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Equilibrium and thermodynamic studies on biosorption of Pb(II) onto *Candida albicans* biomass

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ABSTRACT

Biosorption of Pb(II) ions from aqueous solutions was studied in a batch system by using *Candida albicans*. The optimum conditions of biosorption were determined by investigating the initial metal ion concentration, contact time, temperature, biosorbent dose and pH. The extent of metal ion removed increased with increasing contact time, initial metal ion concentration and temperature. Biosorption equilibrium time was observed in 30 min. The Freundlich and Langmuir adsorption models were used for the mathematical description of biosorption equilibrium and isotherm constants were also evaluated. The maximum biosorption capacity of Pb(II) on *C. albicans* was determined as 828.50 ± 1.05, 831.26 ± 1.30 and $833.33 \pm 1.12\ mg\ g^{-1}$, respectively, at different temperatures (25, 35 and 45 °C). Biosorption showed pseudo second-order rate kinetics at different initial concentration of Pb(II) and different temperatures. The activation energy of the biosorption (E_a) was estimated as $59.04\ kJ\ mol^{-1}$ from Arrhenius equation. Using the equilibrium constant value obtained at different temperatures, the thermodynamic properties of the biosorption (ΔG°, ΔH° and ΔS°) were also determined. The results showed that biosorption of Pb(II) ions on *C. albicans* were endothermic and spontaneous. The optimum initial pH for Pb(II) was determined as pH 5.0.

FTIR spectral analysis of Pb(II) adsorbed and unadsorbed C. albicans biomass was also discussed.

1. Introduction

Heavy metal ions are nowadays among the most important pollutants in surface and ground water. They are often discharged by a number of industries, such as metal plating facilities, mining operations and tanneries, which can lead to the contamination of freshwater and marine environment. Heavy metal ions are extremely toxic and harmful even at low concentrations, which can seriously affect plants and animals and have been involved in causing a large number of afflictions [1–3]. Therefore, the elimination of these metals from water and wastewaters is important to protect public health. Traditional technologies for removal of heavy metals from wastewaters include chemical precipitation, ion-exchange, membrane separation, reverse osmosis, evaporation and electrolysis [4–6]. However, most of them do not exhibit high treatment efficiency, especially at metal concentrations in the range of 0.01–0.1 $g\ l^{-1}$ [1]. Precipitation methods are particularly reliable but require large settling tanks for the precipitation of voluminous alkalines sludges, and a subsequent treatment is needed. Ion exchange has the advantage of allowing the recovery of metallic ions, but it is expensive and sophisticated. Adsorption on solid-solution interface is an important means for controlling the extent of pollution due to heavy metal ions [7]. Activated carbons are widely used because of their high adsorption abilities for a large number of heavy metal ions. However, the price of activated carbons is relatively high, which limits their usage. This has led many researchers to search for low cost materials such as coal, fly ash, agricultural wastes and biosorbents [8]. In general, an adsorbent can be assumed as "low cost" if it requires little processing, is abundant in nature, or is a by product or waste material from industry [7].

It is well known that some metals, such as Cr, Cu, Pb, Sb, Hg and Cd, etc., are harmful to life. They are significantly toxic to human beings and ecological environments [7]. Lead, which is a heavy metal, is widely used in many important industrial applications, such as storage battery, manufacturing, printing, pigments, fuels, photographic materials and explosive manufacturing, but is also one of the most toxic heavy metals [2]. Its presence in drinking water above the permissible limit ($5\ mg\ l^{-1}$) may cause adverse health effects such as anemi, encephalopathy, hepatitis and nephritic syndrome [3].

Biosorption could be such an alternative method of treatment. It employs a wide variety of biomasses, such as algae, fungi and bacteria, for removal of metal ions [9–11].

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Non-living biomass appears to present specific advantages in comparison with the use of living microorganisms. Killed cells may be stored or used for extended periods at room temperature; they are not subject to metal toxicity, and nutrient supply is not necessary. Moreover, pretreatment and killing of biomass either by physical or chemical treatment or crosslinking are known to improve the biosorption capacity of biomass [12].

