Chapter 3
Comparative Study of Kinetics of Catalytic Oxidation Process With Fenton's Reagent of Anionic (2-EHS) and Cationic (CTAB) Surfactants

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ABSTRACT

*In this chapter, a comparative degradation/mineralization study of two surfactants—the anionic surfactant 2-ethyl-hexyl Sodium Sulfate (2-EHS) and the cationic surfactant Cetyltrimethyl Ammonium Bromide (CTAB)— was performed using a combination of AOPs: Fe(II)/H2O2. From experimental studies, it has been established that the optimal pH for the oxidation of surfactants (CTAB and 2-EHS) is the same, and is 2.5. And the optimal concentrations of Fenton reagent for the model system containing cationic surfactant [CTAB]=20 mg/L are [Fe2+]=1*10-3 M, [H2O2]=1*10-3 M and for the model system that contains anionic surfactant [2-EHS]=20 mg/L are [Fe2+]=8*10-4 M, [H2O2]=1*10-3 M. The degradation kinetics of 2-EHS was much faster compared to that of CTAB. As a result of experimental research, it was found that the degradation and mineralization process of anionic surfactant (2-EHS) is highly efficient, and the degree of oxidation/mineralization is 90% compared to cationic surfactant (CTAB), which has an efficiency equal to 50%.*

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INTRODUCTION AND BACKGROUND

Surfactants are a group of organic chemicals that play an important role in personal care and household hygiene products. Surfactants can produce foam in water basins, which inhibits the penetration of oxygen and light, slowing down the process of self-purification of the environment. In addition, it has been reported that surfactant-contaminated river water is toxic to fish and other aquatic organisms and surfactant-contaminated soil inhibits plant growth. Due to the fact that surfactants are dangerous to humans and the environment, it is necessary to remove surfactants from wastewater before disposing of them in the aquatic environment.

Based on the literature reviewed, it can be concluded that catalytic oxidation processes with the Fenton's reagent for the 2-EHS anionic and CTAB cationic surfactants have not been studied. The purpose of this paper was determination the efficiency of the Fenton process for oxidation/mineralization of the 2-EHS and CTAB surfactants in synthetic wastewater under similar conditions.

The following objectives were proposed in order to achieve the aim:

- Investigation of physicochemical parameters influencing the process performance: pH value, oxidation time, the concentration of Fe^{2+}, H_2O_2 and surfactant in the model system;
- Calculation of speed constants and reaction rates according to Physico-chemical parameters and pollutants in the model system;
- Comparison the efficiency of the Fenton process for oxidation/mineralization of the 2-EHS and CTAB surfactants in synthetic wastewater under similar conditions

During the pandemic period, linked to the spread of the coronavirus (COVID-19), the population complies with health requirements and as a result consumes large amounts of surfactants frequently used in the production of detergents and soaps, as well as biocidal products for disinfection (Teymoorian, T. et al., 2021). As a result, the uncontrolled amounts of surfactants and disinfectants are discharged into the sewer system without any structural changes, thus subjecting the treatment plants to excessive pressure. Surfactants are considered emerging pollutants that are not readily degradable and are stable in the ambient environment for a long time. They are toxic to microorganisms and mammals in various environmental matrices (Wiel-Shafran, A. et al., 2009, Sawadogo, B. et al., 2014).

For an indefinite period of time, the use of detergents in personal care and household products such as optical brighteners, stain removers, shampoos and bleaches is expected to increase. According to Cosmetics Europe, the European cosmetics and personal care industry was valued at approximately $95.32 billion in 2019, with a growth rate of approximately 1,5% compared to the previous year [4].

According to some bibliographic sources, the global surfactant-containing cleaning products industry worth $46,8 billion in 2019 is expected to reach $58,3 billion by 2024 and an annual growth rate of 4,5% (Farias, C. B. B. et al., 2021). This growth is based on the increasing awareness of the population around the world about health issues, hygiene and protection against Covid-19 [6].

Although cationic surfactants are not as widely used as anionic and non-ionic surfactants, they are known to be 10 to 100 times more toxic than anionic and non-ionic surfactants even at very low concentrations. In the case of human eye irritation, cationic surfactants are the most irritating of all surfactants (Hermann, R. Et al., 1997). Surfactants can produce foam in water basins, which in turn inhibits the penetration of oxygen and light, thus slowing down the self-purification process of the aquatic environment (Holmberg, K. et al., 2002) In addition, it has been reported that polluted river water containing