Tartrazine Azo Dye Removal and Study of Its Kinetics by Calcium Oxide Nanoparticles Synthesized from Eggshells and Chemical Method (sol-gel)

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Abstract: Researchers are becoming more interested in nanotechnology as a means of producing nanoparticles at no cost and with minimal environmental effect. In this work, the synthesis of stable calcium oxide nanoparticles has been done by utilizing egg shells and chemical method. The goal of the research is the synthesis of calcium oxide nanoparticles using (eggshells and chemical method) and their dye removal efficiency. The results showed that calcium oxide nanoparticles were effective at removing Tartrazine dye. Furthermore, we have investigated the effect of variables such as concentration, adsorbent dosage, temperature, time and pH value. We have observed maximum 10 mg.L\textsuperscript{-1} dye removal at 60, 180 min time interval, pH 2, 3 and 0.3, 0.35 g nanoparticles for CaO\textsubscript{egg} from eggshell and CaO\textsubscript{chem} from chemical method, respectively. The shape of calcium oxide nanoparticles for CaO\textsubscript{egg} and CaO\textsubscript{chem} was rounded crystals with smooth and wavy surface, and range of grain size was (54.68-82.14 nm) and irregular crystal with rough and angular surface with range of grain size (43-72.49 nm), respectively.

Keywords: Eggshells, SEM, Calcium Oxide Nanoparticles, XRD, Tartrazine.

1. Introduction

Pollutants such as dyes are well-known to be dangerous as well as harmful to ecosystems and human life, particularly when levels exceed the threshold limit[1-3]. Azo dyes account for 70% of all dyes used in the world. Since azo dyes include aromatic rings, azo bonds (\textsuperscript{-}N=N\textsuperscript{-}) and sulfonic groups, they are difficult to decompose in nature and have toxic, mutagenic, and carcinogenic properties[4-6]. The azo dye released and used during the dyeing process and food preparation may cause serious health problems that must be addressed, otherwise the number of diseases caused by dye detergents will increase[7]. Tartrazine (E102) \{trisodium, 5-azo-1-(4-sulfonatophenyl)-4-{(sulfonatophenyl) diazenyl}-4H-pyrazole-3-carboxylate\}, figure 1 is synthetic dye which is added to many food products[8,9]. Tartrazine is commonly used to enhance the appearance, color, and texture of foods and soft drinks, as well as to preserve the natural color during processing and storage. It has several advantages over natural dyes, including high stability to oxygen, light, and pH, as well as color uniformity, low microbiological contamination, and lower production costs. Tartrazine, on the other hand, can have health consequences (respiratory issues, chromosomal damage, allergy, thyroid tumors, abdominal pain, hyperactivity, etc.\textsuperscript{[10-13]}). To remove dyes from aqueous solutions, a variety of treatment methods are currently used, containing flocculation\textsuperscript{[14]}, photo-degradation\textsuperscript{[15]}, coagulation\textsuperscript{[16]}, oxidation\textsuperscript{[17]} and electrochemical techniques\textsuperscript{[18]}. However, such approaches do have some disadvantages, such as high costs and complicated operations, as well as the need for additional catalysts\textsuperscript{[19]}. In comparison to the methods described above, the adsorption strategy for removing dyes from aqueous solutions is easy, convenient, and efficient. Zeolite, Polymer, carbon nanotubes, clay, and activated carbon are only a few of materials that have been produced so far as adsorbents \textsuperscript{[20]}. The aim of this work, is synthesis of calcium oxide nanoparticles chemically and using eggshells, then adsorption of tartrazine azo dye from aqueous solutions utilizing calcium oxide nanoparticles as adsorbent.

![Fig. 1. The chemical structure of tartrazine (E102)](image-url)

2. Experimental Part

We have divided experimental part into two parts: the first one is the synthesis of CaO nanoparticles and analysis of for the confirmation of the production of nanoparticles. The second part is the tartrazine azo dye removal.

