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Unique Mixture of (MgO-CdO) Nanoparticles as an Adsorbent for Water Treatment

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Sol-gel method, (MgO) nanoparticles, (CdO) nanoparticles, Adsorption, Removal of iron (II).

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A B S T R A C T

Sol- gel method of synthesis of nanomaterials. Sol gel was applied for synthesis of magnesium oxide (MgO) and cadmium oxide (CdO) nanoparticles. Using magnesium nitrate and cadmium acetate as a raw materials and sodium hydroxide as a solvent for hydrated oxide at room temperature. Hydrated Magnesium oxide and cadmium oxide nanoparticles were annealed in air at 600 °C. The characterization methods include examine the morphology of the oxides surface using field emission scanning electron microscopy (FESEM) and Energy Dispersive X-ray spectroscopy (EDX), Characterization of functional groups was performed using Fourier Transform Infrared analysis (FTIR). X-ray powder diffraction (XRD) was used for examine the size of particles using Debye-Scherrer method. MgO and CdO nanoparticles are produced into spherical structures with average crystallite sizes of (55) and (55.5) nm, respectively. The study of using these nanoparticles as adsorbents were done successfully and the high value of removing percentage of iron about 97.8% and 98.7 respectively. Moreover, the mixture of these nano oxides gives 99.2% releasing of iron ion from polluted water.

1. Introduction

Nanostructured materials with small crystallite sizes and great surface areas are gaining popularity due to their diverse applications such as optical, electronics, sensing devices, and nano electronics [1]. Metal oxides nanostructures have received a part of interest recently owing to their peculiar properties, such as outstanding qualities, mechanical stability, high strength, and great thermal conductivity [2]. Several metal oxide nanostructures, and also CdO, MgO are being developed for a variety of applications [3-5].

MgO is a potential inorganic material that crystallizes in the NaCl structure. MgO is a well-known nontoxic material with distinct mechanical, chemical, optical, and electrical properties. It is widely used in a variety of applications; including antimicrobials, sensors, coatings, water treatment, catalysis, adsorbents, and fuel additives [2-6]. There are many methods can be used for synthesis of the metal oxide nanoparticles such as hydrothermal method, sol-gel method, laser, chemical vapor deposition (CVD), and microwave method are all examples of these methods.

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CdO, among these metal oxide semiconductor nanoparticles, provides critical support in the development of device fabrications due to the formation of oxygen vacancies and interstitial cadmium [7-8]. CdO has been synthesized in a variety of shapes, including rhombus, nanosticks, nanoclusters, nanocrystals, nanoparticles, and nanocubes [9-14]. These formations are accomplished through a variety of methods, including solvothermal, sonochemical, chemical methods, and thermal techniques, evaporation, microwave, and green nanomaterial synthesis [15-21]. The sol-gel method has a significant impact on the final properties of nanomaterials. [22-24].

In this work, the sol gel method was used in order to create MgO and CdO nanoparticles. The nano oxides MgO and CdO were used as an adsorbent material. It used for iron (II) removal from polluted water. Adsorption from polluted water is the unique target. Indeed, mixture of nano oxides examined as an adsorbent for adsorption of iron (II) from polluted water.

2. Experimental

Magnesium oxide was made by mixing (0.2) M from both of magnesium nitrate hexahydrate with (0.2) M of sodium hydroxide then 100 ml of pure ethanol was added drop-by-drop. Then the precipitate was filtered and dried for 2 hours at 600 °C. cadmium oxide was prepared by the same method above by mixing both of (0.2) M from cadmium acetate with (0.2) M of sodium hydroxide then 100 ml of pure ethanol was added drop-by-drop. Sample preparation for spectrophotometry was prepared by taking the exist amount nano oxide with (25 ml) of 10 ppm-concentration of iron(II) solution.

3.Results and Discussion

1.Characterization the nano oxides by (SEM-EDX) analysis

The prepared oxides were characterized by using field emission scanning electron microscopy-energy dispersive X-ray (FESEM-EDX) the images show that MgO and CdO nano oxides in nanosized. Fig. 1 shows the morphologies of two nano oxides. MgO nano oxide appears at the range of (10-55) nm with distorted spherical shape and CdO nano oxide in the range (10-50) nm with homogeneous spherical shape. However, some nanoparticles were aggregate therefor its appears like big mass.

