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Preparation of on Nano Materials and Nano-Chemical Compounds with Adsorption Applications

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KEYWORDS
Nano, Azo, Organic compound, Formazan, adsorption, Dyes, surface ,adsorption, chemical adsorption

ABSTRACT:
In the recent study ,We Synthesized novel Nano-Compounds from azo dyes with Oxadiazole ring involved four groups of Azo in same compounds, then all measurements were carried out to improve their structures ,also nano study was carried out by scanning through light microscopic system, in addition to spectral measurements that act by resonance –spectra and FT.IR- spectra and other analysis. Adsorption on bio-chemical compounds and nano chemicals, attraction or adsorption the accumulation of atoms or molecules of a fluid (called an adsorbent) on the surface of a solid (called an adsorbent). This process creates a layer of molecules or atoms that have accumulated densely on the surface of the adsorbent. Adsorption differs from absorption in that a substance diffuses into a liquid or solid to form a solution. The term absorption combines both processes: absorption and adsorption (or adsorption). The reverse process, which is the expulsion of the adsorbed substance from the adsorbent surface. The nature of the bonds formed depends on the quality of the linked molecules, but the adsorption process is generally classified as physical adsorption (where van der Waals forces are the active ones) or there is also chemical adsorption (chemisorption), which is characterized by covalent bonds.

INTRODUCTION

Synthesis of Nano-Particles as Environmentally friendly materials

Synthesis in an environmentally friendly manner depends on biological systems and plants, as this method is low cost, safe, harmless, less polluting and toxic to the environment, and the scope of synthesis can be expanded. Therefore, environmentally friendly synthesis is preferred over various chemical methods, and the synthesis of nanoparticles in an environmentally friendly manner is subject to stages, including the activation of element ions from Its salt materials are mediated by plant receptors, and the valence states of mono and binary metals change to a state of zero valence, the metal atoms are linked, and the growth phase occurs to form a variety of shapes, and then nanoparticles are created and morphology is formed by activity and plant receptors, and nanoparticles can be synthesized from organisms Microorganisms, including fungi, algae, seaweeds, and rainwater

Nanoparticles

They are ultrafine particles and materials with nanostructures or nanoparticles that are crystalline or amorphous materials and their size ranges between 100 nanometers and they have high strength and low weight and high surface area, and nano-materials, fibers, nanoparticles and nanotechnologies have gained great importance in applications Modern studies and researches and nanoparticles are smaller than the diameter of a human hair by about (100,000) times and smaller than a micrometer (1,000) times. As for the size of fine particles for nanoparticles, their size ranges from (100 to 2500) nanometers, and coarse particles have a size between 2500 to 10,000. nanometers and nano-materials are the bridge that connects microstructures and atoms, that is, they are close in their dimensions to atomic dimensions, and nanoparticles possess magnetic,

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optical, electronic, electrical, chemical, and unique structural properties, and among the most prominent surface area, it does not lose its optical activity when used for a long time, in addition to being inexpensive and non-toxic. properties are their possession of a wide absorption spectrum and depend on Because of its shape and high

