Essay: Thermodynamic, kinetic and isotherms studies of acetic acid adsorption onto activated carbon

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1. Introduction:

Coming from an LEDC background, we always had a problem with the purity of river water. The problem was that purification process of water costs an exceedingly large amount of money. This subject attracted my interest since all of us should be sensitive about keeping a clean environment and leave a clean world for future generations. A short research led me to interest with the adsorption process and activated carbon. Adsorption is powerful technology of treating wastewater by using activated carbon, but what restricted its application is the high cost of activated carbon and its loss during the regeneration. After 1990âtas there were new methods introduced in order to adsorb heavy metal ions by using low cost renewable organic material like agricultural waste materials, seaweeds yeasts and other dead microbial biomass. In order to remove acetic acid from sewage water, two routes were suggested and one of these routes is through using activated carbon. In order to design an adsorbent for such applications, it will require knowledge of equilibrium isotherm as well as adsorption rate data.

The recovery of acetic acid from industrial wastewaters is an important separation problem, and one of the routes suggested for this application is liquid phase adsorption on activated carbon adsorbents. Designing an adsorbent for such applications requires knowledge of equilibrium isotherm as well as adsorption rate data. In the present work, the kinetics of adsorption of acetic acid on activated carbon has been studied. A three-parameter isotherm model has been used to correlate the equilibrium data, and a combined external film transfer-surface diffusion model has been used to simulate the experimental adsorption rate data.

After a short research I have noticed that the adsorption of waste water has been done numerous of times, so I thought if the activated carbon can adsorb metal ions, would it be possible for the carbon to adsorb hydrogen ions from a weak monoprotic acid Then I asked the research question; “To what extent does activated carbon adsorb acetic acid and whatâs the nature of the process?” or “To quantifiably measure the extent of the adsorption of acetic acid by activated carbon and to determine the thermodynamical and kinetical parameters?” or “To estimate activated carbon’s adsorption capacity of acetic acid and the potential effect of thermodynamics and kinetics”

(Need help with the Research question wording, please)
2. Background information:

"Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or a liquid (adsorbent), forming a molecular or atomic film (the adsorbate). It is different from absorption, in which a substance diffuses into a liquid or solid to form a solution. The term sorption encompasses both processes, while desorption is the reverse process" [1].

"Adsorption is operative in most natural physical, biological, and chemical systems, and is widely used in industrial applications such as activated charcoal, synthetic resins and water purification. Similar to surface tension, adsorption is a consequence of surface energy. In a bulk material, all the bonding requirements (be they ionic, covalent or metallic) of the constituent atoms of the material are filled. But atoms on the (clean) surface experience a bond deficiency, because they are not wholly surrounded by other atoms. Thus it is energetically favorable for them to bond with whatever happens to be available. The exact nature of the bonding depends on the details of the species involved, but the adsorbed material is generally classified as exhibiting physisorption or chemisorption" [1].

Physisorption or physical adsorption is a type of adsorption in which the adsorbate adheres to the surface only through Van der Waals (weak intermolecular) interactions, which are also responsible for the non-ideal behavior of real gases as seen in figure(1).

Chemisorption is a type of adsorption whereby a molecule adheres to a surface through the formation of a chemical bond, as opposed to the Van der Waals forces which cause physisorption as seen in figure(1). Adsorption is usually described through isotherms, that is, functions which connect the amount of adsorbate on the adsorbent, with its pressure (if gas) or concentration (if liquid). One can find in literature several models describing process of adsorption, namely Freundlich isotherm, Langmuir isotherm, BET isotherm, etc. [1].

Figure 1: Schematic representation of adsorption process

3. Materials and Methods:

3.1 The adsorbate:

Acetic acid is an organic compound that is a colorless liquid when undiluted. It is the second simplest carboxylic acid (after formic acid) as seen in figure (2), and is an important chemical reagent and industrial chemical [2].

