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Radical Degradation of Acetaminophen with Peroxymonosulfate-Based Oxidation Processes

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Abstract : Perxymonosulfate (PMS)-based oxidation processes, as an alternative of hydrogen peroxide-based oxidation processes, are more and more popular because of reactive radical species ($SO_4^{-\bullet}$, $OH^{\bullet}$) produced in systems. Magnetic nano-scaled particles Fe_3O_4 and ferrous anion (Fe^{2+}) were studied for the activation of PMS for degradation of acetaminophen (APAP) in water. The Fe_3O_4 MNPs were found to effectively catalyze PMS for APAP and the reactions well followed a pseudo-first-order kinetics pattern ($R^2>0.95$). While the degradation of APAP in PMS-Fe^{2+} system proceeds through two stages: a fast stage and a much slower stage. Within 5 min, approximately 7% and 18% of 10 ppm APAP was accomplished by 0.2 mM PMS in Fe_3O_4 (0.8g/L) and Fe^{2+} (0.1mM) activation process. However, as reaction proceed to 120 min, approximately 75% and 35% of APAP was removed in Fe_3O_4 activation process and Fe^{2+} activation process, respectively. Within 120 min, the mineralization of APAP was about 7.5% and 5.0% (initial APAP of 10 ppm and $[PMS]_0$ of 0.2 mM) in Fe_3O_4-PMS and Fe^{2+}-PMS system, while the mineralization could be greatly increased to about 31% and 40% as $[PMS]_0$ increased to 2.0 mM in in Fe_3O_4-PMS and Fe^{2+}-PMS system, respectively. At last, the production of reactive radical species were validated directly from Electron Paramagnetic Resonance (ESR) tests with 0.1 M 5,5-Dimethyl-1-pyrrolidine N-oxide (DMPO). Plausible mechanisms on the radical generation from Fe_3O_4 and Fe^{2+} activation of PMS are proposed on the results of radial identification tests. The results demonstrated that Fe_3O_4 MNPs activated PMS and Fe^{2+} anion activated PMS systems are promising technologies for water pollution caused by contaminants such as pharmaceutical. Fe_3O_4-PMS system is more suitable for slowly remediation, while Fe^{2+}-PMS system is more suitable for fast remediation.

Keywords : acetaminophen, peroxymonosulfate, radicals, Electron Paramagnetic Resonance (ESR)
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