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DESCRIPTION OF DOCTORAL DISSERTATION

The Author of the doctoral dissertation: Kirill Fedorov

Title of doctoral dissertation: Degradation of organic water pollutants using hybrid cavitation-based advanced chemical processes.

Title of doctoral dissertation in Polish: Degradacja organicznych zanieczyszczeń wody z zastosowaniem hybrydowych zaawansowanych procesów chemicznych wykorzystujących zjawisko kawitacji.

Language of doctoral dissertation: English

Supervisor: PhD, D.Sc., Eng. Grzegorz Boczkaj, Professor (Associate).

Date of doctoral defense:

Keywords of doctoral dissertation in Polish: kawitacja, AOPs, ARPs, kawitacja hydrodynamiczna, kawitacja akustyczna, degradacja, utlenianie, rodniki

Keywords of doctoral dissertation in English: cavitation, AOPs, ARPs, hydrodynamic cavitation, acoustic cavitation, degradation, oxidation, radicals.

Summary of doctoral dissertation in English

This doctoral thesis investigates hybrid cavitation-based advanced chemical processes for the degradation of organic pollutants in aqueous conditions. Initially, hybrid processes combining acoustic (AC) or hydrodynamic cavitation (HC) with ozone- and sulfate radical-based advanced oxidation processes (AOPs) were developed and evaluated towards the degradation of BTEXs and 1,4-dioxane. Then HC was integrated with the emerging sulfite/UV advanced reduction process (ARPs) to degrade halogen-containing organic pollutant - clofibric acid (CLA). The effect of solution pH, reagent (radicals precursor)/pollutant molar ratio and common inorganic anions was studied. Radical quenching experiments were performed to determine the predominant radical species responsible for the degradation of pollutants. Based on the reaction intermediates identified in GC-MS and HPLC-UV-DAD, the degradation pathways of pollutants were proposed. The findings demonstrated the key role of cavitation in the hybrid processes performing activation and intensifying the AOPs as well as ARPs leading to high synergistic effect. In the case of HC/ARP, the presence of the reductive species was confirmed and their reactivity with CLA was supported by theoretical calculations - revealing enhanced generation of reductive species and reduced scavenging effect of dissolved oxygen on sulfite/UV when coupled with HC.

Streszczenie rozprawy w języku Polskim

Niniejsza rozprawa doktorska dotyczy badań nad hybrydowymi, kawitacyjnymi zaawansowanymi procesami chemicznymi do degradacji organicznych zanieczyszczeń w warunkach wodnych. Opracowano i oceniono procesy hybrydowe łączące kawitację akustyczną (AC) lub hydrodynamiczną (HC) z zaawansowanymi procesami utleniania (AOPs) opartymi na ozonie lub rodnikach siarczanowych, które zastosowano do degradacji związków z grupy BTEX oraz 1,4-dioksanu. Następnie HC zintegrowano z zaawansowanym procesem redukcyjnym (ARP) anion siarczynowy/UV w celu degradacji halogenowanego zanieczyszczenia organicznego - kwasu klofibrynowego (CLA). Zbadano wpływ pH roztworu, molowego stosunku prekursora rodników do zanieczyszczenia oraz obecności anionów nieorganicznych. Dominujące formy rodnikowe określono na podstawie eksperymentów wygaszania. Na podstawie produktów pośrednich zidentyfikowanych metodami GC-MS i HPLC-UV-DAD zaproponowano ścieżki degradacji zanieczyszczeń. Uzyskane wyniki badań wykazały kluczową rolę kawitacji w aktywacji reagentów oraz intensyfikacji zarówno AOPs i ARPs, prowadząc do wysokiego efektu synergistycznego. W układzie HC/ARP potwierdzono obecność reaktywnych form redukcyjnych, a ich reaktywność względem CLA poparto obliczeniami teoretycznymi, ujawniając zwiększoną generację form redukcyjnych oraz ograniczenie wygaszania rodników przez rozpuszczony tlen w procesie anion siarczynowy/UV sprzężonym z HC.