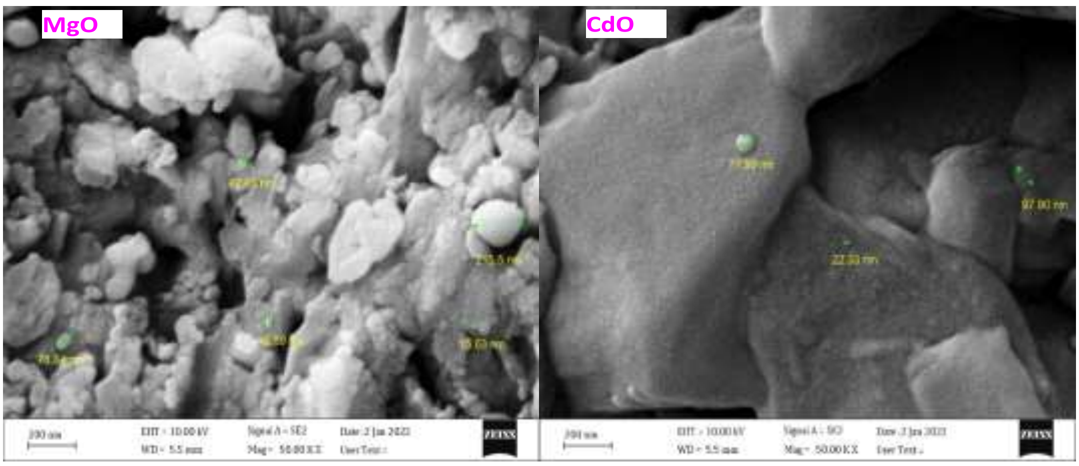

Fig. 1. FESEM images show the morphology of the surface of MgO and CdO nanoparticles.

The EDX technique was used to examine the elemental analysis. By using EDX, the elemental analysis is performed as can be seen in Fig. 2. The elemental analysis for MgO (A) shows the percentage of oxygen are 4.3% and for oxygen is 95.7 % and (B) cadmium oxide nanoparticles show that the percentage of cadmium are (73.5%) and for oxygen are (27.3%) respectively.

