OC-5: Optimization of Oxidation Processes of Hydroquinone using Suction-Cavitation

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A lab-scale loop device for creating hydrodynamic cavitation was applied for hydroquinone (HQ) oxidation without addition of any chemical. The restriction orifice for creating suction-cavitation is fixed on the suction (inlet) side of pump. The degradation of HQ was found about 60% in 180 min. The application of suction rather than positive pressure hydrodynamic cavitation is suggested as energy efficient method. The effect of operation parameters (initial concentration, diameter of restriction) was also discussed. Under optimized conditions (suction-cavitation with hole diameter of orifice plate d=5 mm) the effect of cavitation in combination with oxidation by H_2O_2 was estimated. It is shown that suction - cavitation treatment accelerates hydroquinone oxidation by H_2O_2.

The most promising techniques for wastewater treatment are Advanced Oxidation Processes (AOPs) (Glaze, 1994; Carey, 1992). The AOPs represent a liquid phase radical chain oxidation of substrates by highly reactive •OH-radicals, which are suitable for the mineralisation of hazardous organic pollutants. Cavitation has been shown to be suitable for the production of •OH (Suslick, 1989; Arrojo et al., 2007). There are several theories of cavitation phenomena which are discussed controversially (Margulis, 1990.; LePoint and Millie, 1994). But generally believed that in the collapse phase high pressures and temperatures are generated leading to homolytic cleavage of water molecules (the theory of 'hot spot') (Suslick et al., 1986).

It is known that cavitation can be initiated by acoustic effect (ultrasound US) or through utilization of hydrodynamic phenomena. With the development of sonochemistry increasing importance has been attached to the chemical effects induced by hydrodynamic cavitation (HC) mostly due to it can be able to find application on an industrial scale as against US. Indeed combining HC with other oxidant processes is of great interest because of high synergistic effect (Chakinala et al., 2009). However, HC and the resulting chemical reactions are usually driven by extrusion under positive pressure (push), but little is known about the chemical consequences of HC created by suction (pull). Suction is the flow of a fluid into a partial vacuum, or region of low pressure (Wu et al., 2009).

This investigation was performed to observe the efficacy of hydrodynamic cavitation created by suction for oxidation of hydroquinone (HQ) to compare and optimize AOPs based on suction-cavitation.

At first hydrodynamic cavitational degradation of HQ was carried out in water without addition of other chemicals. Detectable effect of treatment was observed only with very low initial concentration of HQ (5 and 10 μM). As can be seen the degradation of HQ was found about 60 and 30 % with and without orifice plate respectively (Fig. 1). The former can be explained by cavitational influence of pump. With increasing initial concentration the conversion tend to decrease. In addition the degradation of HQ was carried out with various diameters of suction orifice. An optimum is clearly observed at 5 mm.

The energy efficiency assessment for bringing out the chemical transformation based on cavitation phenomenon is offered as unified criteria (Gogate et al., 2001). The electrical energy consumption was directly measured by an energy monitor. The comparison of conversion rates and energy efficiency at negative and positive pressure differential at cavitation under the same others conditions (loop design and volume) was carried out. The last is most important because the pressure pulse is strongly dependent on the design of device. As a result the use of suction – cavitation is suggested as more energy efficient. Under optimized conditions (suction-cavitation with hole diameter of orifice plate d=5 mm) the effect of cavitation in combination with oxidation by H_2O_2 was estimated. Some studies with combination of cavitation phenomena and convenient methods have already been published (Wu et al., 2011). Our results with hydrogen peroxide are reported in Fig. 2. Obviously, the treatment in suction-cavitation reactor can considarably enhance the degradation by H_2O_2.

Hydrodynamic cavitation driven by suction is a novel and interesting method for initiation cavitation effects in liquids with promissing possibilities for application as a base for hybrid methods of wastewater treatment, in particular as after treatment for oxidizing dilute aqueous mixtures of organic compounds. It is shown that suction - cavitation treatment accelerates hydroquinone oxidation by H_2O_2.

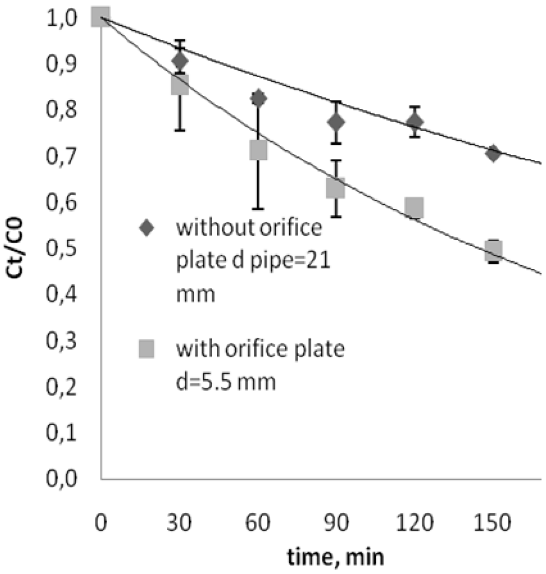

Figure 1 Influence of orifice plate on the degradation of HQ at suction-cavitation. C_0(HQ)= 5 µM, V=0.8 L, pH=5.5, t=25 ºC

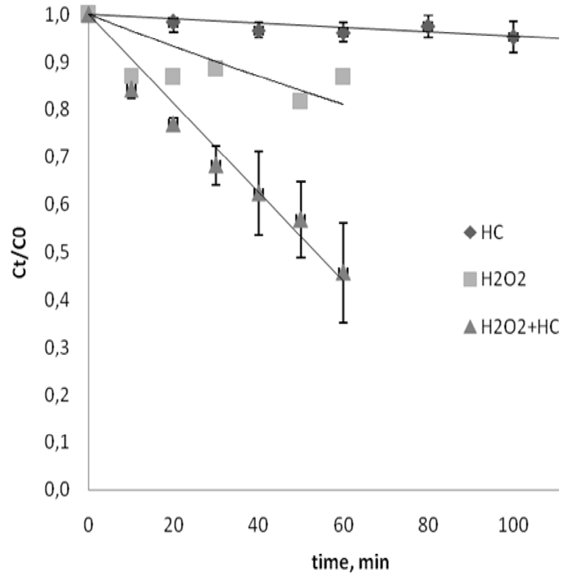

Figure 2 Enhancement of the oxidation HQ with H_2O_2 by suction-cavitation. C_0(HQ)= 0.1 mM, V=0.8 L, pH=5.5, t=25 ºC, P=88 kPa

Acknowledgements

This work was funded by the Ministry of Science and Technology of China as part of International scientific and technical cooperation program (2010DFB93700), the Federal Ministry of Education and Research of Germany (BMBF) as part of the International Cooperation in Education and Research (CHN09/013) and the German Academic Exchange Service (DAAD). We also thank C. Palik for carrying out the HPLC analyses.

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