MW-assisted Pt@C_3N_4/TiO_2 composites for glycerol photoreforming for H_2 production

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Significance and Relevance

Nowadays, hydrogen is considered as one of the most promising energy carriers and studies for green production are increasing in scientific literature. Glycerol photoreforming represents one of the greenest methods to produce hydrogen due to the use of both, a photocatalytic method, and glycerol as biomass-derived material. As known, TiO_2 is the most widely used photocatalyst, and to improve its use under visible light C_3N_4/TiO_2 composites are studied by using a MW-assisted procedure. The effectiveness of the MW is evident not only for its low-energy impact methodology but also for its effect on the morphology of the synthetized materials.

Preferred and 2nd choice for the topic: 1) H_2 storage and transportation, green H_2 production, hydrogen vectors, 2) Photocatalysis and photoelectrocatalytic approaches, solar energy utilization

Preferred presentation: Poster /Short Oral

Introduction and Motivations

Hydrogen and its generation through renewable raw materials are at the heart of the energy transition. Nowadays, hydrogen is often produced by using fossil fuels as starting materials. For this reason, the development of sustainable processes is an increasingly priority goal. In this context, glycerol photo-reforming for hydrogen production represents one of the greenest methods.[1] In fact, glycerol is, a biomass-derived material and photocatalysis is considered one of the most attractive ways to convert solar energy into usable chemicals. TiO_2 is, nowadays, the most used photocatalyst due to its efficiency, safety and affordability. Its principal drawbacks are its limited absorption to UV radiation and fast electron-hole pair recombination. C_3N_4 is a semiconductor that presents a narrower bandgap (2.7-2.8eV) than TiO_2 (3.2eV) so the corresponding C_3N_4/TiO_2 composites are able to extend the absorption to the visible light range. In a previous paper, the composites were produced in two different steps forming C_3N_4 on commercial TiO_2 P25. Here, with the aim to optimize and to make the process more sustainable, one-pot MW-assisted procedure is studied. C_3N_4/TiO_2 composites were thus prepared in only one step from melamine and Ti(iOPr)$_4$ precursor. The effectiveness of the MW is evident not only for its low-energy impact methodology but also for its effect in the morphology of the synthetized materials. Finally, Pt was deposited and tested as Pt@C_3N_4/TiO_2 composites for hydrogen photoproduction through glycerol photoreforming.

Materials and Methods

Here, an example of the synthesis of MW-assisted Pt@C_3N_4/TiO_2 materials is reported.

To obtain the heterojunction between titania and carbon nitride, melamine was dissolved in distilled water prior to adding titanium (IV) isopropoxide dropwise. The amounts were chosen to have a melamine: titania (w/w) ratio of 5. According to the MW-assisted procedure the solution was introduced in a microwave at 180 W for 20 cycles (on for 15 s and off for 20 s). Finally, the solid was filtered, washed with distilled water and dried. The solid was calcined at 550 °C for 1 h in a semi-closed system and denoted as MW_TiO_2CN. Pt@C_3N_4/TiO_2 was prepared by wetness impregnation. Briefly, the appropriate amount of $PtCl_2$ so as to incorporate 1 wt.% of platinum was added to 0.5 g of each catalyst and the solid was calcined at 350 °C for 3 h.

Results and Discussion

Different titania-based photocatalysts were prepared by conventional or MW-assisted methodology[2-3] and compared as catalysts for hydrogen production through glycerol photoreforming. Carbon nitride was added, already prepared or in a one-pot procedure to improve the use of these systems under visible light. According to the design of this study, it is possible to compare the synthetic procedure (conventional/MW), if it has been carried out as a one-pot procedure or in two steps, and the influence of C_3N_4 in the systems. In all cases, Pt was impregnated onto the solids. All materials were well characterized by means of XRD, ICP-MS, N_2 adsorption-desorption, TGA/DSC, XPS, IR, and UV-Vis spectroscopy. From preliminary tests, microwave-synthesized solids show a lower bandgap value than conventional ones, which could improve their photocatalytic efficiency under visible light. Moreover, the influence of the microwave-assisted procedure seems evident also in hydrogen production and the results can be ascribed to the different crystallinity and surface area of MW materials.

References

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