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ALMOND SHELL CARBON AS AN ADSORBENT A COMPARATIVE STUDY ON ADSORPTION OF MONOBASIC AND DIBASIC ACIDS

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Abstract

In this study, adsorption of different monobasic and dibasic acids was performed on Almond shell carbon, which was used as an adsorbent, as it is serves as eco-friendly adsorbents. It has proven to be significantly effective with the provision of satisfactory adsorption capacities for the removal of pollutants from waste water. We have studied adsorption on different monobasic and dibasic acid by taking Almondshellcarbon as an adsorbent.

The monobasic acids and dibasic acids under study were Acetic acid, Propionic acid, oxalic acid and Succinic acid. Almond shells have increasingly been explored as sustainable, low-cost, and efficient adsorbents for removing various pollutants from water. These agricultural by-products offer high porosity and surface area, particularly when converted into biochar or chemically modified. Recent studies emphasize their potential in adsorbing heavy metals, dyes, emerging contaminants, and nutrients like phosphates. Modifications such as activation with $ZnCl_2$ or incorporation into biochar composites further enhance adsorption capabilities. The experimental isotherm data were analyzed using Freundlich and Langmuir models. The adsorption isotherm for Langmuir adsorption isotherm and Freundlich adsorption isotherm was studied for different monobasic and dibasic acid by taking Walnut shellcarbon as an adsorbent.

The results obtained when compared with different acids the conclusion obtained was compared with different monobasic acids (Acetic acid and Propionic acid) dibasic acids (oxalic acid, succinic acid).

From the readings obtained we observed that extent of adsorption of propanoic acid is greater than acetic acid. i.e propanoic acid (0.01219) > acetic acid (0.011

is the presence of 2 CH_2 group in succinic acid or absence of 2 CH_2 group in oxalic acid.

Introduction

Adsorption is the adhesion of atoms, ions or molecules from a gas liquid or dissolved solid to a surface. This process creates a film of the adsorbate on the surface of the adsorbent. Adsorption is present in many natural, physical, biological and chemical system and is widely used in industrial applications such as heterogeneous catalysts, Almond is one of the important agricultural materials. The shells of almond are waste materials and generally discarded as a waste. It can be collected on community basis for reuse. Almond shells can be used as sorbent.

Almond shell wastes based on their potential uses as biomass to produce renewable energy; as a source of organic biopesticides, heavy metal Polymers adsorbents, dye adsorbents, growing media, the preparation of activated carbons and xylo-oligosaccharides, antioxidants or as additives in eco-friendly composites.

Adsorption is the densification of a fluid at an interface. The nature of the interface may be solid-liquid, gas-liquid, liquid-liquid or solid-gas. In this work we focus on adsorption between a solid "adsorbent" and a gaseous "adsorptive species" which is denoted the "adsorbate" in the adsorbed phase. Adsorption is strictly an interfacial phenomenon, unlike "absorption" wherein the absorptive species penetrates the absorbent. Each molecule in the adsorbed phase actually has less entropy than in the bulk gas phase; however, it also has a reduced enthalpy owing to attractive interactions at the interface. This sets up the basic equilibrium of adsorption: a reduction in entropy compared to the gas phase is balanced by a comparable reduction in enthalpy. Adsorption is thus an exothermic process. The favorable interactions at the interface, which enable all adsorption, may be of chemical or physical nature. When chemical bonds occur between the adsorbent and the adsorbate the phenomenon is called chemisorption. When only physical interactions are present (e.g. van der 2 Waals forces), it is called physisorption. "Sorption" is a more general term used for the ambiguous case. In general, chemisorption results in much stronger adsorbent-adsorbate interactions and is effective at higher temperatures, but requires specific adsorbate-adsorbent systems and is less reversible. In this work we focus on physisorptive systems.

Adsorption is present in many natural, physical, biological and chemical system and is widely used in industrial applications such as heterogenous catalysis, pistachio shell carbon, capturing and using waste heat to provide cold water for air conditioning and other process requirement.

Natural adsorbents are plentiful, inexpensive, require little processing, and are effective in removing pollutants. Natural adsorbents are divided into four groups based on their availability status: waste materials from agricultural, fruit waste, plant waste, and bio adsorbents. Solids agricultural wastes are a cheap and abundant source of resources. Sugarcane bagasse, rice husk, oil palm shell, cotton waste, cashew nut shell, garlic peel, almond shell, and other agricultural waste adsorbents can be used to remove pollutants effectively.

Grapefruit peel, orange peel, mosambi peel, mandarianpeel, banana peel, raw date pits, jack fruit peel, pomegranate peel, muskmelon peel, and palm fruit bunch are examples of fruit waste that can be utilized as adsorbents. Plant waste such as plant leaf powder, tea waste, wood chips, saw dust, plant fiber, wood shavings, jute stick powder, oil palm wood, bark, neem leaf powder, and pine sawdust, can all be employed as adsorbents to eliminate pollutants from aqueous solutions. Hair, yeast, chitin and fungi, chitosan, biomass, peat, and eggshell are examples of bio adsorbents that can be utilized for adsorption.

The world literature provides information about the use of by – products of processing vegetables such as cabbage, carrots, tomatoes, eggplants, turnips, cucurbits, and other as adsorption materials. The largest producer of Almond shell is United states ,Spain, Australia, and Turkey are among the four countries leading in almond production.

Almond shell processing by – products include Almond shell. Currently, these materials are disposed of in lands or used as soil amendments, which results in negative environmental impacts and phytotoxicity to plants, respectively. These materials need to be economically and environmentally managed.

For the aim of wastewater treatment, the biosorption of Cr(VI) by the pistachio nut shell in a batch-type reactor was researched in depth. To maximize Cr(VI) removal from aqueous solutions and equilibrium isotherms and kinetic data, the effects of initial Cr(VI) concentration, time, and pH were explored. From a solution containing 3000 ppm of Cr, the Almond shell adsorption capacity was reported to be 103.09 mg/g of adsorbent (VI). It can be concluded that the Langmuir adsorption isotherm was more appropriate for explaining equilibrium than the Freundlich adsorption isotherm. Gibbs' free energy was spontaneous for all interactions, and the adsorption process had exothermic enthalpy values.

The effects of various experimental conditions on the removal of Cu ions from aqueous solution by almond shell were investigated. The point of zero charges for almond shell was between 4.55 to 4.75. The adsorption capacity of the almond nut shell was found to be 66,7mg/g at pH 5.3 and T = 303K.)The pseudo-second-order kinetic model fitted the batch data adequately. The rate constant coconut scale in the absence of diffusional resistance was estimated to be 0.075 mg/g/min respectively at 303 K. The thermodynamic studies showed that the Cu ions adsorption on the coconut skin was spontaneous and endothermic.

