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Adsorption Isotherms of (+D) Sucrose on Multi-wall Carbon Nanotube

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ABSTRACT

In this article, Adsorption isotherms of (+D) sucrose on Multi-wall carbon nanotube have been studied. Using spectroscopy, adsorption of (+D) sucrose on Multi-wall carbon nanotube was investigated and they were accommodated to Freundlich, Langmuir and Temkin models. Regarding the amount of error computed for each model, Langmuir showed the highest accommodation to the experimental findings. Measuring the amount of adsorption of the sample using UV/VIS spectroscopic setup, in different concentrations, it was shown that by increasing the concentration, the amount of adsorption would increase, too. The maximum adsorption was observed at a concentration of 25 mg/L.

Key words: Isotherm, Carbon nanotube, Adsorption, Langmuir model, Freundlich model, Temkin model.

INTRODUCTION

Different definitions have been provided concerning nanoparticles. However, specifically nanoparticles (nanopowders, nanoclusters, and nanocrystals), are microscopic particles of the size of less than 100 nanometers that can be organic or nonorganic. Nanoparticles are so small one could say that there is little disorder in them and thus very hard metals such as lithium, potassium, etc.can be produced from them.

Carbon nanotube is a typical nano-particle being discovered by Iijima in 1991[1]. Carbon nanotubes are hollow cylinder sheets, which may be considered as single molecules due to their small size (nanometric diameter and micrometric length). Small radius, extensive surface area and deformed hybrization (δ-π), have made nanotubes structures with unique physical and chemical characteristics[2] CN T_S can affect the nanoscience and nanotechnology, scienc these materials have a high potential and available in macroscopic quantities. Also, they can absorb a number of atoms and molecules onto them, of which one can mention the adsorption of metal elements such as Lithium, Potassium, Rubidium, Cesium and non-metal elements such as hydrogen, nitrogen, oxygen and methane[3]. The adsorption characteristics of nanotubes is an opportunity for absorption of gases such as Hydrogen and other gases, sensors, catalysts and batteries containing the lithium ion.

Nanotubes are divided into two categories

Single-wall and multi -wall. If the carbon nanotube consists of only one graphite tube, it is single wall and if it contain a number of concentric planes, it is multi wall. The carbon chemistry of multi -wall carbon nanotubes has been of interest for many years. In recent years, much attention has been paid to electrochemical levels of these compounds, since they have a high energy level density and extensive life and recycling[4]. Crystalline perforated structure and the high surface area of CN T_S, as made them a good adsorbant. In view of the fact that multi wall nanotubes were discovered first. Professor Richard Smalley from Rice University extended the production of single wall carbon nanotubes to the graphite laser evaporation.

Working on CN is very difficult, but even today; much progress has been made in different scientific fields. Of their application, one mention medicine and pharmaceutics. Today, they are being used for gene transfer, immunization, vaccination, drug supply to cancerous cells, etc [5] all compounds are adsorbed on the carbon nanotube by two major bonding covalent and noncovalent. The covalent bonding is both on the surface and on the wall of the carbon nanotube while the non- covalent adsorption, which is of physical adsorption type, takes place on the carbon nanotube wall. The structure of the carbon nanotube does not after this adsorption and detachment of the adsorbed substance[6-7].

Carbohydrates are a group of important compounds regarding biology.The structure of which could be expressed in the form of poly hydroxy keton, poly hydroxy aldehyde or their polymers. If the poly hydroxy is keton, it is called ketose and if aldehyde, it is called aldehose[8].

Carbohydrates are divided into 3 groups [9]
Monosaccharides, Disaccharides and Polysaccharides

Monosaccharide is the smallest carbohydrates constituting units which could not be decomposed into smaller parts. Disaccharides consist of two monosaccharide molecules.

Polysaccharides consist of many monosaccharide molecules

The most frequent natural disaccharide is sucrose, which is formed by combination of glucose and fructose.(+D) sucrose is a white solid with formula ($C_{12}H_{22}O_{11}$),a molecular mass of 342.3 gr/mol, a density of 1.587 gr/, a melting point of 186, and is water soluble, with a water solubility of 2000 gr/L (at a temperature of 25°C)[10].

MATERIAL AND METHODS

Material

The adsorbent being used was a carbon nanotube with an outer diameter of 5-10 nanometers, a surface erea of 40-600 and a high purity percentage of 95% from Merck Co.to obtain the (+D) sucrose solution, twice- distilled water was used.

Methods

The solution being used were prepared from dissolving (+D) sucrose in water. At first, a solution with a concentration of 1000 mg/L was prepared. Then, we diluted it to obtain different concentrations (10, 15, 20, 25) mg/L. Given amounts of carbon nanotube (0.01gr) as adsorbants, were added to 100 ml beakers, containing (+D) sucrose solution.

They were agitated by an agitator for 24 hours (the optimum time). After completion of the act, the solution inside the beaker was centrifuged at 10000 Rpm for 20 minutes, so as to separate the solid and the liquid phases from each other. The concentration of (+D) sucrose before and after adsorption was measured using UV/VIS spectroscopic setup.

All the results were obtained at the laboratory temperature (20±25°C)

RESULTS AND DISCUSSION

Different models are used to express adsorption of (+D) sucrose such as the Langmuir linear model, the Freundlich and Temkin model.

