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Photoelectrocatalytic degradation of 2,4-dichlorophenol in a TiO_2 nanotube-coated disc flow reactor (Article)

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Abstract

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Photoelectrocatalytic (PEC) water treatment is a promising technology for organic pollution abatement. Much of the prior research focused on material discovery and optimization. However, challenges exist in scaling-up PEC processes and are associated with designing reactors with effective light irradiation on electrode surfaces and, simultaneously, efficient electrode configurations. We design and demonstrate key reactor design principles, which influence reaction mechanisms, for a reactor using a TiO_2 nanotube-coated disc flow reactor. Degradation of organochlorinated 2,4-dichlorophenol was studied as representative carcinogenic micropollutant. The synergistic photoelectrocatalytic process showed 5-fold faster degradation kinetics than solely electrocatalytic treatment or a greater than 2-fold enhancement over photocatalysis alone. Applicability of photoelectrocatalytic treatment was demonstrated over a wide range of micropollutant concentrations with almost complete abatement even at concentrations up to 25 mg L^{-1} of 2,4-dichlorophenol. Mechanistically, the increase in applied current density efficiency for degradation of 2,4-dichlorophenol was due to stabilization of charge carriers and higher oxidants production rates in the PEC system. Carboxylic acids were identified as the main by-products formed from cleavage of the phenolic ring moieties in 2,4-dichlorophenol. However, very importantly we achieved dehalogenation photoelectrocatalysis with evidence of chlorine heteroatoms released as innocuous chloride anions. Overall, this research demonstrates the importance of PEC reactor design and how properly orientated TiO_2 nanotube-coated disc flow reactors leverage both novel material designs and reactor architectures to achieve pollutant degradation. © 2020 Elsevier Ltd

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Indexed keywords

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Engineering uncontrolled terms: 2 ,4-Dichlorophenol | Degradation kinetics | Electrode configurations | Photo-electrocatalysis | Photoelectrocatalytic | Photoelectrocatalytic degradation | Photoelectrocatalytic treatment | Pollutant degradation

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