Almond shell treated with 2N HCI solution was studied to remove Mn(VII) ions from simulated solutions. Native and mercerized almond nut shell was used to remove Pb2+ ions from simulated solution. The maximum adsorption capacity of Fe-GP Ti-GP> Ce-GP at pH-2.5 was determined to be 91.5 mg/g, 83 mg/g, and 84 mg/g tungsten, respectively. Anions such as chloride, sulfate, and carbonate had minimal effect on tungsten adsorption, whereas fluoride and phosphate significantly impeded it.

In addition to metal cations and metalloids, almond shell processing by products were studied as sorption materials to remove anions from aqueous media. almond nut shell has also proven itself as a good sorption material for removing antibiotics from aqueous media.

Fruit shell activated carbon is an environmentally friendly material with adsorption properties and many unique characteristics. Firstly, it is made from natural plant fruit shells, thus possessing the characteristics of renewable resources, which helps to protect the environment and reduce deforestation.

In addition, the fruit shell activated carbon particles are porous and have a large surface area, which means they can provide more adsorption sites and improve adsorption efficiency. This highly effective adsorption characteristic makes it an important part of oral

Textile industries generate highly colored waste waters that bearing organic and inorganic pollutants, so removal of dyes from these industries is an important practice due to its pollution of environment. Azo dyes are one of the synthetic dyes that used in many textile industries. Azo dye have an azo group band (AN@NA) and because of their low cost, solubility and stability,are widely used in many textile industries.

Azo dye and their intermediate products are toxic, carcinogenic and mutagenic to aquatic life. Several methods such as adsorption, coagulation and flocculation, biological treatment, advanced oxidation processes, photocatalytic process have been used for the treatment of colored wastewater. Removal of dye from colored effluent by adsorption processes has been to be an efficient and economical. Commercial pistachio nut shell carbon (AC) is a most popular adsorbent, but it is expensive.

Natural wastes from agro waste industries are of attention mainly because of their abundance. Production of AC from this source may reduce the cost of wastewater treatment and at the same time open new market for low-cost agricultural byproduct. A number of non-conventional, low cost plant materials (residues) such as babul seed, sunflower stalks, and the peel of cucumis Savita fruit, tamarind fruit shell, orange peel and lemon peel are used as adsorbent.

Water contamination by fluoride is a major concern in many places of the world. When its concentration in drinking water is more than 1.5 mg/L, which is the maximum allowable concentration of fluoride by the World Health Organization (WHO), it can become harmful to people's health, for example, causing dental or skeletal fluorosis.

So, it is quite urgent to develop more advanced and cost-effective techniques to decrease and remove fluoride from the water. Several defluorination technologies of drinking water, such as ion exchange, precipitation-coagulation, reverse osmosis, electrodialysis and nano filtration, have been developed for fluoride removal from water.

The cheapest and effective way to overcome form these problem is adsorption by biowaste, for example almond nut shell carbon. Almond nut shell carbon as an adsorbent, as we know that adsorbents play a very vital role in the adsorption processes. Almond nut shell is low-cost adsorbents, we have simply used the criteria of low cost as well as eco-friendly adsorbents. It has proven to be significantly effective with the provision of studied adsorption on different monobasic and dibasic acid by taking almond nut shell carbon as an adsorbent.

ISOTHERMS

The adsorption isotherms describe the pathway of the interaction of a substrate from the bulk solution to the surface of adsorbate. It represents a relation between the amount of substrate adsorbed per unit mass of adsorbent and the substrate concentration or pressure in the bulk solution at a fixed temperature.

The role of temperature is to determine a modal that describe how adsorption process between sorbent and adsorbate and describe the effect of temperature on adsorption process if favorable or not. Adsorption isotherms were classified into four main groups: L (Langmuir type), H (high affinity), S (cooperative) and C (constant partition). The classification depends on the lower part of the curve when the adsorbate solution is very dilute.

FREUNDLICH ADSORPTION ISOTHERM

Freundlich isotherm is a special case of Langmuir, used for modeling the multi-layer adsorbed on heterogeneous surfaces.

He gave an empirical relation between extent of adsorption with pressure, at a constant temperature:

$x/m = KP$ 1/n……………….. (1)

where, x is the mass of the gas adsorbed on mass, m, of the solid adsorbent at a pressure P. K and n are constants for a given adsorbate-adsorbent pair at a particular temperature. Taking logarithm of equation (1), we get

log (x/m) = $logK$ + 1 $nlog$ P/Po ………….(2)

where P o is the unit pressure required to make the pressure term unitless whose logarithm can then be taken. The validity of Freundlich isotherm can be verified by plotting a graph between log (x/m) and log (P/Po). A straight line with slope equal 1/n and, intercept log K, validates Freundlich adsorption isotherm.

LANGMUIR ADSORPTION ISOTHERM

Irving Langmuir was the first to device a scientifically based adsorption isotherm in 1918. The model applies to gases adsorbed on solid surfaces. It is a semi-empirical isotherm with a kind basis and was derived based on statistical thermodynamics. It is the most common isotherm equation to use due to its simplicity and its ability to fit a variety of adsorption data.

The Langmuir isotherm nonetheless the first choice for most models of adsorption and has many applications in surface Kinetic (usually called Langmuir-Hinshelwood Kinetic) and thermodynamics.

Langmuir suggested that, adsorption takes place through this mechanism

Ag+S ↔ AS,

Where A is a gas molecule, and S is an adsorption site. The direct and inverse rate constants are k and $k_{-1.}$

If we define surface coverage, 0 as the fraction of the adsorption sites occupied, in the equilibrium we have:

$K=k/k_{-1}=\theta/(1-\theta)P$,

Or

$\theta=KP/1+KP$,

Where P is the partial pressure of the gas or the molar concentration of the solution. For every low pressure $\theta \approx KP$, and for high pressure $\theta \approx 1$.

The value of 0 is difficult to measure experimentally, usually the adsorbate is a gas and and the quantity adsorbed is given in moles, grams or gas volumes at standard temperature and pressure (STP) per gram of adsorbent. If we call $\boldsymbol{\nu}_{mon}$ the STP volume of adsorbate required to form a monolayer on the adsorbent (per gram of adsorbent), then $\theta=\boldsymbol{\nu}/\boldsymbol{\nu}_{mon}$, and we obtain and expression for a straight line,

$1/v=1/K\,\boldsymbol{\nu}_{mon}\ 1/P+1/\boldsymbol{\nu}_{mon}$.

