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Insights in the CO2 photo-activation over Titania-Based Photocatalysts for Artificial Photosynthesis

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The development of CO2 valorisation strategies has become a crucial issue and represents a priority for the European Union, which is actively promoting international agreements to control climate change and different programmes for CO2 conversion. Currently, less than 1% of the total anthropogenic CO2 emissions (31.2 Gt/y) are recycled into chemicals or used in industrial applications. One of the most promising strategies is the photocatalytic reduction of CO2 to produce fuels and chemicals by using sunlight as a sustainable energy source (Artificial Photosynthesis, AP). The main drawback arises from the fact that the CO2 molecule is highly stable, which makes very difficult its activation[1].

This work focuses on the study of the gas phase CO2 photoreduction with water using TiO2-based catalysts. Coupling of TiO2 semiconductor with plasmonic noble metal nanoparticles was studied as a pathway to retard the recombination processes and improve the photocatalytic performance in AP process.

Catalysts were fully characterized by XRD, ICP, BET, TGA, SEM, TEM, Raman. Further, in-situ synchrotron-based spectroscopy techniques were performed in ALBA NAP endstation (CIRCE) to get a better understanding of the CO2 photoreduction mechanism. Photocatalytic activity was tested in a continuous-flow gas phase reactor under UV illumination.

Photocatalytic experiments in combination with in-situ spectroscopy studies revealed the influence of surface-adsorbed carbon species in the CO2 reduction mechanism. These studies showed the activation of CO2 molecules under UV illumination to obtain CH3OH and CO. Moreover, these measurements confirmed that the photoreduction mechanism occurs via carbonate/bicarbonate intermediates. The exposure to CO2 + H2O leads to the formation of CO32- and CO2- species. When the sample is irradiated with UV light, new peaks appeared in the O1s and C1s spectra, which are assigned to CH3OH and gas-phase CO, respectively. On the other hand, the introduction of noble metal NPs significantly changed the selectivity of the process, yielding more reduced products, such as CH4. These observations, which were confirmed by spectroscopy studies (including NAP experiments), suggested an enhancement of the charge separation processes due to the electron scavenging ability of the plasmonic metal NPs[2-3].

References

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