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2.1. Materials

All chemicals utilized in this study have analytical grade and purity 98.9%. The following compounds and materials have used for experimentation, i.e., calcium chloride (CaCl₂), eggshells, tartrazine azo dye and distilled water. Purchased were hydrochloric acid with a concentration of 35%–37% and sodium hydroxide with a purity of 97%. (Sigma- Aldrich company.)

2.2. Instrumentation

The instruments employed for the experimentation were SEM ((FE-SEM) TESCAN, MIRA3, France), XRD ((X-Ray diffraction) Xpert, Phillipps, Holland), UV-Vis spectrophotometer (100 Coins/Varian, USA), FTIR ((Shimadzu 8400, Japan),), mortar and pestle, centrifuge, muffle furnace, Whatman filter paper, conical flask, test tubes, beaker, funnel and droppers.

2.3. Synthesis of CaO Nanoparticles from Eggshells

This method began with the use of chicken eggshell as a precursor (PES). Eggshells that had been discarded had been thoroughly cleaned, with deionized water after being thoroughly washed with warm water. The washed sample was then dried for two hours at 120 degrees Celsius before being ground to a powder and sieved through a 100 m sieve. A 1 M hydrochloric acid, 250 mL (HCl), PES (12.5 gm) was dissolved to make a solution of calcium chloride (CaCl₂)[21].

\[
\text{CaCO}_3 (s) + 2\text{HCl (aq)} \rightarrow \text{CaCl}_2 (aq) + \text{H}_2\text{O (l)} + \text{CO}_2 (g) \quad (1)
\]

The following step was the hydrolysis process, which resulted in the formation of sol. The term’sol’ refers to a stable colloidal particle dispersion of precursors a result of a hydrolysis reaction. Metal hydroxide was formed during the hydrolysis process. At room temperature, convert the previous step's homogeneous CaCl₂ solution into 'sol'. 1 M sodium hydroxide, 250 mL (NaOH) was gradually (drop by drop) added (Equation (2)). Condensation formed a ‘gel,’ which was then observed. Because of the slow addition of NaOH, the nucleation rate was low, which encouraged subsequent nucleation. Ca(OH)₂ precipitation one on top of the other, resulting in a highly crystalline gel. Small particles were formed as a result of the condensation reaction. Within the liquid, these were interconnected to form an inorganic network that is rigid and highly crystalline The Ca(OH)₂ gel-containing solution was aged at room temperature for one night.

\[
\text{CaCl}_2 (aq) + 2\text{NaOH (aq)} \rightarrow \text{Ca(OH)}_2 (s) + 2\text{NaCl (aq)} \quad (2)
\]

The filtrate was then cleaned with distilled water to remove impurities that had been adsorbed in the precipitate. The gel was dried at the last of the synthesis process. The solvent (liquid phase) was withdrawn. During this process, as well as significant shrinkage and densification were observed. The powder was allowed to dry for 24 hours. In a 60°C oven before being calcined for 1 hour at 900°C. (Equation (3))

\[
\text{Ca(OH)}_2 (s) + \text{Heat} \rightarrow \text{CaO (s)} + \text{H}_2\text{O (l)} \quad (3)
\]

2.4. Synthesis of CaO nanoparticles from CaCl₂

After dissolved in water, a suitable amount of (CaCl₂) was heated to 40°C. When the solution was quickly mixed, add “20 ml of NaOH (0.1M)”. After the reaction had been heated for 30 minutes, sifting and washing with a pH of about eight was achieved. In this manner, the precursor’s Calcium hydroxide, for example, is a form of CaO, were made and dried at 65°C for 24 hours. After calcining the dried precedents at (900 ℃) Calcium oxide powder was formed after 2 hours. [22, 23]. The reaction's ionic equation is as follows:

\[
3\text{Ca}^{2+} + 6\text{OH}^- \rightarrow 3\text{Ca(OH)}_2(l) \rightarrow 3\text{CaO} + 3\text{H}_2\text{O} \quad (4)
\]

2.5. Removal of Tartrazine (E102)

The removal of tartrazine will be achieved using CaO nanoparticles created during synthesis.

