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Single, Simultaneous and Sequential Applications of Ultrasonic Frequencies for the Elimination of Ibuprofen in Water

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Abstract. The study is about the assessment of single and multi-frequency operations for the overall degradation of a widely consumed analgesic pharmaceutical-ibuprofen (IBP). The selected frequencies were in the range of 20-1130 kHz emissions coming from probes, baths and piezo-electric transducers attached to plate-type devices. Multi-frequency operations were applied either simultaneously as "duals", or sequentially at fixed time intervals; and the total reaction time in all operations was 30-min. The work also covers evaluation of the effect of zero-valent iron (ZVI) on the efficiency of the degradation process and the performance of the reaction systems. It was found that low-frequency probe type devices especially at 20 kHz were ineffective when applied singly and without ZVI, and relatively more effective in combined-frequency operations in the presence of ZVI. The power efficiencies of the reactors and/or reaction systems showed that 20-kHz probe was considerably more energy intensive than all others, and was therefore not used in multi-frequency operations. The most efficient reactor in terms of power consumption was the bath (200 kHz), which however provided insufficient mineralization of the test chemical. The highest percentage of TOC decay (37%) was obtained in a dual-frequency operation (40/572 kHz) with ZVI, in which the energy consumption was neither low nor exceptionally too high. A sequential operation (40+200 kHz) in that respect was more efficient, because it required much less energy for a similar TOC decay performance (30%). In general, the degradation of IBP increased with increased power consumption, which in turn reduced the sonochemical yield. The study also showed that advanced Fenton reactions with ZVI were faster in the presence of ultrasound, and the metal was very effective in improving the performance of low-frequency operations.