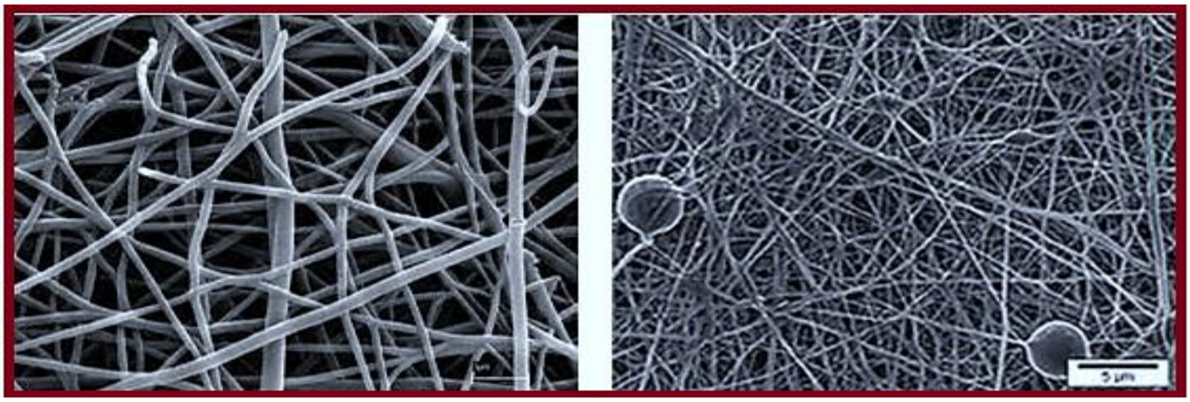


Fig.1 : Nano-fibers prepared for adsorption as example

Experimental Part

All Synthesized novel Nano-Compounds measured by many techniques like scanning through light microscopic system, in addition to spectral measurements that act by resonance –spectra and FT.IR- spectra and other analysis. Some of analysis carried out in Asfahan University.

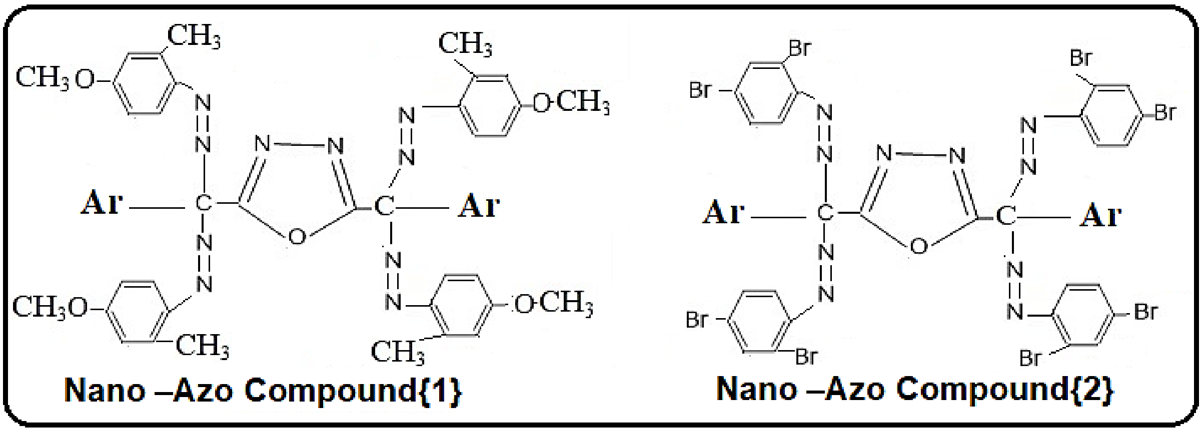
Preparation of Nano-Azo Compounds

Synthesis of Nano-Azo Oxadiazole Compound {1}:

Diamino benzyl bromide (0.002 mol) was reacted with dibromomethyl hydrazine (0.001 mol) in 40 ml absolute ethanol (0.0001 mole) of k_2CO_3 with rotation for (22 hrs) in then cyclization step with manganese oxide , the product filtered, dried , recrystallized to yield compound involved four amino groups as a starting material , then the azotaion reaction carried out via coupling step with m-methyl anisole (0.004 mole) to yield Nano-Azo oxadiazole Compound {1}by following texts [6,7] .

Synthesis of Nano-Azo Oxadiazole Compound {2}:

The starting material which synthesized in first step coupled via azotaion reaction with m-dibromo benzene (0.004 mole) to yield Nano- Azo oxadiazole Compound {2}by following texts [6,7]



