Electrochemical degradation of PAH compounds in process water
Muff, Jens; Søgaard, Erik Gydesen

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Introduction

PAHs (Polycyclic Aromatic Hydrocarbons)

Main sources
- Burning of fossil fuels (oil and coal)
- Wood stove heating of houses and cigarette smoke
- Tar production and use

Human health effects
- Highly toxic, carcinogenic, mutagenic

Threshold values (drinking water)
- 0.005 - 0.010 μg L⁻¹

Characteristics
- Lipophilic and hence low water solubility
- Primarily found in soil and sediment
- Persistent, recalcitrant, and non-reactive

Objectives

- Determine the reaction kinetics for electrooxidation of PAHs in low concentration
- Evaluate the current efficiency at different experimental settings
- Proof the concept by treatment of process water from sediment purification

Experimental procedure

Model compounds
- Naphthalene
- Fluoranthene
- Pyrene

Analytical technique
- HPLC-FLU (Fluorescence)
- Genuine triple determination

Batch recirculation setup

Results & discussion

Model solution study

- The direct electrooxidation of naphthalene is faster than fluoranthene and pyrene (fig. 2).
- The rates of oxidation are increased in a NaCl electrolyte and decreased in NaNO₃ (fig. 1).
- The rates of oxidation are increased with increased current densities (fig. 4).
- The rates of oxidation are decreased by reduced NaCl electrolyte concentration (fig. 5).

Reaction kinetics

- Naphthalene: The electrochemical oxidation followed under all investigated parameters a 2. order reaction kinetics.
- Fluoranthene and Pyrene: The degradation curves could be sufficiently modeled to standard 2. order reaction kinetics.

Current efficiency

- When the current density at different concentrations is evaluated with respect to the specific amount of charge passed through the solution, Q (Ah L⁻¹), a current efficiency constant, kₚ, can be defined similar to the rate constant:

\[ kₚ = \frac{Q}{[C]₀ \cdot t} \]

As figure 6 shows, the current efficiency (electrons in the circuit minus naphthalene oxidation) is increased, whereas the current density is decreased.

Conclusion

- Naphthalene, fluoranthene, and pyrene in low concentrations were efficiently degraded by electrochemical oxidation in the batch recirculation setup.
- The degradation were significantly enhanced in NaCl electrolyte by the indirect hypochlorous acid / hypochlorite oxidation.
- The oxidation of naphthalene followed 2. order reaction kinetics, whereas fluoranthene and pyrene followed 1. order kinetics.
- The current efficiencies of the oxidation were increased at low current densities.