Figure 2: The chemical structure of acetic acid

The hydrogen center (proton) in the carboxyl group (â‘COOH) in carboxylic acids such as acetic acid can dissociate from the molecule by ionization. Because of this release of the proton (H+) acetic acid begins to show acidic characteristics. Acetic acid is a weak monoprotic acid. In aqueous solution, it has a pKa value of 4.76. Its conjugate base is the acetate ion (CH3COOâ‘). A 1.0 M solution (about the concentration of domestic vinegar) has a pH of 2.4, indicating that merely 0.4% of the acetic acid molecules are dissociated [2A].

For this experiment acetic acid was used with different concentrations; firstly used was 1 M solution which then it has been diluted into (0.8, 0.6, 0.4 and 0.2M) and then it was titrated against NaOH using phenolphthalein as an indicator; the pure unadsorbed acetic acid was set to be the control variable for the study.

3.2 The adsorbent:

Activated carbon, also called activated charcoal or activated coal, is a general term that includes carbon material mostly derived from charcoal. For all three variations of the name, “activated” is sometimes substituted by “active.” By any name, it is a material with an exceptionally high surface area. The three main physical carbon types are granular, powder and extruded (pellet). All three types of activated carbon can have properties tailored to the application. Activated carbon is frequently used in everyday life, in: industry, food production, medicine, pharmacy, military, etc. In pharmacy, activated charcoal is considered to be the most effective single agent available as an emergency decontaminant in the gastrointestinal tract. It is used after a person swallows or absorbs almost any toxic drug or chemical.

Activated carbon attracts organic chemicals from vapor and liquid streams cleaning them of unwanted chemicals. "It does not have a great capacity for these chemicals, but is very cost effective for treating large volumes of air or water to remove dilute concentrations of contamination. For a better perspective, when individuals ingest chemicals or are experiencing food poisoning, they are instructed to drink a small amount
of activated carbon to soak up and remove the poisons”[4]. Powdered activated carbon was used in this study. The carbon had a surface area of approximately 850 m2/g. For this research, a sample of the produced carbon was sieved using U.S standard sieves [4]. The reason that activated carbon is such an effective adsorbent material is due to its large number of cavernous pores as you can see in figure(3). These provide a large surface area relative to the size of the actual carbon particle and its visible exterior surface [3]. Activated carbon uses the physical adsorption process whereby attractive van der Waals forces pull the solute out of solution and onto its surface. Once the solute is bound to the carbon is it considered “removed” from the water [3].

Figure 3: Scanning Electron Microscope Images of Activated carbon Pores

3.3 Reaction Mechanism:
This process involved the occurrence of chemisorption. It was suggested that acetic acid reacts with carboxyl group believed to be present on the surface of the activated carbon. The hydrogen center (proton) in the carboxyl group (â‘COOH) in carboxylic acids such as acetic acid can dissociate from the molecule following the equation below and represented in figure (4):

CH₃CO₂H → CH₃C,O₂⁻ + H⁺

At this point of equilibrium the surface is filled with hydrogen ions and canât adsorb more molecules. And for the titration process:

CH₃CO⁻ + H⁺ + NaOH → CH₃ CO₂ Na⁺ + H₂ O

Figure 4: representation of acetic acid adsorption

3.4 Pre-method (test of optimum adsorption and conc.):
Aqueous acetic acid solutions with the following concentration (0.2M, 0.4M, 0.6M, 0.8M and 1M) was prepared. The actual concentration of acetic acid in flasks was determined by titrating acetic acid against 0.5M NaOH and using phenolphthalein as an indicator. A 100ml of 0.6 M acetic acid was prepared in a volumetric flask, a 5g of activated carbon was poured into the flask and was shaken continuously after every 5 minutes a sustainable amount of the solution was poured into a flasks with filter paper. The final volume of the acetic acid was determined by titration. This pre-method step was done to find our control variable and to find the sustainable amount of time it takes to reach the equilibrium and that time was after 30 minutes.