It has also been reported that cell wall soluble proteins, which make complexes with metal ions, can be fixed by some denaturation processes such as heat and organic solvents, ethanol treatments. Deactivated yeast cells do not release protein and exhibit higher metal ion removal capacity than live yeast [13].

The objective of this study was to investigate the biosorption potential of the *Candida albicans* toward Pb(II). The metal loading capacity of yeast biomass was determined as a function of the initial metal ion concentration, contact time, temperature, biosorbent dose and pH. The biosorption data were analyzed by Freundlich and Langmuir isotherm models.

IR spectral analysis was also employed to understand the mode of metal-microbe interaction. Thus, all results suggested that *C. albicans* offers excellent potential for Pb(II) removal from contaminated water.

2. Materials and methods

2.1. 2.1.Microorganism and growth conditions

C. albicans obtained from Biochemistry Research Laboratory culture collections was used in this study. It was grown at 37 °C in agitated nutrient broth liquid media in fermentor. The pH of the media of *C. albicans* was adjusted to 7.0. In the stationary phase of growth, *C. albicans* cells were centrifuged at 5000 rpm at +4 °C for 10 min, washed twice with distilled water and then dried at 80 °C for 24 h. Dried biomass was powdered by using mortar and pastle. The powdered biomass was sieved to select particles 150 μm for use as a biosorbent in batch studies.

2.2. Preparation of metal ion solution

Metal ion solution used in this study was prepared by dilution of 1000 mg l^{-1} stock solution of Pb(II) obtained by dissolving $Pb(NO_3)_2$ in distilled and deionized water.

2.3. Biosorption studies

The biosorption of Pb(II) ions on the dried yeast biomass was investigated in batch biosorption equilibrium experiments. The effect of the initial metal ion concentration, contact time, temperature, biosorbent dose and pH on the biosorption rate and capacity was studied. The effect of contact time and initial metal ion concentration on the biosorption was studied of pH: 5.0 for Pb(II), with varying metal ion concentrations (ranging from 25 to 200 mg l^{-1}). A weighed sample of biosorbent as 50 mg was mixed with a 50 ml of metal ion solution of known initial concentration at 200 rpm for 120 min.

For the other adsorption experiments, 50 ml of metal solution of known initial concentration (25, 50, 100 and 200 mg l^{-1}) was shaken with a certain amount of adsorbent (25 mg) at the desired temperature (25, 35, and 45 °C) for 30 min. At the end of the period, the mixture was centrifuged for 10 min at 4500 rpm. After centrifugation, it was analyzed by using Atomic Absorption Spectrophotometer (UNICAM AAS 929).

The effect of temperature on the biosorption capacity of the biosorbent was determined by using different temperatures (i.e. 25, 35, 45 and 55 °C); the metal ion concentration was 100 mg l^{-1}. To determine biosorbent dose, varying amounts of yeast biomass (i.e. 125, 250, 500 and 1000 mg l^{-1}) in the absorption medium were used and the 100 ml heavy metal ion concentration was 100 mg l^{-1}.

The effect of pH on the biosorption rate was investigated in the pH range of 2.0–5.0. The suspensions were brought to the desired pH (2.0;, 3.0, 4.0 and 5.0) for metal ion by adding 1 M HCl or 1 M NaOH at the beginning of the experiment.

The amount of adsorbed heavy metal ions per unit biosorbent (mg metal ion/g dry biosorbent) was obtained by using the following expression

$$q_e = \frac{[(C_o - C_e)V]}{m} \quad (1)$$

where q_e is the amount of heavy metal adsorbed onto the unit amount of the biomass (mg g^{-1}); C_o and C_e are the concentration of the heavy metal in the initial and equilibrium solution (mg l^{-1}), and after biosorbtion, respectively, V is the volume of the aqueous phase (l) and m is the amount of the biomass (g).

2.4. Statistical analysis

All the experiments were carried out in triplicate, and statistical analysis was performed using SPSS 9.05 for Windows where it was possible to evaluate whether the effect and the interaction among the investigated factors were significant with respect to the experimental error.