Through its slope and 'y' intercept we can obtain $\boldsymbol{\nu}_{mon}$ and k, which are constant for each adsorbent-adsorbate pair at a given temperature. $\boldsymbol{\nu}_{mon}$ is related to the number of adsorption sites through the ideal gas law. If we assume that the number of sides is just the whole area of the solid divided into the cross section of the adsorbate molecules, we can easily calculate the surface area of the adsorbent. The surface area of an adsorbent depends on its structure, the more Pores it has, the greater the area, which has a big influence on reactions on surfaces.

If more than one gas adsorbs on the surface, we define theta E as the fraction of empty sites, and we have

$\theta_E =1/1+\sum_{i=1}^{n} K_i P_i$

Also, we can define theta j as the fraction of the sites occupied the jth gas

$\Theta_j=K_j P_j/1+\sum_{i=1}^{n} K_i P_i$

Where, I is each one of the gas adsorb.

ADSORBENT USED



Fig.1 almond nut shell Fig.2 crushed almond Nut shell Fig.3 almond nut shell carbon

The use of almond nut shell carbon as an absorbent of the industrial pollutant is a new trend. The almond nut shell carbon has a capability as an absorbent since it has high carbon content and density low ash content and uniform pore distribution. As an agriculture waste material, the use of almond nut shell carbon also becomes a solution for environment. Problems with a low- cost production. Moreover, Iran is a tropical country provide a large number of almond nut shell as a raw material for carbon.

The characteristics of carbon depends on the parameters such as temperature, pressure and time period. The need of almond nut shell carbon is increasing due to its applications such as for industries & various human aids.

Almond nut shell is the best material that can be made into carbon as they have a lot of micropores, low ash content high water Solubility and high reactivity. Almond nut shell carbon has become one of the best forms of carbon for water filtration and water Purification in recent years. Additionally, it can effectively absorb Certain impurities.

Almond nut shell carbon referred to a wide range of carbonaceous materials with a high degree of porosity and an extended inter particulate surface area and widely used adsorbent in waste water treatment throughout the world.

They are obtained by combustion, partial condition or thermal decomposition of a variety of carbonaceous substance such as wood, peat, coal, coconut shell, waste of origin (example nutshell, fruits). The process consists of dehydration of the raw material and carbonization followed by activation. The almond nut shell carbon have been obtained powdered carbon as shown in figure above has a large internal surface area and small pore size while the finally divided powdered form from figure is associated with layer pore diameter and a small internal surface area. In the recent, although almond nut shell carbon have been used as an adsorbent, catalyst and catalyst support and in environment application, their adsorption ability and catalytic activity are largely controlled by their surface characteristics.

The existing relationship between the surface properties of almond nut shell carbon and its effectiveness as an adsorbent catalyst emphasizes the importance of developing methodologies to produce almond nut shell carbon with specific properties.

Almond nut shell carbon is unique and versatile adsorbent and they are used for the removal of undesirable odour, colour, taste, and other organic and inorganic impurities (generally referred to as adsorbates) from domestic and industrial wastes, for air purification inhabited places restaurants, food processing, removal of color from various syrups and pharmaceutical products, in air pollution control from industrial and automobile exhaust and in a variety of gas phase applications. They are also well known for their applications in medicine for the removal of toxins and bacterial infections in certain alignments.

Adsorption by almond nut shell carbon is one of the most frequently used method to remove organic compounds from water, because almond nut shell carbon possess perfect adsorption ability for chloro phenols. In this project, the objective is to investigate how the adsorption capacity of almond nut shell carbon is influenced by elevated temperature using different concentrations of parachloro phenol as the adsorbate.

STRUCTURE OF ALMOND NUTSHELL CARBON

Almond shell-derived carbon is increasingly utilized in environmental remediation, energy storage, and catalysis due to its *high fixed carbon content, low ash, and hierarchical porous structure*. The conversion of almond shells into carbonaceous material involves carbonization and activation (physical or chemical), which tailors the structure, surface area, and functional groups of the resultant carbon. Key structural features include **amorphous carbon matrices with microporous to mesoporous architecture**, enhanced by high-temperature treatment and chemical doping. These carbon materials often retain the **intrinsic fibrous structure** of lignocellulosic biomass, aiding in adsorption and conductivity applications.

PHYSICAL STRUCTURE OF ALMOND NUT SHELL CARBON

This refers to how the atoms of almond nut shell carbon is linked together and how this arrangement actually give rise to the adsorption ability of almond nut shell carbon it also describe the various for sizes available on the surface of almond nut shell carbon which is responsible for its wide range of applicability in the sense that the four size of any particular almond nut shell carbon determine to a large extent what it is used for. The physical structure of almond nut shell carbon is further divided into:

PREPARATION OF ALMOND NUT SHELL CARBON

Carbonization was done using vecstar furnace set at 500 oC for 2 hrs. The carbonized product was allowed to cool and prepared ready for activation with H3PO4 and ZnCl2.Chemical activation was carried out using the method of Udeozor and Evbuomwan, [23] with slight modification. 50 g of each of the carbonized product was mixed with 150 mL Phosphoric acid for H3PO4 activation and 150 mL of 0.5 M Zinc Chloride for ZnCl2 activation. Each was thoroughly mixed until it formed a paste which was then transferred into a crucible. The crucibles containing the samples were placed in the furnace and heated at a temperature of 500 oC for 2 hr. After cooling, each sample was washed with 500 mL of 1.2 M HCl followed by 500 mL distilled water until neutrality to remove excess activating agent before filtration with whatman filter paper. The residue was oven-dried at 110 oC for 1 hr, and then kept in an air tight 1904 Osobamiro et al., J. Mater. Environ. Sci., 2020, 11(11), pp. 1903-1913! container for further analysis , they were labelled as APAC (Almond Phosphoric acid Activated Carbon) and AZAC (Almond Zinc chloride Activated Carbon).

2. Materials and Methods

Adsorption process of different mono basic acid (Acetic acid, Propionic acid) dibasic acid (Oxalic acid and Succinic acid)

Materials Used: Almond shell carbon, Mono basic acid (Acetic acid and Propionic acid) Dibasic acids (Oxalic acid and Succinic acid), NaOH, Phenolphthalein, Stoppered bottle, Burette, Pipette, Funnel, Conical flask.

