P-48: Sonoelectrochemical Degradation of Phenol with High Frequency Ultrasound and Stainless Steel Electrode

Yan-Ze Ren[a], Zhi-Lin Wu[a,*], Marcus Franke[a], Patrick Braeutigam[a], Bernd Ondruschka[a,*]

[a] Institute for Technical Chemistry and Environmental Chemistry,
Friedrich-Schiller-University Jena, Lessingstr.12, 07743, Jena, Germany
** Corresponding author.*
Tel.: +49 3641 948400; Fax: +49 3641 948402.
E-mail address: bernd.ondruschka@uni-jena.de

Phenol is a common material and primary pollutant of various industries. It has been produced and used in many industries such as manufacture resins and plastics, petroleum refining, steel production, coal conversion, coal mines, byproducts of agricultural chemicals, dyestuff, textiles, tanning, fiberboard production, painting, pulp and paper, pesticides, pharmaceuticals and even from food processing industries (Entezari and Petrier, 2005, Mahamuni and Pandit, 2006). However, due to the toxicity and stability of the aromatic ring, the treatment of this pollutant group with traditional disposal methods is difficult.

Sonoelectrochemistry was defined as the field of research dealing with the influence of power ultrasound on electrochemical processes (Klima et al., 1995). It is concerned with couple power ultrasound to electrochemical systems to develop new processes and allow their measurement and quantification in combination with ultrasound associated reaction kinetics (Compton et al., 1997). The sonoelectrochemical remediation has some remarkable advantages, such as very mild reaction conditions, excellent mass transfer of reaction solutions and keeps the electrode activity during the process. Sonoelectrochemical treatments are able to treat toxic pollutants in a wide concentration range. Therefore, it is a safe and effective technology with only uses the electricity as reactant (Mason et al., 1990, Gonzalez-Garcia et al., 2010, Pollet et al., 2002).

In this investigation high frequency ultrasound (850 kHz), larger volume (400 mL) and low-cost electrode material (stainless steel) were used (Figure 1). 60% synergetic effect was obtained in the combined reaction system. A total degradation of phenol was achieved with Na_2SO_4 as electrolyte (concentration in solution: 4.26 g/L) and electrical voltage of 30 V at 25°C in 1 hour. The degradation of phenol follows the pseudo-first order of reaction.

Considering cost and application, the energy efficiency of the reaction system was evaluated (Figure 2). The degradation process is more energy efficient with high electrolyte concentration, high electric voltage and high initial concentration of phenol, based on the calculated energy efficiencies under different reaction conditions. Based on the results, the sonoelectrochemical system have great potential of scale up and industrial applications because of the simply structure, low-cost electrode and high energy efficiency for the treatment of high concentration of wastewater solutions.

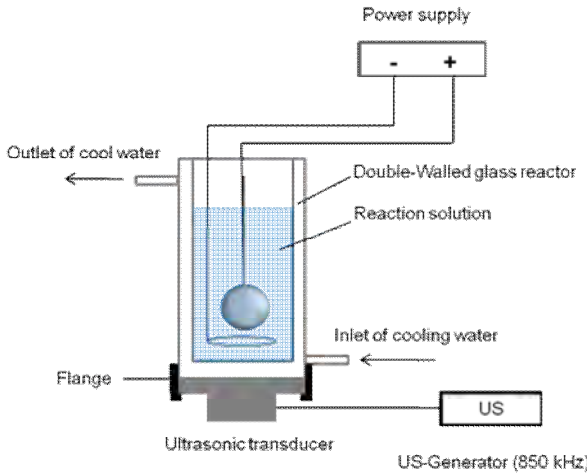

Figure 2: Scheme of the applied apparatuses for sonoelectrochemical processes

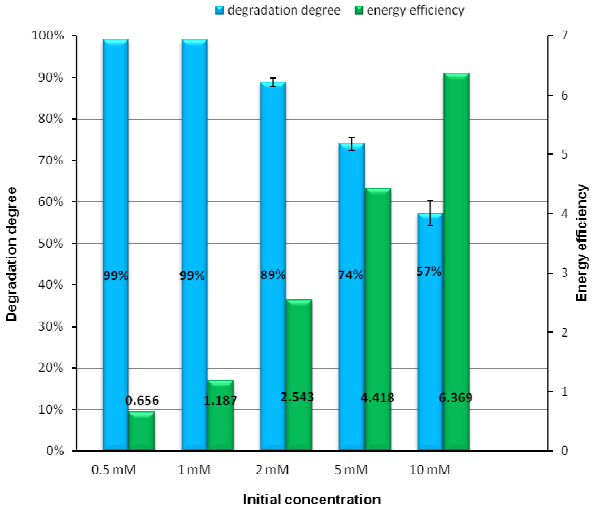

Figure 3: Degradation degrees and energy efficiencies with different initial concentrations (reaction conditions: 400 mL phenol solution (1 mmol/L); electrolyte: Na_2SO_4; electrolyte concentration in solution: 4.26 g/L; electric voltage: 30 V; stainless steel electrodes; US electric power: 170 W; reaction temperature: 25 °C; reaction time: 1 h)

References

Compton, R. G., Eklund, J. C. & Marken, F. 1997. Sonoelectrochemical processes: A review. *Electroanalysis*, 9, 509-522.

Entezari, M. H. & Petrier, C. 2005. A combination of ultrasound and oxidative enzyme: sono-enzyme degradation of phenols in a mixture. *Ultrasonics Sonochemistry*, 12, 283-288.

Gonzalez-Garcia, J., Esclapez, M. D., Bonete, P., Hernandez, Y. V., Garreton, L. G. & Saez, V. 2010. Current topics on sonoelectrochemistry. *Ultrasonics*, 50, 318-22.

Klima, J., Bernard, C. & Degrand, C. 1995. Sonoelectrochemistry: Transient cavitation in acetonitrile in the neighbourhood of a polarized electrode. *Journal of Electroanalytical Chemistry*, 399, 147-155.

Mahamuni, N. N. & Pandit, A. B. 2006. Effect of additives on ultrasonic degradation of phenol. *Ultrasonics Sonochemistry*, 13, 165-174.

Mason, T. J., Lorimer, J. P. & Walton, D. J. 1990. Sonoelectrochemistry. *Ultrasonics*, 28, 333-337.

Pollet, B. G., Lorimer, J. P., Hihn, J. Y., Phull, S. S., Mason, T. J. & Walton, D. J. 2002. The effect of ultrasound upon the oxidation of thiosulphate on stainless steel and platinum electrodes. *Ultrasonics Sonochemistry*, 9, 267-274.