Bourse de thèse MESR 2019, Ecole doctorale de chimie, UCBL

Ceria doped with traces of precious metal for hydrogen production

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Context:

Today hydrogen appears definitely as a key energy vector for future sustainable development in the world. In France, Nicolas Hulot presented on 1st June 2018 a hydrogen deployment plan for the energy transition. So far, large-scale production of hydrogen is obtained from fossil hydrocarbon sources such as natural gas (CH_4), but it must be made greener. One solution is to produce hydrogen from renewable energy sources such as biogas (a mixture of CH_4 and CO_2 produced from wastes). This raises some technical issues, which still have to be overcome. Biogas has to be catalytically reformed into hydrogen. Although conventional catalysts used for CH_4 reforming reactions (steam and/or dry reforming) are cost effective and efficient Ni based materials, they suffer two main drawbacks: (i) their high sensitivity to irreversible poisoning by S containing species present in the biogas even at trace levels after its purification; (ii) their propensity to extensive formation of carbon deposits inducing catalyst deactivation. We then have to explore new directions with more innovative, efficient but still cost effective solutions. A promising and exciting trend in heterogeneous catalysis is to develop thermally stable ultra-divided, or single-atom metal catalysts, and this is the essential motivation of this thesis.

Description of the research project:

During his thesis, the PhD student will dedicate his work in:

(i) More deeply understanding the catalytic sites responsible for the outstanding behavior of ceria-based catalysts doped with traces of precious metal.

(ii) Exploring the exposed surface facets of the ceria doped or not by other Rare Earth elements (Gd, Sm,…) as a possible way to stabilize the active phase at the highest dispersion and then putting a step forward to the tailored synthesis of new advanced catalysts for H_2 production.

The following steps will be considered:

1. **Preparation of model catalysts**. To study the effect of the exposed crystallographic facets of the support, very-well controlled shapes of ceria crystallites (nanorods, cubes and octahedral) will be prepared. Two preparation methods will be used: (i) Hydrothermal methods to prepare ceria with a high control of the crystal size and morphology and (ii) Self-assembly synthesis by condensation of an inorganic phase in the presence of organic micelles to prepare mesoporous ceria. The synthesized nanostructured pure or doped ceria powders will be impregnated by precious metal.
2. **Physicochemical characterization of synthesized supports and catalysts** by different techniques (BET, XPS, Chemical analysis, FTIR, HRTEM, Temperature Programmed Reactions…).

3. **Catalytic studies in CH_4 reforming**. Powders will be tested in dry reforming of CH_4 (CH_4/CO_2 reactions) at atmospheric pressure and temperatures between 650-800 °C. This reaction has recently gained growing interest due to (i) environmental implications, since both methane and carbon dioxide are greenhouse gases, (ii) the produced synthesis gas with low H_2/CO ratio being of particular interest to the synthesis of valuable oxygenated chemicals, and (iii) the highly promising fields of the valorization of renewable energy sources such as biogas for the hydrogen production.

Required profile

Master degree or similar, with good knowledge in catalysis/physicochemistry. Basic knowledge in synthesis will be appreciated.

Contact

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