in the system and affect it negatively too. Due to diverse conditions used in this study, it can be deduced that NZVI-based nanomaterials can be utilized in a variety of environments such as very hot climates, natural water with varying conditions as well as surface or sub-surface systems where the amount of oxygen is different. The benefit of NZVI application is the generation of H_2 which resembles a clean energy form. A good real-life application of electrolysis (PEM) is in oceans or rivers, for instance, where solar energy and wind energy can be good energy sources that are used to split water into H_2 and O_2 . Again, the AD application in real life is the treatment of waste (water or solids) to produce biogas. Future research should focus on determining the cost-effective and conductive electrolytes for H_2 generation as well as cost-effective and efficient PEM materials. Furthermore, the countermeasures for the AD inhibitors should be explored. The NZVI and its bimetallics should also be studied to understand the underlying mechanisms in varied conditions. Due to rapid oxidation hence limited lifetime, the improvement of the Nano iron bimetallic particles (NIBP) lifetime should be proposed. The storage of the nanoparticles remains a challenge so they can be easily oxidized, and their reactivity becomes diminished. As a result, the effective storage means which will minimize the oxidation process as much as possible should be disclosed. The temperature influence is still not clear so future research should account for it. This research work represents information that can be used; to remove contaminants such as heavy metals, to manage waste such as sludge by producing biogas, to resort to renewable energy means since solar power was used to produce H_2 from water as well as to desalinate water while producing renewable energy form (H_2). Although there are some proposed applications, more of the practical applications that can support this research need to be investigated.