3.5 Method:
Aqueous solutions of acetic acid with different concentrations was prepared into five numbered flasks. The total volume of each solution was 100 ml. A 100 ml volumetric flask with a stopper was used in this experiment. The actual concentration of acetic acid in flasks was determined by titrating acetic acid against 0.5M NaOH and using phenolphthalein as an indicator. A 5g of newly opened (so that the carbon has its maximum activation and no vapor and other substances are clogged in the pores) powdered activated carbon was used in this experiment. The active carbon was poured into 2-3 flask at the same time, and the flasks were shake continuously. After five minutes a sustainable amount of the solution was poured into a clinical flask with a filter paper, the same procedure was done for 10, 20, 30 minutes and overnight. Afterwards, the final volume of the acetic acid was determined by titrating the filtered acid against 0.5 M NaOH. This process has been done at room temperature (25 oC), 30 oC and 40 oC by using a thermostat to keep the temperature constant.

Figure 5: a picture of my lab work
Figure 6: the thermostat used in my experiment

3.6 Amount of adsorbent equation:
In this study, the amount of acetic acid adsorbed was calculated from the initial and final concentrations and the volume of solution according to the following equation for both isotherms that will be discussed in the next section [8]:

Qₑ = (V(Cₒ - Cₑ) / m)  

Where, V = Volume of solution (ml)
Cₒ = initial concentration (mg/L)
Cₑ = final concentration (mg/L)
Ce = equilibrium concentration (mg/L)
m = weight of adsorbent (g)
Qe = the amount of adsorption, which is defined as the quantity of adsorbate in (mg) held by weight of adsorbent in (1g).

4. Results and discussion:
Factors effecting adsorption of acetic acid by adsorbent using Batch method:
4.1 Contact time effect:
The effect of period of contact time between the adsorbent and adsorbate on the removal of the acetic was determined by keeping temperature, weight and initial concentration constant, the rate of ions acetic removal by activated carbon with contact time. The rate of uptake of acetic was rapid, 30 min. The obtained results are shown in Table (1) and in Figure (6).
The Adsorption Removal efficiency (ER), at time t, is calculated from the following relation:
\[ \text{ER\%} = \left( \frac{C_0 - C_t}{C_0} \right) \times 100\% \]

Table 1: Effect of contact time on rate of acetic acid removal by activated carbon at 25±0.1°C, adsorbent dose (5) g.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>% removal For 0.2 M</th>
<th>For 0.4 M</th>
<th>For 0.6 M</th>
<th>For 0.8 M</th>
<th>For 1 M</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>45.2</td>
<td>13.2</td>
<td>20.3</td>
<td>15.1</td>
<td>15.6</td>
</tr>
<tr>
<td>10</td>
<td>62.0</td>
<td>37.7</td>
<td>41.9</td>
<td>30.1</td>
<td>36.1</td>
</tr>
<tr>
<td>20</td>
<td>70.8</td>
<td>60.4</td>
<td>55.4</td>
<td>48.4</td>
<td>45.9</td>
</tr>
<tr>
<td>30</td>
<td>78.5</td>
<td>71.0</td>
<td>63.0</td>
<td>58.0</td>
<td>52.0</td>
</tr>
<tr>
<td>Overnight</td>
<td>78.8</td>
<td>71.3</td>
<td>63.2</td>
<td>58.4</td>
<td>53.1</td>
</tr>
</tbody>
</table>

Figure 7: Effect of contact time on rate of acetic acid removal by activated carbon at 25±0.1°C, adsorbent dose (5) g.

4.2 The effect of initial acid concentration:
The effect of initial acetic acid concentration on rate of removal was carried out at 25±0.1°C using different initial acetic acid concentrations in the range (0.2, 0.4, 0.6, 0.8 and 1 M) and using a 5 g adsorbent dose, are shown in Table (2) and Figure (7), which indicate that the percentage removal decreases with the increase in the initial ion concentration, this is because there were no more adsorption sites on the adsorption surface of the adsorbent material.

