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Editorial

Top 10 Cited Papers in the Section "Environmental Catalysis"

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This editorial examines the 10 most cited articles of 2018–2019 published in the "Environmental Catalysis" section of the *Catalysts* journal. The topics covered two strategies to meet the new standards of regulation and to protect the environment and human health: the primary prevention method, which consists of drastically reducing the content of a chemical element in fuel in order to limit its subsequent release by combustion reactions, and the secondary strategy, which concerns intercepting emissions before their release using end-of-pipe technologies. The catalytic oxidative desulfurization of oils in two reviews feature the first strategy, while the selective catalytic reduction of nitrogen oxide (NOx) in 3 reviews and 1 regular article, the catalytic removal of Volatile Organic Compounds (VOCs) in 2 reviews, and the catalytic degradation of water pollutants in 1 review and 1 regular article feature the second one.

Demand for clean fuels is increasing worldwide, with stricter environmental regulations for transportation fuel, particularly with respect to their sulfur content. The two review articles examined the possibility for sulfur fractions of petroleum to be upgraded by the oxidative desulfurization (ODS) process, an alternative process to hydrodesulfurization to reduce energy costs. The review by Sarah Houda et al. (2018) [1] focused on the ODS of heavy oils with high sulfur content (more than 0.5 wt.% S) and showed potential interest in the development of this technology for marine fuels. This article underlines that, notwithstanding the major developments in heterogeneous catalysis and its advantageous recovery, most reactions reported in publications are carried out in homogeneous catalysis, mainly to overcome the problem of reactions in the presence of two phases. The review shows clearly that the ODS process is not yet able to reduce sulfur content in initially high sulfur heavy feeds to ppm level but that the efficiency of heterogeneous catalytic systems could be significantly improved via ultrasound and/or ionic liquid-assisted ODS processes. The second review by Muhammad Nobi Hossain et al. (2019) [2] confirmed that the ODS is now limited to modeling sulfur compounds with short chains and that it is essential to work with real heavy oil raw materials, such as pyrolysis oil from used tires.

The most represented subject in the 10 most cited articles is related to the **selective catalytic reduction (SCR) of NOx**. The first article by Devaiah Damma et al. (2019) [3] critically reviewed the recent research progress on supported transition and mixed transition metal oxide catalysts for low-temperature NH_3–SCR for the removal of NOx. Indeed, the SCR catalyst must be active in a relatively low temperature range (100–300 °C) because the flue gas temperature of the industrial process is as low as 300 °C. Low-temperature NH_3–SCR catalysts should have high DeNOx activity and N_2 selectivity combined with high resistance to SO_2/H_2O. However, the durability of catalysts in the presence of SO_2 and H_2O still needs to be further enhanced. Indeed, the authors identified that most transition metal-based catalysts suffer from low resistance when the reaction feed contains both SO_2 and H_2O streams simultaneously. Therefore, a better understanding of the SO_2 and H_2O inhibition mechanism is still needed in order to design a robust transition metal-based catalyst for NOx removal by SCR with NH_3. Tolerance to water and sulfur of Mn-based catalysts for the same reaction was the topic of the second review article written by Chen Gao et al. (2018) [4]. After a short overview of plausible poisoning mechanisms by H_2O and SO_2, the authors presented the research progress of Mn-based

