Fuel 181 (2016) 670–679

Contents lists available at ScienceDirect

Fuel

journal homepage: www.elsevier.com/locate/fuel

Full Length Article

Enhanced photocatalytic activity for hydrogen evolution of $SrZrO_3$ modified with earth abundant metal oxides (MO, M = Cu, Ni, Fe, Co)

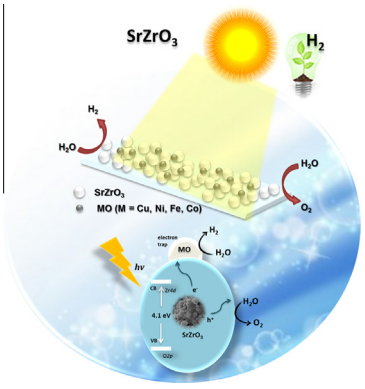
A.M. Huerta-Flores [a], Leticia M. Torres-Martínez [b,*], Edgar Moctezuma [a], O. Ceballos-Sanchez [c]

[a] Facultad de Ciencias Químicas, Universidad Autónoma de San Luis Potosí, Av. Manuel Nava #6, San Luis Potosí, S.L.P. 78290, Mexico
[b] Universidad Autónoma de Nuevo León, UANL, Facultad de Ingeniería Civil, Departamento de Ecomateriales y Energía, Av. Universidad S/N Ciudad Universitaria, San Nicolás de los Garza, Nuevo León C.P. 66455, Mexico
[c] CONACYT Research Fellow-Universidad Autónoma de Nuevo León, UANL, Facultad de Ingeniería Civil, Departamento de Ecomateriales y Energía, Av. Universidad S/N Ciudad Universitaria, San Nicolás de los Garza, Nuevo León, C.P. 66455, Mexico

HIGHLIGHTS

- $SrZrO_3$ photocatalysts catalyzed hydrogen evolution under UV light.
- $SrZrO_3$ photocatalytic activity was improved by co-catalysts addition.
- Best catalytic activity was exhibited by $SrZrO_3$ modified with CuO.
- Charge separation mechanism in $SrZrO_3$–CuO interface is discussed.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 13 March 2016
Received in revised form 3 May 2016
Accepted 3 May 2016
Available online 17 May 2016

Keywords:
$SrZrO_3$
Impregnation
Earth abundant co-catalysts
Hydrogen evolution

ABSTRACT

In this work, we report the photocatalytic activity of a $SrZrO_3$ semiconductor modified with earth abundant metal oxides as co-catalysts (MO, M = Cu, Ni, Fe, Co) dispersed by the impregnation method for hydrogen evolution from pure water. $SrZrO_3$ powders are prepared by traditional solid-state synthesis at 1100 °C by 24 h and then modified by the dispersion of different amounts (0.5%, 1%, 2% and 5%) of metal oxide nanoparticles at 400 °C. The structural, morphological, optical and textural properties of the modified powders were studied by X-ray diffraction (XRD), scanning electron microscopy (SEM), diffuse reflectance spectroscopy (DRS) and the Brunauer–Emmet–Teller (BET) method. The evaluation of the powders as photocatalysts for hydrogen evolution from pure water under UV light is presented, and the effect of loading metal oxide nanoparticles on the photocatalytic activity is discussed. The results confirm that the activity of the $SrZrO_3$ photocatalyst is increased by metal oxide particle loading, which promotes charge separation and higher photocatalytic efficiency. The best activity (1165 μmol g^{-1} h^{-1}) was obtained by 1% CuO loading, corresponding to an increase of 28 times the activity of pure $SrZrO_3$.

1. Introduction

The use of solar energy for the photocatalytic conversion of water into hydrogen and oxygen is a desirable option for the development of new and clean fuel sources. Semiconductor

* Corresponding author.
E-mail address: lettorresg@yahoo.com (L.M. Torres-Martínez).

http://dx.doi.org/10.1016/j.fuel.2016.05.025
0016-2361/

Fig. 1. Dispersion of metal oxide particles MO (M = Cu, Ni, Fe, Co) on $SrZrO_3$ (SZO) by the impregnation method.

