Abstract

Automobile releases of volatile organic compounds and NOx are ones of the most serious threats to air quality, climate change and the future of our planet. Since the first invention of a catalytic converter over half a century ago, the utilization of this technology has stumbled onto many drawbacks--bulkiness and weight of the body, high temperature operation, high cost, high and ineffective loading of noble metal, and their possibility of involuntary release and negative ecological impact. We propose a novel design and development of special type of catalytic converter from noble-metal incorporated photocatalytic nanofibrous membrane. The ultrathin, highly porous and heat resistant spinel and photocatalytic ceramic-based membrane is to be sandwiched between two air-permeable substrates for mechanical support. While noble metals offer unconditionally excellent catalytic sites, the photocatalyst and spinel constituents promote reactivity at low temperature with and without light activation, respectively. The integrated structure is then assembled into a catalytic converter device with various nanofibrous membrane architecture or conformation—stacking, tubular, multiwalls, etc. The catalytic performance is evaluated against different automobile releases such as total carbon, benzene, carbon monoxide and NOx. Along with this applied aspect of the research, platform investigations are conducted with several hypothesis formations. Explored are the effects of choices of noble metals and the deposition methods, wavelengths of activation light, air flow and nanofibrous membrane architecture or conformation. Key findings include "Thermal relaxation in combination with fiberglass confined interpenetrating network: a key calcination process for as-desired free standing metal oxide nanofibrous membrane (RSC Adv., 2016, 6, 86798) and "Air-Treatment Reactor for Nanofibrous Metal Oxide Photocatalytic Membrane: Fabrication and Efficiency" (under preparation). It is expected that the hybrid nanofibrous membrane could provide an unprecedented platform for heat and reactant transfer during reforming, thermochemical stability under the harsh operating conditions, homogeneous distribution and dispersion of the noble metal at its lowest possible loading. Furthermore, the unique findings from the project could shed light into the mechanism of nanofiltration in broad range of applications.

Keywords: Nanofiber, Membrane, Nanospider, Noble Metal, Converter.

Research area / sub area of this project: Nanotechnology/Environmental/Materials Science

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Automobile releases of volatile organic compounds and NOx are ones of the most serious threats to air quality, climate change and the future of our planet. Since the first invention of a catalytic converter over half a century ago, the utilization of this technology has stumbled onto many drawbacks--bulkiness and weight of the body, high temperature operation, high cost, high and ineffective loading of noble metal, and their possibility of involuntary release and negative ecological impact. We propose a novel design and development of special type of catalytic converter from noble-metal incorporated photocatalytic nanofibrous membrane. The ultrathin, highly porous and heat resistant spinel and photocatalytic ceramic-based membrane is to be sandwiched between two air-permeable substrates for mechanical support. While noble metals offer unconditionally excellent catalytic sites, the photocatalyst and spinel constituents promote reactivity at low temperature with and without light activation, respectively. The integrated structure is then assembled into a catalytic converter device with various nanofibrous membrane architecture or conformation—stacking, tubular, multiwalls, etc. During the membrane development, a few pieces of platform knowledge and technology have come to full realization. These include know-how on optimizations of metal coating on nanofibers among various techniques—solution-based reduction, thermal evaporation, sputtering and plasma. Key findings include “Thermal relaxation in combination with fiberglass confined interpenetrating network: a key calcination process for as-desired free standing metal oxide nanofibrous membrane (RSC Adv., 2016, 6, 86798) and “Air-Treatment Reactor for Nanofibrous Metal Oxide Photocatalytic Membrane: Fabrication and Efficiency” (under preparation). Furthermore, we also expect that the findings from the project will shed light into the mechanism of nanofiltration which could be applicable for further developments of various types of nanofiber-based filters.