Benemérita Universidad Autónoma de Puebla

Instituto de Física *"Ing. Luis Rivera Terrazas"*

SEMINARIO SEMANAL
"Dr. Jesús Reyes Corona"

"Production of Formaldehyde through Photocatalytic Reduction of CO_2 over rGO Grafted NiO-CeO_2 Heterostructure Nanocomposite"

Dr. Umapada Pal

Profesor-Investigador IFUAP

Resumen

CO_2 emission led by excessive fossil fuel usage has increased its concentration in the earth's atmosphere to unprecedented level. Therefore, finding ways to prevent the climatic change driven by CO_2 surge is one of the most urgent tasks for the scientific community. While a variety of solutions such as capturing CO_2 in rocks, making CO_2-based copolymers such as polypropylene carbonate (PPC), and electrochemical CO_2 reduction have been suggested for the capture and utilization of CO_2, all these methods require external energy to activate, reduce, and convert CO_2 into fuel products due to high thermodynamic stability of CO_2. As the search for cost-effective efficient methods for CO_2 reduction is continued, utilization of cheap renewable energy such as solar light might be a viable alternative for producing high energy chemicals through CO_2 photoreduction in cheaper way. During the past two decades, various semiconductors such as TiO_2, CdS, $CaFe_2O_4$, ZnO, and TaON have been tested as photocatalysts for CO_2 reduction. However, low efficiency and poor product selectivity of CO_2 reduction remained the principal obstacles for practical application of these photocatalysts. Solar light is one of the sustainable, abundant, and cheaper energy sources, which has been utilized for the reduction of CO_2 and its conversion to fuel. Photoelectrochemical and photocatalytic CO_2 reductions have been carried out using solar light. Taking the advantage of solar light as cheap energy source, PEC and PC CO_2 reductions have been performed over several semiconductor photocatalysts. Use of different semiconductor photocatalysts yielded different solar fuels such as methanol, ethanol and formaldehyde. During the past two decades, various semiconductors such as TiO_2, CdS, $CaFe_2O_4$, ZnO, and TaON have been tested as photocatalysts for CO_2 reduction. However, low efficiency and poor product selectivity of CO_2 reduction remained the principal obstacles for practical application of these photocatalysts. We combined p-type NiO particles with n-type CeO_2 particles to form p-n junction interfaces, which can suppress the charge carrier recombination process at the surface of CeO_2 nanoparticles. Further, we introduced reduced graphene oxide (rGO) in the composite to exploit its high electrical conductivity and charge trapping behavior, which allowed an easy accumulation of electrons at the hybrid composite photocatalyst surface and subsequent sequential multi-electron transfer at each of the intermediate steps of CO_2 reduction process. The sequential multi-electron transfer process induced photocatalytic reduction of CO_2 molecules adsorbed and activated at CeO_2 surface, producing formaldehyde as liquid fuel at 421.09 µmol g^{-1} h^{-1} rate.

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Informes: seminarios@ifuap.buap.mx