

Abstract

Volatile organic compounds (VOCs) continue to be the major source of direct and indirect air pollution. Here, cryptomelane-type octahedral molecular sieve (OMS-2) manganese oxide, amorphous manganese oxide (AMO), and mixed copper manganese oxide (CuO/Mn₂O₃) nanomaterials were synthesized and, together with commercial MnO₂, characterized by various techniques. These catalysts were investigated for gas-phase total oxidation of six VOCs under air atmosphere. Using OMS-2 at 250 °C, the average conversions for toluene, benzene, ethylbenzene, *p*-xylene, *m*-xylene, and *o*-xylene were 75%, 61%, 45%, 23%, 13%, and 8%, respectively, whereas using CuO/Mn₂O₃, 72%, 44%, 37%, 29%, 27%, and 26%, respectively, were obtained. Generally, the conversion of VOCs to CO₂ using the synthesized catalysts increased in the order: *o*-xylene \approx *m*-xylene < *p*-xylene < ethylbenzene < benzene < toluene. However, using commercial MnO₂, benzene (44% conversion) was more reactive than toluene (37%), and the xylenes showed similar reactivities (13–20%). Differences in reactivity among VOCs were rationalized in terms of degree of substrate adsorption and structural effects. For example, the reactivity of xylenes was dictated by the shape-selectivity of stable OMS-2. The higher oxidative activities exhibited by OMS-2, AMO, and CuO/Mn₂O₃ as compared to commercial MnO₂ were attributed to a combination of factors including structure, morphology, hydrophobicity, and redox properties. The mobility and reactivity of active oxygen species were strongly correlated with catalytic activities. Lattice oxygen was involved in the VOC oxidation, suggesting that the reaction could proceed via the Mars–van Krevelen mechanism.