Synthesis and Characterization of Mixed Bismuth Oxide of Nano-structured Particles for Soot Oxidation Catalysis

According to an analysis, held by the European Environment Agency (EEA), it is estimated that "air pollution causes 100 million sick days and 350,000 premature deaths in Europe". Over the last few years, several exhaust gases after treatment technologies have been developed to reduce engine-out emissions. The latter are sources of the main outdoor air pollutants, that is, nitrogen oxides (NOx), volatile organic compounds (VOCs) and particulate matter (PM), which is comprised of solid carbon (soot) and unburned carbonaceous compounds. PM is a major constituent of air pollution and is associated with respiratory and cardiovascular diseases as well as skin cell alterations. In 1976 Ford Motor Company used for the first time CeO_2 in their vehicles and since then it is an irreplaceable material for TWC (three way catalysts). The oxidation activity of soot oxidation catalysts is a result of the combination of two different parameters: 1) the oxygen storage capacity (OSC) of the catalyst and 2) its redox properties. The unique ability of CeO2 to shift between Ce4+ and Ce3+ and the ensuing effect in the creation of oxygen vacancy defects are found to be key factors for its application in heterogeneous catalysis. In literature, the doping of CeO_2 with ZrO_2 is widely studied, as it empowers the catalytic properties of the product. In this study, the goal was the synthesis of nanostructured mixed Bismuth/Cerium oxides via the LPSHS method and their catalytic evaluation as soot oxidation catalysts. The ultimate goal was the replacement of Zr with Bi, as the latter is twice as cheap as the former. In the case of LPSHS method the parameters that were investigated were the calcination treatment, the calcination rate and the (%w/w) quantity of the Bi-doping agent. XRD, SEM, TEM and BET analysis were performed to study the morphology, phase composition and crystallization of the materials. All materials were evaluated as for their catalytic activity in soot oxidation reaction. Thermogravimetric (TG) Analysis occurred during this study and the results have been analyzed with the aid of a multi-population kinetics model, where soot is found to consist of three fractions reacting with different activation energies, namely 120, 180, and 240 kJ/mol. The occurrence of these three fractions is attributed to the formation of distinct families of surface oxygen complexes (SOCs) on the carbon surface which are subsequently gasified and hence cause soot oxidation, in agreement with accepted mechanisms of soot oxidation in the literature. For further study of the Bi metal, Bi_2O_3 and $BiFeO_3$ perovskites were synthesized via a variety of synthesis methods, i.e. LPSHS, ASP and Sol-Gel. Their catalytic activity was poor, so they were not considered as promising candidates for the specific application. However, the replacement of Zr with Bi in a defined composition, lead to the synthesis of a catalyst that had similar if not improved catalytic activity. As the price of Zr is twice as higher as the one of Bi it is believed that further economic research should be done in order to investigate the introduction of Bi in the industry of soot oxidation catalysts.