New Progress in Heterogeneous Catalysis Research

A significant progress in the research on nano-scale catalysis morphological effect conducted by Prof. Shen Wenjie and his collaborators from Dalian Institute of Chemical Physics, Chinese Academy of Sciences was published in the April 9th issue of *Nature* (2009, 458, 746—749). By manipulating the size and morphology of metal oxide nano-particles, the group successfully cracked the tough problem of low-temperature catalytic oxidation of carbon monoxide by taking advantages of non-noble metals, marking a significant progress in basic research on nano-scale catalysis, reduction of vehicle exhaust emission and air pollution. The research work was also given a thorough account by the April 13th issue of C&E News, sponsored by the American Chemistry Society.

Catalytic oxidation is currently the most effective method for removing CO, one of the main pollutants in vehicle exhaust emission and the utilization of fossil fuels. Traditional catalysts, Hopcalite (a mixture of Mn and Cu oxides) for instance, can get rid of CO in low-temperature condition, but they are not active in normal temperature and quickly become inactive with the existence of a trace of water vapor. Noble metals can be used for catalytically oxidizing CO under the circumstance of small amount of water vapor, but on the condition that the temperature is above 100 degree Celsius. Gold nano-particles carried by transition metal oxides are found in recent research to display excellent catalytic activity and stability both in low-temperature condition and with the existence of small amount of water vapor. However, it has always been a challenging task in heterogeneous catalysis research to build a system of non-noble metal catalysts that can be utilized in the high-efficiency oxidization of CO under the condition of low temperature with the existence of water vapor.

By taking advantages of the morphology effects of nano-scale catalytic materials, Shen's group succeeded in sufficiently exposing the highly active crystal face of metal oxides, so as to effectively exhibit their excellent property for oxidizing CO. Through precise control of the preparation conditions, structurally regular Co_3O_4 nanorods are successfully obtained, with the activity (110) crystal plane accounting for more than 40% of the surface. Since there are more Co_{3+} active sites for the oxidization of CO, the complete transformation of CO can be achieved with the existence of water vapor even when the temperature is as low as minus 77 degrees Celsius. The reaction rate is more than 10 times that of nano-scale cobaltosic oxide particles. Under the condition of near cold start of the automobile engine (with a large quantity of water vapor and carbon dioxide), the Co_3O_4 nanorods show outstanding activeness and stability in oxidizing CO. In this way, the CO of the vehicle exhaust emission and hydrocarbon compounds can be oxidized into H_2O and CO_2 by using Co_3O_4 nanorods that display no structural changes. The preparation methods in which the highly active crystal planes are exposed by precise morphological control can also be applied to other metal oxides. In the meantime, the research result sheds light on the basic research on nano-scale catalysis and the development of next generation of high-efficiency metal oxide catalysts.

Prof. Shen's research was supported by the NSFC General Project in 2004 (Grant No.: 20473087) and 2007 (Grant No.: 20773119) respectively.