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| Research Article

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Alum NPs: Electrochemical Effect of Nps on the Treatment of Iraqi River Water Sample by Cyclic Voltammetry

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Annotation
Alum nanoparticles (AL NPs) is one of the compounds that contain aluminum metal in its structure, such as KAL (SO4)2 • 12H2O, which is used in the treatment of water from impurities. Alum was successfully converted to nanostructures using the lyophilization method to obtain the nano scale about 75 nm. The electrochemical study of AL NPs (Alum nanoparticles) using cyclic voltammetry in the river water samples from Iraq, it is very important to study the nanoparticles in drinking water purification. The cyclic voltammo gram of redox reaction of the AL NPs (Alum nanoparticles) in river water before purification have two oxidation current peaks (Ipa) and two reduction current peaks (Ipc) at 900, 300, 550, and -750 mV respectively. The current study included at different concentrations, scanning rates and ph. The stability and reliability of cyclic voltammetry for using glassy carbon electrode in the all experiments. The AL NPs (Alum nanoparticles) has good results in the river water. So, it can be used AL NPs as treatment and sterile agent to the river water in safety method.

Keywords: cyclic voltammetry, river water, alum NPs, redox reaction.

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INTRODUCTION

Nanotechnology is one of the modern scientific research in the novel of different applications of varied fields, pone of this branch of science is Nano-deposed of chemical compounds [1-6].Aluminum is one of the main elements in the periodic table and when combined with oxygen it becomes aluminum oxide which is one of the most widely used and useful products. Aluminum oxide nanoparticles exist as white ball-shaped powder. However, it exists in both solid and liquid forms[7].The periodic voltammogram showed that the electro catalytic oxidation of HX on the surface of DED/N O/NPs/CPE occurs at a lower positive voltage of about 800 mV than the unmodified electrode. Square wave voltammetry results showed that the HX catalytic oxidation peak currents at pH 8.0 have two linear dynamic ranges in the range 0.1–2.0 and 2.0–400.0 µM HX, with a detection limit of 0.07 µM. This method was evaluated for the determination of HX in

water and wastewater samples [8].Aluminum oxide nanoparticles (Al2O3 NPs) were synthesized using a simple but effective probe sonication method. The semiconductor behavior was confirmed from the energy band gap study via diffuse reflection spectroscopy (DRS). The conductivity of the samples was studied by cyclic voltammetry (CV) and electrochemical resistance spectroscopy (EIS) in 0.1 M HCl and 0.1 M NaOH as aqueous electrolytes. The electrode showed specific amplitudes of 0.866 F g-1 and 0.488 F g-1 at a scan rate of 10 mV/sec in acidic and alkaline electrolytes, respectively[9].Growth kinetics of aluminum nanoparticles and electrode position mechanism on a glassy carbon electrode of Al(III) ions dissolved in a choline chloride-based eutectic solvent:

urea. Cyclic voltammetry and timing analyzes indicate that Al electrode position was obtained directly from the Al(III) ions that formed the metallic Al. Evidence of aluminum and nanoparticle deposits was obtained by SEM, EDX and XPS [10]. The aim of this study is to find the effect of alum NPs as an alternative of micro alum molecules in Iraqi river water using cyclic voltammetry.

EXPERIMENTAL MATERIALS AND METHOD MATERIALS

The materials that were used in the research were prepared alum KAl(SO4)2.12H2O from a Chinese company, a solution of hydraulic acid (0.1 M HCl), sodium hydroxide (0.1 M NaCl) and double distilled water, and samples of river water.

METHODS

PREPARATION AND CHARACTERIZATION OF ALUM NPS

The lyophilization method was used to convert the micro alum to nanoparticles by the lyophilizer apparatus shown in Fig. 1. the alum NPs was characterized by spectroscopic methods using field emission scanning electron microscopy (FESEM) and atomic force microscopy (AFM) to confirm its conversion to nanoparticles as shown in Figures 2 and 3 respectively.It was found from FESEM analysis of the morphology and dimension of nanoparticles of Alum NPs as shown in Fig. 2, about 75.15 nm the dimension of alum NPs which included with nanoparticles size [11,12]. also, the spherical form of Alum NPs was shown in AFM analysis as shown in in Fig. 3.

