Electrodeposition of Neodymium on Titanium Electrode for Photoelectrocatalytic Abatement of Ammonia in Aqueous Solution

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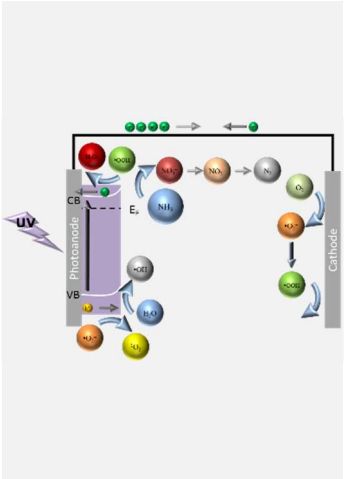

Ammonia has been released into the environment through industrial aqueous effluents and domestic sewage discharging, which in excess can causes noticeable effects on aquatic life and human health. Herein, we report a simple and effective approach to develop a novel photoanode based on potentiostatic electrodeposition of neodymium on titanium electrode for photoelectrocatalytic reduction of ammonia. Electrodepositions were performed at different electrical potentials (-1.8; -1.9 and -2.0 V) and at different time intervals (60 to 180 s). The maximum ammonia removal was achieved at 68% after 60 minutes under ultraviolet radiation and electro-oxidation potential equal -0.2 V (*vs*. SCE) by the use of Nd-Ti electrode prepared at -2.0 V for 150 s. Therefore, this study is regarded an important step toward the development of photoanodes involving a simple method and provides a feasible solution to improve the degradation of ammonia in aqueous media.

Introduction

The presence of contaminants in bodies of water and in industrial and municipal effluents has significantly increased due to population growth and technological development. Among the compounds detected in water systems, ammonia is one of the contaminants that contributes most to pollution due to the various sources capable of dispersing this pollutant, such as domestic sewage and effluents from industries[1]. The presence of ammonia in effluents, coupled with the low efficiency of conventional systems, can lead to a significant increase in the concentration of this contaminant in water resources, which could cause harm to humans and aquatic biota[2]. Photoelectrocatalysis is an advanced oxidative process based on the synergy between electrochemistry and photocatalysis. In this process, a photoactive material is employed as the photoanode and then irradiated with light of suitable wavelength along with the passage of electrical energy through the electrode[3]. To enhance its performance and prolong its lifespan, electrodes are often subjected to modifications, such as coatings with various materials[4]. Among the compounds that can be electrodeposited, neodymium neodymium oxides and hydroxides have attracted interest due to their unique 4f electronic configuration, which imparts specific optical, electrical, and thermal features for applications in advanced materials, thin films, photonics, optical materials, and photocatalysts. Additionally, they promote an increase in electrochemical oxidation capacity when deposited on electrodes.

Material and Methods

The titatnium (ASTM Grade 2) plates were previously cleaned by physical and chemical treatments. The electrodeposition studies of neodymium were conducted using a potentiostat (Metrohm Autolab - PGSTAT 204) and an electrolytic cell, employing solutions of 30 mM of neodymium hexahydrate nitrate ($Nd(NO_3)_3{\cdot}6H_2O$). The electrodeposition of lanthanide was performed by voltammetry and subsequently by chronoamperometry at different potentials (-1.8, -1.9 and -2.0 V) for 150 s. The electrodes were characterized by XRD, SEM-EDS, and impedance. The electro-oxidation of ammonia was conducted in aqueous solution containing 0.5 M KOH and 0.1 M NH_4OH by chronoamperometry at -0.3, +0.2 and +0.6 V for 60 minutes, assisted by ultraviolet radiation ($\lambda \approx 254$ nm).

Results and Discussion

Figure 1 shows the cyclic voltammetry behavior of neodymium electrodepostion on titanium electrode at scan rate equal 50 $mV{\cdot}s^{-1}$ and ambient temperature. Neodymium reduction starts at -1.6 V. Thus, the potentials -1.8, -1.9 V and -2.0 V were chosen to avoid hydrogen evolution.

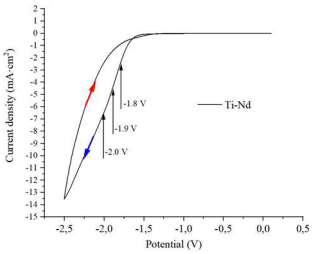

Figure 1. Cyclic voltammogram of neodymium electrodeposition on titanium electrode.

In the XRD patterns of neodymium electrodeposited films on titanium electrode the diffractions peaks of neodymium hydroxide and oxide. Figure 2 shows the peaks at 27.5º and 30.5º, which were indexed to the (100) and (321) Nd_2O_3 crystal planes, respectively[6]. The diffraction peak at 37.7º corresponding to $Nd(OH)_3$ (111)[6].

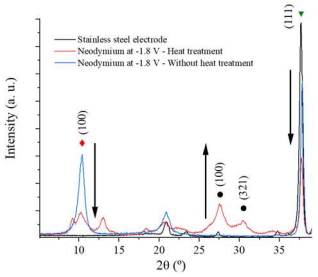

Figure 2. XRD diffraction patterns of Nd-Ti electrodes prepared at -1.8 V for 150 s before and after heat treatment.

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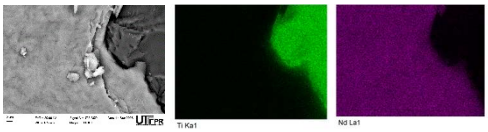

Figure 3. SEM-EDS mapping for Nd-Ti electrodes prepared at -2.0 V for 150 s.

The SEM-EDS analysis are presented in Figure 3 and confirm the presence of Nd on the titanium surface.

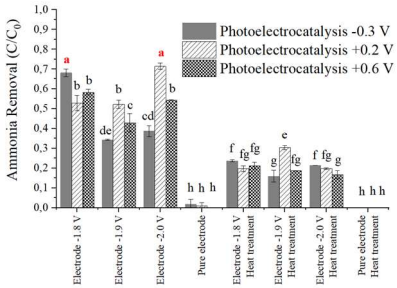

Figure 4. Effect of electrodeposition potential and electro-oxidation potential on ammonia photoelectrocatalysis.

Figure 4 shows the ammonia abatement after 60 minutes under UV radiation with different potentials. The maximum ammonia removal was achieved at 68% after 60 minutes under ultraviolet radiation and electro-oxidation potential equal +0.2 V (*vs*. SCE) by the use of Nd-Ti electrode prepared at -2.0 V for 150 s. . The results obtained provide a potential route for electrochemical treatment of ammonia by using a Nd-Ti electrodes.

Conclusions

The results obtained demonstrate that the electrodeposition processes by chronoamperometry at potentials between -1.8 to -2.0 V are capable of coating the surface of titanium electrodes with neodymium. The photoelectrocatalytic activity of these electrodes was evaluated in the degradation of NH4OH, with satisfactory responses, demonstrating that the integration of electro-oxidation and photocatalysis processes is promising for application in the removal of refractory contaminants in aqueous media.

Acknowledgments

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