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Sonoelectrochemical oxidation of Ibuprofen

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Introduction

Sonoelectrochemical system a combine process of ultra sound (US) and electrolysis (EC) is a promising and new advance oxidation process which can generate highly reactive and unstable hydroxyl radicals with high oxidation potential of 2.80V[1]. Till date, no research on ibuprofen oxidation using combined method of sonoelectro chemistry is reported. Besides, contradictory researches on lower and higher frequencies due to differences in mechanism have been claimed.

At high frequency, hydroxyl radicals are generated, which directly oxidize organic pollutants whereas at low frequency, mass transfer rates of electro-active species from the bulk solution to electrode surface as well as desorption/adsorption mechanisms are considerably accelerated[4]. In the present study, comparison of effects of ultrasonic high frequency (1000 kHz) and low frequency (35 kHz) on sonoelectrochemical oxidation of Ibuprofen has been investigated. Besides, ibuprofen oxidation using alkaline and acid supporting electrolytes at various system conditions is also studied.

Material Methods

2mg/L of 98% pure Ibuprofen (Sigma Aldrich) was prepared in distilled water. Fig. 1 shows the sono-electrochemical undivided cell consisting of 1L reactor with water jacket, a platinum anode, a stainless steel cathode and an ultrasonic cup horn type wave producer (Mirae UltrasonicTech.Co.,MX-15100).Sono-electrochemical experiments were performed potentiostatically with a constant voltage of 30V provided by power supply, PNCYS, EP-3010 (regulated DC Power supply) and 100 W/L ultrasonic power intensity. NaOH and H_2SO_4 were used as supporting electrolytes. Finally, the samples were analyzed using HPLC equipped with UV detector (Agilent Technologies 1260 infinity).

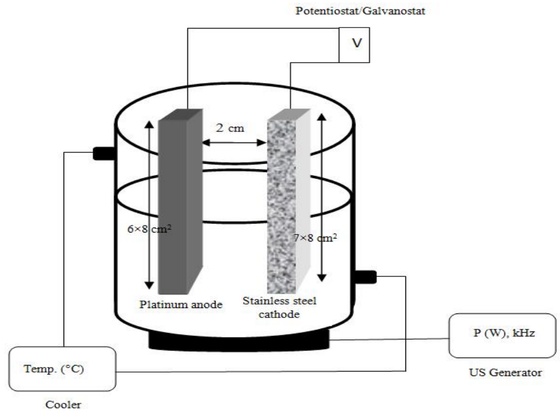

Fig.1 Experimental Setup of a Batch Reactor.

Results and Discussion

Sonoelectrochemical oxidation of Ibuprofen followed pseudo first order reaction. At 1 000 kHz, the kinetic constant was 0.027 min^{-1} but in the case of 35 kHz it was 0.014 min^{-1} (**fig.2**).

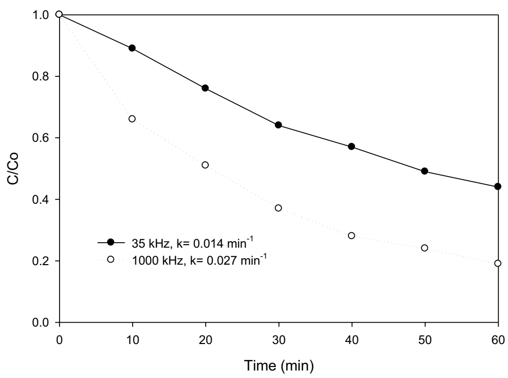

Fig. 2 Effect of 35 kHz and 1000 kHz (US/EC system).

Higher frequency favors radical production while lower frequency favors vapor phase pyrolysis due to high temperatures that are achieved during bubble collapse. Since Ibuprofen is not volatile, it must have degraded at bubble-bulk interface under the influence of reactive OH· radicals. Besides, high frequency shorter bubble life time the bubble collapse per unit time producing m ore OH· radicals is increased facilitating the interface transport activities[5].

Proceeding the experiment at higher frequency, alkaline medium, NaOH (pH 10.17) gave better result with reaction kinetic rate 0.037 min^{-1} than acidic H_2SO_4 (pH 2.14) with 0.028 min^{-1} (**fig. 3**). NaOH has higher conductivity than H_2SO_4. Under alkaline condition the main anion is OH^- which changes into OH· radical (oxidation potential= 2.80V) by losing electrons on the anode surface. The transfer of OH^- ions towards anode is enhanced by ultrasonic waves enhancing the oxidation process[6].

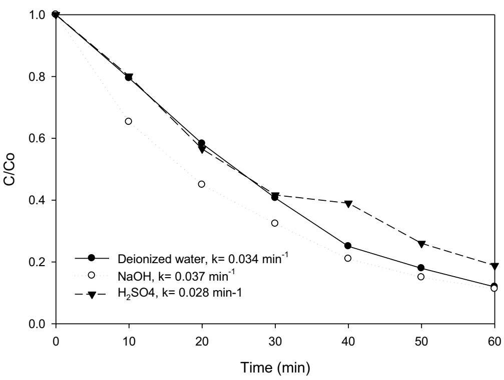

Fig. 3 Effect of NaOH and H_2SO_4 media on high frequency 1000 kHz-US/EC system.

Explaining the system more, when ultrasound alone (**fig. 4**) was irradiated, H_2SO_4 was found to be more effective with kinetic rate constant of 0.033 min^{-1}. However, for both electrolysis (EC) alone (**fig. 5**) and for the combined system (**fig. 3**), NaOH gave higher degradation with 0.022 min^{-1} and 0.037 min^{-1} respectively.

Conclusion

The combination of ultrasound with electrochemistry can be effectively utilized as clean technology for the degradation of Ibuprofen an emerging organic pollutants in aquatic environment.

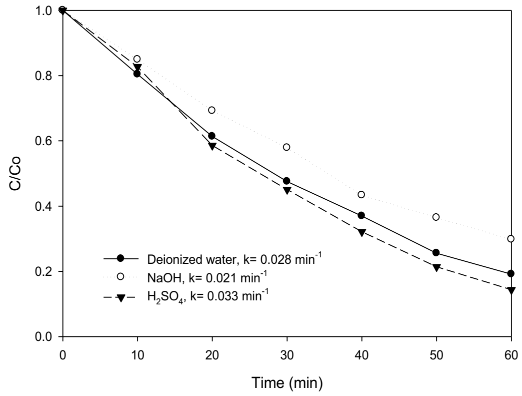

Fig. 4 Effect of NaOH and H_2SO_4 media on high frequency 1000 kHz-US system.

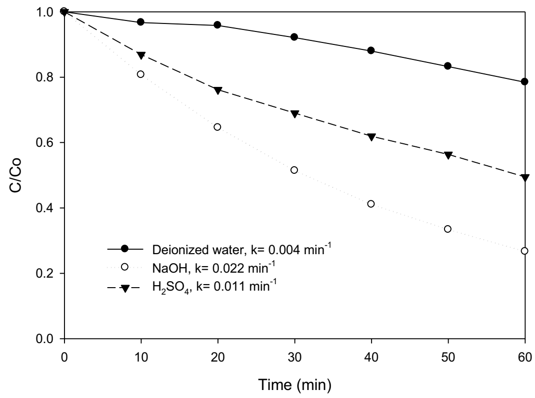

Fig. 5 Effect of NaOH and H_2SO_4 media on EC syst em.

Acknowledgement

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