Scheme. 1: Preparation of Nano –Azo Compounds { 1, 2}

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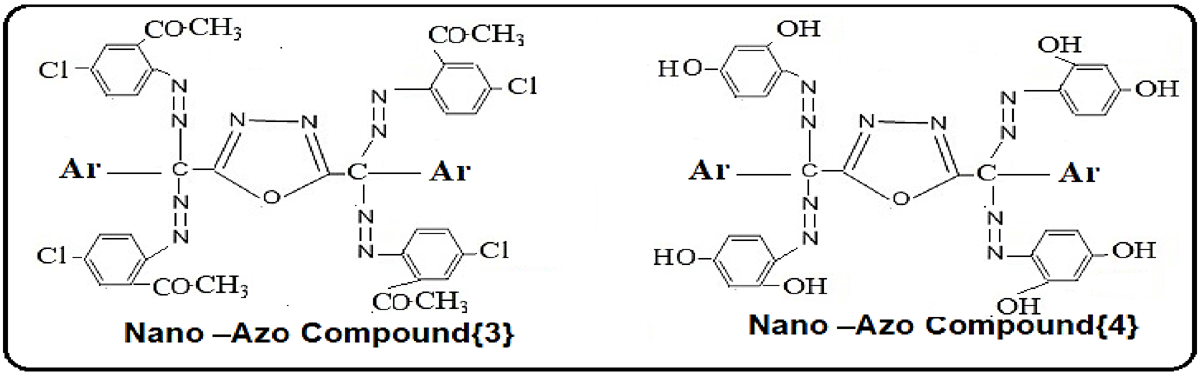
Synthesis of Nano-Azo Oxadiazole Compound {3}: The starting material which synthesized in first step coupled via azotaion reaction with m-chloro acetophenone (0.004 mole) to yield Nano- Azo oxadiazole Compound {3}by following texts [6,7].

Synthesis of Nano-Azo Oxadiazole Compound {4}: The starting material which synthesized in first step coupled via azotaion reaction with m-dihydroxy benzene (0.004 mole) to yield Nano- Azo oxadiazole Compound {4}by following texts [6, 7].

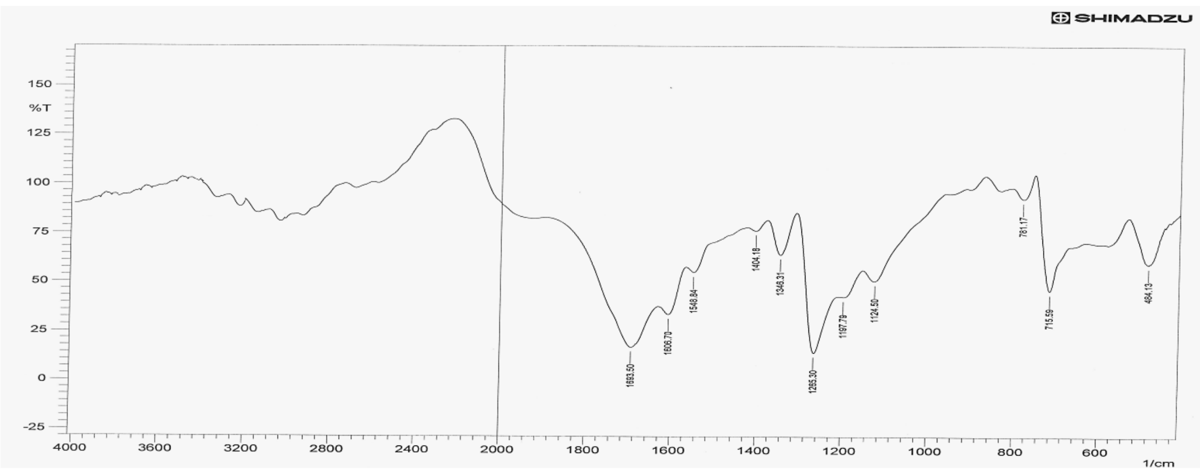


Scheme. 2: Preparation of Nano –Azo Compounds { 3, 4}

Results and Discussion

All Synthesized novel Nano-Compounds measured by many techniques like scanning through light microscopic system, in addition to spectral measurements that act by resonance –spectra and FT.IR- spectra and other analysis.

FT.IR- Spectral Indication of Nano-Azo Oxadiazole compounds : It indicated to formation our compounds by appearance of band represented by azo group (-N=N-) for all compounds at : {(1425, 1464) , (1435 ,1498), (1438 , 1471) ,(1455, 1488) } cm^{-1} respectively and other bands appearance in figures of FT.IR-Spectra , all frequencies clarified according to reference[25] .



