Title

Ammonia production from seawater and air by a new method that utilizes renewable and waste energy

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Abstract

In line with recent increasing interest in renewable energy solutions, ammonia (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 NH_3 production methods. Additionally, when hydrogen is used to produce NH_3 via conventional methods, carbon dioxide (CO_2) is generated. To overcome these problems, we developed an NH_3 production method from air and seawater using renewable energy. In this research, NH_3 was generated simply by venting N_2 gas into a thick Na^+ solution. Based on the analysis, we found microbubbles generated by creating high surface tension at the gas-liquid interface during aeration generate $N^{\bullet}$, $H^{\bullet}$, and metal Na from N_2, water, and Na^+, respectively, and the metal Na catalyzes the $N^{\bullet}$ and $H^{\bullet}$ reactions to generate NH_3. When verifying this method, we discovered NH_3 generation was optimized under the following three solution conditions: 1) >1 mol/L, 2) >343 K, and 3) pH 5–7. Based on these points, equipment using renewable energy and waste heat to produce NH_3 by the following three processes was fabricated. I. Air was used as the 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 CO_2. Using this equipment, manufacturing costs equivalent to the Haber-Bosch process were achieved, and CO_2 was fixed as sodium bicarbonate.