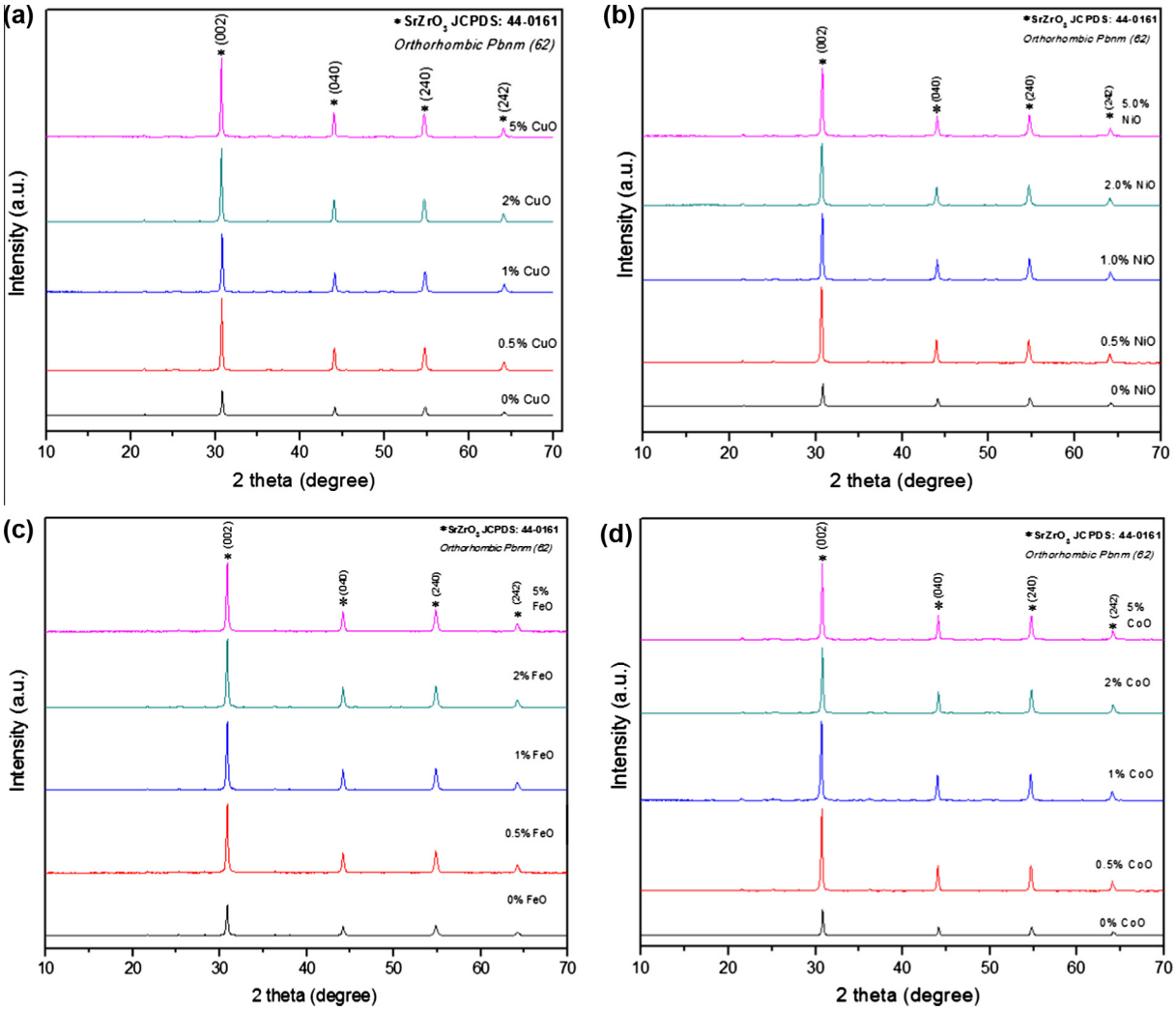


Fig. 2. XRD patterns of $SrZrO_3$ modified with metal oxide particles: (a) M = Cu, (b) M = Ni, (c) M = Fe and (d) M = Co.

oxides have shown promising performance in photocatalytic processes with the possibility of optimizing their properties through the design of their crystal and electronic band structures to achieve the required potential for the overall water splitting reaction. However, they usually have large band gaps that make them active only under UV light [1]. Photocatalysts with the ability to utilize visible light and suitable band structures are needed for the water splitting reaction. The overall photocatalytic process involves the absorption of light with an energy equivalent to or greater than the band gap of the semiconductor to generate