2.5. Analytical procedure

The concentration of unadsorbed Pb(II) in the supernatant was determined by using an AAS with an air-acetylene flame. Deuterium background correction was used, and the spectral slit width was 1.3 nm. The working wavelength for Pb(II) was 283 nm. The instrument response was periodically checked by using standard metal solutions.

IR spectra of dried and metal loaded dried *C. albicans* biomass were recorded in a Mattson 1000 FTIR spectrophotometer in KBr pellet.

3. Result and discussion

3.1. Effect of contact time and initial metal ion concentration

Time of contact of adsorbate and adsorbent is of great importance in adsorption, because it depends on the nature of the system used. Microbial metal uptake by non-living cells, which is metabolism-independent passive binding to cell walls (adsorption), as well as to other external surfaces, is generally considered a rapid process, occurring place within a few minutes. According to literature, metal ion adsorption reaches equilibrium, within 5–15 min [14–16]. This has supported very well our observation of Pb(II)-yeast system equilibrium where adsorption was achieved almost within 30 min as shown in Fig. 1.

The initial metal ion concentration remarkably influenced the equilibrium metal uptake and adsorption yield as shown in Fig. 1. The amount of metal ion adsorbed (mg g^{-1}) increased with increase in contact time and initial concentration. It is seen that nearly 30 min is required for the equilibrium adsorption to be attained for different initial concentrations. This rapid initial uptake of metal ion may be an important parameter for a practical application of biosorption in industrial wastewater [17].

When the initial Pb(II) ions concentration varied from 25.0 to 200 mg l^{-1}, the loading capacity of *C. albicans* increased nearly from 48 to 370 mg g^{-1} (Fig. 1). The increase of loading capacities of

Table 1
Effect of initial Pb(II) concentration on kinetic parameters for biosorption of Pb(II) on *C. albicans*

Pb(II) initial concentration (mg l^{-1})	Pseudofirst-order kinetics			Pseudosecond-order kinetics		
	k_1 (min^{-1})	q_e (mg g^{-1})	R^2	k_2 (g mg^{-1} min^{-1})	q_e (mg g^{-1})	R^2
25	0.076	7.80	0.587	0.061	48.780	0.999
50	0.072	9.90	0.420	0.013	95.238	0.999
100	0.070	21.71	0.351	0.006	188.675	0.999
200	0.067	17.39	0.390	0.005	370.370	0.999

pH 5.0, dose of *C. albicans*: 50 mg ml^{-1}, temperature: 25 °C, agitator speed: 200 rpm.

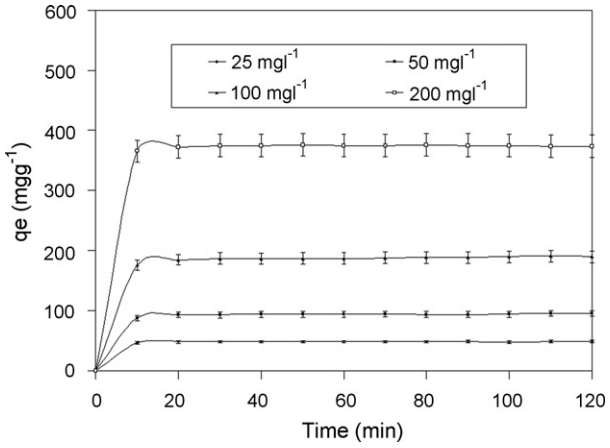

Fig. 1. Effect of time and initial metal ions concentration on the biosorption of Pb(II). Biomass concentration: 25 mg, volume: 50 ml, pH 5.0. The bars represent the standard error of the mean ($p < 0.05$).

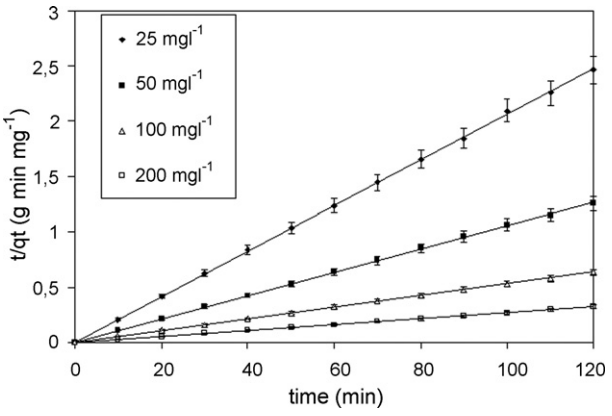

Fig. 2. Pseudo second-order kinetics for biosorption of *C. albicans* on Pb(II) at 25 °C.

biosorbents with the increase of metal ion concentration is probably due to higher interaction between metal ions and biosorbent.

