COMPLETE OXIDATION OF VOLATILE ORGANIC COMPOUNDS OVER MANGANESE OXIDE CATALYSTS

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Over 300 chemicals are designed as VOCs by the U.S. Environmental Protection Agency and most of them are highly toxic/carcinogenic substances that contribute to photochemical smog, global warming and so on. Therefore, VOCs are carefully regulared and different technologies have been developed to control their release to the atmosphere. Catalytic oxidation is one of the most widely used techniques to control VOCs emissions at relatively low temperatures: it is less fuel intensive compared to thermal oxidation and it is highly versatile with the possibility to treat waste streams with different VOC concentrations and effluent flow rates.
In this work, a set of highly crystalline MnO_x catalysts (namely Mn_2O_3, Mn_3O_4 and Mn_xO_y) was obtained by the solution combustion synthesis (SCS). Catalytic activity tests using ethylene as probe molecule confirmed that Mn_3O_4 is the most active catalyst in VOCs oxidation. Similar results where obtained with propylene and toluene. Indeed, the active phase Mn_3O_4 can be considered as a spinel structure of $Mn^{2+}(Mn^{3+})_2O_4$, in which the presence of both Mn^{2+} and Mn^{3+} cations (= Lewis acidic sites) may favor redox-cycles (i.e. MvK-type mechanisms). On the other hand, this beneficial effect was not observed with Mn_xO_y showing multi-crystalline phases. Hence, the most active catalysts are those that exhibit the best redox properties as confirmed by complementary analysis ($Mn_3O_4 > Mn_2O_3 > Mn_xO_y$). The flow rate effect on the catalytic activity was also investigated: lower flow rates of VOCs may cause longer residence times of molecules which lead to more complete reactions (deeper oxidations), in agreement with previous studies. Since real industrial emissions usually contain mixtures of VOCs, studies of the catalytic activity on a single VOC partially represent the catalyst application. Therefore, the catalytic behavior of MnO_x systems was also investigated with mixtures of VOCs (ethylene, propylene and toluene). Preliminary results suggest that the total oxidation temperature of the mixture strongly depends on the temperature at which the most stable VOC is oxidized. Further catalytic studies could be done with ceramic monolithic supports coated with Mn_3O_4 to better simulate the catalyst working conditions.

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