PROCEDURE:

Prepared aqueous solution of acids into numbered flask as labelled, the total volume of each solution is 50ml taken in Stoppard bottles. Transfer 10ml of the solution from each bottle into the conical flask. Add 2-3 drops of Phenolphthalein indicator and titrate against NaOH. Once the end point is reached, read the burette reading. The volume of base$V_{1.}$. Calculate the actual concentration of oxalic acid C_1 in the flask number 1 to 5 respectively, and write it down in the table. Using practical balance weigh 5 portions of walnut shell carbon, each portion1 gram. PlacedAlmond shell carbon into numbered flask into stoppered bottle and shake them, wait for 20 minutes, the process of adsorption is in progress. Mix the mixtures for several times by shaking the flask. (The process of adsorption is a function of times it is important to put on ion feel into flask at the same time to provide adsorption for the same period in each flask). Filter the mixtures into clean and dry flask to avoid disturbing effect of adsorption of acid into filtering paper, remove away the first portion of filtration approximate of 5ml. Determine the final concentration of acid C, in each of the flask after adsorption from each solution, pipette out 10ml of oxalic acid solution and transfer it to clean and dry conical flask. To this conical flask containing oxalic acid solution at 2 to 3drops of Phenolphthalein indicator. Now, titrate this solution against NaOH in the burette, note down the burette reading. The volume of base V_2

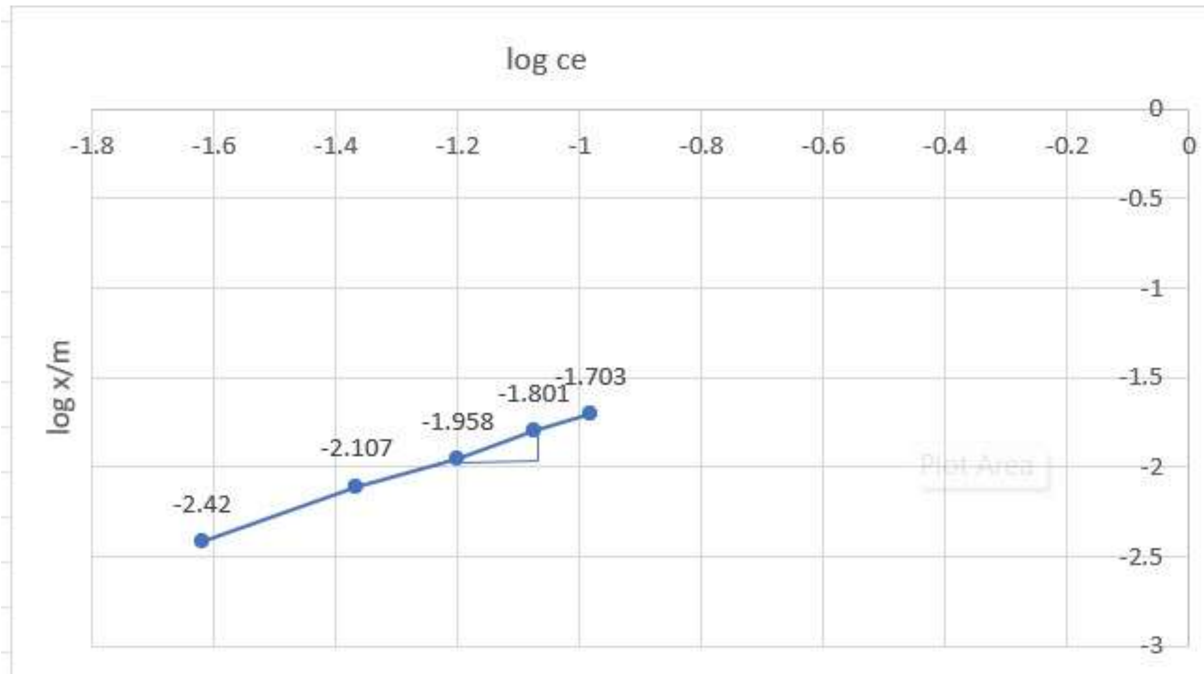
PROCEDURE TABULAR COLUMN: -Dilution ofacids

Bottle No.	Vol. of acid added (0.5N)	Volume of water added in ml	Amount of almond nut shell carbon added in gm
1	50	00	1
2	40	10	1
3	30	20	1
4	20	30	1
5	10	40	1

TABULAR COLUMN :

SI. NO	Initial concentration of	Vol. of titrant taken in ml	Amount of almond shell Carbon added	Burette reading	Ce = B.R*0.1/10Eq.con.o	X=Co-Ce/20 Amount adsorbed	x/m	Log(x/m)	Log Ce	Ce (x/m)
1	0.5	10	1	10.4	0.104	0.0198	0.0198	-1.703	-0.982	0.0020
2	0.4	10	1	8.4	0.084	0.0158	0.0158	-1.801	-1.075	0.0013
3	0.3	10	1	6.3	0.063	0.011	0.011	-1.958	-1.200	0.0006
4	0.2	10	1	4.3	0.043	0.0078	0.0078	-2.107	-1.366	0.0003
5	0.1	10	1	2.4	0.024	0.0038	0.0038	-2.420	-1.619	0.00009

GRAPH: FREUNDLICH ADSORPTION ISOTHERM (OXALICACID)