3.2. Adsorption kinetics

It is important to be able to predict the rate at which contamination is removed from aqueous solutions in order to design an adsorption treatment plant. In order to investigate the mechanism of adsorption at different initial concentrations and different temperatures, characteristic constants of adsorption rate were determined by using a pseudo first-order equation of Lagergren based on solid capacity, and pseudo second-order equation based on solid phase adsorption [18].

$$\log(q_e - q_t) = \log q_e - \left(\frac{k_1}{2.303}\right) t \quad (2)$$

where q_e and q_t refer to the amount of Pb(II) adsorbed (mg g^{-1}) at equilibrium and at any time, t (min), respectively, and k_1 is the equilibrium rate constant of pseudo first-order sorption (min^{-1}). The values of the rate constant, k_1, equilibrium adsoption capacity, q_e, and the correlation coefficient, R^2, were calculated from the plots of $\log(q_e - q_t)$ versus t (figure is not shown) (Table 1).

Kinetic data were further treated with pseudo second-order kinetic model [18]. The differential equation is as follows:

$$\frac{t}{q_t} = \left(\frac{1}{k_2 q_e^2}\right) + \left(\frac{1}{q_e}\right) t \quad (3)$$

where k_2 is the equilibrium rate constant of pseudo second-order adsorption (g mg^{-1} min^{-1}). If pseudo second-order kinetics is applicable, the plot of t/q_t versus t should show a linear relationship (Fig. 2) at different initial metal ion concentrations. The correlation coefficients (R^2) for the second-order rate kinetic model are higher than 0.99 (Table 1). These indicate that the adsorption of Pb(II) from aqueous solution on *C. albicans* obeys pseudo second-order kinetic model. A similar phenomenon was observed in the adsorption of Pb(II) on *Pleurotus ostreatus* [19] and Pb(II) on *Sargassum* sp. [2].

3.3. The effect of temperature and the activation energy

To determine the effect of temperature on the biosorption of Pb(II), experiments were also conducted at 25, 35, 45 and 55 °C. The degree of biosorption increases with increased temperature, indicating that the biosorption is endothermic (figure is not shown).

It was observed that Pb(II) biosorption followed pseudo second-order kinetics at all the temperatures studied. The rise in temperature increased the values q_e and k_2. The values of various kinetic parameters obtained are presented in Table 2. The kinetic parameters at different temperatures were plotted in terms

Table 2
Kinetic parameters for biosorption of Pb(II) on *C. albicans* at different temperatures

Temperature (°C)	Pseudofirst-order kinetics			Pseudosecond-order kinetics		
	k_1 (min^{-1})	q_e (mg g^{-1})	R^2	k_2 (g mg^{-1} min^{-1})	q_e (mg g^{-1})	R^2
25	0.070	21.71	0.35	0.006	188.675	0.999
35	0.067	21.07	0.56	0.007	188.678	0.999
45	0.062	13.79	0.44	0.010	188.680	0.999
55	0.092	69.81	0.77	0.011	192.301	0.999

pH 5.0, biomass concentration: 25 mg, volume: 50 ml, initial Pb(II) concentration: 100 mg l^{-1}, agitator speed: 200 rpm.