CYCLIC VOLTAMMETRIC TECHNIQUE

A NuVant Systems Inc. cyclic voltmeter was used in the current research experiments, manufactured in the USA. It is a potentiostat that connects to three electrodes in a 15 mL quartz cell, the working electrode (GCE glassy carbon electrode), the reference electrode (Ag/AgCl electrode), and the counter electrode (platinum wire) as shown in Fig.4. The potentiostat is then connected to the computer as shown in Fig.5 to explain the results by cyclic voltamography

Fig. 1: Lyophylization Instrument

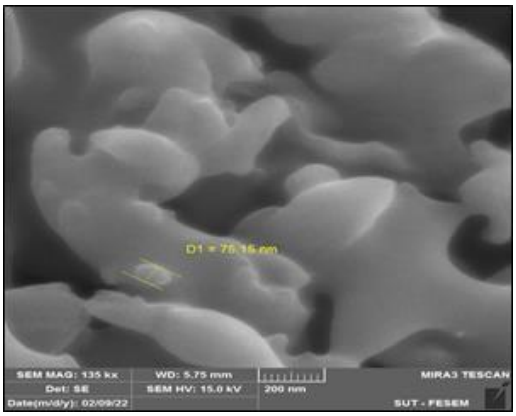

Fig. 2: FESEM of Alum NPs

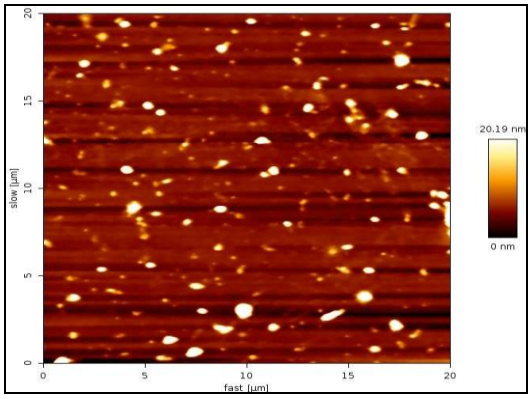

Fig. 3: AFM of Alum NPs

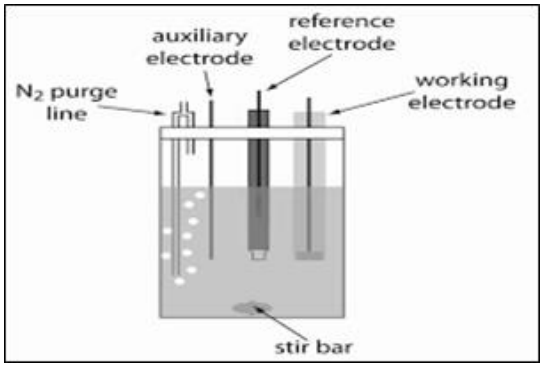

Fig. 4: Cyclic voltammetric cell

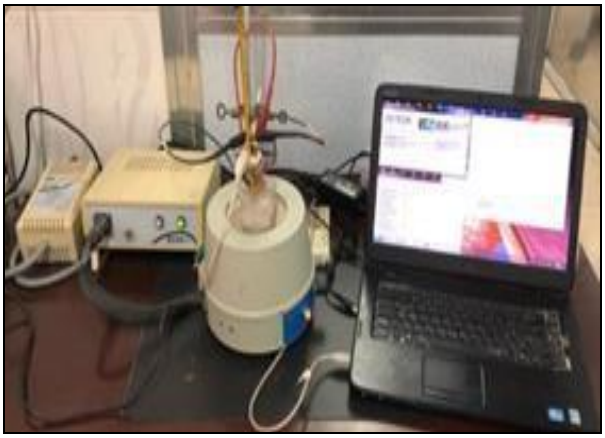

Fig. 5. Cyclic voltammetry set up

3. RESULTS AND DISCUSSION

The importance of the river water for using to the human service, it was needed to purified from the pollution, one of the treated method of purification the river water is alum materials, the topic was studied from the electrochemistry side using the cyclic voltammetry technique. Nano-alum was used as an alternative to the micro-alum due to the oxidative effects of the micro-alum, where the micro-alum was converted to nano-alum using the physical method by lyophilization. Both SEM and AFM, and the diagnostic results showed that the alum solution was converted to nano-alum by the quantitative and qualitative measurement

