STUDY OF POLLUTANT PARTICLES STATUS OF COLORED TEXTILE WASTEWATER IN SEMI-BATCH OXIDATIVE REACTOR

M. Vafaee[1,2], M. E. Olya[2], J. Y. Drean[1], O. Harzallah[1], A. H. Hekmati[3]
[1]*Laboratoire de Physique et Mécanique Textiles (LPMT), Université de Haute-Alsace, Mulhouse, France.*
[2]*Department of environmental research, Institute for Color Science and Technology, Tehran, Iran.*
[3]*Department of textile engineering, Islamic Azad University, South Tehran Branch, Tehran, Iran.*
Corresponding author: maedeh.vafaee@uha.fr

ABSTRACT

The textile industries are known as one of the important source containing hazardous materials. Recently, different techniques (physical, chemical…) have been used for the wastewater treatment. Among of them, photocatalytic oxidation as an advanced oxidation process is a useful treatment for removal of the organic pollutants. According to the recent studies, it would be necessary to the choice of a photoreactor with high efficiency for wastewater treatment. Finding of the optimum parameters and flow regime inside the reactor are necessary to study the process efficiency. In addition, the hydrodynamics of a reactor can be characterized from the residence time distribution.

Key Words: WASTEWATER TREATMENT, PHOTOREACTOR, DYE REMOVAL

1. INTRODUCTION

Dyeing is one of the most effective and popular methods used for coloring textiles and other materials. Photocatalytic oxidation is an advanced oxidation process for removal of the organic pollutants. According to previous studies, it would be necessary to choice of a photoreactor with high efficiency for decolourisation of wastewaters [1-5]. In recent years, heterogeneous photoreactors are recognized for the effective and commonly reactor where the photocatalyst particles are presented inside them. Although having a simple design and high surface area for adsorption and reaction in slurry photoreactor, it has different disadvantages such as time consuming of separation or filtration of the solution, the agglomeration of the nanoparticles especially in high amounts, difficult recovery of photocatalysts and the problems to keep the nanoparticles amount in continues process. So, a fixed bed photoreactor or using the immobilized photocatalyst is recommended. Although using an immobilized photoreactor has the less efficiency compared to the suspension photoreactor for the same quantity of photocatalysts due to decreasing the photocatalyst surfaces. Considering the different design of photoreactors, the flat plate geometry has been investigated to maximize the UV light irradiation [6,7]. In this respect finding the optimal design needs a deep study starting from fluid dynamic considerations, together with the evaluation of the light's distribution inside the reactor core.

2. MATERIALS AND METHOD

In the present research, the synthesized nanophotocatalysts have been combined with polymers via electrospinning method to prepare a fixed bed photoreactor for dye removal of colored wastewaters. Acid Red 18 (AR18, commercial name: Ponceau 4R), which is used in coloration process of textiles was purchased from Alvan Sabet Co. (Iran) for the present research as a sample of synthetic azo dyes. Degradation process under UV irradiation was carried out on the semi-batch circulation stainless steel photo reactor. The applied photoreactor is consist of 500 g reservoir, circulation pump, low pressure mercury UV lamp with 6 Watts electrical power that emitted light at 254 nm, and a vertical cylinder.

2.1 EXPRIMENTAL RESULTS AND DISCUSSION

The dye solution was circulated between two vertical cylinders that the inlet and outlet tube are made of Quartz and Pyrex, respectively. The evolution of Electical conductivity using NaCl solution at the outlet of the reactor c (ts) makes it possible to know the experimental RTD. The variation of the tracer concentration at the outlet of the reactor was studied using a conductimetric probe. 2 mL of the NaCl solution (250 g.L^{-1}) was injected at the reactor inlet, to determine the RTD for a very short time, so as not to disturb the flow regime, the signal obtained at the probe output, at each instant t, is amplified, converted into a digital value and recorded. The output signal is proportional to the concentration of NaCl, c (ts). By comparing figures a and b (Villermaux, 1982) it is clear that the RTD functions of our reactor are introduced of the other reactor behavior and it is clear that the RTD functions of our reactor are not introduced as a simple piston or ideal reactor and it could be simulated as a complex

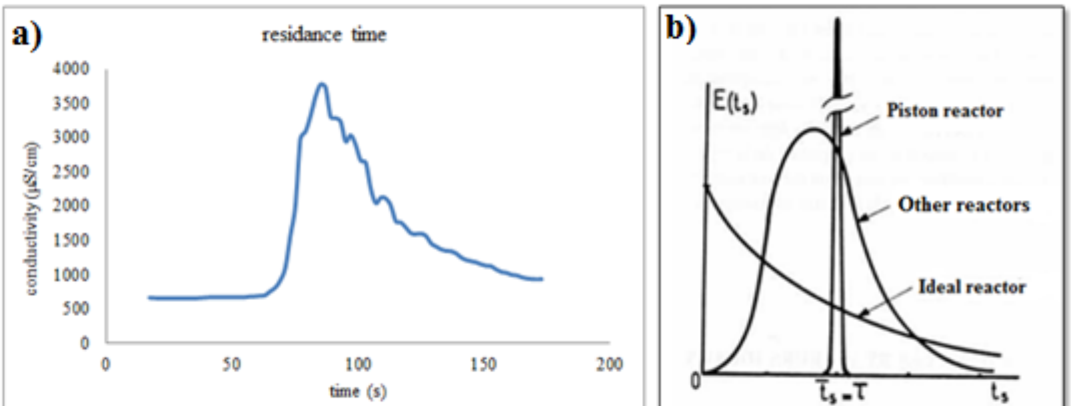

Figure1. RTD curve (a) and RTD schematic of different reactor types (b)

reactor.