Table 2: Effect of initial concentration for acid removal at 25±0.1°C, adsorbent dose (5) g and contact time 30 min.

<table>
<thead>
<tr>
<th>Co (M)</th>
<th>Activated carbon</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>0.054</td>
</tr>
<tr>
<td>0.53</td>
<td>0.154</td>
</tr>
<tr>
<td>0.74</td>
<td>0.274</td>
</tr>
<tr>
<td>0.93</td>
<td>0.391</td>
</tr>
<tr>
<td>1.22</td>
<td>0.586</td>
</tr>
</tbody>
</table>

Figure 8: Effect of initial concentration for acid removal at 25±0.1°C, adsorbent dose (5) g, and contact time 30 min.
The results suggest that the available binding sites on the biomass (activated carbon) may have different affinities towards acetic acid. Adsorption of acetic acid on the activated carbon is dependent upon different factors such as hydration effects and hydrolysis effects. Hydration effects can dominate when the binding is weak.

4.3 Adsorption isotherms:
The relationship between the amount of a substance adsorbed per unit mass of adsorbent at constant temperature and its concentration in equilibrium is called the adsorption isotherm. The equilibrium adsorption isotherms are important in determining the adsorption capacity of activated carbon. Two theoretical isotherm models were used; Langmuir and Freundlich model.

4.3.1 Langmuir isotherm:
In 1916, Irving Langmuir published an isotherm for gases adsorbed on solids, which retained his name. It is an
empirical isotherm derived from a proposed kinetic mechanism [5]. It is based on four hypotheses:
The surface of the adsorbent is uniform, that is, all the adsorption sites are equal.
Adsorbed molecules do not interact.
All adsorption occurs through the same mechanism.
At the maximum adsorption, only a monolayer is formed: molecules of adsorbate do not deposit on other,
already adsorbed, molecules of adsorbate, only on the free surface of the adsorbent as seen in figure(8).

For liquids (adsorbate) adsorbed on solids (adsorbent), the Langmuir isotherm (Fig. 9) can be expressed by

\[ Q_e = \frac{b \cdot Q_m \cdot C_e}{1 + b \cdot C_e} \]  

Where \( Q_e \) is the substance amount of adsorbate adsorbed per gram of the adsorbent, the unit of \( Q_e \) is mmol.g\(^{-1}\), resp. mol.kg\(^{-1}\). \( Q_m \) is the maximal substance amount of adsorbate per gram (or kg) of the adsorbent. The unit of \( Q_m \) is mol.g\(^{-1}\) (or mol.kg\(^{-1}\)). \( b \) is the adsorption constant which is coefficient related to the affinity between the adsorbent and adsorbate (mol\(^{-1}\).dm\(^3\)); \( C_e \) (mol.dm\(^{-3}\)) is the concentration of adsorbate in liquid [1].

The Langmuir constants was determined by linearizing form the equation 3 into:

\[ \frac{C_e}{Q_e} = \frac{C_e}{Q_m} + \frac{1}{b Q_m} \]

The linear plots of \( C_e/Q_e \) versus \( C_e \) is shown in Figure (10), the Langmuir constants was determined from the graph, in which the intercept represents the value of \( 1/Q_m b \), and the slope corresponds to \( 1/Q_m \).

Slope = 0.0614 which represents \( 1/Q_m \) and intercept = 0.0112 which represents \( 1/Q_m b \), thus: \( Q_m = 88.7 \) mol.g\(^{-1}\) and \( b = 5.45 \) mol\(^{-1}\).dm\(^3\)

Table 3: Langmuir calculations.

