Title:

Novel V_2O_5-TiO_2 catalytic membrane reactor coupled with ozonation for the removal of micropollutants in aqueous environments

Authors & affiliations:

T. N. Tran[1], H. Tak[1], Y. Chung[1], C.Son[1], S. Kang[1]
[1]Korea Advanced Institute of Science and Technology (KAIST), Republic of Korea

Abstract:

The frequent detection of micropollutants (MPs) in wastewater treatment effluent poses a threat to ecosystems and human health. Recently, hybrid catalytically active membranes (CM) that incorporate advanced oxidation processes (AOPs) with membranes for simultaneous degradation of MPs and separation of pathogens have received great attention due to their high processability and cost-effectiveness for water treatment.

In this study, vanadium oxide-titanium dioxide composite (V_2O_5-TiO_2) integrated with a ceramic ultrafiltration membrane was fabricated via a pore filling and impregnation method as a novel CM (V_2O_5-TiO_2@CM) for the catalytic ozonation of di-2-ethylhexyl phthalate (DEHP) from aqueous environments.

Successful fabrication of V_2O_5-TiO_2@CM was confirmed with the assistance of modern characterization technologies. XRD analysis showed the deposited tetragonal rutile TiO_2 and orthorhombic V_2O_5 phases on the membrane surface. SEM/EDX images revealed that the V_2O_5-TiO_2 nanoparticles were evenly dispersed over the membrane surface and the inner pores. This is consistent with the decrease in the average membrane pore size from 157 nm to 103 nm after V_2O_5-TiO_2 doping, resulting in a reduction of membrane permeability by 56%. V_2O_5-TiO_2@CM coupled with ozonation exhibited excellent degradation of DEHP (95%) within 20 s under the reaction conditions of 500 µg/L DEHP, 2.0 mg/L ozone, at pH 7.0 and 23 ^oC. Furthermore, ozonation with V_2O_5-TiO_2@CM resulted in the mineralization of DEHP into CO_2 and H_2O up to 55% within 20 s through a ring-rupturing by abundant hydroxyl radicals ($^{\bullet}OH$) in the confined space of the membrane pores with micro or nano-scales.

Consequently, the results suggested that V_2O_5-TiO_2@CM coupled with ozonation can be a promising alternative for the degradation of micropollutants such as DEHP in water treatment processes.