Immobilized zinc oxide (ZnO) photocatalysts, and their use in continuous-flow photo-reactors for wastewater treatment

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ABSTRACT

In spite of the progress achieved on the photo-catalysis during the last 20 years, particularly with reference to the destruction of a great variety of recalcitrant contaminants in water streams, there is still a gap of knowledge on the optimization of the performance of continuous-flow photo-reactors [1,2]. Zinc-oxide (ZnO) nanoparticles were immobilized on adequately pre-treated borosilicate glass spheres by immersing the spheres in an aqueous solution of zinc acetate dehydrate (ZnAc) under stirring at 80°C for 30 min, separating the spheres from the solution, calcinating them in an oven at 450°C for 2 hrs. The procedure was repeated several times to enhance the amount of ZnO photocatalyst deposited on the glass substrate. Batch experiments of the photocatalytic degradation of methylene blue (MB) were performed in a double-wall glass reactor by using as light source a UV-lamp of nominal power 6 W and emission peak at 365 nm. The residual MB concentration was measured with UV-Vis spectroscopy. Both the percentage of the photocatalyst that remains attached on the glass substrate, and the 1st order kinetic constant of the photocatalytic reaction rate were determined for several iterative cycles.

A cylindrical photo-reactor of diameter 5 cm and total height 20 cm was constructed from PMMA. In the middle of the reactor, an axisymmetric cylindrical PMMA case was placed to accommodate the UV-lamp, while the intermediate annular space was packed with ZnO-coated glass beads. With the aid of a peristaltic pump, the MB solution was fed, at constant flow rate (1-4 mL/min), in the bottom of reactor, while the effluent escaping from the top of the reactor was transferred into a continuously-stirred vessel through which the water stream was recycled toward the photo-reactor. Liquid samples were collected from the recycling vessel, at regular intervals, to measure the MB concentration as a function of time. A 1-dimensional dynamic mathematical model of the operation of the continuous flow system was developed by coupling the mass-transfer with reactive processes. The model was used for: (i) the estimation of photocatalytic reaction kinetics by fitting its numerical solution to transient experimental measurements; (ii) the design of experiments; (iii) the process scale-up.

REFERENCES

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