<table>
<thead>
<tr>
<th>C theoretical</th>
<th>Co (M)</th>
<th>% Error</th>
<th>V of NaOH</th>
<th>Ce (mmol/g)</th>
<th>Ce/Qe</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.25</td>
<td>25.0</td>
<td>0.054</td>
<td>0.20</td>
<td>3.93</td>
</tr>
<tr>
<td>0.4</td>
<td>0.53</td>
<td>32.5</td>
<td>0.154</td>
<td>0.38</td>
<td>7.53</td>
</tr>
<tr>
<td>0.6</td>
<td>0.74</td>
<td>23.3</td>
<td>0.274</td>
<td>0.47</td>
<td>9.32</td>
</tr>
<tr>
<td>0.8</td>
<td>0.93</td>
<td>16.3</td>
<td>0.391</td>
<td>0.54</td>
<td>10.79</td>
</tr>
<tr>
<td>1.0</td>
<td>1.22</td>
<td>22.0</td>
<td>0.586</td>
<td>0.63</td>
<td>12.69</td>
</tr>
</tbody>
</table>

Figure 11: Langmuir Ce/Qe vs Ce

4.3.2 Freundlich isotherm:
Freundlich isotherm is an empirical model used to describe the adsorption in aqueous systems. Freundlich isotherm typically uses to explain the adsorption isotherm of the activated carbon [9].
The Freundlich sorption isotherm, one of the most widely used mathematical descriptions, gives an expression encompassing the surface heterogeneity and the exponential distribution of active sites and their energies, hence the multilayer formation is highly expected. This leads to significant change in the adsorption isotherm, since Freundlich equation has been employed to represent the change in the amount of adsorbate per unit area, or mass of adsorbent with equilibrium concentration of the adsorbate as seen in figure (11).

Freundlich equation could be written as follows:

\[ Q_f = k_f C_e^{1/n} \]

and in linearized form is:

\[ \log Q_f = \log k_f + \frac{1}{n} \log C_e \]

Where \( C_e \) is the equilibrium concentration in mg/L, \( Q_f \) is the amount of adsorbate adsorbed per unit weight of adsorbent (mg/g). \( k_f \) is a parameter related to the temperature and \( n \) is a characteristic constant for the adsorption system under study.

Figure 12: Freundlich multilayer formation

Table 4: Freundlich table.

<table>
<thead>
<tr>
<th>C theoretical</th>
<th>Co % Error</th>
<th>V of NaOH</th>
<th>Ce X= Co-Ce % remov</th>
<th>Qf log Ce log (Qf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.3</td>
<td>25.0</td>
<td>0.5</td>
<td>0.2</td>
</tr>
<tr>
<td>0.4</td>
<td>0.5</td>
<td>32.5</td>
<td>1.5</td>
<td>0.2</td>
</tr>
<tr>
<td>0.6</td>
<td>0.7</td>
<td>23.3</td>
<td>2.7</td>
<td>0.3</td>
</tr>
<tr>
<td>0.8</td>
<td>0.9</td>
<td>16.3</td>
<td>3.9</td>
<td>0.4</td>
</tr>
<tr>
<td>1.0</td>
<td>1.2</td>
<td>22.0</td>
<td>5.9</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Figure 13: Freundlich graph
The linear plots of log Ce versus log Qf is shown in Figure (12), the Freundlich constants was determined from the graph, in which the slope represents the value of 1/n, and the intercept corresponds to Kf.
Slope= 0.487 which represents the value of 1/n and the intercept= -0.7643 which represents the value of log (Kf) thus:
\[ n = 2.05147 \]
\[ K_f = 0.17204 \]
The experimental data show that both Langmuir and Freundlich were fitted for the adsorption of acetic acid on activated carbon.

4.4 Temperature effect on adsorption:
The adsorption of acetic acid on the activated carbon surface was studied at room temperature (25°C) as well as at the other two temperatures (30.0 and 40.0°C), the initial concentration of acetic acid was about 0.2 M and adsorbents dosage 5 g.
The obtain results are shown in Table (5) and Figure (13); the plot of removal percentage versus (Co), to obtain the general shape of the adsorption isotherms which represents the isotherms of acetic acid on the activated carbon at different temperatures [8].

Table 5: Removal percentage of Acetic acid at different temperatures.

