Indoor Biological Air Pollutants Removal by Photocatalysis

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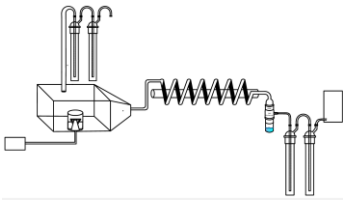

Indoor air quality (IAQ) is crucial for the health and comfort of occupants1, however, the lack of modification for air risk in the design and construction of modern buildings combined with factors such as humidity, results in poor indoor air quality by increasing the concentration of biological contaminants such as bacteria, viruses and other pathogens that trigger health problems2. In order to provide pathogen-free enclosed spaces, Advanced Oxidation Processes (AOP) have become a relevant research topic. In this work, an aerosolization system was developed with a quartz photoreactor containing ZnO/Zeolite and irradiated with UV. The results show that the system had an efficiency in the inactivation of 61.86% for *Lactobacillus casei*.

Introduction

Biological pollutants stand out as major contributors to indoor air quality and play an important role in the transmission of airborne pathogens3.
WHO declared the COVID 19 as a pandemic in March 2020. COVID 19 has three major routes of spread: droplets expelled during respiratory activities, fomites and aerosols. Aerosols represent a potential hazard in the process of covid 19 infection. Not only COVID 19 is transmitted by aerosols, but also bacteria or other viruses of importance, such as *Klebsiella pneumoniae*, *Streptococcus pneumoniae*, *Escherichia coli*, Influenza H1N1, etc., which cause significant illnesses in humans. This scenario has generated the urgent need to provide enclosed spaces that guarantee zero risk of pathogen transmission, that are economical and that allow occupancy during disinfection. AOP generates high concentrations of OH° hydroxyl radical, and is positioned as a viable mechanism to achieve viral and bacterial inactivation4. The present work aims to inactivate pathogens present in bioaerosols by means of ZnO/Zeolite placed in a photoreactor that is irradiated with UV light at low residence times to maintain a contagion-free environment and reduce the risk of infection indoors.

Material and Methods

1. An aerosolization system was designed consisting of: bioaerosol generation, closed space simulation chamber, inactivation system, aerosol capture and safety filter.
2. In order to determine the risk of infection, the model described by Gammaitoni and Nucci (1997) and the Wells-Riley equation (Riley et al.,1978) were used, based on the flow rate and droplet size generated by the nebulizer5
3. To carry out the heterogeneous photocatalysis process, zinc oxide particles deposited on zeolite were synthesized by the functionalization method, which was carried out according to the process proposed by Xia. & Tang (2003)6. The particles were characterized by XRD diffraction.
4. To evaluate the performance of the photobioreactor on the inactivation of the biological agents present in the aerosols, a 70 mL, 19 x 5 cm tubular spiral reactor was used, which was irradiated with an 8 W, 254 nm.

Results and Discussion

From the volumetric balance of purge and reactor feed, the 2.9 L aerosolization chamber was sized,as shown in Figure 1. With this volume, the risk

percentage was calculated above-mentioned mathematical model, which was 100%.

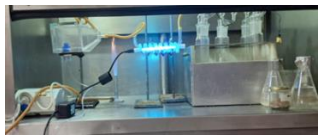

Figure 1. ZnO/Zeolite Inactivation System

Two tests were performed: methyl orange (1.6g/L) and *Lactobacillus casei* to obtain their elimination efficiency, with a residence time of 0.47 s. Four systems were established to evaluate efficiency, which are shown in Table 1. We obtained similar efficiencies in both tests, being the highest in system 4. The results obtained were compared with data reported in the literature, which are shown in Table 2; They inactivated MS2 virus at low residence times (0.125 s) with a 11 W lamp power, obtaining a removal efficiency of 48 % . In our experimentation, the highest efficiency was 56.4% for Methyl orange (MO), and 61.8% for *Lactobacillus casei* (*LC*) with a residence time of 0.47 s and using a power of 8 W.

Table 1. AM and *LC* removal efficiencies

Test	Aim	Efficiency MO (%)	Efficiency *LC* (%)
Impaction system (without zeolite/ UV)	Evaluate the impaction system	28.03	24.48
UV impaction system	Evaluating the effect of UV light without substrate	28.05	37.73
Impaction system (with zeolite)	Evaluating the effect of ZnO/Zeolite	35.23	57.54
Impaction system (Zeolite + UV)	To evaluate the effect of heterogeneous photocatalysis.	56.46	61.86

Table 2. Efficiencies reported in literature (Jeonghyun Kim & Jaesung Jan, 2018).

Pollutant	Radiation	Residence time (s)	Wavelength (nm)	Power (W)	Efficiency (%)
MS2	UV	0.125	254	11	48
AM/ *LC*	UV	0.47	254	8	56.4/ 61.8

Conclusions

According to the data obtained and previously compared with the literature, we can mention that the proposed system has generated high efficiencies at low residence time. We reached 56.4 and 61.8 % for AM and *LC* respectively.

Acknowledgments

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