Development of Fe-group nanoalloy catalysts for realization of carbon neutral society

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The increased concerns over climate issues due to the CO_2 emission have spurred the development of alternative and sustainable energy cycle systems. On this standpoint, we have pursued the creation of the new energy cycles excluding CO_2 production process. Recently, we have proposed the alcohol/carboxylic acid energy cycle as "Carbon Neutral Energy Cycle (CN Cycle)".[1] In this system, energy is derived from selective partial oxidation of liquid alcohol having a high boiling point with less volatility to carboxylic acid without producing completely-oxidized CO_2. The ethylene glycol (EG)/oxalic acid system is noted as a possible CN cycle (Figure 1). From the partial oxidation of EG to oxalic acid, about 80% energy can be generated compared with that from complete oxidation of EG to CO_2. Therefore, EG/oxalic acid system is expected to have the sufficient function for energy storage and distribution. For realization of this CN cycle, the key is creation of the catalyst exhibiting highly selective partial oxidation of EG to oxalic acid. Based on the viewpoint of the substitution of rare and/or harmful metal elements, utilization of abundant transition metal element with relatively less toxicity as a catalyst is also the important issue to be investigated. In this study, we apply iron-group nanoalloy catalysts for EG oxidation.[2] For the purpose to enhance the catalytic activity and selectivity, precise control of the metal composition and mixing states of nanoalloys are important points. Therefore, we have focused on synthesis of atomically-well-mixed Fe-group nanoalloy catalysts based on chemical reduction. In this report, we describe the systematic investigations of the electrochemical EG oxidation on ternary and bimetallic nanoalloys supported on carbon (Vulcan) (FeCoNi/C, FeCo/C, FeNi/C, and CoNi/C), together with their synthetic methods and structural properties (Figure 2).

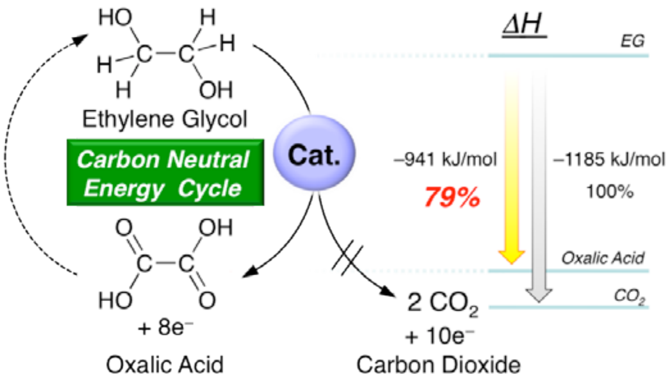

Figure 1. Carbon neutral energy cycle using ethylene

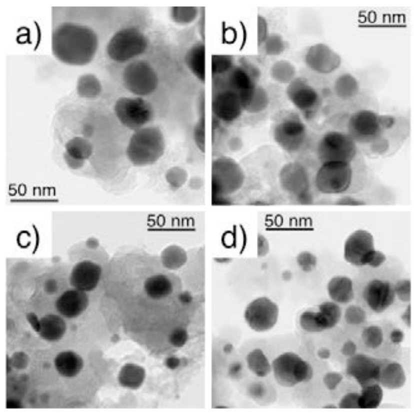

Figure 2. STEM images of (a) FeCoNi/C, (b) FeCo/C, (c) FeNi/C, and (d) CoNi/C nanoalloy catalysts.

References

[1] Takeguchi T., Arikawa H., Yamauchi M., Abe R., "Selective Ethylene Glycol Oxidation reaction for Carbon Neutral Energy Cycle System", *ECS Trans.*, Vol. 41, No. 1. (2011), pp 1755-1759.

[2] Yamauchi M., Abe R., Tsukuda T., Kato K., Takata M., "Highly Selective Ammonia Synthesis from Nitrate with Photocatalytically Generated Hydrogen on CuPd/TiO_2", *J. Am. Chem. Soc.*, Vol. 133, No. 5. (2011), pp 1150-1152.