2.5.1. Preparation of 1000 mg.L⁻¹ Tartrazine Dye Solution

1000 mg.L⁻¹ solution of TAR (E102) has been dissolving 0.1 g of TAR within 100 mL of D.W. Initially, 100 mg.L⁻¹ solution from 1000 mg.L⁻¹ has been prepared following dilution. After that, were prepared the solutions of

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10, 20, 30 mg.L⁻¹. The efficiency of color removal was calculated utilizing Eq. 5. Where \( C_i \) is a concentration of TAR before adding CaO nanoparticles and \( C_e \) represent its concentration after adding CaO nanoparticles as an adsorbent.

\[
\text{Adsorption} \% = \frac{C_i - C_e}{C_i} \times 100
\]  

(5)

2.5.2. Procedure of E102 Azo Dye Removal

The first procedure was achieved using 12 mL of E102 dye( 10 mg.L⁻¹) was put in the conical flask, then add 0.35 g of CaO nanoparticles that synthesized form eggshells and pH 3 was adjacent using A solution of 0.1 M HCl or 0.1 M NaOH The mixture was shaking for 60 min, heating at 283 K and centrifugation for 5 min (4000 rpm). After filtration, the solution was measured the absorbance against the blank solution at 427 nm.

The second technique was carried out utilizing 12 mL of E102 dye( 10 mg.L⁻¹) was put in the conical flask, then add 0.3 g of CaO nanoparticles that chemically synthesized and pH 2 was adjacent using 0.1 M of HCl or 0.1 M of NaOH solution. The mixture was shaking for 180 min, heating at 283 K and centrifugation for 5 min (4000 rpm). After filtration, the solution was measured the absorbance against the blank solution at 427 nm.

2.6. Detailed Study of CaO Nanoparticles

The subsequent step of the experiment is the characterization of synthesized CaO nanoparticles. The structure, morphological and chemical composition of CaO nanoparticles has been analyzed using X-ray diffractometers (XRD) (X- Ray diffraction) Xpert, Philips, Holland.), Scanning Electron Microscope (SEM) and thermo gravimetric analysis (TGA)(DSC-TGA,Q600,America.), equipment. The shape and size of calcium oxide nanoparticles have been showed utilizing SEM (FE-SEM) TESCAN, MIRA3, France.), The examination of the crystal structure of synthesized CaO nanoparticles has been achieved using XRD (X-Ray diffraction) Xpert, Phillips, Holland.). FTIR spectra were performed for the collection of functional groups, present in this synthesis of CaO nanoparticles.

The further studies contain: effect of dye concentration, amount of adsorbent, pH value, temperature, and time adsorption on removing dye and various kinetic studies.

3. Results and Discussion

In this study, two nanoscale surfaces were prepared for calcium oxide. The sol gel method was used to prepare the first surface from egg shells residues, the second surface was prepared by the chemical method (sol- gel), and the resulting of Calcium hydroxide It has been calcined from the two methods at 900 °C to obtain the nanoscale surface of calcium oxide.

3.1. Atomic Force Microscopy (AFM)

Atomic force microscopy (AFM) ((Spm-AA300, Angstrom). images of one of the selected samples provide additional information on the morphology of the surface, shape, as well as particle size [24]. AFM is employed to examine the topography and shape of various Nanomaterials, including Nanosheets of graphene [25], metal oxide nanoparticles[26], and metal nanoparticles.