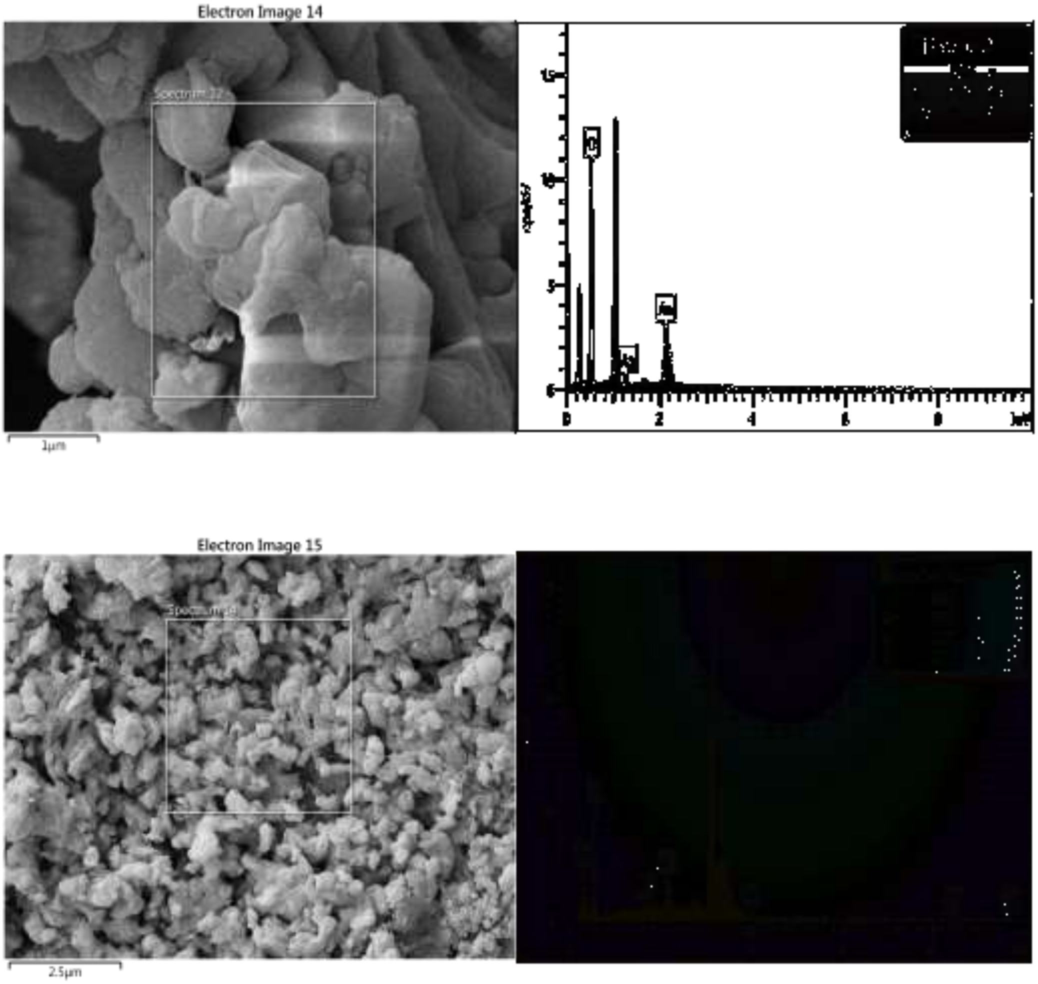

Fig. 2. EDX spectra for(A) MgO Nanoparticles and(B) CdO Nanoparticles respectively.

2. Fourier Transform Infrared analysis (FTIR)

The functional groups of the magnesium oxide nanoparticles was determined by using FTIR spectrum in the range from (400-4000) cm^{-1}, where we notice from Fig. 3 (a) the appearance of an average peak at (2993-3467) cm^{-1} as a result of OH-expansion associated with the surface of the materials of water molecules, which is a characteristic vibration of hydroxyl and the appearance of an average peak at (455 and 470) $cm^{-1}$and it characterizes the vibrations extending from the Mg-O bonds and the appearance of symmetric expansion at 1068 cm^{-1} resulting from a group C-O-C.

The FTIR spectra of CdO nanoparticles synthesized are depicted in Fig. 3 (b). It describes the FTIR spectrum of CdO. At 1400 cm^{-1}, the metal-oxygen (Cd-O) bond is detected, representing the formation of CdO. The O-H stretching of water molecules chemically associated with CdO results in a wide band in the range 3442-3400 cm^{-1}. The formation of new absorption bands in the 666 cm^{-1} is fit to the Cd–oxygen stretching of CdO.

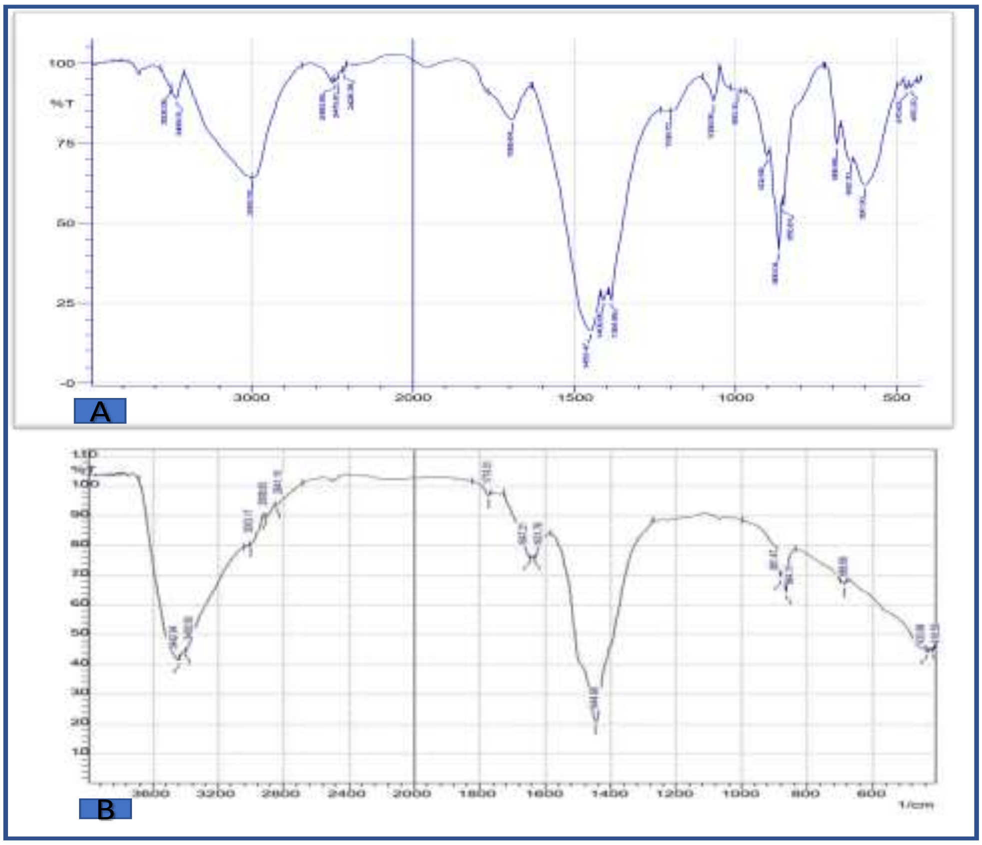

Fig. 3. FTIR spectrum of (A) MgO nanoparticles (B) CdO nanoparticles.