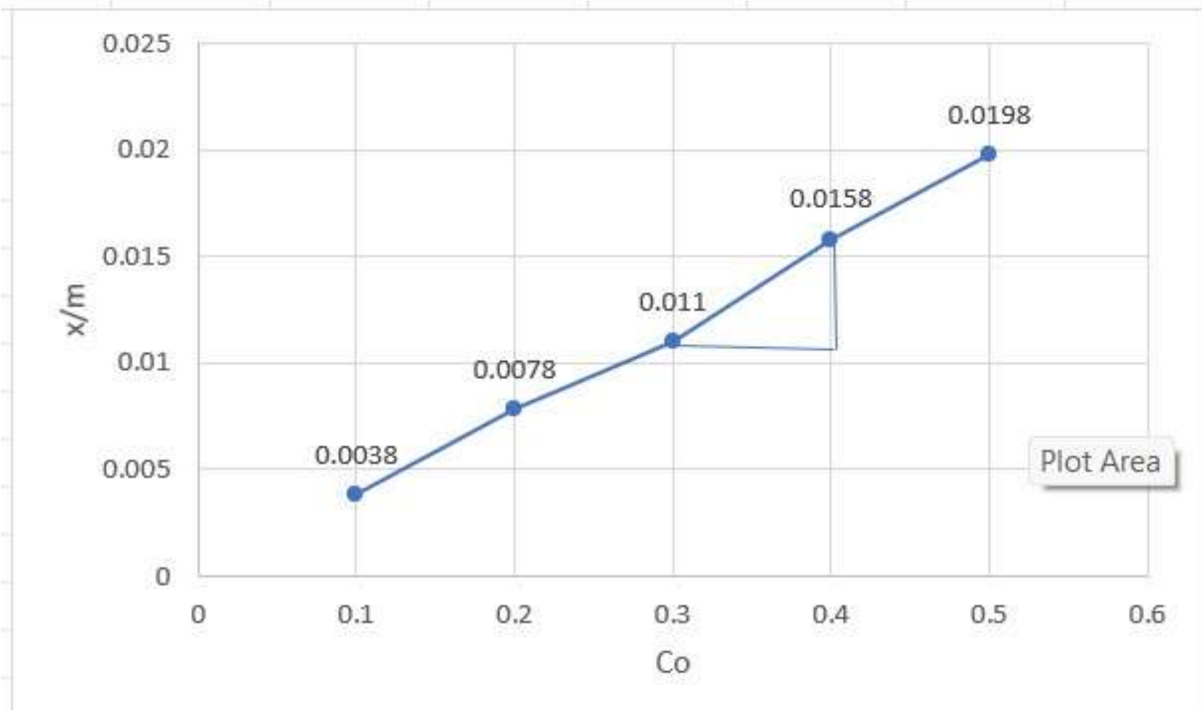


SLOPE = (-1.801)-(-1.958)/(-1.1)-(-1.2)

= 0.17/0.1

= 1.57

GRAPH : LANGMUIR ADSORPTION ISOTHERM (OXALICACID)



SLOPE = (0.0158)-(0.011)/(0.4)-(0.3)

= 0.0048/0.1

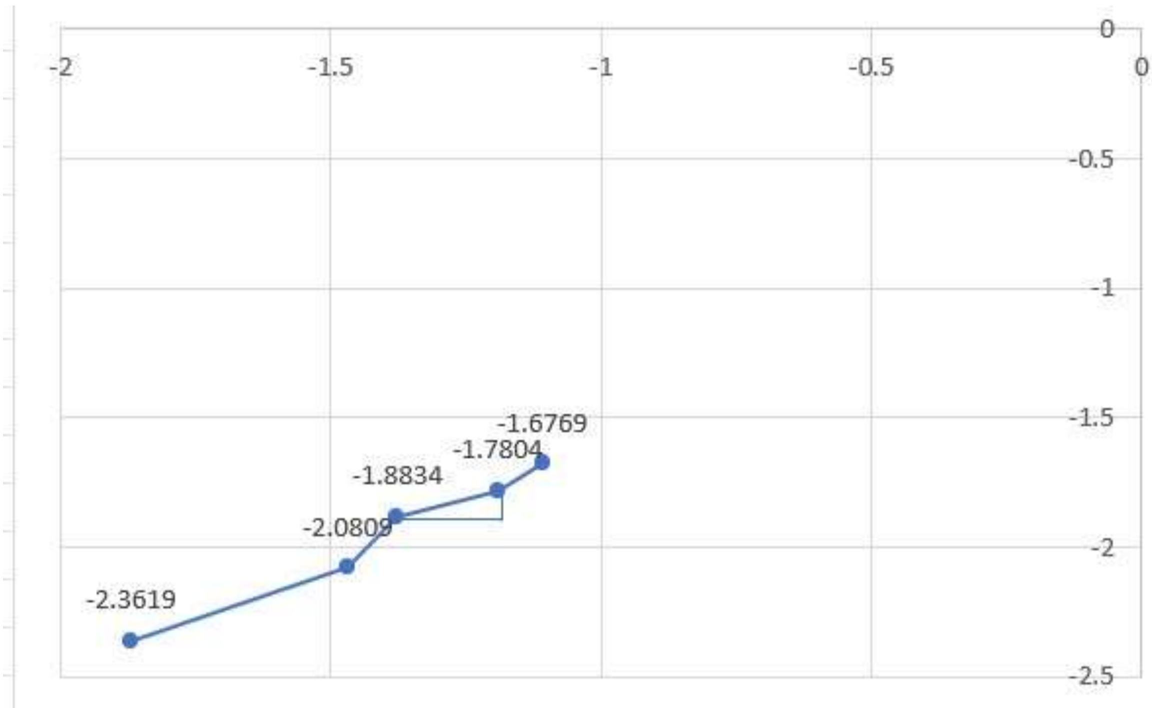
= 0.048

TABULAR COLUMN :-

SI. NO	Initial concentration of Succinicacid(Co)	Vol. of titrant taken in ml	Amount of almond shell Carbon added in gm	Burette reading	Ce = B.R*0.1/10Eq.con.of acid in mol/dm^3	X=Co-Ce/20 Amount adsorbed in moles	x/m	Log(x/m)	Log Ce	Ce (x/m)
1	0.5	10	1	8.2	0.082	0.0209	0.0209	-1.676	-1.086	0.00171

								9	1	
2	0.4	10	1	7.6	0.076	0.0162	0.0162	-1.7804	-1.1191	0.00123
3	0.3	10	1	6.8	0.068	0.0116	0.0116	-1.8824	-1.2674	0.00788
4	0.2	10	1	3.4	0.034	0.0083	0.0083	-2.0804	-1.4685	0.000282
5	0.1	10	1	1.5	0.015	0.00425	0.00425	-2.3619	-1.8239	0.000063

GRAPH: FREUNDLICH ADSORPTION ISOTHERM (SUCCINIC ACID)