The Fig. 2 show the two and three dimensions of Images from AFM and the corresponding the distribution of sizes of Calcium oxide prepared from eggshells and calcined at CaO900°Ceg and Calcium oxide prepared by the chemical method (Sol-Gel method) and calcined with the same temperature CaO900°Cchem. The estimated RMS (root mean square) average surface roughness and grain size values were measured and described in the table 1 by making a deposit a micro volume of the solution colloidal on high-quality mica and drying it at room temperature in a clean laminar flow chamber.

**Table 1.** The average roughness, grain size, and root mean square of CaO900°Ceg and CaO900°Cchem, nanoparticles prepared from eggshells and method (Sol-gel method)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Avg. diameter</th>
<th>Roughness average</th>
<th>Root mean square</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO900°Ceg</td>
<td>82.14nm</td>
<td>6.55nm</td>
<td>7.69 nm</td>
</tr>
<tr>
<td>CaO900°Cchem</td>
<td>72.49nm</td>
<td>9.22nm</td>
<td>11.2 nm</td>
</tr>
</tbody>
</table>
3.2. Diffraction of X-rays (XRD)

XRD results synthesized calcium oxide nanoparticle from raw eggshell, as well as the calcined at 900°C is shown. Figure 3 pattern XRD showed Calcium oxide (CaO) is a good match (PDF Card No. 99-0070). At 2θ = 37.85, the main peak appeared. Furthermore, several peaks appeared at 32.37, 37.58, 53.06, 64.41, 67.68, which are also assigned to the lime phase planes (111), (200), (220), (311) and (222). The results show that during the synthesis, the CaCO₃ was completely in raw eggshell converted to CaO. The mean Calcium oxide crystallite size nanoparticle was calculated using Equation of Scherrer's d =kλ/β cos θ, where d is mean crystallite size, λ is wavelength, k is Scherrer constant, θ is Bragg's angle, β and is structural broadening As a result, the average crystallite size was calculated to be 54.68nm[24].
Figure 4 depicts Calcium hydroxide (Ca(OH)$_2$) X-ray diffraction patterns samples. All of the diffraction peaks in Figs. 4, agree with a standard Ca(OH)$_2$ structure (Portlandite, JCPDS card No. 00-004-0733). The hexagonal crystal system, as well as the lattice parameters (a = 3.43018 Å, b = 3.10096 Å, c = 4.91178 Å). After two hours of heating at 900 °C, the precursors [Ca(OH)$_2$] easily decomposed into calcium oxide (CaO). (lime, syn, JCPDS card No. 00-004-0777) utilizing the cubic crystal system, as well as the lattice parameters (a = 4.8105 Å). In the XRD patterns, some of the calcite peaks [CaCO$_3$] shown in Fig.4 Carbonation of Calcium hydroxide (Ca(OH)$_2$) and Calcium oxide (CaO) by atmospheric Carbon dioxide (CO$_2$) occurs quickly. According to the literature, Calcium hydroxide and Calcium oxide carbonation reaction occurs very quickly[25]. As a result, the average crystallite size for CaO$_{chem}$ was calculated to be 43 nm.

![Fig. 3. X-ray diffraction pattern of CaO900°C_{chem}](image)

![Fig. 4. X-ray diffraction pattern of CaO900°C_{chem}](image)

3.3. Scanning Electron Microscope (SEM)

Calcium oxide samples were roasted at 900 °C, using an eggshell waste and chemical method. During the calcination of Calcium oxide from eggshell waste in the laboratory oven, an initial blast was observed. The sorbent test SEM image was completed under high vacuum with a "" and an incr(FE-SEM) TESCAN, MIRA3, France).... easing speed voltage of 200 keV. Fig .5 depicts this. The images show that the nanoparticles used are less than 100 nm in size. This implies that the orchestrated sorbent can be measured at the Nano scale. The surface morphology of the calcium oxide samples was studied. Fig. 5 shows SEM microphotographs of calcium oxides (CaO) samples obtained 2 hours later of calcination at 900 °C of Calcium hydroxide (Ca(OH)$_2$) material. The results revealed that the size of the particles varied significantly, as well as agglomeration. Depending on their origin, in general, CaO from eggshell Fig. 5 has larger particles than CaO from chemical method Fig.6. CaO crystals from eggshell are rounded and have smooth and wavy surfaces. Fig.5 in compared to CaO from chemical method, which has irregular crystals with rough and angular surfaces Figs.6. Eggshell CaO particles exhibit greater agglomeration, which reveals the merging of individual units to form an interconnected skeleton structure. Both samples show a general lack of pores.

