

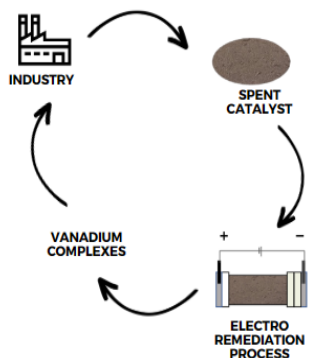
Effect of Applying Electrokinetic Remediation on the pH of Vanadium Recovery from Deactivated Fluidized Catalytic Cracking Catalysts

POSTER

Ph.D. Student: N

Journal: XXX

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The influence of applying an electric field on the pH of vanadium removal from waste from the fluidized catalytic cracking unit of petroleum, treated using the electrokinetic remediation technique, was evaluated in this study. The aim was to establish an alternative route for producing this metal, thereby promoting the circular economy through the reuse of industrial waste. Experiments were carried out with applications of 0.5, 11, and 20 V of electrical potential, using sodium citrate solution as an electrolyte. The results indicated that the best vanadium removals (178 ppm) occurred with applications of higher electrical potentials, resulting in the development of a higher pH of the medium. An energy cost 43 times greater was observed with the application of 20 V compared to 5 V, against a 7.5 times increase in vanadium removal under the same conditions.

Introduction

Fluidized catalytic cracking (FCC) is an important stage in petroleum refining, in which extensive carbon chains are broken to obtain derivatives with greater added value. The process is viable due to the application of a catalyst, which, after cycles of use and regeneration, is partially discarded. This material is classified as hazardous waste, requiring adequate disposal, and is currently destined for controlled landfills or co-processing in cement plants. However, treating this waste could lead to the establishment of a circular and sustainable economy, by recovering metals from their structure and reapplying them in industry [1,2].

In this work, waste treatment was considered by applying the electrokinetic remediation technique, analyzing the influence of electrical potential on the pH of vanadium removal present in the deactivated catalyst.

Material and Methods

The material used in this study was the deactivated catalyst from the FCC process, provided by Brazilian refineries, containing 3300 ppm of vanadium. Electrokinetic remediation was conducted in a system with the bed containing the deactivated catalyst, attached to an anode chamber and double cathode chamber [3]. A cationic membrane was installed in the double cathodic chamber, and internal circulation of 0.1 mol/L NaCl was carried out. At the end of the chambers, electrodes were positioned (Ti/Ir-Ru on the anode and lead on the cathode), connected to a power source responsible for supplying the electrical potential that leads to the migration of ions. Electrical potentials of 5, 11, and 20 V (and a potential-free blank) were applied for 48 h. The electrolyte used was a 0.5 mol/L sodium

citrate solution.

Samples of the contaminated electrolyte solution were collected close to the cathode chamber and subjected to polarography voltammetric analysis to determine the vanadium concentration (797 VA Computrace HDME Metrohm®) and pH value (HI1083, Hanna). The vanadium content present in the catalyst after treatment was analyzed using the X-ray Fluorescence technique (XRF, Malvern PANalytical Axios-mAX). The electric current developed in the bed was measured over the time of the experiment and its average value was used to calculate the energy consumption of the experiments.

Results and Discussion

Figure 1 shows the pH graph of the medium as a function of experiment time and applied electrical potential.

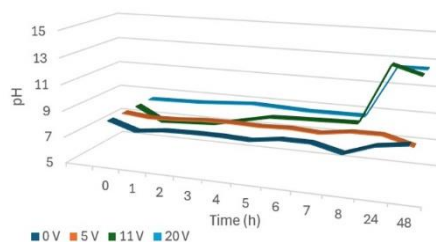


Figure 1. pH graph of the medium as a function of experiment time and applied electrical potential.

It was observed that the increase in the electrical potential to 11 V and 20 V promoted an increase in pH after 8 h of the process due to the electrolysis of

water, even with the use of the double cathode chamber, whose objective was to maintain the pH reasonably constant, at a value that would favor hydrogen reduction reactions.

Figure 2 shows the response surface relating to the concentration of vanadium in the collected samples, the pH near the cathode chamber, and the applied electrical potential.

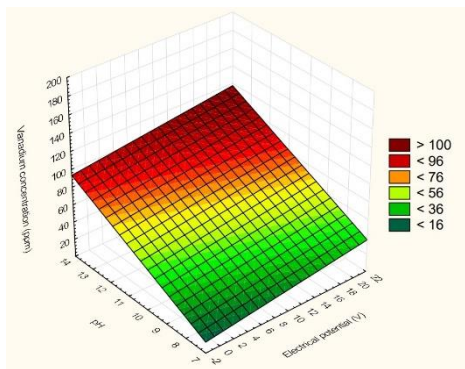


Figure 2. Response surface relating vanadium concentration, pH of the cathode chamber, and electrical potential.

It was observed that vanadium removal increased in experiments with the application of higher electrical potential and high pH. Therefore, the best vanadium removal occurred in the experiment with 20 V electrical potential.

Finally, the energy viability of the technique was observed. Table 1 lists the energy consumption and total vanadium removal of the experiments carried out.

A lower energy consumption (19.20 Wh/kg) was observed for applications with lower electrical potential (5V), with less vanadium removal (29.1%). With the increase in electrical potential to 20 V, energy consumption increased by 43 times, against an increase in vanadium removal of 7.5 times. The application of 11 V provided the greatest vanadium removal among the experiments (45.5%).

The results obtained indicate that with higher electrical potentials, parallel reactions (such as water hydrolysis) are favored, consuming part of the energy given to the system. This fact is directly linked to the increased pH in the cathode chamber in the cases mentioned above.

The best energy efficiency was observed with the application of 5 V, however, the application of 11 V also proved to be energetically viable.

In experiments with 11 V and 20 V of applied electrical potential, vanadium precipitation was observed in the cathode chamber and on the electrode, since the electrolyte used complexes vanadium in alkaline media.

Table 1. Experimental energy consumption values and vanadium removal.

Electric potential (V)	Energy consumption (Wh/kg) ^a	Vanadium removal (%)
0	0.0	2.7
5	19.2	29.1
11	140.8	45.5
20	832.0	33.9

^aBase being the mass of the treated catalyst.

Conclusions

The pH variation in the reactor was influenced by the applied electrical potential, despite the use of the double chamber. Vanadium removal was improved when higher electrical potential was applied, causing, however, greater energy consumption and vanadium precipitation due to the increase in pH near the cathode chamber. The rise in energy consumption caused by the increase in applied electrical potential was not proportional to the improvement in vanadium removal.

Thanks

The authors would like to thank the financial support of the Programa de Recursos Humanos da Agência Nacional de Petróleo, Gás Natural e Biocombustíveis – PRH-ANP, supported by resources from the investment of oil companies qualified under the P, D Clause.&I of ANP Resolution No. 50/2015.

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