3.Powder Diffraction of X-rays

The X-Ray diffractogram and values of MgO CdO are determined to be in good agreement when associated to the standard JCPDS data. The synthesized samples are characterized for their structure by X-ray diffraction (Bruker AXS8) with (CuKα) radiation (λ = 1.5406 Å) by using Scherer Eq. (1)

$$D = 0.9\lambda/\beta\ COS\theta \tag{1}$$

Hence, (D) represents the mean grain size, (λ) represents the wavelength (CuKα), (β) represents the full width at the half-maximum, and θ represents the diffraction angle. The X-ray diffraction peak caused by MgO, CdO nanoparticles are shown in Fig. 4 (a), Fig. 4 (b) after calcination respectively. The average particle size of each sample was calculated using Scherer equation the results shows that MgO nano particles with diameter (55) nm however, the particles size (55.5) nm for CdO.

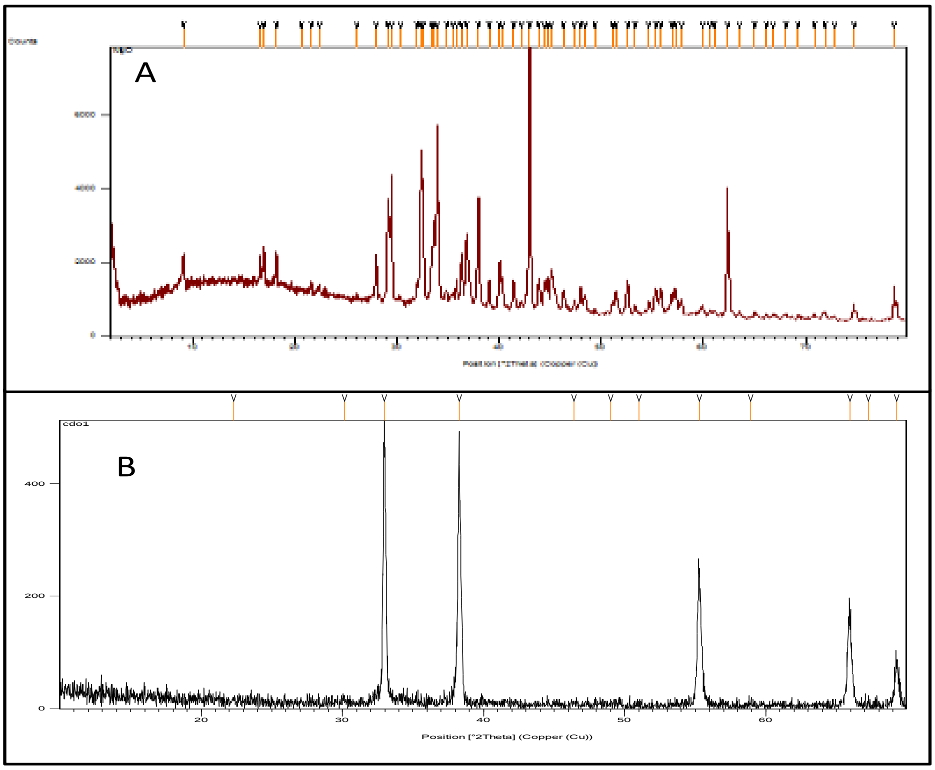

Fig. 4. shows the XRD pattern for (A) MgO and (B) for CdO.

Application of MgO and CdO nanoparticles

The synthesized nanoparticles from both MgO and CdO are used as an adsorbent of iron (II) from polluted water. Spectrophotometric method was used for this aim. Fig. 5 shows the maximum wavelength of 1,10-phenanthroline with iron at 510 nm. For calculation of absorbance of iron-1,10-phenanthroline before and after adding of MgO and CdO nanoparticles. The Eq. (2) was used

$$Ads\% = (A_0 - A_t/A_0) * 100 \qquad (2)$$

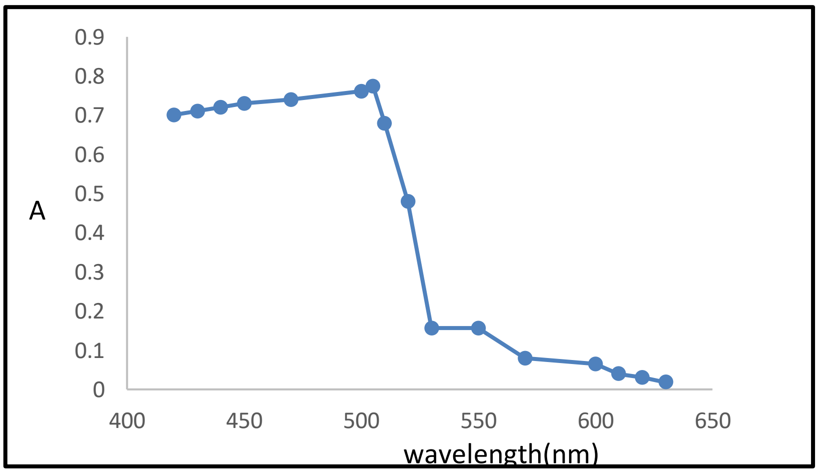

Fig. 5. The maximum wavelength of (iron-1,10-phenanthroline) using spectrophotometric method.