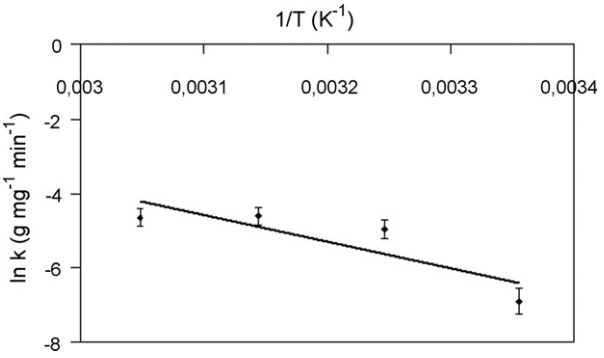

Fig. 3. Arrhenius plot.

of Arrhenius Eq. (4) [6].

$$\ln k_2 = \ln k_o - \frac{E_a}{RT} \quad (4)$$

where k_2 is the rate constant pseudo-second order of adsorption ($g\,mg^{-1}\,min^{-1}$), k_o is the independent temperature factor ($g\,mg^{-1}\,min^{-1}$), R is the gas constant ($J\,mol^{-1}\,K^{-1}$), and T is the solution temperature (K). A plot of ln k_2 versus $1/T$ gives a straight line, and the corresponding activation energy was determined from the slope of linear plot (Fig. 3).

The activation energy for the biosorption of Pb(II) *C. albicans* was found to be 59.04 kJ mol^{-1}. From the value of activation energy it appears that the biosorption of Pb(II) on *C. albicans* is a chemical adsorption process. This is confirmed from the fact that the activation energy for chemical adsorption is usually more than 4–6 kJ mol^{-1} [6].

3.4. The effect of biosorbent dose

The effect of biosorbent dose on the amount of Pb(II) ions removed was studied by the application of different doses between 125 and 1000 $mg\,l^{-1}$ at a Pb(II) concentration of 100 $mg\,l^{-1}$ at 25 °C (Fig. 4). The removal of Pb(II) ions was also dependent on the concentration of yeast biomass used in the adsorption medium; the more the biomass, the higher the removal efficiency. %Adsorption increased from 91.19% to 96.44% but q_e decreased from 729.59 ± 1.22 to 96.44 ± 1.09 mg g^{-1} when biosorbent concentration increased from 125 to 1000 $mg\,l^{-1}$. Several researchers have earlier reported that the increase in the efficiency of removal with an increase in the adsorbent dosage is due to the increase in the number of adsorption sites [14,20]. The decrease in unit adsorption with increasing dose of biosorbent is basically due to biosorption sites that remain unsaturated during adsorption reaction [21].

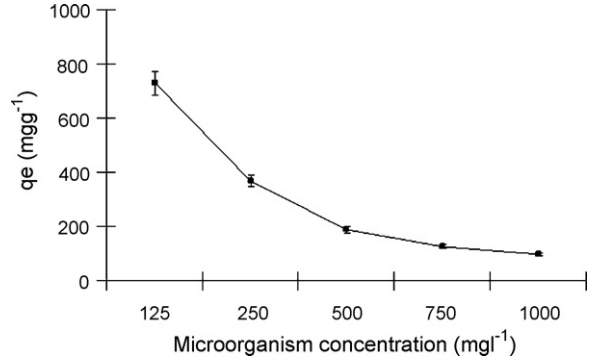

Fig. 4. Effect of microorganism concentration on initial adsorption rates. pH 5.0, initial metal concentration: 100 $mg\,ml^{-1}$, agitator speed: 200 rpm. The bars represent the standard error of the mean ($p < 0.05$).

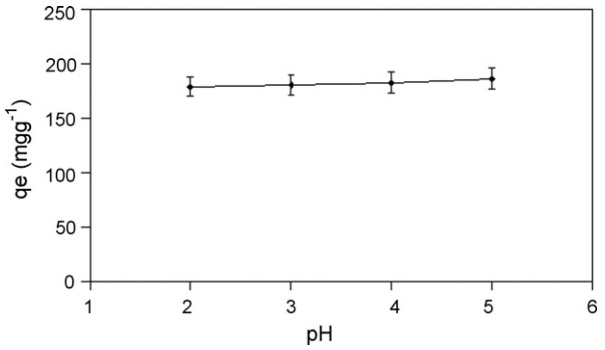

Fig. 5. Effect of initial pH on initial adsorption rate. Initial metal ion concentration: 100 $mg\,l^{-1}$, biomass concentration: 50 $mg\,ml^{-1}$, T: 25 °C, agitator speed: 200 rpm. The bars represent the standard error of the mean ($p < 0.05$).

