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Carbon Catalysis: Potential and Challenges

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Carbon is traditionally used as catalyst-support in catalysis, but new more research works have been performed to use carbon materials as (metal-free) catalyst.

In this presentation, we discuss the applications of nanocarbon as high-performance catalyst for dehydrogenation and selective oxidation reaction. Dehydrogenation of ethylbenzene to form styrene is an important industrial processes and it has recently been demonstrated that various sp^2 based carbon such as mesoporous carbons, nanofilaments, carbon nanotubes and onion like carbon materials are active as catalysts for this reaction. These carbon based catalysts represent an environmentally friendly alternative to K-promoted metal oxides that are used commercially. We found that the main requirement for effective catalysts is a high density of vacancies in a sp^2 framework and the preferred vacancies are those that form –C=O functionalities in O_2 atmosphere. In this regard curved sp^2 carbon materials, nanotubes and onion-like structures are superior to planar sp^2 carbon materials since the defect density can be higher in the curved materials. The requirements for effective heterogeneous carbon-based catalysts are different from the requirements for many other applications where carbon nanomaterials with pristine sp^2 networks are favored. The sp^3-hybridized ultra-dispersed diamonds are also highly active in the oxidative dehydrogenation of ethylbenzene to styrene, but less selective.

The challenge for industrial application of nanocarbon is the large-scale production of nanocarbons with contronable and repeatable structure. However, Loose CNTs/CNFs are unsuitable as they cannot be controlled in their suprastructural properties and operations of compaction can destroy or at least inhibit the access of the reactant medium to the nanostructures. It is mandatory for chemical applications to use only one chemical element for all dimensions of structuring and to avoid the combination of nanocarbon with non-carbon support structures. Recently, we have successfully modified activated carbons obtained from the bio-waste of palm oil production as host for the growth of nanocarbon. CNTs/CNFs can be immobilized on the outer surface and nested inside of the activated carbon leading to hierarchically structured carbon materials that are highly suitable for sorption and catalytic applications and for binder-filler applications.

Reference:

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