

# Ammonia Production From Seawater and Air by a New Method that Utilizes Renewable and Waste Energy

Ando, Yuka (School: Shizuoka Kita High School)

Kizu, Nene (School: Shizuoka Kita High School)

Yamamoto, Hinata (School: Shizuoka Kita High School)

In line with recent increasing interest in renewable energy solutions, ammonia ( $\text{NH}_3$ ) has been attracting attention as an energy carrier. However, environmental conditions often affect current renewable energy sources and are thus unsuitable for conventional  $\text{NH}_3$  production methods. Additionally, when hydrogen is used to produce  $\text{NH}_3$  via conventional methods, carbon dioxide ( $\text{CO}_2$ ) is generated. To overcome these problems, we developed an  $\text{NH}_3$  production method from air and seawater using renewable energy. In this research,  $\text{NH}_3$  was generated simply by venting  $\text{N}_2$  gas into a thick  $\text{Na}^+$  solution. Based on the analysis, we found microbubbles generated by creating high surface tension at the gas-liquid interface during aeration generate  $\text{N}^\bullet$ ,  $\text{H}^\bullet$ , and metal Na from  $\text{N}_2$ , water, and  $\text{Na}^+$ , respectively, and the metal Na catalyzes the  $\text{N}^\bullet$  and  $\text{H}^\bullet$  reactions to generate  $\text{NH}_3$ . When verifying this method, we discovered  $\text{NH}_3$  generation was optimized under the following three solution conditions: 1)  $>1 \text{ mol/L}$ , 2)  $>343 \text{ K}$ , and 3)  $\text{pH } 5\text{--}7$ . Based on these points, equipment using renewable energy and waste heat to produce  $\text{NH}_3$  by the following three processes was fabricated. I. Air was used as the  $\text{N}_2$  source, and aeration was performed by a pump powered by solar or wind energy. II. Concentrated seawater was used as an electrolyte solution, and the water temperature was maintained using solar and waste heat. III. The pH level was adjusted with  $\text{CO}_2$ . Using this equipment, manufacturing costs equivalent to the Haber-Bosch process were achieved, and  $\text{CO}_2$  was fixed as sodium bicarbonate.