3.5. Effect of pH

The effect of initial pH on Pb(II) ions uptake capacity of *C. albicans* was investigated between pH 2.0–5.0 at 100 $mg\,l^{-1}$ initial metal ion concentration and at temperature 25 °C. At pH values higher than 6.0, biosorption studies could not be performed due to the precipitation of Pb(II) ions. As seen from Fig. 5, the removal of Pb(II) from aqueous solution was affected little by medium pH. The maximum biosorption of heavy metal ions on the biomass was observed at pH 5.0 for Pb(II).The highest metal uptake values obtained for Pb(II) was 186.10 ± 0.9 mg g^{-1}. The lowest metal uptake value was determined at pH 2.0 for Pb(II) (178.92 ± 1.01 mg g^{-1}).

Earlier studies on heavy metal biosorption have shown that pH is the most important parameter affecting the biosorption process [17,22,23].

The metal biosorption depends on the protonation or unprotonation of functional groups (such as, amino, carboxyl, sulfhydryl and phosphate groups) on the surface of the cell wall. The ionic forms of the metal ions in solution and electrical charge of the cell wall components depend on the solution pH. The interaction of heavy metal ions with yeast biomass could be primarily with the carboxylate groups (pK_a value in the range 3.5–5.0) of the cell wall components. At pH values above the isoelectric point, there is a net negative charge on the cell wall components, and the ionic state of the cell wall, such as carboxyl, phosphate and amino groups, will be in such a way as to promote reaction with metal cation. Several researchers have investigated the effect of pH on biosorption of heavy metals by using different kinds of microbial biomass [20,24].

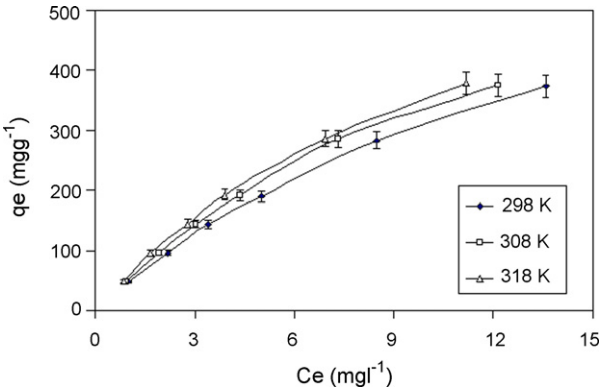

Fig. 6. Adsorption isotherms of Pb(II) on *C. albicans* at different temperatures.

Table 3
Isotherm parameters for Pb(II) biosorption on *C. albicans*

Temperature (°C)	Langmuir constant			Freundlich constant		
	Q_m (mg g^{-1})	b (l mg^{-1})	R^2	k	n	R^2
25	828.50	0.060	0.995	51.309	4.716	0.935
35	831.26	0.067	0.994	55.488	5.096	0.881
45	833.33	0.074	0.986	59.896	5.020	0.843

pH 5.0, biomass concentration: 25 mg; volume: 50 ml, initial Pb(II) concentration: 100 mg l^{-1}, agitator speed: 200 rpm.

Ferraz and Teixeira used brewer's yeast for Pb(II) removal and found that metal uptake increased with increase in medium pH and had a maximum value at pH 5.0 [25].

3.6. Adsorption isotherm analysis

In order to optimize the biosorption process parameter, we modelised the equilibrium curve (Fig. 6). Both Langmuir and Freundlich models were tested.

The Langmuir model is described by the following equation [8,18]:

$$\frac{C_e}{q_e} = \frac{1}{bQ_m} + \frac{C_e}{Q_m} \quad (5)$$

where q_e adsorbent metal ion quantity per gram of biomass at equilibrium (mg g^{-1}), Q_m the maximum amount of metal ion per unit weight of biomass to form a complete monolayer on the surface bound (mg g^{-1}) and b a constant related to the affinity of the binding sites (l mg^{-1}). Q_m and b are calculated from the slope and intercept of the straight lines of plot C_e/q_e vs. C_e.

Freundlich model equation is of the form [8,18]:

$$qe = kCe^{1/n} \quad (6)$$

where k and n are the Freundlich's constants related to the adsorption capacity and adsorption intensity of the adsorbent characteristics of the system [1]. k and n can be determined from the linear plot of log q_e versus log C_e.

