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Evaluation of a submerged membrane vis-LED photoreactor (sMPR) for carbamazepine degradation and TiO_2 separation

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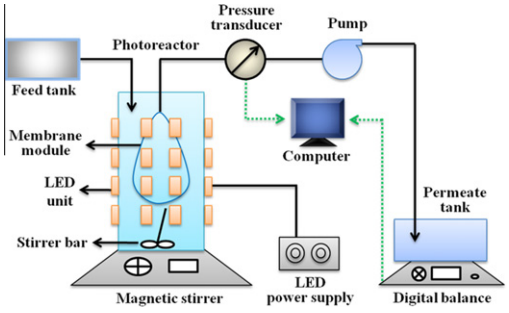
HIGHLIGHTS

- A hybrid sMPR system was investigated in a continuous flow-through mode.
- The carbamazepine degradation, TiO_2 separation and membrane fouling were evaluated.
- The long-term operation of the sMPR system was investigated.

GRAPHICAL ABSTRACT



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ABSTRACT

A hybrid submerged membrane photoreactor (sMPR) combining a photoreactor irradiated with visible-light-emitting diode (vis-LED) and a submerged hollow fiber PVDF microfiltration (MF) membrane module was investigated in a continuous flow-through mode. A global carbamazepine (CBZ) photocatalytic degradation rate constant at steady state was achieved at $(19.4 \pm 2.35) \times 10^{-3}$ min^{-1} with hydraulic residence times (HRTs) in the range of 30–300 min using a visible-light responsive C–N–S tridoped TiO_2 (T0.05-450). An alkaline pH condition was favorable for the CBZ photocatalytic degradation. The inhibitory effects of inorganic anions on the CBZ photocatalytic degradation followed the order of silica > phosphate > nitrate > bicarbonate > sulfate > chloride. The net effect of humic acid (HA) on the CBZ degradation depended on the three competitive phenomena: (i) HA as an electron shuttle promoting the generation of $\cdot O_2^-$ while reducing the electron–hole recombination, (ii) HA competing with CBZ for the active sites of the photocatalyst, and (iii) HA contributing to the light attenuation in the photoreactor. The MF membrane realized effective separation of T0.05-450 as the turbidity of permeate water was <0.1 NTU. A steady-state transmembrane pressure (TMP) was achieved after its increase in the first 2 h due to the deposition of TiO_2 cake layer on the membrane surface. NaOH (pH = 11) and 0.5 mM EDTA (pH = 11) solutions were efficient for cleaning the membrane surface fouled by HA. For the long-term operation of the sMPR system, the reduction of CBZ photocatalytic degradation efficiency could be attributed to the decrease of the photocatalyst dosage in the suspension, and the aggregation and deactivation of TiO_2 particles during the prolonged operation.

1. Introduction

Heterogeneous photocatalysis using UV-excited TiO_2 has appeared as a potentially cost-effective and environmentally-sustainable water treatment alternative for the removal of biorefractory

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