.

$$C(t_s) = \frac{c(t_s)}{c_0} \tag{1}$$

One of the most important parameters in the reactor is Bernoulli's effect. This effect shows the lowering of fluid pressure in regions where the flow velocity increased. The principal energy equation is expressed as follow:

$$P_1 + \frac{1}{2}\rho V_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho V_2^2 + \rho g h_2 - W_{pump} \tag{2}$$

Where; the variable of P, V and h refer to the pressure, speed and height of the fluid and W is the power of used pump in the process. After calculation of the pressure inside the reactor, the force flowing through the nanofiber was obtained and shown in table 1.

Table1: Calculation of the flow parameters in the photo reactor

P_{atm} (MPa)	Δh (m)	W_{pump} (W)	Fluid head (L.min^{-1})	P_2 (MPa)

1.01	0.16	4	4	1.07

To evaluate the best efficiency, it is also important to determine the optimum parameters inside the reactor. Finding of the flow regime (laminar, transient or turbulent) of the solution in the reactors is necessary to study the process efficiency. To characterize it, the Reynolds number which represents the ratio between inertial resistance and the viscous resistance has been calculated as follows:

$$Re = \rho u d_h / \mu \qquad (3)$$

Where ρ is density of the fluid ($kg.m^{-3}$), u: velocity of the fluid ($m.s^{-1}$), d_h: the hydraulic diameter (m) and μ: the dynamic viscosity of the fluid (Pa.s). The velocity of the fluid can be determined from the flowing fluid, the reactor volume and the reactor height as:

$$\tau = V_r / Q \quad , u = 1/\tau \qquad (4)$$

τ: resistance time (s)
Q: debit of fluid (m^3 / s),
V_r: the reactor volume (m^3),
l: the reactor height (m)
According to the above equations, the results were presented in table 2.

Table2: The Reynolds number value for the photoreactor

L reactor (m)	t (min)	V($m.min^{-1}$)	τ(min)	Debbie ($L.min^{-1}$)	Reynolds number
0.2	0.4	0.5	0.4	0.48	415

According to the obtained results, laminar flow was detected the flow regime inside the reactor and these other results confirmed the ability of the reactor used for treatment of the organic pollution with a high efficiency and also, could be a method to know the mechanical behavior of the pollutant particles.

3. REFERENCES

1. S.Mohammadzadeh, M.E.Olya, A.M.Arabi, A.Shariati, M.R.Khosravi Nikou, Synthesis, characterization and application of ZnO-Ag as a nanophotocatalyst for organic compounds degradation, mechanism and economic study, *Journal of Environmental Sciences*, 2015, Vol 35, 194-207.

2. Mohsen Haji beygi, Meisam Shabanian, Mehrdad Omidi-Ghallemohamadi, Hossein Ali Khonakdar, Optical, thermal and combustion properties of self-colored polyamide nanocomposites reinforced with azo dye surface modified ZnO nanoparticles; *Applied Surface Science*, 2017, Vol 416, 628-638.

3. N.R. Neti, G.R. Parmar, S. Bakardjieva, J. Subrt, Thick film titania on glass supports for vapour phase photocatalytic degradation of toluene, acetone, and ethanol, *Journal of chemical engineering*, 2010, Vol 163, 219-229

4. W. Wang, Y. Ni, C. Lu, Z. Xu, Hydrogenation temperature related inner structures and visible-light-driven photocatalysis of N-F co-doped TiO_2 nanosheets, *Applied surface science*, 2014, Vol 290, 125-130.

5. Lin, C. C., & Wu, M. S., Feasibility of using UV/H_2O_2 process to degrade sulfamethazine in aqueous solutions in a large photoreactor, *Journal of Photochemistry and Photobiology A: Chemistry*, 2018, Vol 367, 446-451.

6. L. S., Roselin, G. R. Rajarajeswari, R, Selvin, V. Sadasivam, B. Sivasankar, & K. Rengaraj, Sunlight/ZnO-mediated photocatalytic degradation of reactive red 22 using thin film flatbed flow photoreactor. *Solar Energy*, 2002, 73(4), 281-285.

7. Gade, R., Ahemed, J., Yanapu, K. L., Abate, S. Y., Tao, Y. T., & Pola, S., Photodegradation of organic dyes and industrial wastewater in the presence of layer-type perovskite materials under visible light irradiation. *Journal of environmental chemical engineering*, 2018, 6(4), 4504-4513.