Spect. 1: Nano Azo Oxadiazole Compound {1}

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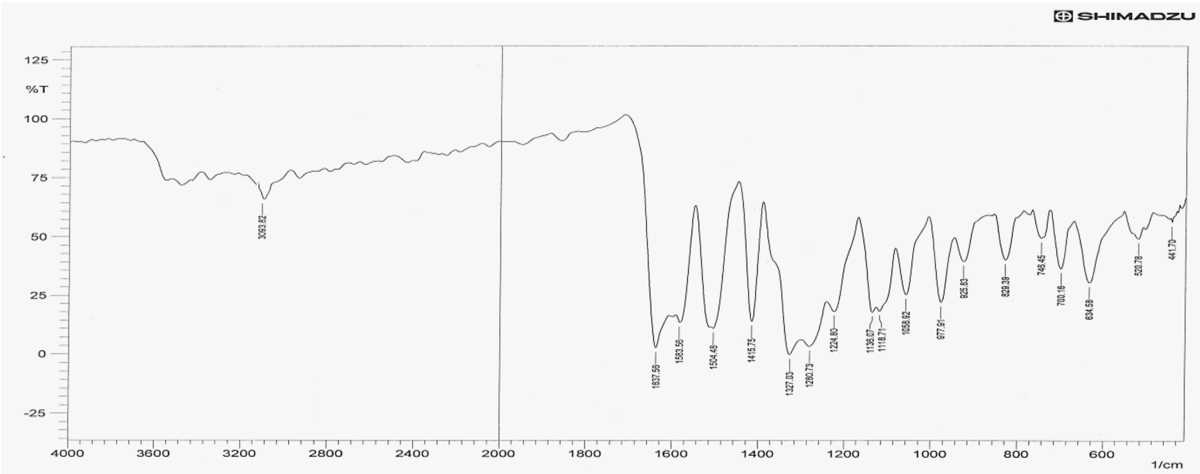
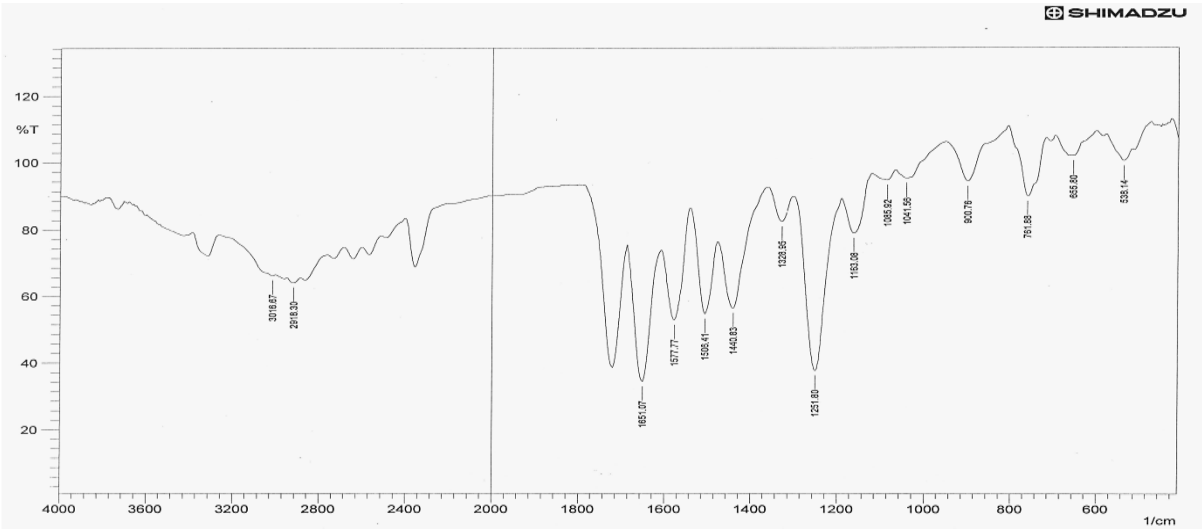
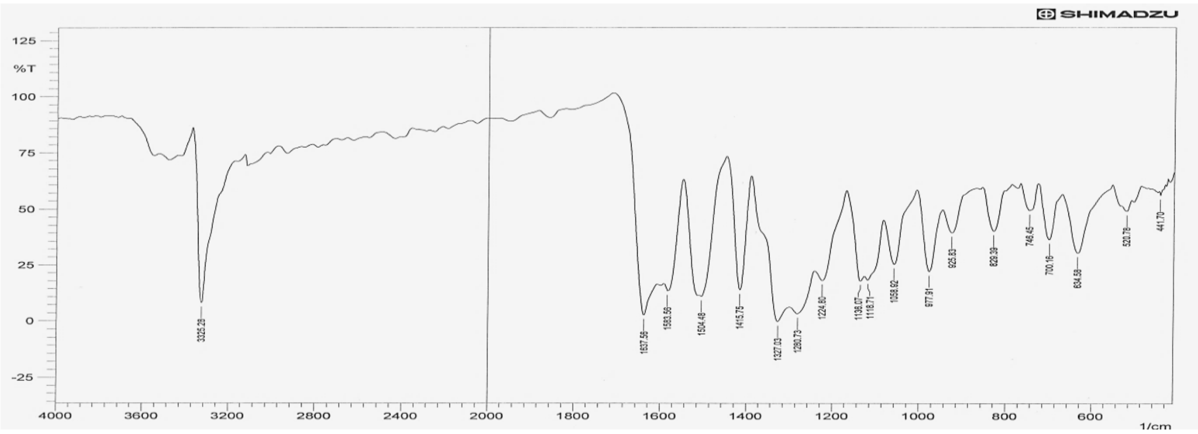


