Aromatic Dye Removal by Combination of Anaerobic and Micro-Aerobic Degradation Processes

Osmar F. de Menezes (osmar.fonseca@ufpe.br), Lourdinha Florencio, Mario Kato, and ***Sávia Gavazza*** (savia@ufpe.br) (Federal University of Pernambuco, Recife, PE, Brazil)

Background/Objectives. Textile wastewaters are rich in aromatic dyes, which became pollutants of water bodies and soil in many countries, such as China, India, Brazil, and others. Bioremediation involving the combination of anaerobic and aerobic biological processes is an important alternative for aromatic dye degradation. In opposition to physicochemical processes, the biological treatment presents lower cost and promotes the degradation of the dyes, not only their phase transference. The azo bond reduction under anaerobic conditions decreases the effluent coloration. Then, aromatic amines, which are colorless, although highly toxic, are formed. These amines can undergo aerobic degradation. Regarding biomass, mixed anaerobic and aerobic microbial cultures may be able to reduce azo bonds and degrade aromatic amines when subjected to a cyclic oxygen exposure. Micro-aeration (working with 5 to 10% of the oxygen saturation level) may also be enough for mineralization of aromatic compounds. In this perspective, the scope of this study was to apply discontinuous micro-aeration within single chamber sequencing batch reactors (SBRs) to enhance azo dye degradation and toxicity removal from textile wastewater.

Approach/Activities. Three independent sequencing batch reactors (R1, R2 and R3) working with distinct anaerobic-aerobic cycles and 5 L of working volume (replacement volume of 50%) were operated at mesophilic temperature of 37 ± 1 °C, for 107 days. In each reactor, the cycle time was 24 h distributed in: filling (15 min), reacting (23 h), settling (30 min) and drawling (15 min). The 23h of reaction time in R1 was completely anaerobic. R2 combined anaerobic stage of 12 h with 11 h of micro-aeration stage in the reaction time. R3 operated similarly to R2, with intermittent air supply (30 min every 2 h) in the 11 h of the micro-aerated stage. Anaerobic sludge from a pilot scale UASB reactor treating real textile wastewater was used as inoculum (2.5 gVSS L^{-1} in the mixed liquor). Synthetic textile wastewater was composed of: Direct Black 22, a tetra-azo dye (0.03 mM; DB22; $C_{44}H_{32}N_{13}Na_3O_{11}S_3$; molecular weight: 1083.97 g mol^{-1}), ethanol as electron donor (1200 mg L^{-1} of Chemical Oxygen Demand - COD), $NaHCO_3$ as buffer (1200 mg L^{-1}), macro- and micro-nutrients solution.

Results/Lessons learned. Apparent steady state conditions for color removal were established after 58 days. DB22 removal was 81.4 (77.6 - 85.2), 74.5 (68.5 - 80.6) and 76.8% (73.4 - 80.1) for R1, R2 and R3, respectively. R1 accumulated larger fractions of aromatic amines than the other reactors throughout the operational period. On the other hand, R2 and R3 have maintained a stable and very similar removal levels for these compounds. Aromatic amines accumulated under anaerobic conditions, and were well removed by the combination of anaerobic and micro-aerobic conditions. No acute ecotoxicity (Microtox® with *Vibrio fischeri*) was observed in the influent with DB22 or in the effluent from the reactors that were micro-aerated. Conversely, the accumulation of aromatic amines in R1 generated significant toxicity, with a dilution factor of 88.15 (i.e., sample effective concentration that caused an inhibition of 50% in bioluminescence). These results confirm the need for the combination of anaerobic and aerobic processes in aromatic-dyes bioremediation. Our kinetic results indicate that oxygen was inhibitory for methanogenesis during the anaerobic phases of the reactors with micro-aeration. In R2 and R3, the oxygen-induced inhibition of methanogenesis favored the transport of reducing equivalents for azo bonds cleavage, increasing the rate of decolorization. Futhermore, oxygen in the reactors with micro-aeration was more damaging to methanogenic community than the accumulation of toxic amines in the anaerobic reactor.