Evaluation of Hydrogen Photocatalytic Production Parameters using TiO_2 doped with platinum under low-intensity radiation

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Introduction

- The exponential exploitation of fossil fuel reserves and the problems induced by climate change demand that we find new alternatives to fossil fuels [1].
- Hydrogen (H_2) is a carbon-free gas with high energy density, considered an ideal fuel candidate for decarbonization [2].
- With the use of abundant and renewable resources, such as biomass residues and sunlight, heterogeneous photocatalysis emerges as a green technology.
- The photocatalytic process is considered a promising method of converting solar energy into usable chemical energy, enabling the production of H_2 from renewable sources [3].
- In photocatalysis, a catalyst, usually a semi-conductor, is susceptible to excitation by an electromagnetic radiation source, where surface reactions lead to the conversion of an adsorbed substrate, which may have H_2 as a product [4].
- In this study, the process variables were evaluated: pH and concentrations of the sacrificial agent (glycerol), catalyst, and dopant (platinum), in a photocatalytic reactor with a system developed for multiple simultaneous reactions.

Methods

- The developed photocatalytic reactor (Fig. 1) allows up to eight reactions individually, with similar incident light intensity and agitation speed between the reaction flasks.
- The reaction compartment has a symmetric radial disposition of the reaction flasks (43 ml), with a low-intensity light irradiation source (70W halogen lamp) in the center, which is cooled by a fan-cooler.

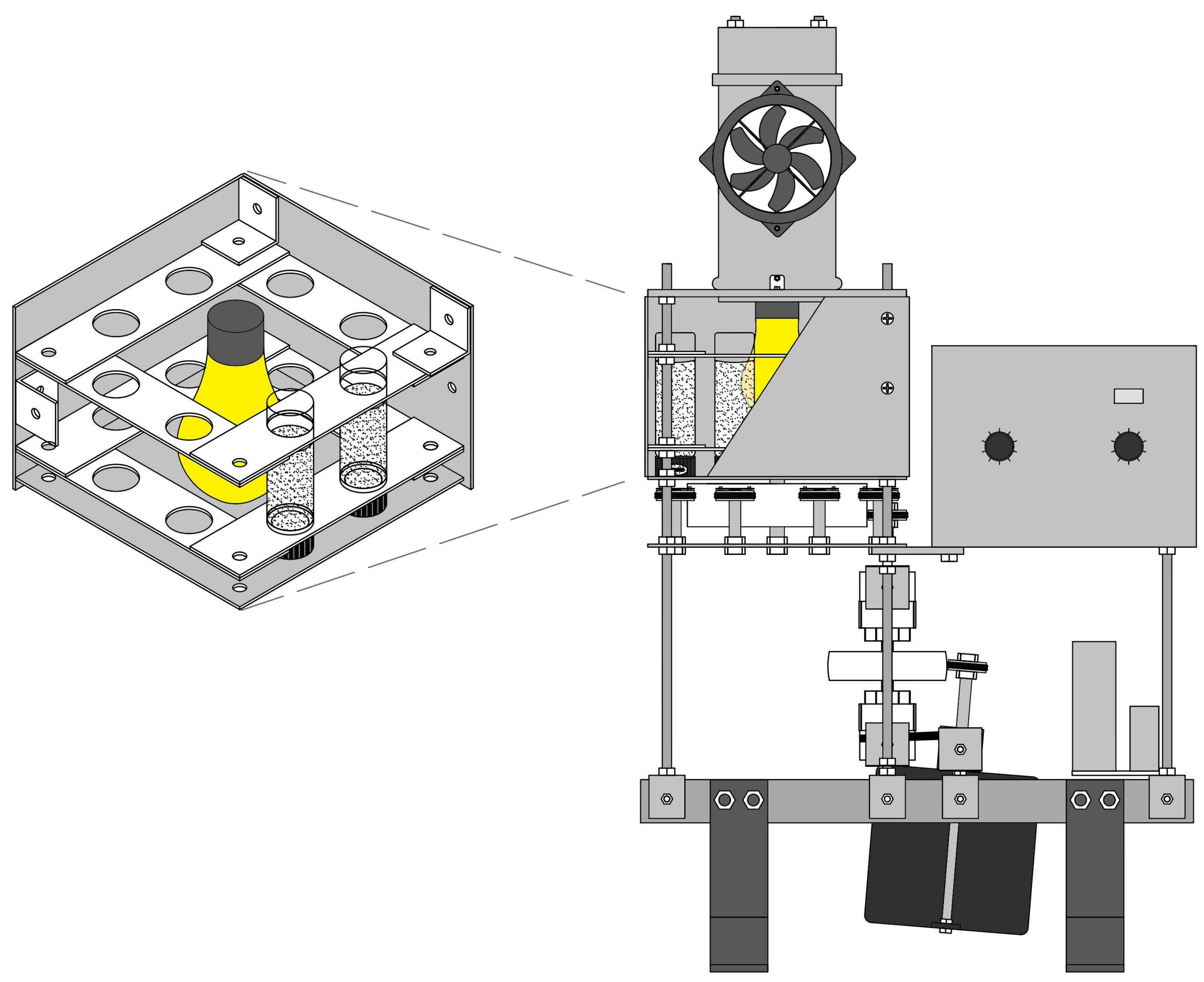

Figure 1 - Multiple simultaneous reaction photocatalytic reactor

- Glycerol was used as a sacrificial agent, being considered a biomass residue derived from biodiesel production [5].
- The photocatalysts were produced from photodeposition of different dosages of platinum onto titanium dioxide (TiO_2@Pt).
- The analysis of the variables was performed in a two-level (2k) factorial experimental design, as shown in Table 1.