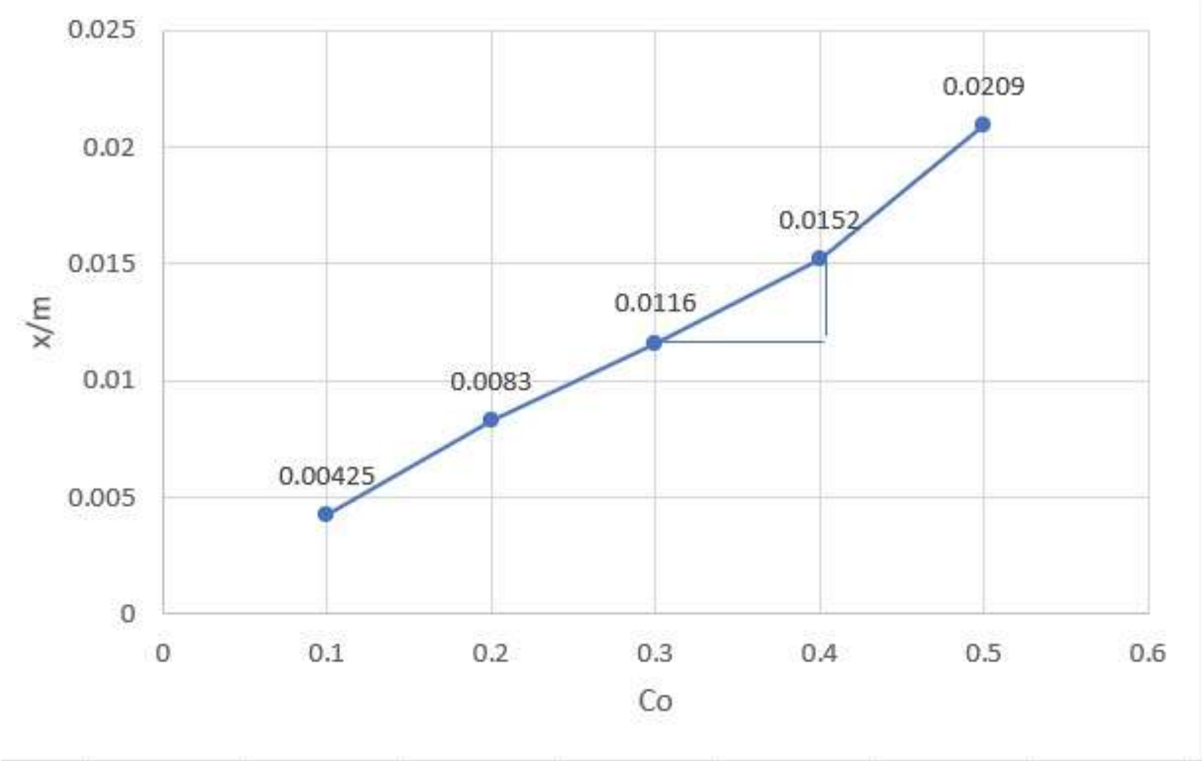


SLOPE=(-1.7804)-(-1.8834)/(-1.2)-(-1.4)

= 0.103/0.2

= 0.515

GRAPH : LANGMUIR ADSORPTION ISOTHERM (SUCCINICACID)



SLOPE =(0.0152)-(0.0116)/(0.4)-(0.3)

= 0.0036/0.1

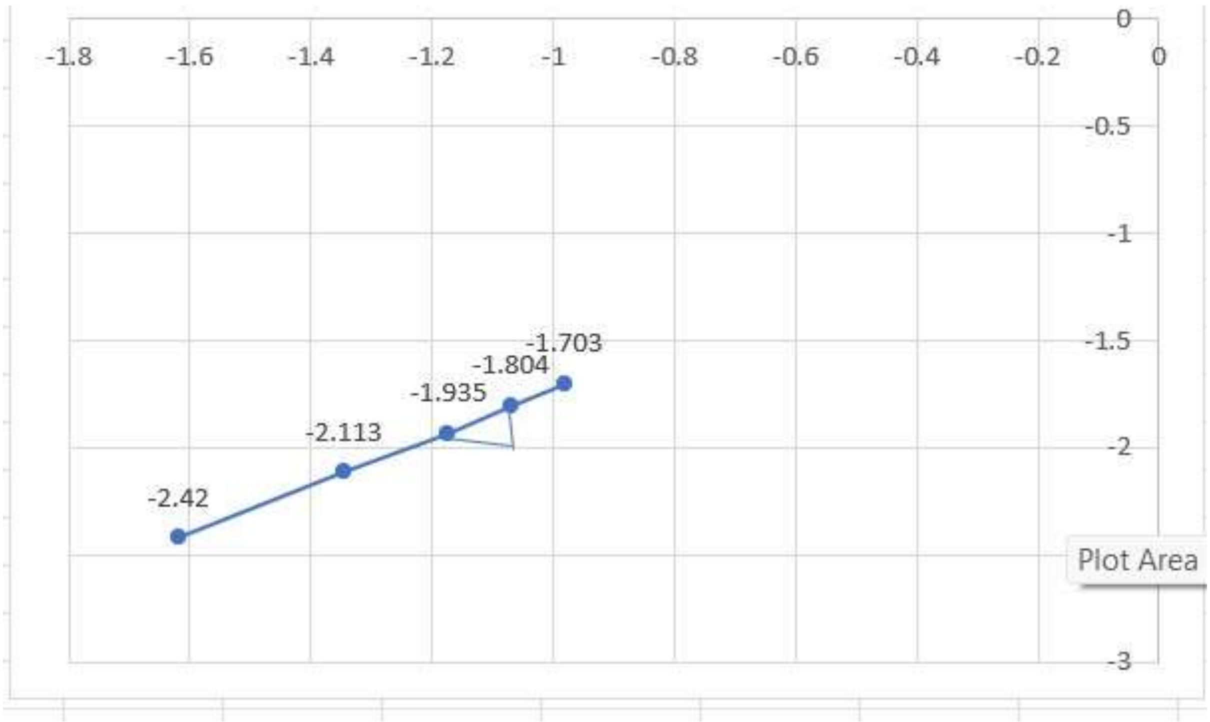
= 0.036

TABULAR COLUMN :-

SI. NO	Initial concentration of Aceticacid(Co)	Vol. of titrant taken in ml	Amount of almond shell Carbon added	Burette reading	Ce = B.R*0.1/10Eq.con.of	X=Co-Ce/20 Amount adsorbed in	x/m	Log(x/m)	Log Ce	Ce (x/m)

1	0.5	10	1	10.4	0.104	0.0198	0.0198	-1.703	-0.982	0.0020
2	0.4	10	1	8.5	0.085	0.0157	0.0157	-1.804	-1.070	0.0013
3	0.3	10	1	6.7	0.067	0.0116	0.0116	-1.935	-1.173	0.0007
4	0.2	10	1	4.5	0.045	0.0077	0.0077	-2.113	-1.346	0.0003
5	0.1	10	1	2.4	0.024	0.0038	0.0038	-2.420	-1.619	0.00009

GRAPH: FREUNDLICH ADSORPTION ISOTHERM (ACETIC ACID)

