An assessment of synthesis and effeciveness of potassium ferrate(VI) as a green agent in the treatment of carwash wastewater

Maciej Thomas[1], Joanna Kuc[2], Teresa Stryszewska[3]

1. Faculty of Environmental Engineering and Energy, Cracow University of Technology, POLAND, Cracow 31-155, Warszawska 24, E-mail: maciej.thomas@pk.edu.pl
2. Faculty of Chemical Engineering and Technology, Cracow University of Technology, POLAND, Cracow 31-155, Warszawska 24, E-mail: joanna.kuc@pk.edu.pl
3. Faculty of Civil Engineering, Cracow University of Technology, POLAND, Cracow 31-155, Warszawska 24, E-mail: tstryszewska@pk.edu.pl

Abstract – The paper deals with possible synthesis and use of potassium ferrate(VI) (K_2FeO_4) for the treatment and disinfection of carwash wastewater. Potassium ferrate(VI) was synthesized by wet method and the quality of the product was studied by SEM/EDX. The purity of the product was 90%. The treatment process was optimized by CCD and RSM. The optimum conditions for COD were established at pH 5.8, 0.97 g/L dose of K_2FeO_4 and with reaction time 23 min. Simultaneously, COD was decreased by 79.8%. At the same conditions the total proteolytic bacteria decreased by 92.1%. The application of ferric chloride as coagulant was also evaluated. The study indicated that the use of potassium ferrate(VI) and anionic flocculant is the better option than the use of ferric chloride and the same flocculant. The application of potassium ferrate(VI) is a viable option for the treatment of carwash wastewater.

Keywords – potassium ferrate(VI), carwash wastewater, central composite design, response surface methodology, water treatment

Introduction

One of the leading clean water consumers are carwashes. In many countries, the law requires 70–80% of carwash wastewater to be recycled [1]. This wastewater is characterized by certain physicochemical parameters that differ based on the cleaning processes, the amount of reused water, and the detergents or conditioners used in washing process. The main characteristic of this wastewater is low surface tension caused by the presence of residual surfactants [2]. It was found that for carwash wastewater the temperature is in the range of 28 to 30°C, pH of 5.9 to 8.8, total suspended solids (TSS) from 265 to 794 mg/L, chemical oxygen demand (COD) from 320 to 1019 mg O_2/L, oil and grease from 180 to 200 mg/L, turbidity from 118 to 380 NTU, and electrical con-ductivity from 84 to 100 μS/cm [3]. Recently, K_2FeO_4, a green chemical, is frequently proposed for the treatment of various types of wastewater and waste [4-6]. Because of thet, the aim of this paper is to examine the suitability of K_2FeO_4 as a green alternative, in the treatment of carwash wastewater. By adjusting the most important process parameters and monitoring the outcome, the efficiency of the treatment process was evaluated. The pH-value, reaction time, and amount of K_2FeO_4 were optimized using central composite design (CCD) and response surface methodology (RSM). The reduction of the number of microorganisms in wastewater under both treatments was compared in discussed processes.

Materials and Methods

The wastewater used in the research was collected from anautomatic carwash located in Cracow, Poland. The wastewater from carwash was collected in 1-L bottles every hour per 24 hours by an autosampler and were transported and stored at 4°C. From average wastewater the microbiological and physicochemical analysis were performed. The properties and quality of synthesized potassium ferrate(VI) was studied by SEM/EDS, UV-VIS. All chemical used in the study were analytical or microbiological grade. All physicochemical and microbiological analysis

were performed according to ISO standards. In optimizing carwash wastewater treatment, CCD/RSM were used to plan the experiments and analyze the effects of three input parameters (pH, concentration of K_2FeO_4 (g/L), and process time (min) on COD value (g O_2/L). COD is one of themost important parameters that characterizes wastewater contamination. For this reason, it was selected to gauge the wastewater treatments' effectiveness.

Results

The SEM/EDX analysis indicated that crystal potassium ferrate(VI) was characterized by a purity of 90% and a typical appearance of crystals. Fig. 1 presents SEM/EDS analysis results.

