Wet Electrolytic Oxidation for Wastewater Clean-up: Investigation in a Bench Scale Continuous Reactor

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Wet electrolytic oxidation (WEO), which can offer potential attractive for treatment of highly loaded industrial wastewater, is the coupling of hydrothermal oxidation (wet oxidation) and electrochemical technique. An efficient oxidation to mineral compounds of several organics and an apparent current efficiency higher than 100% has been reported previously, using a WEO batch system [1]. In this work, we report an investigation of WEO in the bench scale continuous reactor. A model wastewater composed by 2-aminoethanol (14,000mg L^{-1}) and Cl^- (800mg L^{-1}) was used for this investigation. The influence of current density, Faradaic contribution and feed flow rate on the TOC removal rate and the behavior of nitrogen compounds at the treated water were studied in this work.

Fig.1 shows the flow diagram of the bench size continuous WEO system. The wastewater was continuously fed and pressurized by a plunger type pump up to 7MPa. The air, which is used as external oxidant, was mixed with wastewater before pre-heating. The airflow rate was kept at 1.3 times the stoichiometric amount for complete oxidation of 2-aminoethanol. Prior to entering in to the reactor, the wastewater and the air are pre-heated by the heat exchanger and electrical heater at temperature up to 250°C. The reactor, in which the electrolytic oxidation takes place at galvanostatic conditions, has an effective volume of 3 liter and anode area of 64 dm^2. The reaction products are cooled in the heat exchanger, separated in liquid and gases at the fluid separator and then depressurized by means of control valves.

Fig. 2 illustrates the influence of anode current density on the TOC removal rate during the continuous steady state WEO for different wastewater flow rate. A linear dependency of TOC removal rate on current density was observed for 3 - 9 L h^{-1} flow rates. Fig.2 also shows the voltage between the electrodes (U) during the WEO. A typical voltage was 6V when the reactor was operated at 9A dm^{-2}.

Fig.3 illustrates the TOC removal rate in function of Faradaic contribution for the different flow rates. Faradaic contribution was defined as being the quotient between supplied electrical charge (Q) and the theoretically required charge for the anodic oxidation (Q* from the Faraday' law). For the case of 2-aminoethanol, Q* is 348Ah per mol. For all feed flow rates, the TOC removal rate was almost 100% at Faradaic contribution near 0.8. The difference in TOC removal rate at low Faradaic contribution was found to be mainly due to the effect of wet oxidation. Once residence time is a reaction controlling parameter in wet oxidation, higher TOC removal rate is obtained for low flow rates.

Fig.4 shows the ammonium and nitrate ions concentration after the WEO treatment for the case of 9L h^{-1} flow rate. Ammonium, stable at wet oxidation condition, are released from the amino group of 2-aminoethanol. Ammonium nitrogen seems to be converted to nitrogen gas directly or with a prior oxidation to nitrates. Nevertheless, both ions were effectively removed at Faradaic contribution near 0.8.

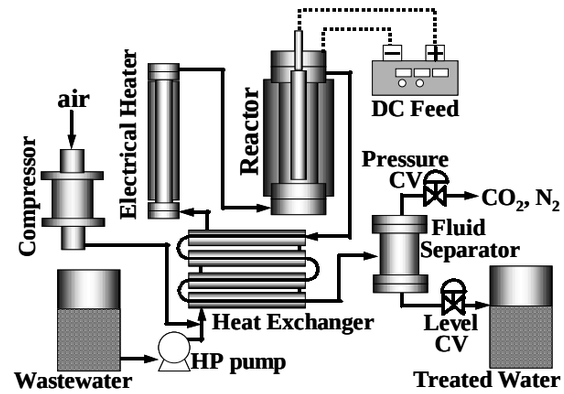

Fig.1. Flow diagram of continuous bench WEO system.

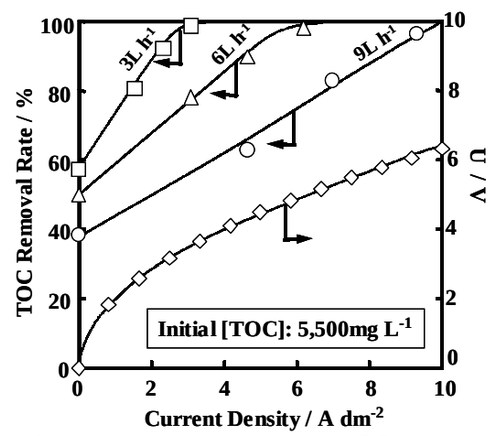

Fig.2. Influence of current density on TOC removal rate.

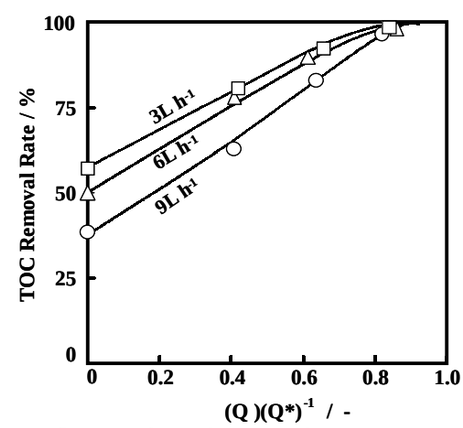

Fig.3. Influence of Faradaic contribution on TOC removal.

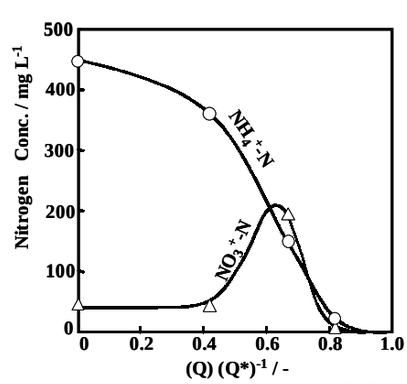

Fig.4. Ammonium and nitrate ions after WEO.

Reference.

1. Serikawa, et al.: J.Appl. Electrochemistry, 30 (2000) 875.