Spect. 2: Nano Azo Oxadiazole Compound {2}



Spect. 3: Nano Azo Oxadiazole Compound {3}



Spect. 4: Nano Azo Oxadiazole Compound {4}

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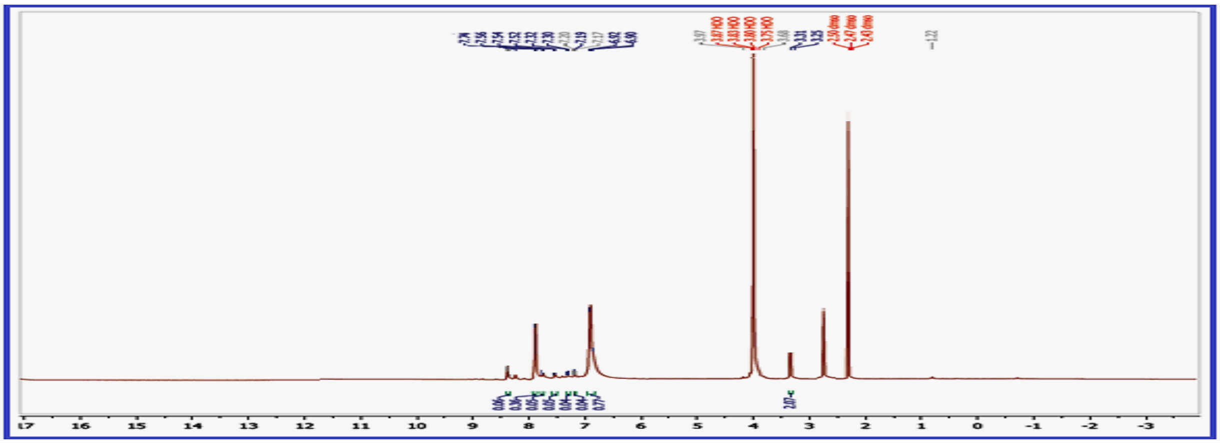
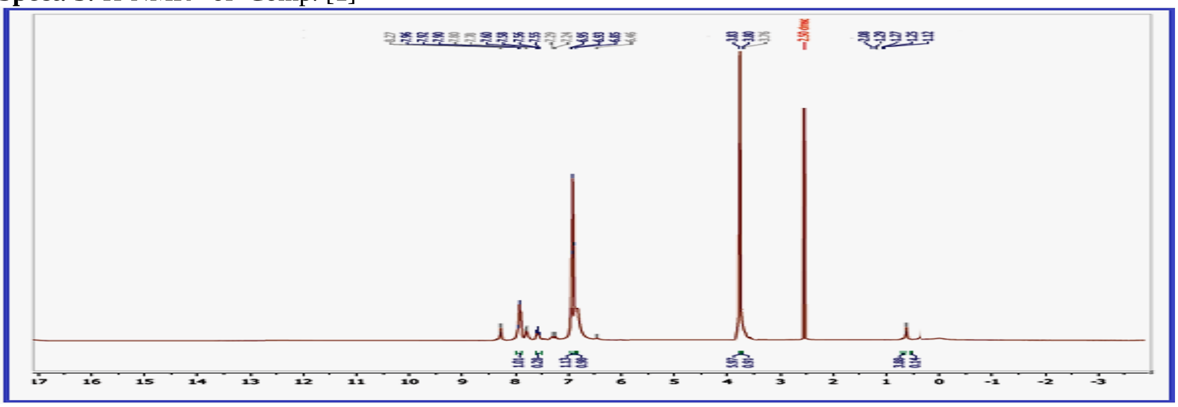
H.NMR - Spectral Indication of Nano-Azo Oxadiazole compounds :