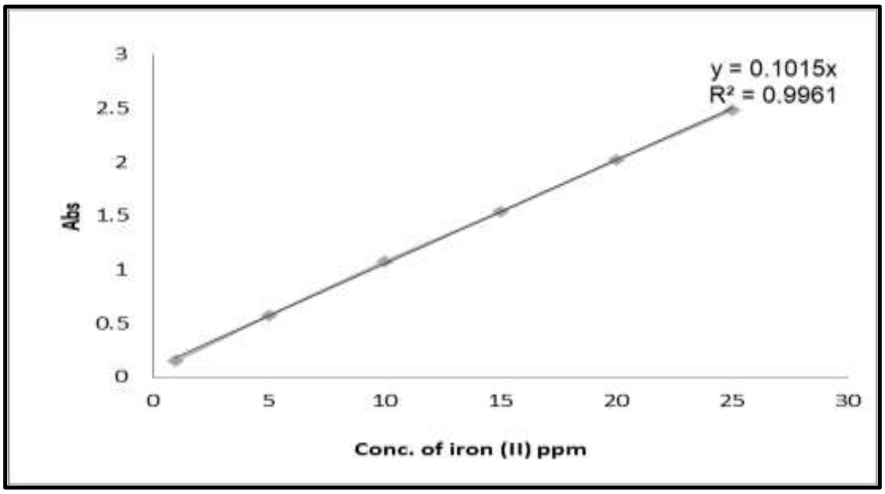

Fig. 6. Calibration curve of (iron-1,10-phenanthroline) using spectrophotometric method.

First, the calibration curve of (iron-1,10-phenanthrolin) was prepared at the range (1-25) ppm from iron at maximum wavelength 510 nm. Then (10) ppm concentration was chosen for examine the adsorption procedure using MgO and CdO as an adsorbent. The adsorption percentage of releasing of iron was calculated using the equation (2). The optimum condition of this experiment was done before adsorption. Many parameters which affect the adsorption were studied such as equilibrium time, temperature, acidity function and initial adsorbent dosage. Fig. 7 shows these parameters such as contact time, weight of adsorbent, initial concentration of iron ion and acidity function.