![Fig. 5. SEM image of Nano of CaO900C°eg sorbent](image)
3.4. Thermogravimetric Analysis (TGA)

Figs. 7 and 8 show the curves of CaO synthesized from eggshell and Ca(OH)\textsubscript{2} gel synthesized by chemical method, respectively. In eggshell, weight loss totaling 52.19 percent was observed, and at 450 °C temperature, Carbon dioxide (CO\textsubscript{2}) is emitted into the atmosphere. The high worth loss of eggshell ignition during calcination, the conversion of Calcium carbonate (CaCO\textsubscript{3}) to calcium oxides (CaO) and Carbon dioxide (CO\textsubscript{2}) [27]. In the case of Calcium hydroxide gel (Ca(OH)\textsubscript{2}), three analyses were performed: 32-430 °C, 430-700 °C, and 700-1000 °C, with 8.999 percent, 8.533 percent, and 2.480 percent mass changes, respectively. The vaporization of physically adsorbed water causes the losses. CO\textsubscript{2} is released during the decomposition of Calcium hydroxide gel (Ca(OH)\textsubscript{2}) to calcium oxides (CaO) and the decomposition of Calcium carbonate (CaCO\textsubscript{3}) to calcium oxides (CaO). [24].

![Fig. 6. SEM image of Nano of CaO900°C chem sorbent](image)

![Fig. 7. Thermogravimetric analysis (TGA) eggshell curve](image)

![Fig. 8. Calcium hydroxide gel (Ca(OH)\textsubscript{2}) thermogravimetric analysis (TGA) curve](image)
3.5. FTIR Analysis

The FTIR spectra of eggshell, Calcium hydroxide gel (Ca(OH)$_2$), and CaO nanoparticle synthesized from raw eggshell and chemical method. The FTIR spectrum of raw eggshell presented three fundamental bands at 1398.44, 871.85 and 711.76 cm$^{-1}$ corresponding to the C-O bond vibration modes in CO$_3$ groups: asymmetric stretching ($\nu_3$), out of-plane bending ($\nu_2$) and in-plane bending ($\nu_4$) respectively, of the CO$_3$ groups[28] the Ca(OH)$_2$ gel FT-infrared (FTIR) spectrum for CaO$_{eg}$ and CaO$_{chem}$, respectively depicts a distinct absorption peak at 3041.73 cm$^{-1}$ associated with the (OH ) hydroxyl group stretching mode[23, 29-31], and a peak at 1417.73 cm$^{-1}$ associated with the out of plane bending of CO$_3$ in CaCO$_3$. CaO nanoparticles, on the other hand, revealed peaks at 1444.42 cm$^{-1}$, 1064.51 cm$^{-1}$, and 863.95 cm$^{-1}$, which were attributed to C–O bonds, indicating that CaO nanoparticles have been carbonated [32, 33]. The lack of a strong absorption in the 1415.52 cm$^{-1}$ region CaCO$_3$ is indicated, the eggshells fundamental component was no longer present Due to the fact that it had already been converted to CaO.

3.6. Effect of Amount CaO Nanoparticles

The amount of nanoparticles played a considerable role in efficiency of decolorization. The experimentation has been achieved using a various amount of CaO nanoparticles from (0.05-0.35 g). The influence of the nanoparticles amount on tartrazine azo dye was plotted in the form of a graph. The maximum amount of TAR removal (10 mg.L$^{-1}$) was observed at 0.35 g for eggshells and 0.3 g for chemical method. The amount of the nanoparticles effect on decoloration of TAR dye has been graphically represented in Fig. 9.