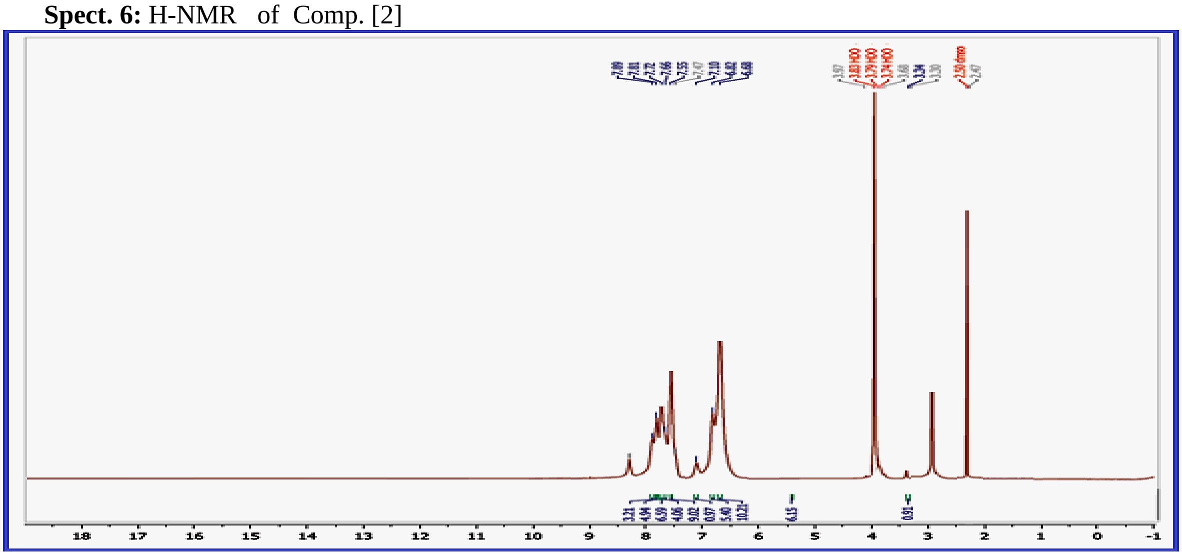
It indicated to formation of Nano-Azo oxadiazole compounds by appearance of peak at : δ (11.13) for (OH) hydroxyl group in compound {4} ,and peak at (3.06) for proton of methoxy group ($-OCH_3$) in compound [1],also appearance peak at : δ (2.03) for ($CO-CH_3$) protons of ketone group in compound [3] ,also other peaks clarified according to reference(25) .