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catalysts for water and sulfur resistance. Mixing MnOx with relevant metal (Ce, Cu, Fe, etc.) oxides and loading the Mn species on an appropriate support (TiO_2, activated carbon, Al_2O_3, etc.) appears to be an effective strategy to tackle the poisoning issue. However, the reasons for this tolerance enhancement as well as the role of the support need to be further explored. Interestingly, the authors also highlighted the preparation of monolithic catalysts as an alternative to improving the tolerance of Mn-based SCR catalysts to H_2O and SO_2 and as a commercial perspective of application of these catalytic formulations. Besides, Ke Zhang et al. (2018) [5] showed that the MnOx–Fe_2O_3/vermiculite monolithic honeycomb catalyst (prepared by an extrusion method) demonstrates excellent DeNOx performance and cycling stability. The NO conversion of the monolithic honeycomb catalyst was stable over the entire period of SO_2 introduction, highlighting its good SO_2 resistance. Moreover, the extent to which the NO conversion decreased after SO_2 introduction in the feed was relatively slight at 20 °C even if the catalyst did not regain its initial activity when SO_2 was removed, probably due to the formation of sulfates covering the active sites of the catalysts. The fourth article by Feng Gao et al. (2018) [6] was devoted to the recent progress in atomic-level understanding of Cu/SSZ-13 selective catalytic reduction catalysts currently on the market for the control of NOx emissions from diesel vehicles. More specifically, the review focused on recent advances in the nature of catalytically active copper species, some limiting reactions involved in the SCR mechanism, and the effects of copper speciation on catalyst stability. In particular, the authors pointed out that the formation of CuO_x aggregates is detrimental to both SCR selectivity and catalyst stability, with recent results demonstrating a possible "catalytic" role of CuO_x aggregates in the degradation of zeolite structures. On the basis of this new knowledge at the molecular level highlighted in this review, the authors were able to propose ways to rationally design Cu/SSZ-13 catalysts in order to optimize their performance and stability.

Regarding the topic of VOC abatement, two very interesting reviews were published. The review article by Savita KP Veerapandian et al. (2019) [7] analyzed the combination of nonthermal plasma (NTP) and various zeolites as an adsorbent and/or catalyst for the removal of different VOCs. This article summarizes the advantages of combining the zeolites and NTP in sequential adsorption plasma catalysis for enhanced VOC removal efficiency and reduced energy costs. The effect of various process parameters during adsorption of VOCs and plasma discharge for VOC oxidation was discussed. This work highlighted the importance of the stability and regenerative capability of the zeolites used in plasma catalysis and emphasized the need for systematic study on this for scale-up and real-world application of this technology. M.V. Grabchenko et al. (2018) [8] provided a survey of the current state of catalytic removal of VOCs as well as CO and soot oxidation over Ag/CeO_2 materials. Through an analysis of these three oxidation reactions, this article brought to light the important role of metal–support interaction in Ag/CeO_2 composites. The configuration of the silver–ceria interface provides the enhanced catalyst performance caused by synergistic effects of silver and cerium oxide. The authors underlined that appropriate selection of the synthesis method would allow for the desired features of the composites to be obtained, required for emerging applications such as photo- and electrocatalysis.

The advanced oxidation process (AOP) is currently used for **pollutants' catalytic degradation in water**. The review paper by Bing Wang et al. (2019) [9] focused on the application of heterogeneous catalysts in catalytic ozonation processes to provide key directions for catalyst selection in this AOP. Among the heterogenous catalysts studied in the literature, bulk and supported metal oxides, carbon materials, and minerals modified with metals allow for significant improvement in the removal efficiency of the organic matter present in effluents. In spite of abundant literature on the subject, the review demonstrated that applications are mainly limited to the laboratory field and that, if commercial application of the process is to be developed, it is necessary to clarify the reaction mechanism of catalytic ozonation and to get as close as possible to the real conditions in which the oxidation process must be used. The article of Kristina Fischer et al. (2018) [10] emphasized

another AOP and presented an easily up-scalable method to synthesize highly active TiO_2 nanoparticles on a polyethersulfone microfiltration membrane to remove methylene blue or carbamazepine in water in a continuous way. In this paper, the authors presented an innovative method consisting either in premodifying the membrane with carboxyl groups or in treating the TiO_2 nanoparticles with ultrasound. The ultrasonically treated nanoparticles gave the highest photocatalytic activity in the degradation of carbamazepine and showed no decrease in degradation after nine cycles. This result can be related to the uniform distributed TiO_2 nanoparticles withstanding high shear stress due to strong bonding between TiO_2 and the polymer or the carboxyl group on the membrane, respectively.

Analysis of these 10 papers highlights that not only the design of new heterogeneous catalysts but also the development of catalytic processes are needed for cleaner air and water. I hope that you enjoy reading these most cited articles in the "Environmental Catalysis" section of our journal which are summarized in this editorial as much as I do.

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