Robust, Scalable and Tunable $\text{Al}_2\text{O}_3$-$\text{TiO}_2$ Binary Nano-array based Monolithic Catalysts for Diesel Oxidation

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Introduction
Monolithic catalysts are dominantly applied as exhaust emission after-treatment catalysts for vehicles as a result of low back pressure, high surface area and reduced usage of catalyst materials.[1] However, Empirical washcoated powder-form catalysts, lacking the well-defined structural and geometrical configurations, severely compromises the catalytic performance and materials utilization efficiency. Furthermore, the intrinsically non-adherent particle-based washcoat may be easily subjected to high velocity flow erosion.[2] We have reported that Metal oxide nano-array based monolithic catalysts with well-defined structure and improved mechanical robustness could be a potential candidates as high efficient catalysts for emission control. A great number of materials had been fabricated through a general hydrothermal method, and the catalytic activity of as-prepared nano-array catalysts could be tuned by morphology and element doping.[3,4] Latest research results demonstrate that the addition of $\text{TiO}_2$ to the conventional $\text{Al}_2\text{O}_3$ support increases catalysts’ sulfur tolerance, which is very important to enhance the catalysts’ performance and life-time.[5] In this study, a cost-effective solution synthesis of commercial scale $\text{Al}_2\text{O}_3$-$\text{TiO}_2$ binary nano-array has been successfully achieved on the inner walls of cordierite monoliths. Diesel oxidation performances are also carried on $\text{Al}_2\text{O}_3$-$\text{TiO}_2$ binary nano-array as well as reference model catalysts to investigate the structure and catalytic activity relationship.

Materials and Methods
A simple hydrothermal synthesis procedure which allows the one-step, one-pot, large scale growth of aligned, $\text{Al}_2\text{O}_3$-$\text{TiO}_2$ binary nano-array adhered on the inner walls of 3D honeycomb monoliths. The CO oxidation and propane oxidation catalytic property using $\text{Al}_2\text{O}_3$-$\text{TiO}_2$ binary nano-array have been systematically investigated, respectively. The chemical-physical properties of as-prepared $\text{Al}_2\text{O}_3$-$\text{TiO}_2$ binary nano-array catalysts were fully characterized by using Chemisorption BET surface area characterization and temperature programmed sorption/desorption/reaction spectroscopy, and electron microscopy.

Results and Discussion
The synergistic functions between $\text{Al}_2\text{O}_3$ binary nanowire and $\text{TiO}_2$ nanorod have been revealed by correlating the composite multifunctional catalytic properties with its crystallographic, chemical and electronic structures unraveled by a wide array of electron microscopy and spectroscopy. The referenced catalysts $\text{TiO}_2$ coated on $\text{Al}_2\text{O}_3$ were also fabricated and investigated. The binary nanostructured catalysts demonstrated here could provide a new class of multifunctional building blocks for various energy and environment applications.

Significance
The well-defined $\text{Al}_2\text{O}_3$-$\text{TiO}_2$ binary nano-array catalysts we demonstrated here show an excellent catalytic oxidation activity and could potentially be used in mobile and stationary exhaust emission control. The $\text{Al}_2\text{O}_3$-$\text{TiO}_2$ binary nano-array catalysts will also provide a new class of multifunctional building blocks for various energy and environment applications. Besides, the novel binary structured nano-array catalysts provide a new model test bed to investigate the structure and catalytic activity relationship, which could help for high efficient nanocatalysts rational design.

Acknowledgement
The authors are grateful for the financial support from the US Department of Energy and the National Science Foundation.

References