Variables	Variable level		
	-1	0	1
[Gly] (% v/v)	5.0	12.5	20
[Cat] ($g.L^{-1}$)	0.1	0.3	0.5
$[Pt]_{\%}$	0.1	0.5	1.0
pH	2.0	6.0	10

Table 1 - Experimental planning variables and their values per level

Results

- Response surface methodology (RSM) was applied to indicate the condition with the highest photocatalytic performance.
- A maximum hydrogen production rate (HPR) of 1,005 μmol H_2 $.g^{-1}$ $.h^{-1}$ was obtained with concentrations of catalyst, platinum and glycerol in 0,1 $g.L^{-1}$, 1,0% (w / w), 5% (v / v), respectively, and pH 2.
- The catalyst concentration, the only significant variable in the process, has a negative correlation, that is, the lower its concentration, the greater the response in terms of HPR.

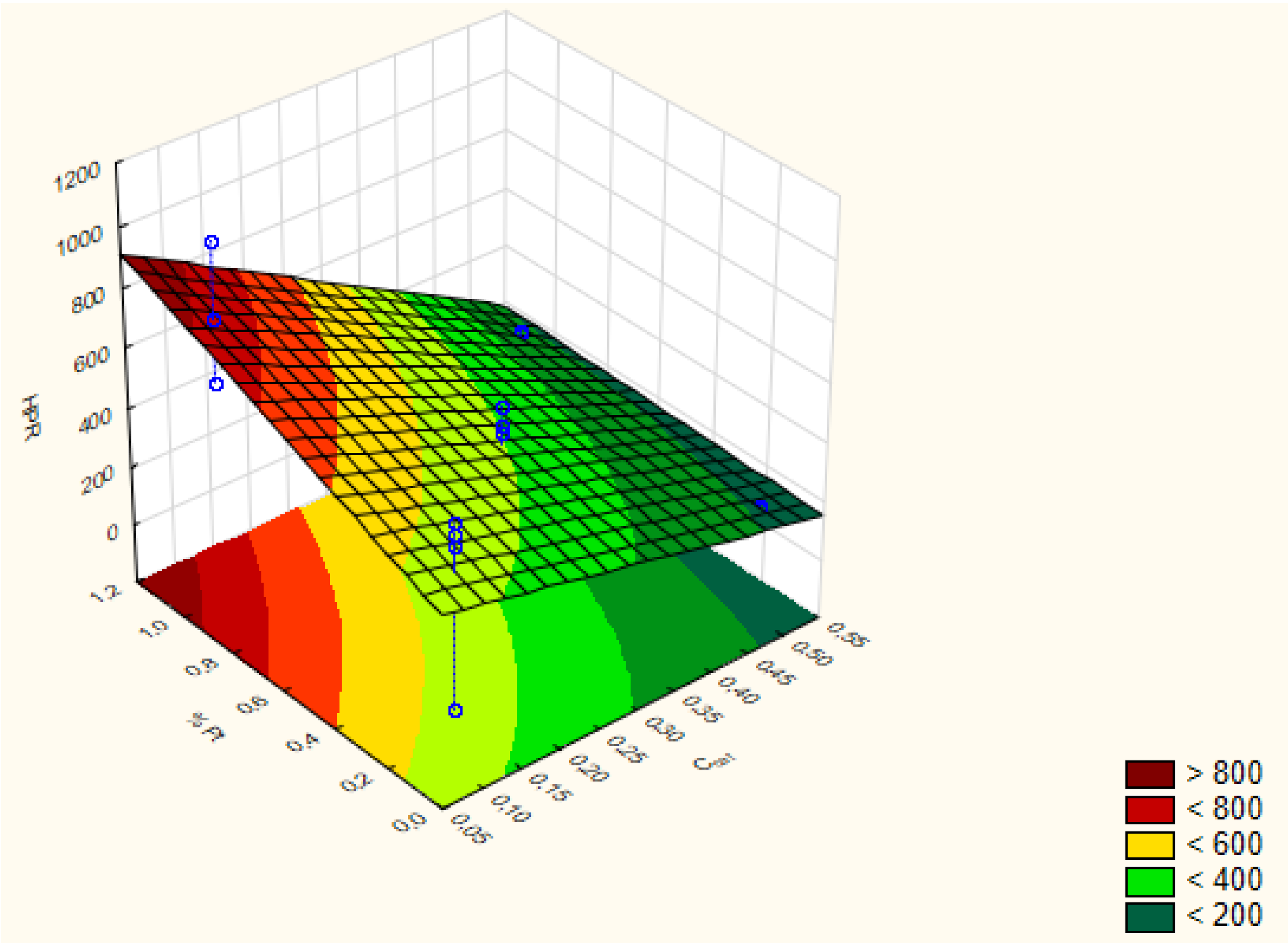

Figure 2 - Surface plot for [Cat] ($g.L^{-1}$) x $[Pt]_{\%}$ x HPR

Conclusions

- The developed reactor proved to be efficient in the experimental planning (reduction of almost 85% of the time needed with a usual reactor).
- The pH and [Gly] variables showed little influence on the HPR, being able to favor a large-scale process without the precise control of its conditions.
- The synthesized photocatalyst proved to be efficient under low-intensity visible radiation with high H_2 production performance even at low concentrations.

Bibliography

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