3.7. Effect of Initial Adsorbate Concentration

In this work TAR dye solution 12 mL of various concentrations (10- 30 mg.L$^{-1}$) were blended with 0.35 g for NPS eggshells and 0.3 g for NPS chemical method in the conical flasks. The influence of initial TAR dye concentration on removal efficiency utilizing CaO nanoparticles is presented in Fig.10. For two types nanoparticles in removal effect over 78 % with initial adsorbate concentration 10 mg.L$^{-1}$.

3.8. The Effect of pH on the Removal of TAR Dye

The influence of pH was observed which has also affected the decolorization of TAR dye. The CaO nanoparticles give maximum decolorization at a certain level when the pH was increased and then more increase has a negative effect on the decolorization. The maximum removal was carried out with pH 3 for NPS eggshells and pH 2 for NPS chemical method. The pH effect on TAR dye removal is graphically represented in Fig.11.

3.9. The Effect of Temperature on TAR Dye Removal

The effect of temperature (283- 313 K) was showed which has affected the decolorization of TAR dye. The ideal temperature for dye removal is 283 K for NPS eggshells and for NPS chemical method. The temperature effect on TAR dye removal is graphically represented in Fig.12.
3.10. Time Effect on TAR Dye Removal

The decolorization of TAR dye at 283 K was investigated. Initially, 12 mL TAR dye solution has been taken, and 0.35 g from NPS eggshells or 0.3 g from NPS chemical method was added. The mixture solution was heated for 30-180 min at 283 K for NPS eggshells and for NPS chemical method. The perfect time observed has been 60 min for NPS eggshells or 180 min for NPS chemical method. The time effect on TAR dye removal is graphically represented in Fig.13.

3.11. Kinetic Study of CaO Nanoparticles Isotherm

Adsorption kinetics describes the rate solute absorption, which governs the adsorption reaction's residence time. A batch experiment was carried out to investigate the rate of TAR dye (10 mg/L) adsorption by on the CaO eg and CaO chem (0.35 & 0.3 g) at pH 2&3, respectively.

Model of Pseudo-first Order

Laguerren [34] described the pseudo first order model.

\[ \ln(qe - qt) = \ln qe - (k1)t \]  

where \( qe \) and \( qt \) are the TAR dye adsorbed amounts mg g\(^{-1}\) at equilibrium and at any time \( t \), respectively, and \( k1 \) (min\(^{-1}\)) is the pseudo first order equation's adsorption rate constant. The plot of \( \ln(qe - qt) \) versus \( t \) should yield a linear relationship between the values of \( k1, qe \), as well as the correlation coefficient \( R^2 \) were calculated. Because of the low correlation coefficients (\( R^2 > 0.5277 \), \( R^2 > 0.7093 \)) at different temperatures, a pseudo first order kinetic model for the adsorption of TAR dye on CaO eg and CaO chem are less applicable, Fig.14.

Model of Pseudo-second Order

The differential equation[35] represents Model of pseudo-first order

\[ \frac{t}{qt} = \frac{1}{k_{24e}} + \frac{t}{qe} \]  

Fig. 11. The effect of pH on the removal of TAR dye (1) eggshell, (2) chemical method

Fig. 12. The effect of temperature on TAR dye removal. (1) eggshell, (2) chemical method

Fig. 13: Time effect on TAR dye removal (1) eggshell, (2) chemical method
Where $k_2$ is the adsorption of pseudo-second order equilibrium constant rate (g/ mg.min). The slope and intercept of the t/qt versus t, plot were used to compute the second order rate constant $k_2$. The correlation coefficients ($R^2 > 0.99$) for both adsorbent different temperatures were discovered, and the calculated qe values match the experimental data very well, Fig.15.

