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Integration of electro coagulation and adsorption for the treatment of tannery wastewater – The case of an Algerian factory, Rouiba

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Abstract

Tanneries have a severe impact on the water quality if they are rejected without treatment. Indeed, they contain not only an important amount of biodegradable compounds, like proteins and fats, but also non-readily biodegradable wastes, such hydrolyzed piles and toxic heavy metals like chromium, the most toxic, which is extensively used for skin tanning. The main problem associated with this anthropogenic contamination is chromium toxicity for living organisms. To reduce the pollution of tannery wastewaters, the development of efficient processes from a technical and an economical point of view is needed. To this aim the efficiency of coupling electrocoagulation (*EC*) and adsorption (*AD*) in terms of COD removal, turbidity decrease and residual chromium (VI) amount was examined in this work

Keywords: Adsorption; Chromium (VI); Electrocoagulation; Integrated processes; Wastewater treatment.

Nomenclature

AD	Adsorption
EC	Electrocoegualtion
EC+AD	Coupling process

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1. Introduction

The tannery effluent is a mixture of biogenic matter of hides and a large variety of organic and inorganic chemicals [1]. Tannery effluent is a major source of aquatic pollution with high chemical oxygen demand (COD) and chromium content [2]. Indeed 60% of the tanneries use almost 32% of chromium as agent of tanning [3, 4]. In addition, according to Tiravanti et al. [5], 50 % of chromic salts are released with wastewater. Hence, the wastewater of tanning process is an important source adding chrome pollutant to the environment. In addition, the cost of the chromium metal is also important and it is possible to be recovered from the wastewater [6]. The effective removal of chromium from aqueous wastes is among the most important issues in the world today.

A number of methods exist for the removal of this metal. The choice of a wastewater treatment process depends on several factors like efficiency, cost and environmental compatibility. Electrocoagulation is an efficient method where the flocculating agent is generated by electro-oxidation of a sacrificial electrode and, generally made of iron and aluminum. In this process, treatment is done without adding any chemical coagulant of flocculants, thus reducing the amount of sludge, which must be disposed. Another advantage of the electrocoagulation is its simplicity of design and operation, and ability to eliminate the colloidal particles of small sizes [7, 8].

Adsorption [1, 9, and 10] technique is largely utilized for the removal and recovery of chromium from tanning wastewater. On the other hand, adsorption on activated carbon has been found to be a suitable alternative for wastewater. When the electrocoagulation and adsorption are applied, the parameters pollution such as: COD, turbidity and residual concentration of chromium were partially eliminated. To reduce the pollution of tannery wastewaters, or more exactly to improve the yields of elimination, the development of efficient processes from a technical and an economical point of view is needed. To this aim the efficiency of coupling electrocoagulation (*EC*) and adsorption (*AD*) was examined. According to our research in the literature, only N.Vivek Narayanan et al [11] have studied the effect of the addition of the granular activated carbon to the electrocoagulation reactor on the removal of chromium from synthetic solution. Not any work was published yet on the removal of tannery wastewater pollutants by electrocoagualation using aluminum soluble electrodes coupled with adsorption using a granular carbon.

The aim of this study is to show the performances of the electrocoagulation coupled with adsorption process. The COD, turbidity, and the residual chromium (VI) concentration were measured before and after each treatment .i.e. after the electrocoagulation process (EC), after adsorption process (AD) and finally after coupling process (EC+AD).

2. Materials and methods

2.1 Methods

The adsorption experiment was investigated as follows: 0.5 g of activated carbon was mixed with 500 ml of tannery effluent, and then the mixture was agitated in a glass beaker for 2h30 min. The electrocoagulation experiment was conducted in an electrocoagulation cell of capacity 800 ml fabricated of glass. The tannery effective volume was 500 ml. The electrodes used were aluminum plates. The anodes and cathode were connected to the respective terminals of DC rectifier and electric power was supplied by a stabilized power source through the DC. The effluent was treated at 1.5 A current. The duration of electrolysis was 2h30 min. The coupling experiment consists in adding 0.5 g of activated carbon to the electrocoagulation cell. All operation conditions were remained constant (mass of activated carbon, current density, surface of electrodes, temperature, and volume). The solution was agitated with a magnetic stirrer during each experiment at 400 tr /min. pH, turbidity, COD and hexavalent Cr concentration were measured at the end of each experiment after filtration except pH and turbidity.

2.2 Sample

Sample used in this study was collected from effluent tannery of Rouiba of Algerian. The typical characteristics of this sample is presented in Table 1

2.3 Analysis

Standard methods were adopted for quantitative estimation of COD, pH, turbidity and residual concentration of Cr (VI). COD measurements, were performed according to the standard method [12]. Diphenyl carbazid colorimetric method was used for the determination of Cr (VI) according to the Balasubramanian method [13]. The pH was measured by pH monitor (HANNA 210 instruments). The turbidity was measured by HANNA instruments CP2000. The conductivity was also measured by conductimeter of HANNA instruments LP2000 model

Table 1: Characteristics of tannery effluent

Parameters	***Values***
Temperature (°C)	19
pH	3.38
Conductivity (mS/cm)	70.6
Turbidity (NTU)	40.7
hexavalent Cr concentration (µg/l)	232

3. Results and discussion

The following Tables 2 and 3 show the results obtained from different treatments such as adsorption, electrocoagulation (E C) and coupling process (EC+AD)

Table 2: Characteristics of tannery effluent after treatment

Parameters	**Values**		
	EC	*AD*	*EC+AD*
pH	4.11	3.61	3.76
Conductivity (mS/cm)	87.7	85.4	88.5
Turbidity (NTU)	2.1	2.92	1.6
hexavalent Cr concentration (µg/l)	53	175	19
DCO (mg/l)	960	1440	480

Table 3 shows that the removal efficiency for all considered parameters, turbidity, COD and residual chromium (VI), was significantly improved when both considered processes were coupled (*EC + AD*), leading to a residual chromium (VI) concentration below 50 µg/L, which is the inhibitory threshold according to the American Protection Agency.[14]

Table 3: Comparison of the removal yields recorded by electrocoagulation, adsorption and their integration

Parameters	**Processes**		
	EC (%)	*AD (%)*	*EC+AD (%)*
Turbidity (NTU)	94.25	93.3	96.1
Chromium (VI)	24.6	77	92
COD	25	50	75

4. Conclusion

From the results obtained it can be concluded that the electrocoagulation can be used for the treatment of tannery wastewater. The electrocoagulation can be used for the treatment of tannery wastewater by generation of polymerized complex molecules and liberation of oxygen and hydrogen gas at the electrodes significantly reduce the COD, turbidity and chromium. The adsorption process as well as the electrocoagulation can also used for treatment of tannery wastewater. The addition of GAC, as adsorbent to the electocoagulation reactor resulted in remarkable increase in the removal rate of chromium, COD and turbidity. In comparison to conventional techniques, the coupling process achieves faster removal of pollutants. So, this method may pave way for a new dimension in the field of water treatment. In order to reduce the cost of this new technique, it can be replaced the granular activated carbon by a low cost adsorbent from vegetal origin. This idea will be the object of our next work.

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