Table 1: Parameters of Langmuir, Freundlich and Temkin

(D+) sucrose	R2	q_m (kg/g)	b (mg-L)	R2	q_m (kg/g)	n	R2	A	B	b (mol-J)
	0.9614	0.267	0.75	0.855	0.545	0.307	0.842	2.12	1.16	20.74

These models are used to describe the amount of the solute being adsorbed to adsorbing surface. In this study, the best model that accords the experimental data is that of Langmuir.

Langmuir model

As mentioned, it is one of the physical models of the adsorption isotherm the assumptions of which lead into the Langmuir adsorption isotherm. The most important basic assumptions of the model could be stated as follows:

- The adsorption ΔH is independent from the coverage ratio and all points of adsorption are equivalent
- Any point of adsorption can adsorb only one species
- Adsorption is effected in single layer form

The adsorption reactions that follow this model are called ideal adsorption reaction.

The Langmuir model follows the equation:

$$\frac{c_e}{q_e} = \frac{1}{q_{m+b}} + \frac{c_e}{q_m} \qquad ...(1)$$

In this equation, (mg/L) is the amount of the substace adsorbed to the adsorbing surface,

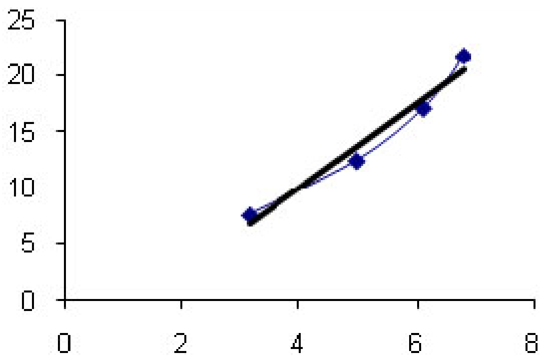

Fig. 1: Langmuir isotherm of (+D)sucrose

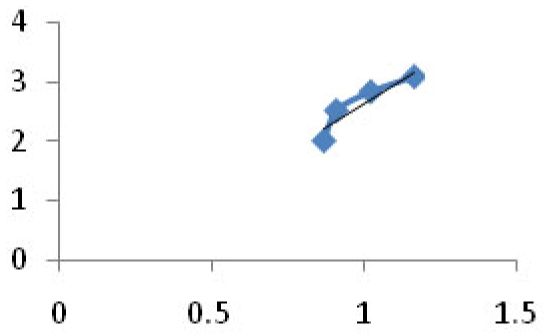

Fig. 2: Langmuir isotherm of (+D)sucrose

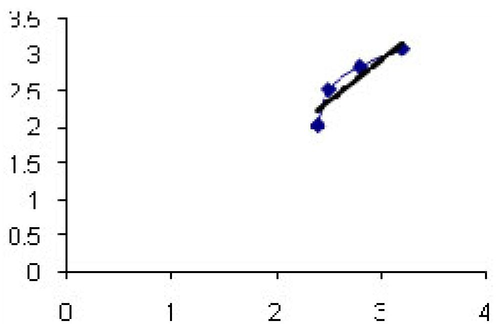

Fig. 3: Temkin isotherm of (+D)sucrose

is the adsorption equilibrium constant, b is the adsorption capacity and (mg/L) is the equilibrium concentration of the solute after equilibrium.

To compute Langmuir parameters, we drew the graph of versus c_e/c_q versus c_e, where $1/q_m$ denoted the slop and $1/q_{m*b}$ denoted the intercept.

Freundlich model

This model is an empirical equation mostly being used to understand metallic ions on heterogeneous surfaces with multi-layer adsorption as well as the adsorptions where the amount of adsorption increase with the intention of an unlimited adsorption.

This model follows the equation:

$$In\ q = In\ k_f + \frac{1}{n} In\ c_e \qquad ...(2)$$

Where the amount of the substance adsorbed to the adsorbing surface is, is the equilibrium constant of the solute after equilibrium n and k_f and are the adsorption intensity and capacity, respectively.

To compute Freundlich parameters, we drew the graph of q_e versus In c_e and considering the equation provided, the slope of the curve was 1/n and its intercept was In k_f.

Temkin model

Tomkins isotherm has a factor that clearly shows the intractions between the absorbent and the absorbed particles.

$$q_e = B\, In\, A + B \ln c_e \qquad ...(3)$$

$$B = \frac{RT}{b} \qquad ...(4)$$

b is constant Temkin, A the constant relating to the bonding energy, B is is the adsorption isotherm, q_e the amount of the substance adsorbed to the adsorbing surface and c_e is the equilibrium concentration of the solute after equilibrium .

To find Temkin parameters, we drew the graph of versus with a slope of B and an intercept of In A.

Adsorption isotherm on carbon nanotube are shown in figs.1-3 .also, the computational parameters of each model are shown in the following table.

CONCLUSION

In this article, as you observe, the amount of adsorption is increased with concentration. It was shown that the concentration of 25 (ppm) has the highest adsorption. Thus one can say that the Bear´s low holds (the direct relation of adsorption and concentration). Regarding (+D) sucrose, considering the numerical value of the regression coefficient (correlation), the Langmuir adsorption isotherm has the highest accord to the experimental results. Therefore, one can conclude that adsorption on (+D) sucrose has taken place on carbon nanotube in single layer form.

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