The Langmuir and Freundlich adsorption constants evaluated from the isotherms at different temperatures with the correlation coefficients are presented in Table 3. Values of coefficients of correlation R^2 show that the Langmuir model fitted best to our experimental data. The fact that the Langmuir isotherm fits the experimental data very well may be due to homogeneous distribution of active sites onto adsorbent surface, since the Langmuir equation assumes that the surface is homogeneous [18].

3.7. Thermodynamic parameters

In engineering practice entropy and Gibbs free energy factors should be considered in order to determine what process will occur spontaneously. Thermodynamic parameters such as enthalpy change (ΔH°), Gibbs free energy change (ΔG°) and entropy change (ΔS°) can be estimated by using equilibrium constants changing with temperature. The values of standard Gibbs free energy change for the biosorption process were evaluated by using b values obtained from the Langmuir model at different temperatures and are presented in Table 4 [1]. The Gibbs free energy change of the sorption reaction is given by the following equation

$$\Delta G^\circ = -RT \ln b = -RT \ln K \quad (7)$$

where R is universal gas constant (8.314 J mol^{-1} K^{-1}) and T is absolute temperature.

As seen from Table 4, the negative value of ΔG° confirms the feasibility of the process and spontaneous nature of metal ion adsorption with high preference of metal ions for biosorbent. The equilibrium constants may be expressed in terms of enthalpy change of adsorption of temperature as follows

$$\frac{d \ln K}{dT} = \frac{\Delta H^\circ}{RT^2} \quad (8)$$

According to Eq. (8), the effect of temperature on the equilibrium constant b is determined by the sign of ΔH°. Thus, when ΔH° is positive, i.e. when the adsorption is endothermic, an increase in T results in an increase in K. Conversely, when ΔH° is negative, i.e. when the adsorption is exothermic, an increase in T causes a decrease in K.

The change with temperature of the free energy change and the equilibrium constant can be represented as follows

$$\Delta G^\circ = \Delta H^\circ - \Delta S^\circ \quad (9)$$

$$\ln b = \frac{\Delta S^\circ}{R - \Delta H^\circ / RT} \quad (10)$$

where values of ΔH° and ΔS° can be calculated from the slope and the intercept of the plot between ln b versus $1/T$ [1,18].

Using Eq. (10), standard enthalpy and the entropy changes of sorption process were determined from the ln b ln T plots (Fig. 7), and are also represented in Table 4. The enthalpy changes of the biosorption of the Pb(II) on *C. albicans* were found to be +7.924 kJ mol^{-1} while ΔS° was 105.12 J mol^{-1} K^{-1}. As seen from Table 4, the positive values of ΔH° suggested the endothermic nature of adsorption [1]. This is also supported by the increase in value of uptake capacity of biosorbent with the rise in temperature. The positive value of ΔS° reflects the affinity of Pb(II) and shows the increasing randomness at the solid/liquid interface during the sorption of Pb(II) on selected sorbent [6].

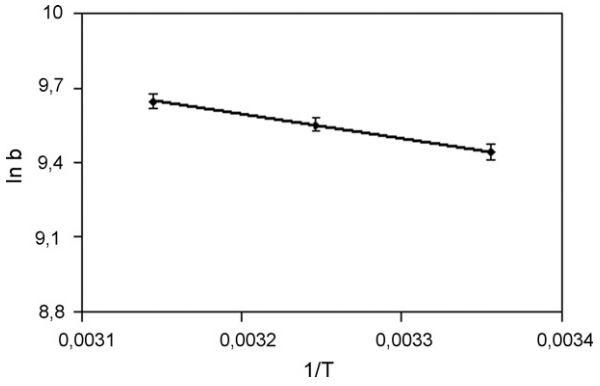

Fig. 7. Plot of ln b versus 1/T.