3.1. Study Different Concentration of Alum NPs in River Water Sample

Alum NPs was used in river water samples at different concentrations to study the electrochemistry properties of nanoparticles in the water, Fig. 6 illustrated two oxidation and two reduction current peaks of alum NPs in water at 800, 250, 750, and -500 mV, respectively. The two oxidation current peaks can be canceled by the two reduction peaks, that the oxidation current peaks act as a good reagent to killing the microorganisms present in the water and the reduction peaks act as antioxidant reagent in the water [13-15].

Good relationship with straight lines of the first and second oxidation – reduction peaks of alum NPs in river water sample shown in Fig. 7 and 8 respectively, as in the following:

First oxidation – reduction peaks:

Y=71.424X + 35,857 with high sensitive value of R2= 0.9703 Y=-16.071X – 4.1143 with high sensitive value of R2=0.903

Second oxidation – reduction peaks:

Y= 28.929X + 22.429 with high sensitivity value R2= 0.9694

Y= -13.571X – 24.500 with high sensitivity value R2= 0.9601

The good relationships indicated that the process of the Alum NPs in river water flow with reversible reaction between oxidation and reduction reaction in the good electrolyte (river water medium) [16].

Study the Effect of Different Scan Rates

The different scan rates was studied of Alum NPs in river water to finding the relationships between oxidation – reduction current peaks as shown in Fig. 9.

Good relationship with straight lines of the first and second oxidation – reduction peaks of alum NPs in river water sample as shown in Fig. 10 and 11 respectively, as in the following:

First oxidation – reduction peaks:

Y=668.48X + 25.33 with high sensitive value of R2= 0.9829

Y= -99.939X – 2.7133 with high sensitive value of R2=0.8192

Second oxidation – reduction peaks:

Y= 385.45 + 164 with high sensitivity value R2= 0.971

Y= -412.73X – 17.2 with high sensitivity value R2= 0.9363

Study the Effect of different pH

Both acidic and alkaline pH media were studied of river water present with alum NPs peak at 1V in pH 2 has been enhanced in pH 10, so the alkaline pH of river water has good properties against to reduce the biological pollution by killing the microorganism in the water medium [17].

Reproducibility Study

The potential cycling of the redox of Alum NPs in river water was carried out after scanning ten times to find the effect of redox current peaks, reflecting the stability and reliability at the surface of GCE in electrolyte. It was found the RSD after calculation for two oxidation and two reduction peaks about ±1.5, ±2.1, ±0.95, and ±0.88, respectively. Fig. 13 illustrated the cyclic voltammogram of Alum NPs in Iraqi river water after ten scanning, the oxidation – reduction current peaks of the Alum NPs have good overlapping in the cyclic voltammogram [18,19].

CONCLUSION

In the current research, the cyclic voltammetry technique was used to evaluate the effect of alum nanoparticles action on the water of a river in Iraq by studying the oxidation peaks that appeared at the at 900, 300 mV. The two oxidation peaks of alum NPs have proven that they can eliminate the microorganism in sterilizing river water without using sterile materials such as chlorine or others oxidative chemical compound. Also the other two reduction current peaks at 550, and -750 mV were appeared in the cyclic voltammogram act as balance to the oxidation peaks by gain of electrons. So, it can be used alum NPs as treatment and sterile agent to the river water.

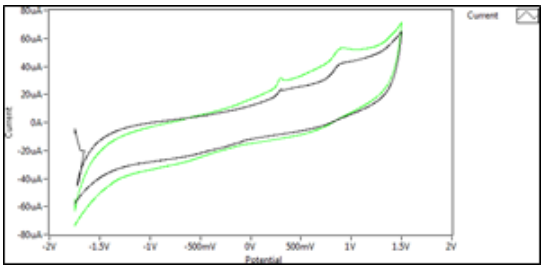

Fig. 6: cyclic voltammogram of alum NPs at different concentrations (0.05 – 0.35 mM) in river water sample on GCE as working electrode and Ag/AgCl as reference electrode at scan rate of 0.1 Vsec-1.

