

# Morphology control enriches active surfaces in metal oxides

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## Method Article

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# Abstract

## Introduction

Base transition-metal oxides are not sufficiently active at ambient temperature and are also severely deactivated by moisture presented in the feed stream when they are used for catalyzing low-temperature oxidation of CO, which is widely applied in cleaning air and lowering automotive emissions. The conventional spherical nanoparticles of metal oxides are usually constructed by truncated octahedron, surrounded by less active  $\{111\}$  and  $\{001\}$  planes that do not favor the presence of catalytically active sites for the oxidation reactions. Therefore, the active sites are often the surface defects located in the corners and edges of the spherical particles in heterogeneous catalysts. It is generally acknowledged that only the atoms on the sub-layers are easily exposed in these defects and thus contribute considerably to the catalysis. Now, nanorod-shaped tricobalt tetraoxide that predominantly exposes the reactive  $\{110\}$  planes can not only catalyze CO oxidation at a temperature as low as 196 K but also hold substantial stability in the co-presence of moisture. The dominantly exposed  $\{110\}$  planes in the  $\text{Co}_3\text{O}_4$  nanorods hold  $\text{Co}^{3+}$  active sites on the surfaces while other planes such as  $\{001\}$  and  $\{111\}$  hold only  $\text{Co}^{2+}$  sites. Because  $\text{Co}^{3+}$  sites are catalytically much more active than  $\text{Co}^{2+}$  sites for CO oxidation, a strong morphology-dependent phenomenon has been observed that the nanorods exhibit markedly (almost one order of magnitude) higher catalytic activity than that of the conventional spherical nanoparticles. This sort of approach by morphology control that allows preferential exposure of the catalytically active sites will lead to the development of highly efficient oxidation catalysts of the next generation.

## Procedure

- (1) Dissolve 4.98 g of cobalt acetate tetrahydrate in 60 ml of ethylene glycol at room temperature. Heat the mixture to 160 °C gradually.
- (2) Add 200 ml of aqueous 0.2 M  $\text{Na}_2\text{CO}_3$  solution drop wise to the mixture with a final pH value of 10 at 160 °C under vigorous stirring and a continuous flow of nitrogen.
- (3) Age the slurry at 160 °C for 1 h under vigorous stirring and a continuous flow of nitrogen.
- (4) Filter the slurry and wash the precipitate with water at room temperature.
- (5) Dry the solid at 50 °C overnight under vacuum.
- (6) Calcine the dried solid at 450 °C for 4 h in air.