Accepted Manuscript

Article

Atomically dispersed Au_1 catalyst towards efficient electrochemical synthesis of ammonia

Xiaoqian Wang, Wenyu Wang, Man Qiao, Geng Wu, Wenxing Chen, Tongwei Yuan, Qian Xu, Min Chen, Yan Zhang, Xin Wang, Jing Wang, Jingjie Ge, Xun Hong, Yafei Li, Yuen Wu, Yadong Li

Science Bulletin
www.scibull.com

PII: S2095-9273(18)30325-6
DOI: https://doi.org/10.1016/j.scib.2018.07.005
Reference: SCIB 455

To appear in: *Science Bulletin*

Please cite this article as: X. Wang, W. Wang, M. Qiao, G. Wu, W. Chen, T. Yuan, Q. Xu, M. Chen, Y. Zhang, X. Wang, J. Wang, J. Ge, X. Hong, Y. Li, Y. Wu, Y. Li, Atomically dispersed Au_1 catalyst towards efficient electrochemical synthesis of ammonia, *Science Bulletin* (2018), doi: https://doi.org/10.1016/j.scib.2018.07.005

Atomically dispersed Au_1 catalyst towards efficient electrochemical synthesis of ammonia

Xiaoqian Wang,[1†] Wenyu Wang,[1†] Man Qiao,[2] Geng Wu,[1] Wenxing Chen,[3] Tongwei Yuan,[4] Qian Xu,[5] Min Chen,[1] Yan Zhang,[1] Xin Wang,[1] Jing Wang,[1] Jingjie Ge,[1] Xun Hong,[1] Yafei Li,[2] Yuen Wu[1]*, Yadong Li[3]

[1]Department of Chemistry, *i*ChEM (Collaborative Innovation Center of Chemistry for Energy Materials), University of Science and Technology of China, Hefei 230026, China
[2]Jiangsu Collaborative Innovation Centre of Biomedical Functional Materials, School of Chemistry and Materials Science, Nanjing Normal University, Nanjing 210023, China.
[3]Department of Chemistry and Collaborative Innovation Center for Nanomaterial Science and Engineering, Tsinghua University, Beijing 100084, China
[4]NEST Lab, Department of Chemistry, College of Science, Shanghai University, Shanghai 200444, China
[5]National Synchrotron Radiation Laboratory, University of Science and Technology of China, Hefei 230029, China

[†]Xiaoqian Wang and Wenyu Wang contributed equally to this work.

*Correspondence: yuenwu@ustc.edu.cn

Abstract

Tremendous efforts have been devoted to explore energy-efficient strategies of ammonia synthesis to replace Haber-Bosch process which accounts for 1.4% of the annual energy consumption. In this study, atomically dispersed Au_1 catalyst is synthesized and applied in electrochemical synthesis of ammonia under ambient conditions. A high NH_4^+ Faradaic efficiency of 11.1% achieved by our Au_1 catalyst surpasses most of reported catalysts under comparable conditions. Benefiting from efficient atom utilization, an NH_4^+ yield rate of 1,305 μg h^{-1} mg_{Au}^{-1} has been reached, which is roughly 22.5 times as high as that by supported Au nanoparticles. We also demonstrate that by employing our Au_1 catalyst, NH_4^+ can be electrochemically produced directly from N_2 and H_2 with an energy utilization rate of 4.02 mmol kJ^{-1}. Our study provides a possibility of replacing the Haber-Bosch process with environmentally benign and energy-efficient electrochemical strategies.

Keywords

NH_3 synthesis, metal single sites, electrocatalysis, Haber–Bosch process, nitrogen reduction

1. Introduction

As one of the most essential industrial chemicals, ammonia (NH_3) is currently produced on an enormous scale of over 150 megatons per year by the Haber–Bosch process which requires pressures of 200 to 300 atmospheres and temperatures from 300 to 500 °C. To date, this energy- and capital-intensive process accounts for 1.4% of the annual energy consumption and around 3% of global CO_2 emissions [1-5]. Electrocatalytic approach, especially driven by renewable energy,