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Full Paper

Bismuth-Oxide-Decorated Graphene Oxide Hybrids for Catalytic and Electrocatalytic Reduction of CO_2

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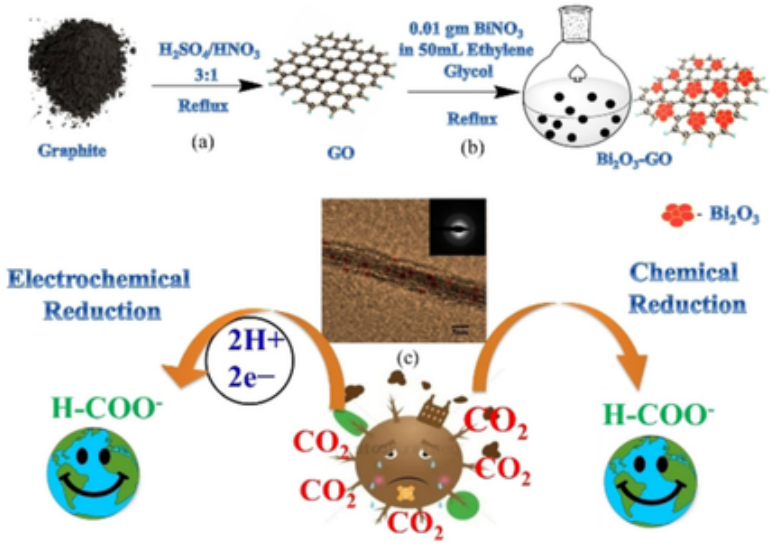
Graphical Abstract

Formate from CO_2: A facile chemical synthetic route is demonstrated for the fabrication of Bi_2O_3@GO nanomaterials. These show remarkable stability and extremely high activity toward electrocatalytic and catalytic hydrogenation of CO_2 for direct formate production.



Abstract

Global warming challenges are fueling the demand to develop an efficient catalytic system for the reduction of CO_2, which would contribute significantly to the control of climate change. Herein, as-synthesized bismuthoxide-decorated graphene oxide (Bi_2O_3@GO) was used as an electro/thermal catalyst for CO_2 reduction. Bi_2O_3@GO is found to be distributed uniformly, as confirmed by scanning electron and transmission electron microscopic analysis. The X-ray diffraction (XRD) pattern shows that the Bi_2O_3 has a β-phase with 23.4 $m^2\,g^{-1}$ BET surface area. Significantly, the D and G bands from Raman spectroscopic analysis and their intensity ratio (I_D/I_G) reveal the increment in defective sites on GO after surface decoration. X-ray photoelectron spectroscopic (XPS) analysis shows clear signals for

Bi, C, and O, along with their oxidation states. An ultra-low onset potential (−0.534 V vs. RHE) for the reduction of CO_2 on Bi_2O_3@GO is achieved. Furthermore, potential-dependent (−0.534, −0.734, and −0.934 vs. RHE) bulk electrolysis of CO_2 to formate provides Faradaic efficiencies (FE) of approximately 39.72, 61.48, and 83.00 %, respectively. Additionally, in time-dependent electrolysis at a potential of −0.934 versus RHE for 3 and 5 h, the observed FEs are around 84.20 % and 87.17 % respectively. This catalyst is also used for the thermal reduction of CO_2 to formate. It is shown that the thermal reduction provides a path for industrial applications, as this catalyst converts a large amount of CO_2 to formate (10 mM).

Conflict of interest

The authors declare no conflict of interest.

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