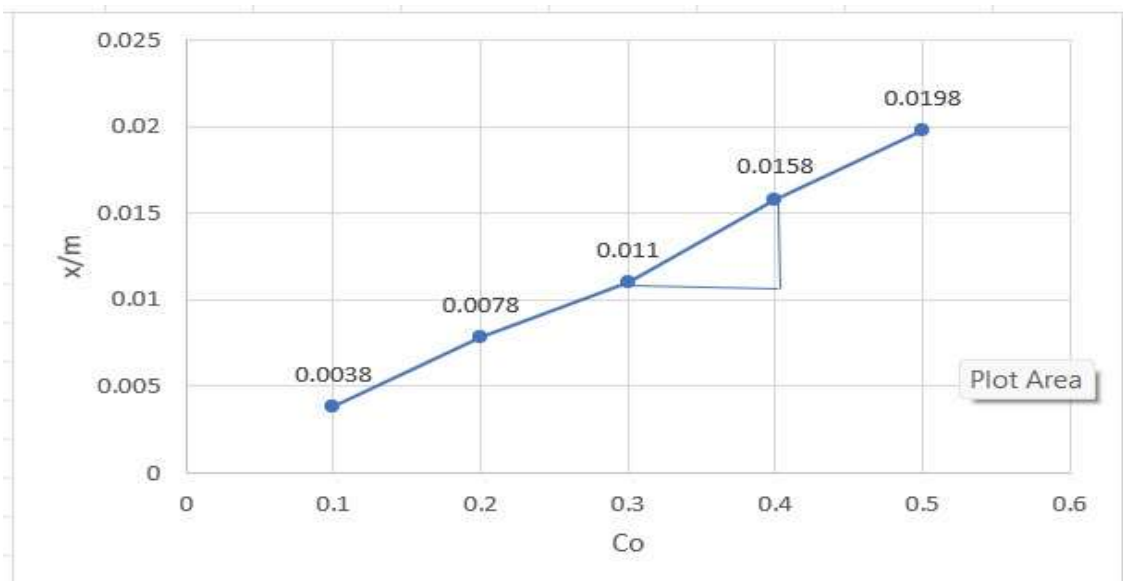


SLOPE = (-1.804)-(-1.935)/(-1.1)-(-1.2)

= 0.131/0.1

= 1.31

GRAPH : LANGMUIR ADSORPTION ISOTHERM (ACETICACID)



SLOPE = (0.0158)-(0.011)/(0.4)-(0.3)

= 0.0048/0.1

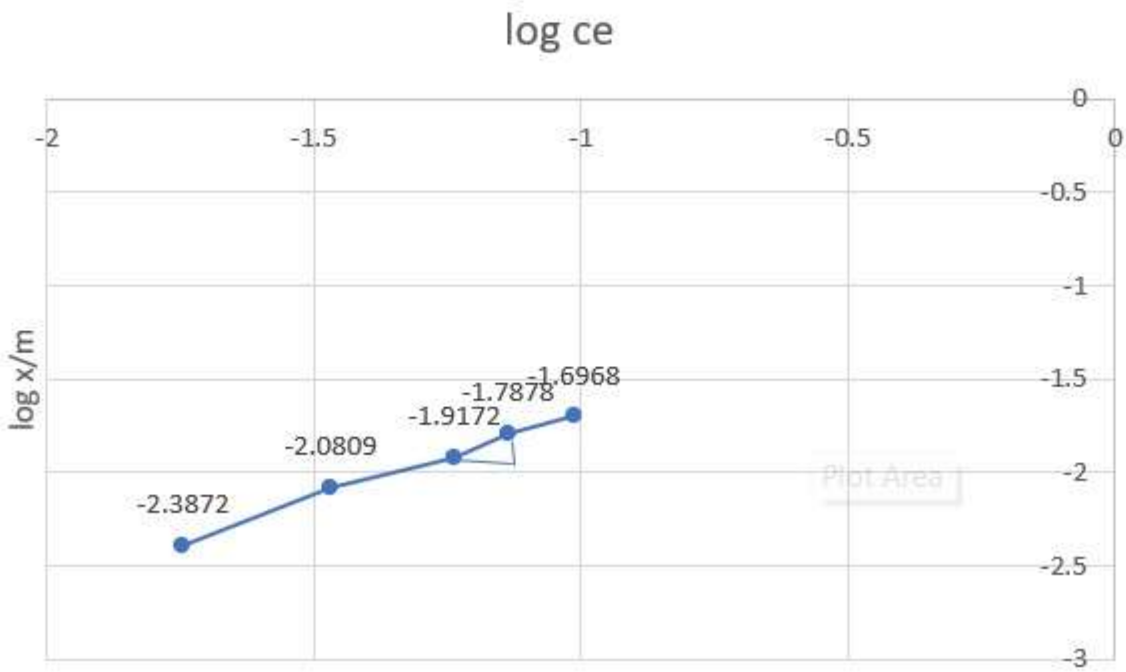
= 0.048

ADSORPTION OF PROPANOIC ACID ON ALMOND NUT SHELL CARBON

TABULAR COLUMN: -

SI. NO	Initial concentration of Propanoic	Vol. of titrant taken	Amount of almond shell Carbon added	Burette reading	Ce = B.R*0.1/10Eq.con.of	X=Co-Ce/20 Amount adsorbed in	x/m	Log(x/m)	Log Ce	Ce (x/m)
1	0.5	10	1	9.8	0.097	0.02015	0.02015	-1.6968	-1.0132	0.0019
2	0.4	10	1	7.3	0.073	0.0163	0.0163	-1.7878	-1.1366	0.0011
3	0.3	10	1	5.7	0.058	0.0121	0.0121	-1.9172	-1.2365	0.0007
4	0.2	10	1	3.4	0.034	0.0083	0.0083	-2.0809	-1.4685	0.0002
5	0.1	10	1	1.8	0.018	0.0041	0.0041	-2.3872	-1.7447	0.00007

GRAPH: FREUNDLICH ADSORPTION ISOTHERM (PROPANOIC ACID)

