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Photo-electrocatalytic valorization of glycerol to glyceraldehyde by WO3-based materials

AUTHORS

Jie YU / IRCELYON, 2 AVENUE ALBERT EINSTEIN, VILLEURBANNE
Chantal GUILLARD / IRCELYON, 2 AVENUE ALBERT EINSTEIN, VILLEURBANNE
Frederic DAPPOZZE / IRCELYON, 2 AVENUE ALBERT EINSTEIN, VILLEURBANNE
Philippe VERNOUX / IRCELYON, 2 AVENUE ALBERT EINSTEIN, VILLEURBANNE
Angel CARAVACA / IRCELYON, 2 AVENUE ALBERT EINSTEIN, VILLEURBANNE

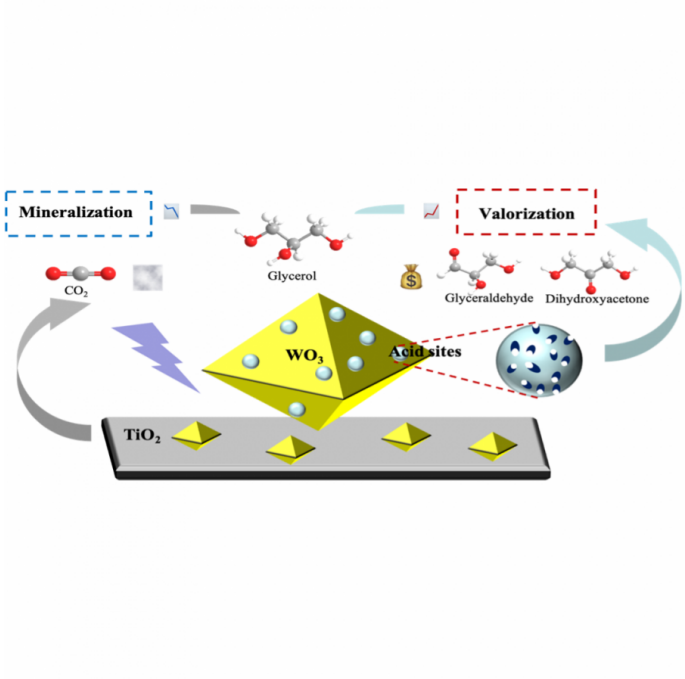
PURPOSE OF THE ABSTRACT

Biodiesel is a renewable, biodegradable, non-toxic, low-sulfur fuel, and its performance is quite similar to fossil fuel diesel, so it can be used as a clean and renewable energy alternative to fossil fuels. In the practical production process of biodiesel, around 0.1 tons of by-product glycerol will be generated followed by the fabrication of 1 ton of biodiesel. [1] A feasible way to avoid resource waste is to convert glycerol into more valuable chemical products, which can create good economic benefits and cater to the global low-carbon and energy-saving environmental protection needs by avoiding direct burning of crude glycerol. [2] Photocatalysis is considered a green and energy-saving technology that utilizes light to generate charge carriers and active species to activate the target molecules. [3]

In this study, the performance of WO3-based catalysts for the selective photooxidation of glycerol towards glyceraldehyde was obtained. By comparing the activity of pure TiO2 (Anatase, Rutile, and P25) and pure WO3 (prepared by a simple hydrothermal method), it is found that: i) TiO2 catalysts allowed for a higher overall conversion of glycerol, where the selectivity to glyceraldehyde was limited by its further photooxidation, and ii) WO3 catalyst exhibits slower kinetics for glycerol oxidation but shows an outstanding selectivity (29%) and yield (13%) of glyceraldehyde. While the activity of TiO2 was attributed to electronic effects (better separation of photogenerated charge carriers), the high glyceraldehyde selectivity of WO3 was linked to its enhanced acidity, which selectively activates C-O bonds in glycerol, and facilitates the desorption of glyceraldehyde (avoiding its further photooxidation) (Figure 1). Hence, a commercial WO3/TiO2 material (DTW5) was proven to combine the best features of both semiconductors, with high levels of glycerol conversion and selectivity (19%) to glyceraldehyde. [4] This study opens a new field dealing with the development of advanced photocatalytic materials to valorize glycerol into high added-value products.

Furthermore, an external voltage was introduced to construct a photoelectrocatalytic glycerol conversion system. DTW5 and post-treatment WO3 was coated on ITO glass as working electrodes. It is found that, compared with the pure photocatalytic system, the applied potential can greatly promote the separation of photogenerated electrons and holes, which greatly improves the production of the target product glyceraldehyde (Figure 2). This research realizes glycerol resource utilization and hydrogen production under mild conditions, which will help change the existing energy structure and contribute to achieving carbon neutrality.

FIGURES



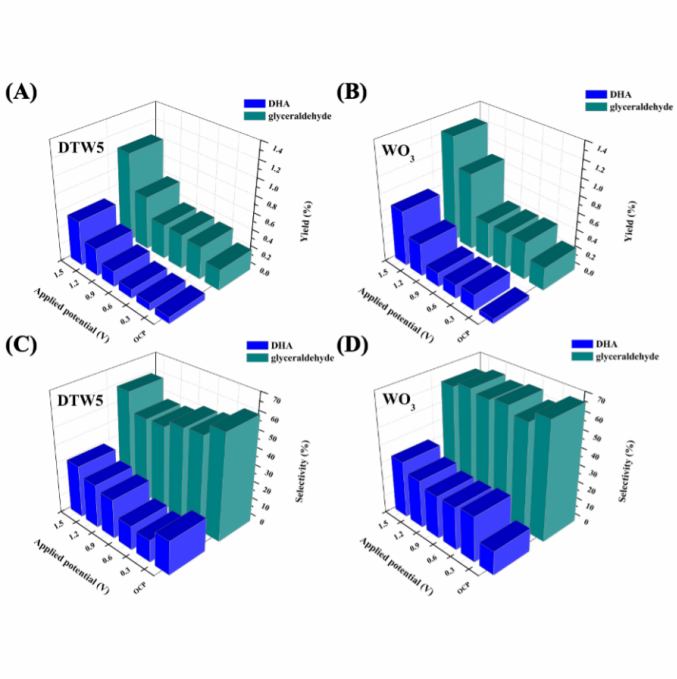


FIGURE 1

Figure 1

Comparison of TiO2 based- and WO3-based catalysts

FIGURE 2

Figure 2

Variation of (a-b) the yield and (c-d) the selectivity of glyceraldehyde and DHA on DTW5 and WO3 catalysts as a function of the applied potential in the photoelectrocatalytic tests as well as in the photocatalytic test (denoted as open circuit potential,

KEYWORDS

photoelectrocatalysis | glycerol valorization | WO3 | biomass conversion

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