Hetero-atomic Carbon Nanostructures for Carbon Dioxide Reduction

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Abstract:
According to a recent report on the future of carbon dioxide (CO_2) emission[1], it has been predicted that in the coming few decades (2010-2060) approximately 496 gigatonnes of CO_2 will be produced due to fossil fuel combustion by existing infrastructure. High level of CO_2 may drastically effect the global environment due to greenhouse gas effect. However, CO_2 can be electrochemically converted into fuel or commodity chemicals[2,3]. In this study, we found that polyacrylonitrile (PAN) based hetero-atomic carbon nanofibers and 1-ethyl-3-methylimidazolium tetrafluoroborate (EMIM-BF_4) makes an efficient co-catalyst system for CO_2 reduction. Our results indicate negligible overpotential (-0.17 V) for CO_2 reduction and more than an order of magnitude (~13 times) higher current density compared to the highly efficient silver catalyst under similar experimental conditions. The superior performance is credited to the nanofibrillar structure and high binding energy of key intermediates to carbon nanofibers surfaces. The rate of CO_2 reduction also depends on the water mole fraction in the electrolyte due to variation in pH of the solution[4]. In present system, the maximum CO_2 reduction rate was observed in 75 mol% water and 25 mol% EMIM-BF_4 solution and attributed to the high availability of protons. In light of X-ray photoelectron spectroscopy (XPS) analysis, the CO_2 reduction ability of carbon nanofibers is accredited to the reduced carbon atoms rather than electronegative nitrogen atoms[5]. This finding offers a new generation of metal-free and non-precious catalysts with much higher efficiency than the existing noble metal catalysts.

Keywords: Carbon dioxide conversion, catalyst, carbon nanofibers, electrochemical reduction.

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