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Gas phase photocatalytic spiral reactor for fast and efficient pollutant degradation

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Abstract

Photocatalytic reactors for the degradation of gaseous organic pollutants often suffer from major limitations such as small reaction area, sub-optimal irradiation conditions and thus limited reaction rate. In this work, an alternative solution is presented that involves a glass tube coated on the inside with (silver-modified) TiO_2 and spiraled around a UVA lamp. First, the spiral reactor is coated from the inside with TiO_2 using an experimentally verified procedure that is optimized toward UV light transmission. This procedure is kept as simple as possible and involves a single casting step of a 1 wt% suspension of TiO_2 in ethanol through the spiral. This results in a coated tube that absorbs nearly all incident UV light under the experimental conditions used. The optimized coated spiral reactor is then benchmarked to a conventional annular photoreactor of the same outer dimensions and total catalyst loading over a broad range of experimental conditions. Although residence time distribution experiments indicate slightly longer dwelling of molecules in the spiral reactor, no significant difference in by-passing of gas between the spiral reactor and the annular reactor can be claimed. Acetaldehyde degradation efficiency of 100% is obtained with the spiral reactor for a residence time as low as 60 s, whereas the annular reactor could not achieve full degradation even at 1000 s residence time. In a final case study, addition of long-term stable silver nanoparticles, protected by an ultra-thin polymer shell applied via the layer-by-layer (LbL) method, to the spiral