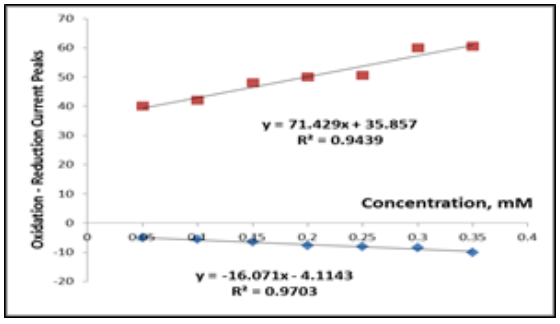

Fig. 7: relationship between the two oxidation – reduction current peaks at 800 and 750 mV respectively of Alum NPs in river water against to the different concentrations

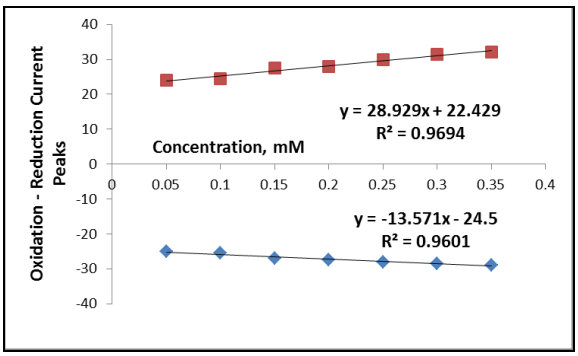

Fig. 8: relationship between the two reduction current peaks at 250 and -500 mV respectively of Alum NPs in river water against to the different concentrations.

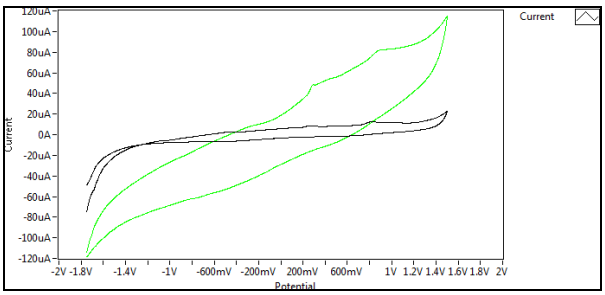

Fig. 9: cyclic voltammogram of alum NPs at different scan rates (0.01 – 0.1 V sec-1) in river water sample on GCE as working electrode and Ag/AgCl as reference electrode.

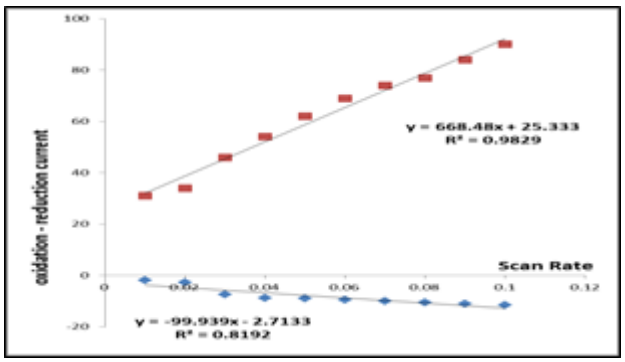

Fig. 10: relationship between the two oxidation – reduction current peaks at 800 and 750 mV respectively of Alum NPs in river water against to the different scan rates

