ISCRE25 FLORENCE 2018 BRIDGING SCIENCE & TECHNOLOGY
The 25th International Symposium on Chemical Reaction Engineering
20-23 May 2018 Florence, Italy www.aidic.it/iscre25

Packed bed photoreactor at semi-pilot scale for the removal of water pollutants using visible light emitting LEDs

Olga Sacco, Vincenzo Vaiano*

University of Salerno, Department of Industrial Engineering, Via Giovanni Paolo II, 132, Fisciano (Salerno)

**Corresponding author: vvaiano@unisa.it*

Highlights

- Packed bed photoreactor at semi-pilot scale was tested.
- The photoreactor was irradiated by visible light emitting LEDs.
- N-doped TiO_2 immobilized on polystyrene spheres was used as structured photocatalyst.
- The system was effective in the removal of different water pollutants.

1. Introduction

Actually, photocatalytic reactors configuration have been the objective of several papers but in most cases, suspended photocatalysts were used [1]. Alternative configuration for photocatalytic reactors is the packed-bed ones in order to avoid the separation of the photocatalyst from the treated water. With the use of light-emitting diodes (LEDs), the design of photoreactors has been significantly facilitated and the durability of the light source has been improved. Moreover by using a flexible LEDs strip as external light source, it is possible to use a simple cylindrical geometry for photoreactor, enhancing, in this way, the contact between the photocatalyst and the water to be treated. In this work, it was developed a packed bed photoreactor at semi-pilot scale using a visible light active structured photocatalyst. The packed bed reactor was irradiated by visible light emitting LEDs for the evaluation of photocatalytic activity in the removal of different types of water pollutants.

2. Methods

The experimental setup is shown in Figure 1. The packed-bed reactor has cylindrical geometry, made in pyrex glass and loaded with a visible light active structured photocatalyst (325 g). The visible light irradiation of photoreactor was realized surrounding the external surface with a LEDs strip (electrical power: 81.6 W) with an emission spectrum in the wavelength range from 400 to 800 nm. The visible light active structured photocatalyst is composed by N-doped TiO_2 particles supported on polystyrene spheres (mean diameter: 12mm) [2]. Methylene blue dye (MB) has been initially used as model pollutant with initial concentration equal to 7 mg/L. The MB concentration was measured by a UV–Vis spectrophotometer at λ = 663 nm. Additionally, mineralization of MB was evaluated in terms of total organic carbon (TOC).

3. Results and discussion

Under visible light irradiation, the system allowed to achieve the complete MB discoloration with TOC removal of about 85 % after 240 min of irradiation time. The kinetic evaluation has been performed using first order kinetics for MB photodegradation, considering plug- flow behavior inside the packed bed (Equation 1) and neglecting the external mass transfer phenomena. In order to verify this last hypothesis, the apparent kinetic constant was estimated from the data obtained when the photoreactor operated in continuous mode and at steady-state condition.

$$-\ln(1-X) = k \cdot \frac{W_{cat}}{Q_0} \qquad \text{Equation 1}$$

Where X is the MB conversion [-], k is the apparent kinetic constant [L g^{-1} min^{-1}], W_{cat} is the photocatalyst weight [g] and Q_0 is the liquid flow rate [L min^{-1}] in the range 6.3-74 mL min^{-1}. Figure 2 reports the behavior of $-ln(1-X)$ as a function of W_{cat}/Q_0 obtained for different liquid flow rate.

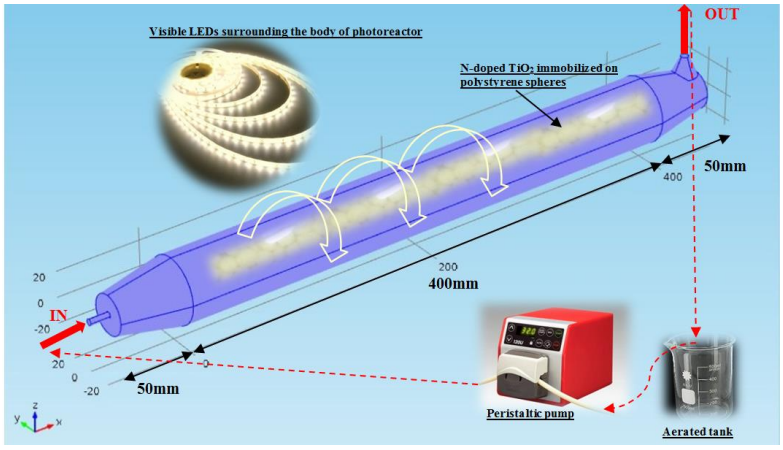

Figure 1. Experimental set-up with the packed-bed photoreactor at semi-pilot scale.

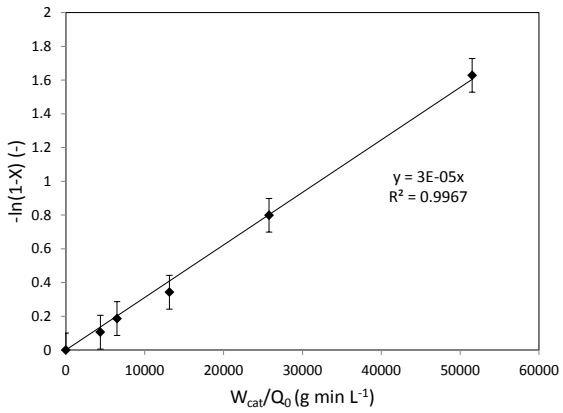

Figure 2. Kinetic evaluation for the packed-bed photoreactor operating in continuous mode; visible light intensity: 78 mW cm^{-2}

The slope of the obatined straight line is the value of *k*. It is worthwhile to note that this last result allows to confirm the hypothesis that external mass transfer phenomena can be neglected since all the experimental data as a function of W_{cat}/Q_0 can be described with only one value of *k*.

4. Conclusions

A packed-bed photoreactor at semi-pilot scale using a visible light active structured photocatalyst and irradiated by visible light emitting LEDs has been preliminarily tested in the removal of methylene blue dye under different operating conditions. The kinetic evaluations confirmed that external mass transfer phenomena can be neglected. The packed-bed photoreactor was also effective in the removal of water pollutants of emerging concern, such as ceftriaxone, paracetamol and caffeine.

References

[1] O.M. Alfano, D. Bahnemann, A.E. Cassano, R. Dillert, R. Goslich, Catal. Today, 58 (2000) 199-230.
[2] R. Ata, O. Sacco, V. Vaiano, L. Rizzo, G. Y.Torea, D. Sannino, J Photochem Photobiol A Chem., 348 (2017) 255-262

Keywords
Packed bed photoreactor at semi-pilot scale; visible LEDs; visible light active structured photocatalyst; water and wastewater treatment.