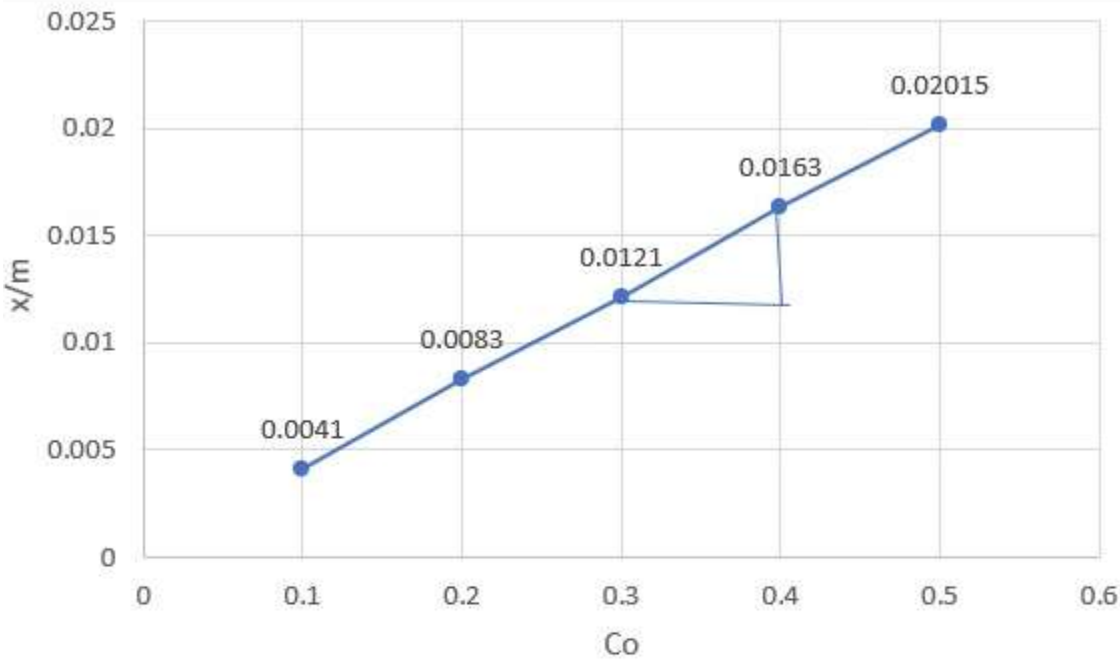


SLOPE = (-1.7878)-(-1.9172)/(-1.1)-(-1.2)

= 0.1294/0.1

= 1.294

GRAPH : LANGMUIR ADSORPTION ISOTHERM (PROPANOICACID)



SLOPE = (0.0163)-(0.0121)/(0.4)-(0.3)

= 0.0042/0.1

= 0.042

Application of adsorption:

- **Production of high vacuum:** The last traces of air can be absorbed by charcoal from a vessel evacuated by a vacuum pump to achieve a very high vacuum.
- **Gas masks:** A gas mask (a device made of activated charcoal or a combination of adsorbents) is commonly used in coal mines to adsorb poisonous gases.
- **Control of humidity:** Adsorbents such as silica and aluminium gels are used to remove moisture and control humidity.
- **Colour removal from solutions:** Animal charcoal removes colours from solutions by adsorbing coloured impurities.
- **Heterogeneous catalysis:** Adsorption of reactants on the solid surfaces of catalysts accelerates the reaction. There are numerous industrially

important gaseous reactions that use solid catalysts. The production of ammonia with iron as a catalyst, the production of H_2SO_4 through a contact process, and the use of finely divided nickel in the hydrogenation of oils are all excellent examples of heterogeneous catalysis.

- **Separation of inert gases:** Adsorption on coconut charcoal at different temperatures can separate a mixture of noble gases due to the difference in the degree of adsorption of gases by charcoal.
- **In curing diseases:** Several drugs are used to kill germs by becoming adsorbent on them.
- **Froth floatation process:** Using pine oil and a frothing agent, a low-grade sulphide ore is concentrated by separating it from silica and other earthy matter.
- **Adsorption indicators**: Surfaces of certain precipitates, such as silver halides, have the property of adsorbing dyes such as eosin, fluorescein, and others, resulting in a distinct colour at the endpoint.
- **Chromatographic analysis:** Chromatographic analysis based on the adsorption phenomenon has a variety of applications in analytical and industrial fields.
- **Purification of water:** Impurities are adsorbed on the alum stone when alum stone is added to water, and the water is purified.
- **Separation of noble gases by Dewar's flask process:** In the presence of heated coconut charcoal, a mixture of noble gases (Neon, Argon, and Krypton) is passed through a Dewar's flask. Argon and Krypton gels have been absorbed, leaving Neon.
- **In dying of cloth**: Mordants such as alums are used in dying of cloth. The adsorbed dye particles which otherwise do not stick to the cloth.
- **In ion exchange resins:** The organic polymer containing groups like -COOH, -SO, H-NH2 etc possess the property of selective adsorption of ion from solution. These are quite useful in the softening of water and also in the separation of the elements of the lanthanide series (alsocalled as rare earths) from the mixture.
- **In quantitative analysis**: Certain qualitative test such as the lake test for the confirmation of AI ions are based upon adsorption, ie AL(OH), has a capacity to adsorb the colour of blue litmus from the solution.
- **In pharmaceutical industry:** Some drugs can absorb the germs on them and hence kill them and save us from the diseases. Activated charcoal,

magnesium oxide, tannic acid etc are used for the absorption of poisonous and toxic substances. Adsorption is also used in vitamin B1 preparation, bacterial filtration, pharmaceutical adsorption, etc.

- **In clarification of sugar**: Sugar is decolourised by treating sugar solution with charcoal powder. The latter adsorbs the undesirable colors present.
- **In the paint industry**: The dissolved gases in paints are removed using suitable adsorbents during the manufacture of paints. Dissolved gases do not adhere well to the surface to be painted and thus show poor covering power. Wetting agents are used to remove the gaseous, liquid, or solid films on the paints surface.
- **In water conservation:** In countries like Australia where there is acute scarcity of water during summer, a layer of stearic acid is sprayed over the lakes and other water reservoirs. It is adsorbed on the surface of the water, thereby minimizing the loss of water by evaporation.

CONCLUSION

Comparision of difference between monobasic acids (acetic acid and propanoic acid).

From the readings obtained we observed that extent of adsorption ofpropanoic acid is greater than acetic acid.

i.e propanoic acid (0.01219) > acetic acid (0.01172) the reason behind the above conclusion is the presence of CH_2group in propanoic acid and absence ofCH_2group in acetic acid.

Comparision of difference between dibasic acid (oxalic acid and succinic acid)

From the readings obtained we observe that the extent of adsorption of succinic acid is greater than oxalic acid. i.e, succinic acid (0.01225) > oxalic acid (0.01164) the reason behind the above conclusion is the presence of $2CH_2$ group in succinic acid or absence of $2CH_2$ group in oxalic acid.

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