<table>
<thead>
<tr>
<th>Co</th>
<th>25°C</th>
<th>30°C</th>
<th>40°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ce%</td>
<td>Qe</td>
<td>Ce%</td>
<td>Qe</td>
</tr>
<tr>
<td>0.25</td>
<td>0.0537</td>
<td>78.5</td>
<td>3.925</td>
</tr>
<tr>
<td>0.53</td>
<td>0.1537</td>
<td>71.7</td>
<td>5.26</td>
</tr>
<tr>
<td>0.74</td>
<td>0.2738</td>
<td>63.3</td>
<td>9.324</td>
</tr>
<tr>
<td>0.93</td>
<td>0.3906</td>
<td>58.5</td>
<td>10.788</td>
</tr>
<tr>
<td>1.22</td>
<td>0.5856</td>
<td>52</td>
<td>12.688</td>
</tr>
</tbody>
</table>

Figure 14: Removal percentage at different temperatures
It was noticed that when raising the temperature, the amount of acidic acid that were adsorbed decreased, and that adsorption process appeared to be an exothermic one. Thus the lower temperatures are favorable for adsorption of acetic acid.
The explanation for this process could be attributed to the decrease in the thickness of the carbon boundary layer when raising the temperature hence, it ability to adsorb acetic acid decreases.

4.5 Thermodynamic studies:
Thermodynamic parameters such as the free energy (\( \Delta G \)), enthalpy (\( \Delta H \)) and entropy (\( \Delta S \)) changes during adsorption can be evaluated from the Equations (7, 8 and 9) below, as in [6]; where Kc is the equilibrium constant, Ce is the equilibrium concentration in solution (mg/L-1) and Qe is the amount adsorbed (mmol/g). \( \Delta G \), \( \Delta H \) and \( \Delta S \) are changes in Gibbs free energy (kJ.mol-1), enthalpy (kJ.mol-1) and entropy (J.mol-1K-1), respectively. R is the gas constant (8.314 J.mol-1.K-1) and T is the temperature in (K); Table 12. Plots of log Kc versus 1/T are used to calculate the values of \( \Delta H \) from the slope and \( \Delta S \) from the intercept resulted from plots. The \( \Delta G \) values were obtained using Equation (8).

\[
\log K_c = \frac{\Delta S}{2.303} - \frac{\Delta H}{2.303RT}
\]

Table 6: Effect of temperature on the thermodynamic equilibrium constant for adsorption of acetic acid (about 0.8M) on the activated carbon surface.

\[
T (c) \quad T (k) \quad \text{Inverse temp. (K *10-4)} \quad \text{Kc log (Kc) \ \Delta G R2}
\]

| 25 298.15 | 3.35 | 27.62 | 1.44 | -8225.98 | 0.994 |
| 30 303.15 | 3.23 | 22.55 | 1.35 | -7878.72 |
| 40 313.15 | 3.19 | 16.83 | 1.23 | -7374.43 |

Figure 15: \log (Kc) versus inverse temperature
Table (7) contains the basic thermodynamic values of acetic acid adsorption on activated carbon at different temperatures. The enthalpy values of adsorption (\( \Delta H \)) of acetic and carbon system were found to possess a negative value indicating an exothermic adsorption process. The value of the entropy reflect the change in the order and orientation of the solvent molecules around the hydrated ions in aqueous medium when acetic...
The value of (â​So) was positive due to the negativity of â​Go and this suggests a lower order in the solvated states of the acetic acid, in other word the positive value of â​S means that the adsorption process accompanied by an increase in entropy for the adsorption of acetic acid onto the activated carbon surface, which is the driving force. The values of the change in the free energy (ΔGo) value of acetic acid adsorption on adsorbents was found to possess a negative value indicate that the process is feasible and the adsorption is spontaneous in nature.