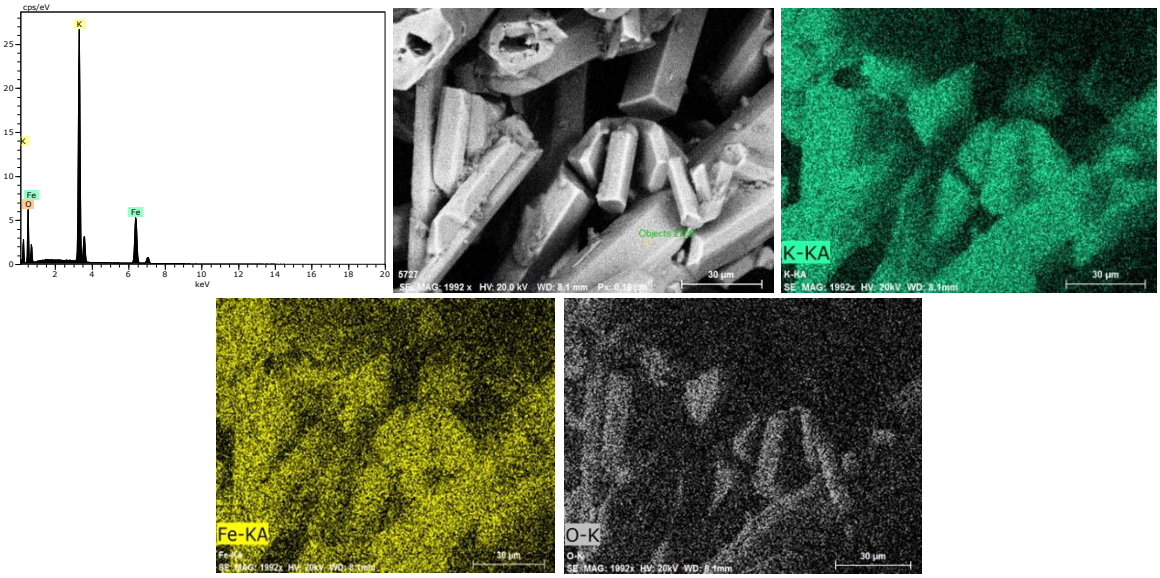

Fig. 1. SEM/EDS analysis results

The tested wastewater was characterized by pH 7.1, COD 0.89 mg O_2/L and TOC 0.28 g/L. In addition, the wastewater had an intense putrefactive odor, the intensity of which was rated as 5 (very strong). The number of proteolytic bacteria was 2.4 x 10^3 cfu/mL. The conducted research with the use of planning and optimization of experiments made it possible to identify the most favorable parameter values, at which the reduction of the COD value was the greatest. Statistical studies showed a very good fit of the experimental values to the values approximated from the model (R^2 0.9496, R^2_{adj} 0.9160). Fig. 2 shows the change in the COD value of wastewater, depending on pH, K_2FeO_4 dose and reaction time. It was calculated that the lowest COD values (0.18 g O_2/L) can be obtained at pH 5.8, K_2FeO_4 dose 0.97 g/L during 23 min. A confirmation experiment was performed and the estimated value was in agreement with the experimental value, and the reduction in COD was 79.8%.

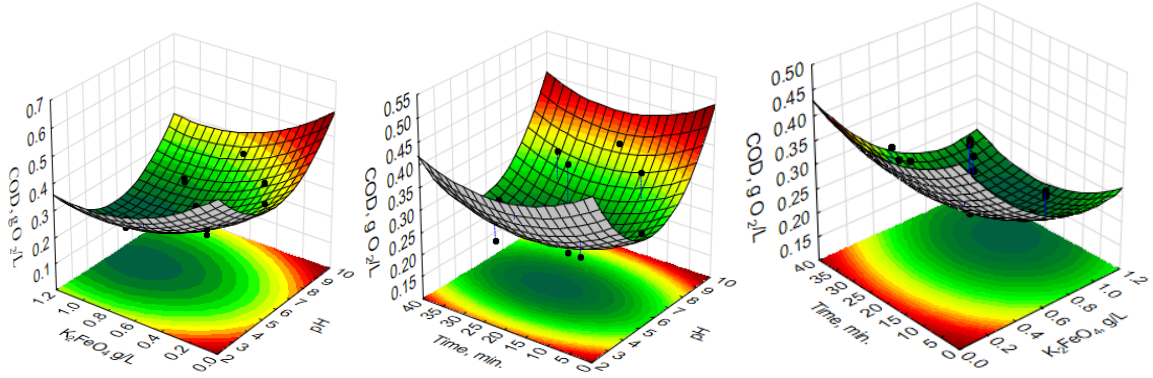

Fig. 2. The Change of COD value depending on pH, K2FeO4 concentration and reaction time

Conclusions

The use of K_2FeO_4 for the treatment of wastewater from truck washes allowed, among others, to reduce the COD value by 79.8% and significantly reduce the intensity of the odor (very weak, putrefactive), which was related to the reduction in the number of proteolytic bacteria (92.1 %).

References

[1] Zaneti RN, Etchepare R, Rubio J (2013) Carwash wastewater treatmentand water reuse-a case study. Water Sci. Technol. 67:82-88. https://doi.org/10.2166/wst.2012.492.

[2] Janik H, Kupiec A (2007) Trends in modern car washing. Pol. J. Environ.Stud. 16:927-931.

[3] Priya M, Jeyanthi J (2019) Removal of COD, oil and grease from auto-mobile wash water effluent using electrocoagulation technique. Microchem. J. 150:104070. https://doi.org/10.1016/j.microc.2019.104070.

[4] Kliś S, Barbusiński K, Thomas M, Mochnacka A (2019) Application ofpotassium ferrate (VI) for oxidation of selected pollutants in aquaticenvironment-short review. Arch Civil Eng Environ 12:129-137.https://doi.org/10.21307/ACEE-2019-012.

[5] Kliś S, Barbusiński K, Thomas M, Mochnacka A (2020) Application of potassium ferrate(VI) in the treatment of selected water and wastewater pollutants-short review. Arch Civil Eng Environ 13:129-138.https://doi.org/10.21307/ACEE-2020-011.

[6] Thomas M, Zdebik D (2019) Treatment of real textile wastewater byusing potassium ferrate(VI) and Fe(III)/H_2O_2. Application of Aliivibrio fischeri and Brachionus plicatilis tests for toxicity assessment. Fibres Text. East. Eur. 3:78-84. 10.5604/01.3001.0013.0746.