Contribution ID: **4** Type: **Invited Oral**

Plasmas for the catalyst applications

With the increasing concerns in the resource, energy, environmental and others, one can expect a further rapid demand for the catalyst or the catalytic process.Plasmas are very promising with it. There are three major directions on the plasma applications for the catalyst. One is to combine the plasma with the catalyst, normally for the activation and utilization of inert molecules like methane, CO2, H2S and nitrogen. The 2nd is to prepare the catalyst with unique structure. The 3rd is to treat or the modify the surface of the catalyst or the catalyst support for the specific properties. The first direction has been extensively investigated but many challenges remained. Two general mechanisms for the combination have been presented. One is the plasma promoted catalytic conversion. The other is the catalyst enhanced plasmas. Because of the challenges in the operando catalyst characterization and in the in situ plasma diagnoses, most of the published works were just reports of the experimental results. A multidisciplinary effort is immediately needed if one would like to see a rapid application of the combination, especially it is expected that the renewable energy will be sufficient for the plasma conversion. In addition, the present plasma generation uses various high voltage techniques.For the future applications, the high electric-field generated plasmas must be developed for the better performances of the plasma conversions.For the 2rd direction with the plasma preparation, huge opportunities exist.The nucleation and crystal growth under the influences of plasmas are totally different from the conventional thermal preparation. Therefore one can get very different crystals or nanoparticles using the plasmas. These crystals or nanoparticles can be good catalysts. Especially, one can use plasmas to create catalysts, which cannot be made using the conventional techniques. These includes the unique alloys and nitrides. One can use the plasmas operated at room temperature to make the catalysts on the thermal sensitive supporting materials or soft materials, like metal-organic frameworks, porous polymers, carbon with ultrahigh surface area, DNA, proteins, gel and others. This has significantly extended the scope of the catalytic materials for applications like bio-conversion. The plasma defect engineering is being also found to be helpful for many unique applications. With the plasma deposition or spray techniques, the metal, glass, diamond, wood and other substrates can be good catalyst supporting materials in the future. The plasma oxidation at low temperatures can find more applications in the regeneration of the catalysts. Site controllable catalyst preparation can be available using plasmas. For the 3rd direction with the treatment or the modification of the surface of the catalyst or the support, it has been found applications in the changes of the surface properties, like the hydrophilicity. It can be used for the removal of the moisture or other contaminants on the surface. With the increasing uses of the organic or polymer based catalysts, plasma modification or treatment will have more applications in the changes of the functional groups. Many other opportunities remain in this direction with challengs as well.

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Session Classification: Catalysis

Track Classification: Catalysis