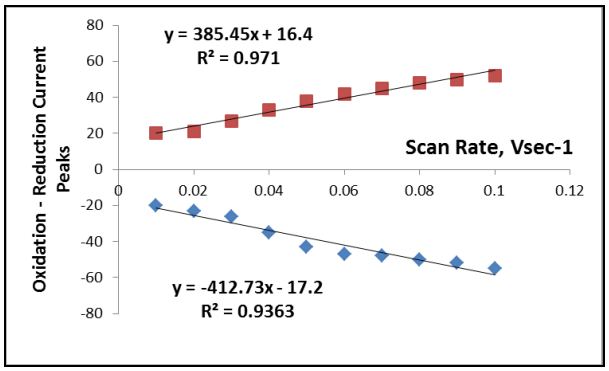

Fig. 11: relationship between the two oxidation – reduction current peaks at 250 and - 500 mV respectively of Alum NPs in river water against to the different scan rates

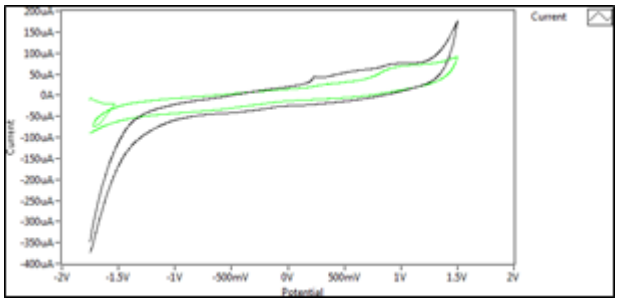

Fig. 12: cyclic voltammogram of alum NPs at different pH (green line at pH 2 and black line at pH 10) in river water sample on GCE as working electrode and Ag/AgCl as reference electrode at scan rate of 0.1 Vsec-1.

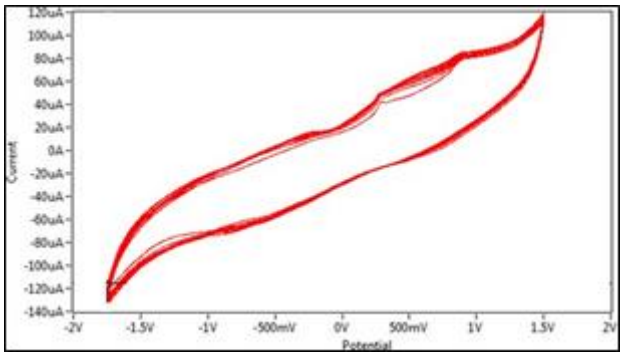

Fig. 13: cyclic voltammogram of alum NPs at ten scanning in river water sample on GCE as working electrode and Ag/AgCl as reference electrode at scan rate of 0.1 Vsec-1

REFERENCES

1. Muhammed Mizher Radhi, Hanaa Naji Abdullah, Sura A. Al-Asadi, Emad A. Jaffar Al-Mulla., Electrochemical oxidation effect of ascorbic acid on mercury ions in blood sample using cyclic voltammetry, Int J Ind Chem (2015) 6:311–316
2. Muhammed Mizher Radhi, Hanaa Naji Abdullah, Majid Sakhi Jabir, Emad Abbas Jaffar Al-Mulla, Electrochemical Effect of Ascorbic Acid on Redox Current Peaks of CoCl2 in Blood Medium, Nano Biomed. Eng., 2017, Vol. 9, Iss. 2, 103-106.
3. Muhammed Mizher Radhi , Emad A. Jaffar Al-Mulla, Use of a grafted polymer electrode to study mercury ions by cyclic voltammetry, Research on Chemical Intermediates, 2015, Volume 41, Issue 3, pp 1413-1420
4. Muhammed Mizher Radhi, Firas K. Mohamad Alosfur, Noor J. Ridha, Voltammetric Characterization Of Grafted Polymer Modified With ZnO Nanoparticles On Glassy Carbon Electrode, Russian Journal of Electrochemistry, Russian Journal of Electrochemistry, 2018, Vol. 54, No. 1, pp. 27–32
5. Mahesh S. Jadhav, Omprakash S. Chavan Aniket P. Sarkate, D. S. Pardeshi, An alum [KAl (SO4)2.12H2O] catalyzed microwave assisted multicomponent synthesis of bioactive functionalized benzylpyrazolyl coumarin and quinolinone derivatives in PEG, chemistry and materials research, 2015
6. Bottomley, L.; Bottomley, L.A. (2010). Chemistry 1310: Laboratory Manual. Plymouth, MI: School of Chemistry & Biochemistry, Georgia Institute of Technology and Hayden-McNeil Publishing.
7. Austin, George T. (1984). Shreve's Chemical process industries (5th ed.). New York: McGraw-Hill. p. 357.
8. Mahbobeh Moazampour, Fahimeh Tahernejad-Javazmi, Maryam Salimi-Amiri, Hassan Karimi-Maleh and Mehdi Hatami, Voltammetric determination of hydroxylamine in water and waste water samples using a NiO nanoparticle/new catechol derivative modified carbon paste electrode, J. Electrochem. Sci. Eng. 4(4) (2014) 135-144
9. K.B. Kusuma, M. Manju, C.R. Ravikumar, H.P. Nagaswarup, M.A. Shilpa Amulya, M.R. Anilkumar, B. Avinash, K. Gurushantha, N. Ravikantha, Photocatalytic and electrochemical sensor for direct detection of paracetamol comprising γ-aluminium oxide nanoparticles synthesized via sonochemical route, Sensors International, 1 (2020) 100039.
10. E. Rodríguez-Clemente, Tu Le Manh, C. E. Guinto-Pano, M. Romero-Romo, I. Mejía-Caballero, P.Morales-Gil, E. Palacios-González, M. T. Ramírez-Silva and M. Palomar-