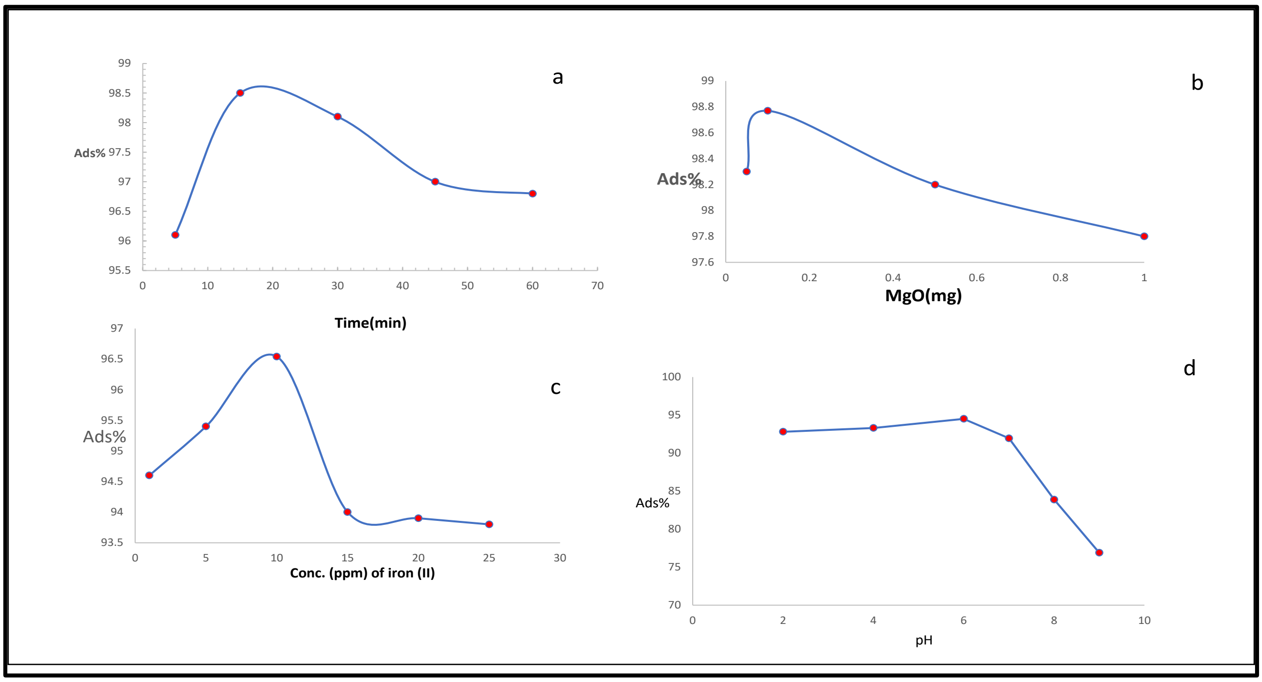

Fig. 7. The optimum conditions for adsorption of iron by MgO nanoparticles shows (a) the equilibrium time of adsorption is 15min, (b) weight of adsorbent is 0.1gm(c)the concentration of iron(II) is 10ppm and d) pH is 6.

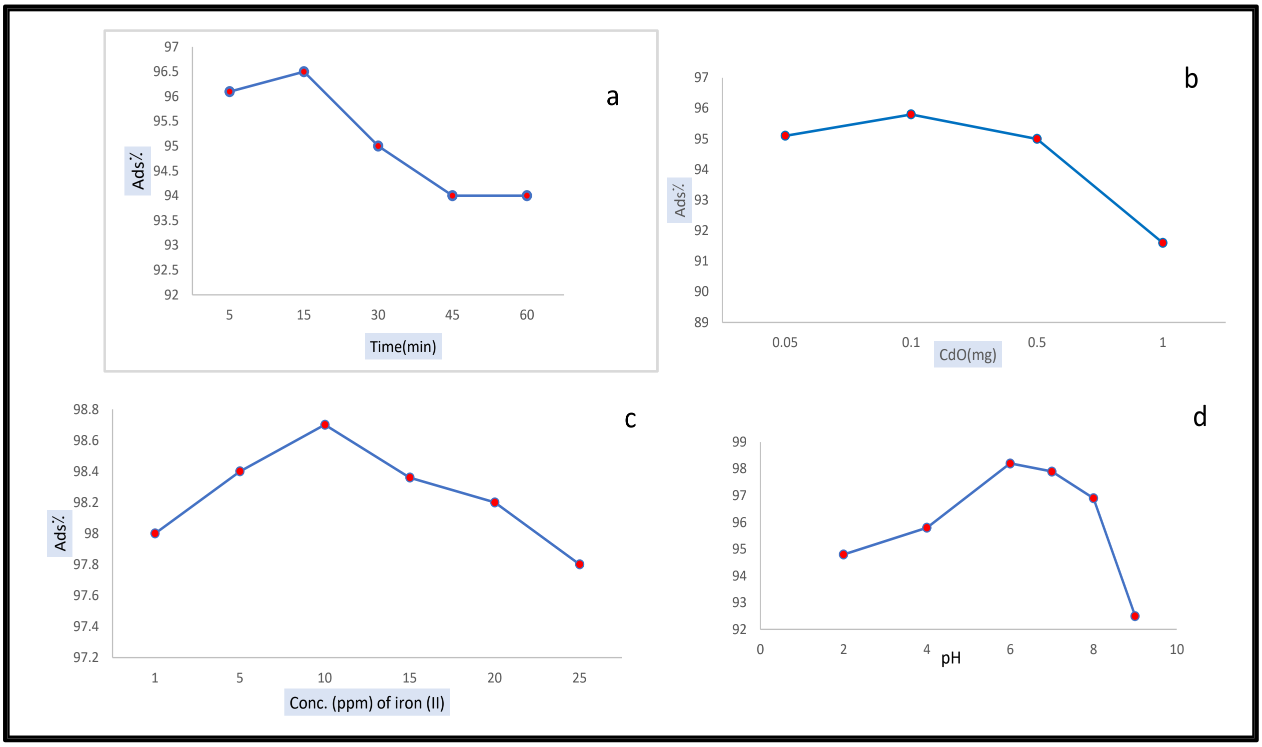

Fig. 8. The optimum conditions for adsorption of iron by CdO nanoparticles shows (a) the equilibrium time of adsorption is 15min, (b) weight of adsorbent is 0.1gm (c) the concentration of iron (II) is 10ppm and d) pH is 6.