Table 7: Values of thermodynamic functions for the adsorption of acetic ion on the activated carbon surfaces at different temperatures

<table>
<thead>
<tr>
<th>T (c)</th>
<th>â​G (J. mol-1)</th>
<th>R2</th>
<th>â​S (J.mol-1)</th>
<th>â​H(KJ.mol-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>-82.25</td>
<td>0.994</td>
<td>13.21</td>
<td>-29.96</td>
</tr>
<tr>
<td>30</td>
<td>-78.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>-73.74</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.6 Kinetic study:
“The kinetic adsorption data were investigated to understand the dynamic of the adsorption process in terms of the order of the rate constant. Assuming a pseudo first order kinetic, the Lagergren equation was used for the studied” [7].

\[ \log \frac{Q_0 - Q_t}{Q_t} = \log \frac{Q_0}{K_{ad} t} \quad \text{……………10} \]

Where Qe and Qt the amount of acetic acid adsorbed at equilibrium and at time (t) respectively. The plot of ln (Qe-Qt) versus time (t) gives a straight line and pseudo first order rate constant K min-1 can be calculated from the slope of that line since initial concentration of Acid was about 0.8 M.

Table 8: kinetic study table.

<table>
<thead>
<tr>
<th>time (min.)</th>
<th>Qe</th>
<th>Qt</th>
<th>Qe-Qt</th>
<th>ln(Qe-Qt)</th>
<th>R2</th>
<th>K min-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>10.79</td>
<td>10.69</td>
<td>0.1</td>
<td>-2.30259</td>
<td>0.988</td>
<td>0.078</td>
</tr>
<tr>
<td>10</td>
<td>10.73</td>
<td>0.06</td>
<td>-2.81341</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>10.745</td>
<td>0.045</td>
<td>-3.10109</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>10.76</td>
<td>0.03</td>
<td>-3.50656</td>
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<td></td>
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<tr>
<td>30</td>
<td>10.79</td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure (15): Ln (Qe-Qt) vs time
The kinetic constants and correlation coefficients of this model were calculated and are given in Tables (8) respectively. The values of R2 for the pseudo first order for most adsorption systems are satisfactory. Therefore, it has been concluded that the pseudo-first order adsorption model.

5. Conclusion:
High concentration level of acetic acid can be adsorbed on to activated carbon. This process can be used to hydrogen ions and other toxic material such as metal from aqueous solutions. The adsorption equilibrium time was 30. The study showed that (5 g) of adsorbent weight is very substantial to obtain at great adsorption for acetic acid.

The isotherms of acetic acid on the adsorbent obeyed both Langmuir and Freundlich. Mostly, the thermodynamic parameters show the spontaneous and exothermic adsorption processes of acetic acid onto the surfaces of adsorbent. The study further demonstrated that the adsorption process was on first order in kinetic. Adsorbents which are used in the study can be used successfully for removal of hydrogen ions from acids, the maximum removal efficiency percentage was observed up to (78.5%). The maximum adsorption capacity was obtained for activated carbon (88.7 mol.g-1).

6. Error prorogation:
Burette: Å± 0.1 ml
Balance: Å±0.0005 g
Pipette: Å± 0.04 ml
Temperature regulator: Å± 0.005

7. Evaluation and further investigation:
This study shows the importance of adsorption to remove the hard boing particles in the acetic acid also it shows how powerful the adsorption process is in which it can remove contaminants too such as heavy metals ions (Pb2+, Cr3+, Ni2+, ......). Carbon adsorption process is the best method for removal because itâ​s simple, time saving, unexpansive and
involving no sophisticated apparatus. Different treatments and combinations of treatments are proposed to effectively manage the waste water, classical techniques of heavy metal removal from solution included the following processes: metal salts precipitation this method require large quantities of chemicals electrolytic methods, adsorption, ion exchange and evaporation. The problem of removing pollutants from water are grown with rapid industrialization the discharge of toxic into water courses in a serious pollution problem. The classical technique are utilized to remove pollutants have some of disadvantages, but in the recent years many modifications methods are followed to reached to the best results. This study could lead to the study of using some of the agricultural byproducts as low coast adsorbents.

8. References:

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