Pardavé, Aluminum Electrochemical Nucleation and Growth onto a Glassy Carbon Electrode from a Deep Eutectic Solvent, J. Electrochem. Soc. 166 D3035(2019).

11. Kim, B. Y. S., Rutka, J. T., & Chan, W. C. W. (2010). Nanomedicine. New England Journal of Medicine, 363(25), 2434–2443.
12. Pandey, P., and Dahiya, M. (2016). A Brief Review on Inorganic Nanoparticles. Journal of Critical Reviews, 3(3), 18–26.
13. Sebastian Chalupczok , Peter Kurzweil , and Helmut Hartmann, Impact of Various Acids and Bases on the Voltammetric Response of Platinum Group Metal Oxides, International Journal of Electrochemistry, Volume 2018, 6 pages
14. Yousif Kadhim Abdul-Amir, Muhammed Mizher Radhi, Emad Abbas Jaffar Al-Mulla, Use of Nano-Sensors of the Interferences between Pb((II) with Each of Mg(II), Zn(II), Mn(II), Ca(II), Co(II) and PO4 -3 in Blood Medium: An Electrochemical Study, Nano Biomed. Eng., 2017, Vol. 9, Iss. 3, p199-207.
15. Muhammed Mizher Radhi, Nawfal Khalid Al-Damlooji, Baquir Kareem Abed, Dawood Salman Dawood, and Tan Wee Tee, Electrochemical Sensors for Detecting Mn (II) in Blood Medium, Sensors and Transducers, Vol. 149, Issue 2, 2013, pp. 89-93.
16. Ali Nazarizadeh, Alexander H. Staudacher, Nicole L. Wittwer, Tyron Turnbull, Michael P. Brown, Aluminium Nanoparticles as Efficient Adjuvants Compared to Their Microparticle Counterparts: Current Progress and Perspectives, Int. J. Mol. Sci. 2022, 23, 4707.
17. Abbas Hajizade1, Firouz Ebrahimi, Ali-Hatef Salmanian, Ayyoob Arpanaei, Jafar Amani, and Ivan Kempson Nanoparticles in Vaccine Development, Journal of Applied Biotechnology Reports, Volume 1, Issue 4, Autumn 2014; 125-134
18. MM Radhi, MS Khalaf, ZO Ali, RI Omran, Voltammetric analysis of Zn (II) in present of each ascorbic acid (AA) and folic acid (FA) in human blood samples, AASCIT Commus 3, 113-119.
19. MM Radhi, WT Tan, MZB Ab Rahman, AB Kassim, Electrochemical characterization of the redox couple of [Fe (CN) 6] 3−/[Fe (CN) 6] 4− mediated by a grafted polymer modified glassy carbon electrode, Journal of chemical engineering of Japan 43 (11), 927-931, 2010