The releasing percentage was 98.7% using MgO and 97.8% using CdO respectively. In this study the mixture of two nano oxide gives 99.22 % which is high than each oxide unaccompanied. Fig. 9 shows these results.

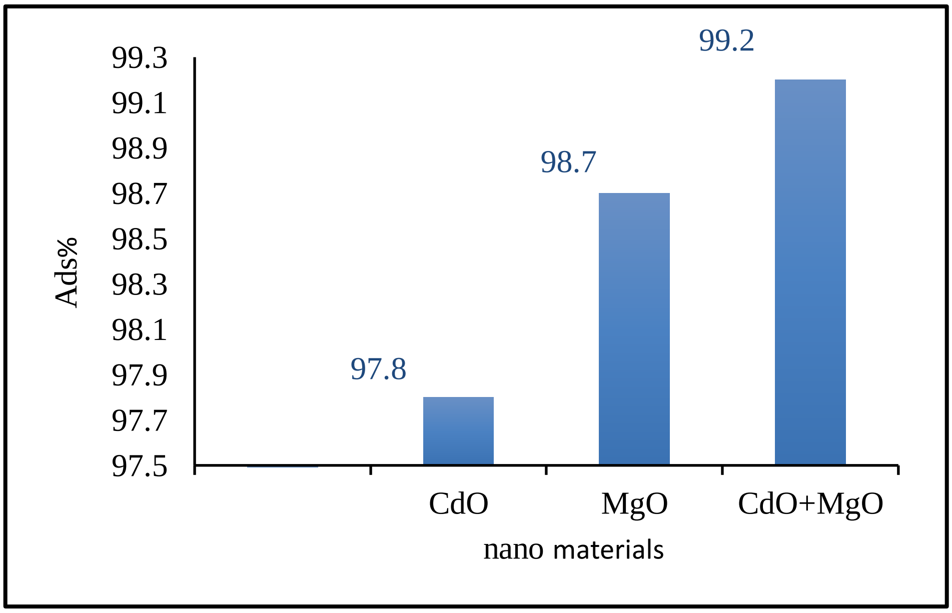

Fig. 9. shows the Adsorbing% of mixture of nano oxides (MgO-CdO) is the highest 99.2%.

From our knowledge this is the first time that mixture of oxide used instead of only one in order to get high percentage of removing. It might be that nano surface will give not only the high surface area for adsorption but also might give more charging and Van der Waals force.

Conclusion

This bottom - up strategy provides a straightforward, quick, non-toxic, and economically feasible method for the synthesis of MgO and CdO nanoparticles. Sol gel approach is successfully used to create MgO and CdO nanoparticles with a crystallite size less than (54) respectively. By using X-ray diffractograms to determine their structure, these nanoparticles are identified as nanostructures. Using Debye Scherer's formula, it is determined that the crystallite size of MgO and CdO nanoparticles are in nano range. By using SEM-EDS, the elemental analysis is performed and the morphology of the nanoparticles almost is spherical for both of two oxides. The production of MgO and CdO is confirmed also by Fourier Transform Infrared Spectroscopy. The study of using these nanoparticles as adsorbents were done successfully and the high value of release percentage about 98% was get. However, the mixture of these oxides gives 99.2% releasing of iron ion from polluted water.

References

[1] R. Taman, M. Ossman, M. Mansour, H. Farag, Journal of Advanced Chemical Engineering **5**(3), (2015).

[2] S.H. Tamboli, R. Patil, S. Kamat, V. Puri, R. Puri , Journal of Alloys and Compounds **477**(1-2), 855 (2009).

[3] A. Taufik, H. Tju, S.P. Prakoso, R. Saleh, AIP Conference Proceedings, **2023**(1), 020035 (2018).

[4] A. de Jesús Ruíz-Baltazar, S.Y. Reyes-López, M. de Lourdes Mondragón-Sánchez, A.I. Robles-Cortés, R. Pérez, Results in Physics **12**, 989 (2019).

[5] S. Sagadevan, S. Vennila, J.A. Lett, A.R. Marlinda, N.A.B. Hamizi, M.R. Johan, Results in Physics **15**, 102543 (2019).

[6] M.K.I. Senevirathna, P.K.D.D.P. Pitigala, E.V.A. Premalal, K. Tennakone, G.R.A. Kumara, A. Konno, Solar Energy Materials and Solar Cells **91**(6), 544 (2007).

[7] K.D. Salman, H.H. Abbas, H.A. Aljawad**,** Journal of Physics: Conference Series **1973**(1), 012104 (2021).

