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ELECTROCOAGULATION TECHNIQUE FOR REMOVING METAL IMPURITIES FROM WASTE WATER

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Abstract: In this paper, an attempt has made to search various methods for the removal of metal impurities from waste water with the help of electrocoagulation technique[1]. Use of iron electrode was proved better for the removal of metal impurities such as Arsenic(As), Chromium(Cr)[2]. Different electrodes were used to study the influence of different parameters on removal of metal impurities. Various parameters such as time of electrolysis, initial and final pH, initial and final concentration, distance between electrodes, rate of stirring and current density were used [1,2].

Keywords: Electro coagulation, removal of metal impurities, arsenic, chromium.

1. Introduction

Now a days, major environmental pollutants are metal impurities such as Arsenic, Chromium [3]. Arsenic (As) is a harmful and its ingestion affects thevarious organs of human beings like cardiac, vascular system and central nervous system [4].Being carcinogenic, Arsenic also act as endocrine disruptor which leads to blocking of steroids that regulates no. of biological processes. Combination of Arsenic with carbon and hydrogen leads to the formation of organic arsenic compounds & its combination with oxygen, chlorine and sulphur forms inorganic arsenic compounds. Inorganic arsenic is more toxic than organic arsenic compounds[3]. From the electroplating fertilizer industry and chromate preparation, Chromium (Cr) is released into aquatic environment[1]. Different techniques have been used for removal of metal impurities from waste water such as adsorption, precipitation, membrane separation and electro dialysis. But most suitable and economical technique is precipitation, which is based on chemical coagulation[5]. Precipitation is effective in removal of industrial effluent but chemical coagulation leads to secondary pollution which is caused by added chemical substances. So, due to this limitation along with low cost effective treatment, electro coagulation method is employed for removing metal impurities from waste water[6]. Electro coagulation is a technique used for waste water treatment due to its ability to eliminate impurities that are not easily removed by filtration or chemical treatment system[7].

2. Principle of electrocoagulation

The main principle of electro coagulation is based on electrolysis process, it means decomposition of ions by passing electricity. The process was employed either in water or in electrolyte solution so that there will be possibility of transfer of ions between electrodes[10]. Shammas et al. stated that with the applied current coagulation starts and they have capacity to remove small particles and to settle them. Electro coagulation involves the pair of metals called electrodes. Electro coagulation can be used for treatment of waste water and also capable of removing impurities from waste water[13].

3. Reaction and Mechanism of electrolysis

The electro coagulation process includes the formation of coagulants by iron ions from Fe electrodes. During electro coagulation process, iron cations were formed at anode and at cathode,there was a formation of hydrogen gas.

Oxidation of Fe takes place at anode which is given below:

$M \rightarrow M^{2+} + 2e^-$

In acidic medium following reactions takes place:

$M + 2H^+ \rightarrow M^{2+} + H_2$

Other reactions can also takes place in alkaline medium:

$M^{2+} + 2OH^- \rightarrow M(OH)_2$

Using acidic condition:

$M^{2+} + 1/4O2 + 5/2H2O \rightarrow M(OH)_3 + 2H^+$

M^{2+} ions are oxidised into M^{3+} in presence of oxygen and in presence of water.

$M^{2+} + 1/4O2 + 1/2H2O \rightarrow M^{3+} + OH^-$ [1].

From these reactions, they observed that Fe^{2+} ions are formed which reduces the chromium ions i.e Cr^{6+} to Cr^{3+} and As^{3+} to As^{6+}

There is formation of chromium hydroxide and iron hydroxide.

$X^{6+} + 3M^{2+} \Leftrightarrow X^{3+} + 3M^{3+}$

$Y^{3+} + 2M^{2+} \Leftrightarrow Y^{5+} + 2M^{2+}$

Formation of precipitates:

$X^{3+} + 3OH^- \Leftrightarrow X(OH)_3$

$M^{3+} + 3OH^- \Leftrightarrow M(OH)_3$

$M^{2+} + 2OH^- \Leftrightarrow M(OH)_2$

In above cases, M = Fe electrode, X = Chromium(Cr) and Y = Arsenic(As)

After this process, sludge is separate out from the treated water. The maintenance factors that affects the coagulation of electro coagulation process is not so difficult[13].

4. Factors affecting coagulation

4.1Effect of electrode material

Electrode material is the one of the important parameter to get the maximum removal efficiency in electro coagulation process. In electro coagulation process, various electrodes can be used such as Al,Mg,Zn,Fe,Cd etc.(Mickley2009). Beside this, Al and Fe electrodes are used most commonly in electro coagulation process because of some advantages of Al and Fe as compared with other electrodes[10].

4.2 Effect of pH

In the electro coagulation method, the performance of pH of the solution is very important. At pH 3-9, 91%-95% of chromium was removed using Fe-Fe electrode pair, 82%-93% chromium was removed by using Al-Al electrode pair and 91%-97% chromium was removed by Al-Fe electrode pair. When these pairs were used at pH 9 complete chromium was removed within 40 min. of electro coagulation process[8]. At pH 6-8, highest arsenic removal was observed using Fe electrodes. During this process,it was observed that there was oxidation of arsenic(III) to arsenic(v) and adsorbed on to hydrous Fe_2O_3[9]. It was observed that with increase in pH ,removal of metal impurities also increases[8].

4.3 Effect of electrode distance

The distance between two electrodes also affects the electrolysis process. During electrolysis process, the gap between two electrodes was partially filled with gases which increase its resistance. Distance between two electrode can control various parameters that can affect the electrolysis process and the energy consumption (Ghosh et al.2008)[10]. Effect of final electrode distance on removal of impurities has been observed by many researchers [11].

4.4 Effect of concentration

By varying initial concentration from 10 to 100 mg/L, various experiments were performed and effect of initial concentration on metal ion removal efficiency was studied. When initial concentration was high, it show lower initial removal efficiency as compared to low initial concentration. Removal efficiency of As(III) decreased with increase in initial concentration in 30 min. Removal efficiency of chromium also decreases in 30 min[1].

4.5 Consumption of energy and operating cost

One of the most important parameter for removal of impurities is energy consumption. By using Fe and Al electrodes, the operational cost is power consumption in electro coagulation process. At higher conductivity of solution, low consumption of energy was observed. It was observed that at about conductivity of 15mS/cm, power consumption no longer decreases[12].

5. Conclusion

Toxic metals are one of the most important environmental hazard and leads to various heaths hazards it not only affect human but also affect the animal. Metal impurities can be removed by different technologies. One of the most important and efficient method for removal of impurities is electrocoagulation[15]. Electrocoagulation has been examined as an effective technique for removing metal impurities from aqueous solution using iron electrode[1]. With increase in initial pH of solution, removal efficiency of metal impurities increases[8]. When initial concentration is low, it shows high removal efficiency as compared to when initial

concentration is high[1]. In EC process, iron electrode was used for removal because it gives better results than other electrode like aluminium and titanium. 99% of arsenic was removed by iron electrode[2].

6. References

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