Fig. 14. The first order kinetic model’s applicability to TAR dye adsorption on (1)CaO eg, (2) CaO chem absorbent

Fig. 15. The second order kinetic model’s applicability to TAR dye adsorption on (1)CaO eg, (2) CaO chem absorbent.

3.11.1. Comparison of the Isotherm Absorption Models

Isotherms are mathematical relationships that are derived and adapted to describe a specific adsorption system through specific assumptions which are a good source for obtaining data related to the nature of different systems by calculating some of the constants specific to each isotherm[36]. In this study two models of isotherms were chosen for the purpose of applying them to the experimental results for the adsorption process they are the Freundlich isotherm and Langmuir. This study was accomplished by using the nanomaterial of calcium oxide, which was prepared in two ways: the first is from eggshells and the second is the chemical method, sol gel.

3.11.1.1. Langmuir and Freundlish Isotherm

Freundlich and Langmuir isotherms were applied to the practical data obtained from the study of the adsorption system under study, as the values of the Feruendlich constants (K, n) were calculated from the relationship between the value of (log qe and log Ce) according to the following equation

$$\log q_e = \log K_F + \frac{1}{n} \log C_e$$  (8)

Also, Langmuir’s constant (b) and the theoretical maximum amplitude of adsorption (Qmax) were calculated from the relationship between (Ce / qe) versus (Ce) and according to the following equation

$$\frac{C_e}{q_e} = \frac{1}{b Q_{max}} + \frac{C_e}{Q_{max}}$$  (9)

The program (Excel) was used to complete the necessary graphs to calculate the values mentioned in this paragraph.

Table 2. The values of the Freundlich and Langmuir constants and the correlation coefficient values of the dye adsorption process on the surface of nanoscale calcium oxide prepared by two methods from eggshells and chemical method, sol gel

<table>
<thead>
<tr>
<th>Adsorbate</th>
<th>Langmuir parameters</th>
<th>Freundlich parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO eg</td>
<td>$K_L$ 1.1879 0.9300</td>
<td>$K_F$ 0.23988 1.8864</td>
</tr>
<tr>
<td></td>
<td>$q_{in}$ 0.21503</td>
<td>$n$ 0.25995 2.1593</td>
</tr>
<tr>
<td>CaO chem</td>
<td>$0.19776 1.23046$</td>
<td>$0.9589 0.25995$</td>
</tr>
<tr>
<td></td>
<td>$R^2 0.9300 0.854$</td>
<td>$R^2 0.8054 0.88774$</td>
</tr>
</tbody>
</table>

Where it was observed that the dye corresponds to a large extent with the Langmuir equation.
From observing the values of the Frendelsh constants and the value of the correlation coefficient $R^2$, it was found that the tartrazine dye It does not correspond to the Freundlich equation.

4. Conclusion

In this research, experimentation for green synthesis of CaO nanoparticles using eggshell has been achieved. This eco-friendly technique of synthesis of nanoparticles has been recommended over physic-chemical techniques. Calcium oxide nanoparticles, which have been synthesized, are low-cost molecules that can act as dye absorbents. In addition, it is the best way of using natural materials for the synthesis by avoiding the expensive and toxic chemicals. The synthesized nanoparticles can be utilized in various field like pharma, biochemistry, industry and agriculture. In the present work, tartrazine dye was removed by CaO nanoparticles as well as the effect of concentration CaO nanoparticles, pH value and contact time was observed that was satisfactory. The maximum time was 60, 180 min; pH 2, 3 and 0.3; 0.35 g nanoparticles for eggshells and chemical method, respectivaly has proved synthesized calcium nanoparticles as the best condition for removing the tartrazine azo dye. The adsorption process was described by both the linear and non-linear Freundlich isotherm models. The kinetic study clearly revealed that the pseudo-second-order kinetic model has the best fit and the highest correlation coefficient value.

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References