[8] V.K. Gupta, A. Fakhri, S. Tahami, S. Agarwal, Journal of colloid and interface science **504**, 164 (2017).

[9] A. Tadjarodi, M. Imani, H. Kerdari, K. Bijanzad, D. Khaledi, M. Rad, Nanomaterials and Nanotechnology **4**, 16 (2014).

[10] S.D. Bunge, K.M. Krueger, T.J. Boyle, M.A. Rodriguez, T.J. Headley, V.L. Colvin, Journal of Materials Chemistry **13**(7), 1705 (2003).

[11] R. Srinivasaraghavan, R. Chandiramouli, B.G. Jeyaprakash, S. Seshadri, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy **102**, 242 (2013).

[12] D. Choi, G.H. Jeong, S.W. Kim, Bulletin of the Korean Chemical Society **32**(11), 3851 (2011).

[13] A. Askarinejad, A. Morsali, Chemical Engineering Journal **150**(2-3), 569 (2009).

[14] J.H. Kim, Y.C. Hong, H.S. Uhm, Japanese Journal of Applied Physics **46**(7R), 4351 (2007).

[15] Y.C. Zhang, G.L. Wang, Materials Letters **62**(4-5), 673 (2008).

[16] Z. Naseb, Z. Al-Abdullah, T. Ibrahim, Journal of Chemical, Biological and Physical Sciences **11**(1), 036 (2020).
[17] T. Athar, S. Shafi, A.A. Khan, Materials Focus **3**(5), 341 (2014).
[18] Z.T. Alabdullah, I.A. Altameemi, A.M. Sadda, Egyptian Journal of Chemistry **64**(8), 4017 (2021).
[19] T. Prakash, G. Neri, E.R. Kumar, Journal of Alloys and Compounds **624**, 258 (2015).
[20] W. Wang, Y.J. Zhu, Inorganic Chemistry Communications **7**(9), 1003 (2004).
[21] C.M. Martínez, Sustainable Chemistry and Pharmacy **27**, 100611 (2022).
[22] R. Wahab, S.G. Ansari, M.A. Dar, Y.S. Kim, H.S. Shin, Materials Science Forum **558**, 983 (2007).
[23] D.S. Nakonieczny, A. Sambok, M. Antonowicz, M. Basiaga, Z.K. Paszenda, C. Krawczyk, B. Ziębowicz, H. Lemcke, P. Kałużyński, Reviews on Advanced Materials Science **58**(1), 218 (2019).
[24] M.S. Mastuli, N. Kamarulzaman, M.A. Nawawi, A.M Mahat, R. Rusdi, N. Kamarudin, Nanoscale research letters **9**(1), 1 (2014).

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مكون جديد من (اكاسيد المغنيسيوم الكادميوم النانوية) كممتز لمعالجة المياه

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معلومات البحث

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القبول 30 تشرين الاول 2022
النشر 20 كانون الاول 2022

الكلمات المفتاحية

طريقة الصل-جل ، الجسيمات النانوية لاوكسيد المغنيسيوم(MgO) والجسيمات النانوية لاوكسيد الكادميوم(CdO) الامتزاز، إزالة الحديد (II)

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الملخص

استخدمت طريقة الصل-جل لتخليق المواد النانوية. تم تطبيق طريقة لتخليق أكسيد المغنيسيوم (MgO) النانوي وجسيمات أكسيد الكادميوم (CdO) النانوي. تم استخدام نترات المغنيسيوم وخلات الكادميوم كأملاح وهيدروكسيد الصوديوم كمذيب في درجة حرارة الغرفة. تم تلدين أكسيد المغنيسيوم المائي وجسيمات أكسيد الكادميوم النانوية في الهواء عند 600 درجة مئوية. تشمل طرق التشخيص فحص مورفولوجيا سطح الأكاسيد باستخدام المجهر الإلكتروني الماسح والتحليل الطيفي للأشعة السينية المشتتة للطاقة ، وتم إجراء تشخيص المجموعات الوظيفية باستخدام تحليل فورييه للأشعة تحت الحمراء.كما تم استخدام حيودالأشعة السينية لفحص حجم الجسيمات باستخدام طريقة ديباي شرر. تم إنتاج الجسيمات النانوية MgO و CdO في هياكل كروية بمتوسط أحجام بلورية (55) و (55.5) نانومتر ، على التوالي. تمت دراسة استخدام هذه الجسيمات النانوية كممتزات بنجاح وبلغت نسبة إزالة الحديد العالية 97.8٪ و 98.7 على التوالي. علاوة على ذلك فإن خليط هذه الأكاسيد النانوية يعطي 99.2٪ من إطلاق أيون الحديد من المياه الملوثة

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