Table 4
The thermodynamic constants of adsorption obtained for Pb(II)

Temperature (°C)	$-\Delta G^\circ$ (kJ mol^{-1})	ΔH° (kJ mo1^{-1})	ΔS° (J mol^{-1}K^{-1})	Standard deviations
25	23.398			
35	24.462	+7.928	105.120	±0.07
45	25.500			

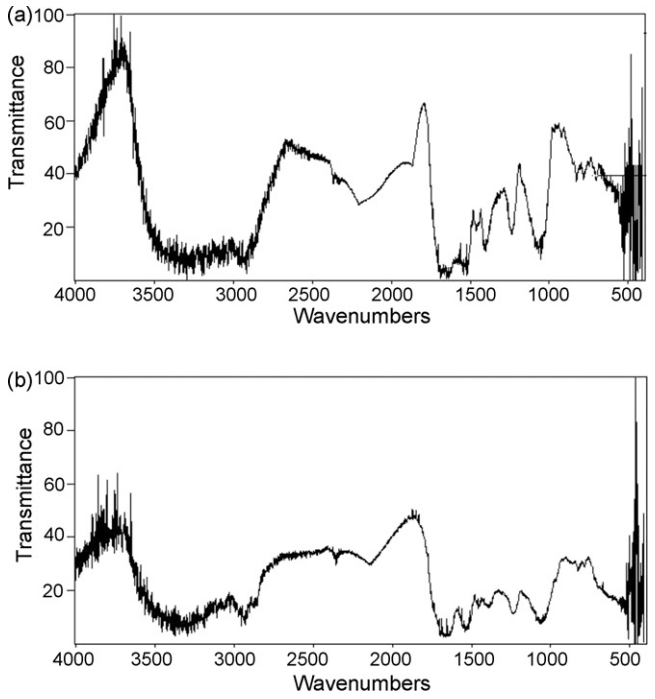

Fig. 8. IR spectra of *C. albicans* (a) before metal was loaded and (b) after metal was loaded.

3.8. FTIR spectral analysis

Biomass cell walls are made of large molecules (peptidoglycan) linked with teichoic acid and polysaccharides. These molecules and intracellular substances possess functional groups which can adsorb heavy metals. These groups of the type —NH, carboxylate anions (—COO^-), hydroxyl (—OH), and others (—C—N), (—C—O), (—C—H), (—C=O) present different affinities towards metallic ions [26].

The FTIR spectra of unloaded and metal loaded *C. albicans* biomass in the range of 400–4000 cm^{-1} were taken to find out which functional groups are responsible for the biosorption. Fig. 8a and b show the results obtained. The FTIR spectrum of unloaded biomass indicated changes in the region of 2059–500 cm^{-1} as compared to Pb(II) loaded biomass. The peak at 1697 cm^{-1} is caused by the vibration of —C=O groups. In addition, 1658 and 1550 cm^{-1} are caused by δO—H and —C=C— vibrations. 1519, 1241 and 1306 cm^{-1} representing δC—H, δN—H and υCOO^- peaks. The band observed at about 1450 cm^{-1} is δ C—H bending in the aromatic ring. The FTIR spectra of *C. albicans* biomass exposed to Pb(II) ions are slightly lower than those of metal unloaded biomass. After adding Pb(II), due to Pb—N and O—S—O and Pb(II) interactions, Pb—N and —O—Pb interactions are shown at 1419 and 1072 cm^{-1}. As it is shown in spectrum metal–ligand interaction is more evident at 1697, 1635 and 1550 cm^{-1} because of —C=O, δO—H and —C=C— vibrations.

These results have been considered to give the presence of functional groups on the *C. albicans* cell surfaces.

4. Conclusion

The biosorption properties of *C. albicans* were studied for Pb(II) in the present work. The results indicate that *C. albicans* may be used as an inexpensive, selective, effective and easily cultivable biosorbent for the removal of Pb(II) ions from solutions. The adsorption process has been shown to be affected from experimental conditions, such as pH, initial metal ion concentration, temperature, contact time and adsorbent dose. The Freundlich and Langmuir isotherm models were used for Pb(II) sorption on to dried *C. albicans* cells, and it was found that the experimental data for Pb(II) ions would be described appropriately by the Langmuir model. The interactions between Pb(II) and functional groups on the cell wall surface of the biomass were confirmed by FTIR analysis.

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