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Editorial: Carbon-based catalytic engineering for sustainable industrial applications

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Editorial on the Research Topic
Carbon-based catalytic engineering for sustainable industrial applications

Carbon-Based catalysis has become one of the burgeoning topics since the 21st century, playing a fundamental role in the development of sustainable heterogeneous catalytic processes. Carbon materials are economic catalytic supports that contribute the anchoring sites for green active centers as the driving force for industrialization catalytic processes. The use of non-metal carbon materials as catalyst also leads to entirely different reaction mechanisms in comparison with traditional metal-based catalysts. Consequently, Carbon-Based catalytic engineering processes are flourishing, and the comprehension of their related phenomena is of high importance for sustainable industrialization and process development.

This Research Topic collects four recent innovative developments concerning the catalytic applications of carbon based materials for catalysis. It will further shed light on the potential use and rapid expansion of carbon-based catalysts.

"*Graphene nanoplatelets promoted CoO-based catalyst for low temperature CO_2 methanation reaction*" Zhong et al. Methanation of CO_2 is an important reaction for reducing CO_2 emissions in a power-to-gas system. Compared to cobalt supported on gamma-Al_2O_3, cobalt supported on graphene nanoplatelets (GNPs) showed significantly better performance for CO_2 methanation. Cobalt supported on GNPs was capable of 15% conversion of CO_2 to CH_4 at temperatures below 250°C, compared to 5% for cobalt supported on Al_2O_3. *In situ* thermogravimetric analysis (TGA) demonstrated that the Co/GNP catalyst was stable to 400°C. The maximum catalyst mass-specific CH_4 yield was obtained at a Co loading of 5_{wt}% on GNPs; however, high Co loading on GNPs deactivated the reactivity of the Co/GNP catalyst. Transmission electron microscopy (TEM) demonstrated that 5_{wt}% Co/GNPs had the smallest and most dispersed cobalt nanoparticles. Excessive loading of cobalt tended to form isolated large Co nanoparticles. X-ray photoelectron spectroscopy (XPS) and Raman spectrometry revealed that more CoO phases were maintained on the surface of 5_{wt}% Co/GNPs, indicating that the interaction between the Co and the GNPs had more of an impact on cobalt's redox capacity than did particle size, which ultimately affected cobalt's active phase during the CO_2 reduction process. Furthermore, Raman spectrometry demonstrated that Co loading led to an increase in graphene defects. Higher Co loading on GNPs resulted in fewer interfaces between Co and GNPs due to the agglomeration of Co nanoparticles.

"*Promotion of Au nanoparticles on carbon frameworks for alkali-free aerobic oxidation of benzyl alcohol*" Du et al. We synthesized a series of modified Co-ZIF-67 materials with tunable morphology to support fine Au nanoparticles for the alkali-free aerobic oxidation of benzyl alcohol. Structure promotion was performed using Stöber silica as a hard template, which was subsequently removed by NaOH etching before gold immobilization. The texture structure of Au/(Si)C was greatly improved with increasing surface area and volume. CoO_x was simultaneously introduced into the carbon shell from the Co-ZIF-67 precursor, which consequently facilitated the specific Au-support interaction *via* bimetallic synergy. XRD, XPS, and TEM images demonstrated the redispersion of both Au and CoO_x as well as the electronic delivery between metals. Analysis of the chemical and surface composition suggested a surface rich in $Au^{\delta+}$ with abundant lattice oxygen contributed by CoO_x in the final Au/(Si)C, which improved the transformation rate of benzyl alcohol even in an alkali-free condition. Au/(Si)C with finely dispersed Au particles showed excellent catalytic performance in the alkali-free environment, with 89.3% benzyl conversion and 74.5% benzaldehyde yield under very mild conditions.

"*Kinetic study of multiphase reactions under microwave irradiation: A mini-review*" Adavi et al. Microwave (MW) heating is rapid, selective, and volumetric, and it is a compelling non-conventional heating approach for driving chemical reactions. The effect of MW irradiation on the kinetics of thermal/catalytic reactions is still under debate. A group of researchers reported that the effect of MW heating on reaction kinetics is highlighted through the non-thermal effects of MWs on kinetic parameters and reaction mechanisms in addition to the thermal effect. However, another group attributed the observations to the thermal effect only. In the present work, we summarized and critically synthesized available information in the literature on the subject. It can be concluded that MW heating has solely the thermal effect on gas-solid reactions, and the variations of kinetic parameters are related to the direct and indirect impacts of that. Temperature measurement limitations, physical structure variation, and non-uniform temperature distribution are the primary sources of the discrepancy in previous studies. In ionic liquid-solid reactions, the presence of electromagnetic fields can affect the movement of ions/polar molecules which can be considered a non-thermal effect of MWs. However, the effect of MW absorption by solid/catalyst, and the formation of hot spots must be taken into account to avoid potential discrepancy. Therefore, further theoretical/experimental studies are required to clarify the effect of MWs on liquid-solid reactions. In addition, developing reliable temperature measurement methods and isothermal reaction domain are required for an accurate kinetic study during MW irradiation.

"*Three basic open access software tools for academic analysis of photocatalytic particles*" Mendoza-Acosta et al. There is currently great interest in photocatalytic degradation technologies of pollutants in industrial effluents. This is due to the need to reduce the environmental pollution generated by the textile industry's high demand of clothing for fast fashion; in addition to severe environmental problems, this also generates social problems. Since the catalysts of this type of processes are usually nanoparticles of metal oxides such as zinc and titanium, it is necessary to promote research into the synthesis and evaluation of photocatalysts. Therefore, this article describes three free basic access tools for the academic analysis of nanoparticles, from experimental design to representation, using the study of kinetics and particle size analysis. After pre-selecting easily accessible software, it was found that RStudio, J-Image, and Vesta are very useful programs for the analysis of nanoparticles in the respective areas of statistical processing, image analysis, and three-dimensional representation.

Author contributions

JL: Writing–original draft, Writing–review and editing. WL: Visualization, Writing–review and editing. NW: Visualization, Writing–review and editing. K-HW: Visualization, Writing–review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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