Spect. 5: H-NMR of Comp. [1]



Spect. 6: H-NMR of Comp. [2]



Spect. 7: H-NMR of Comp. [3]

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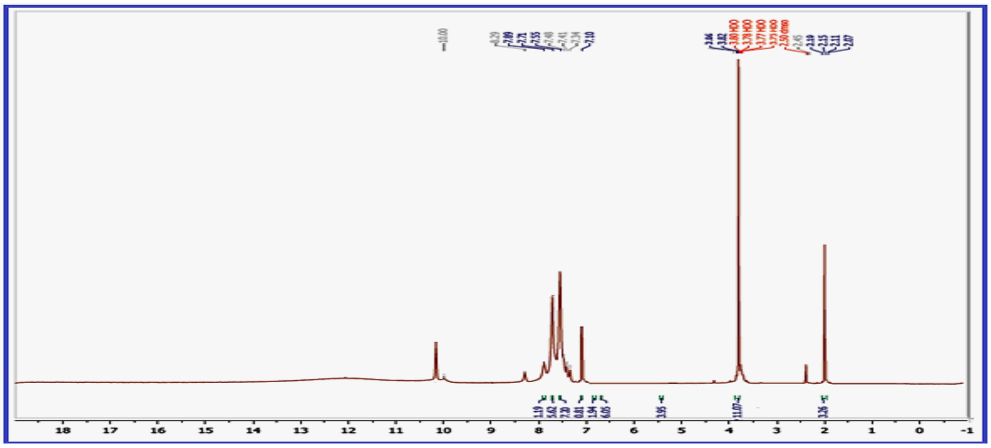
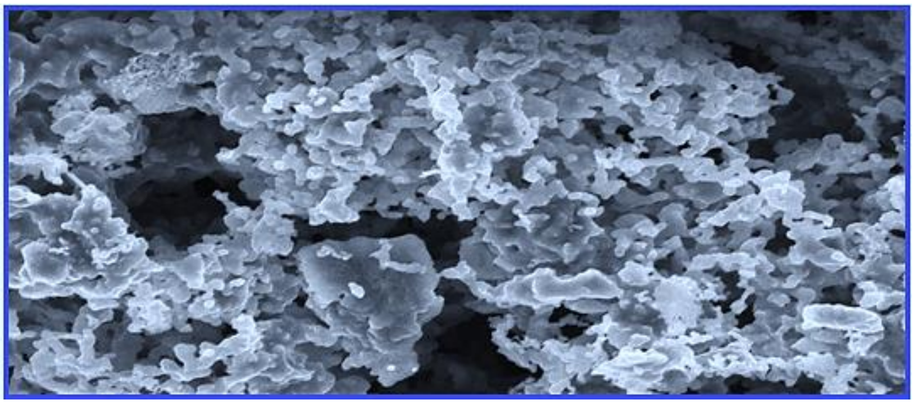


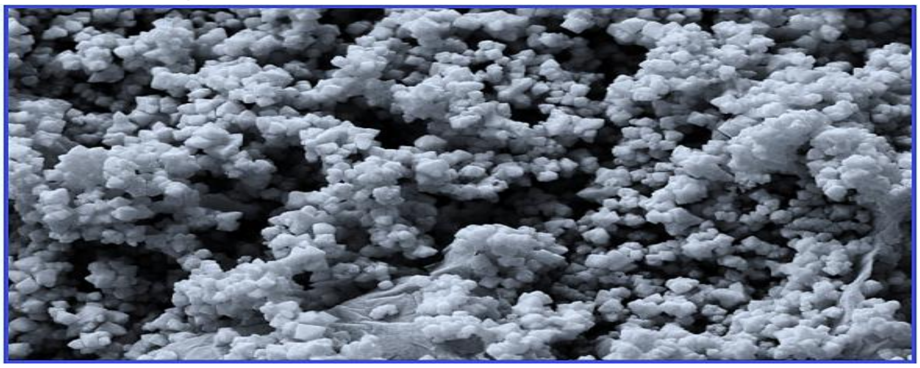
Spect. 8: H-NMR of Comp. [4]

Scanning Electron Microscopy (FESEM) :

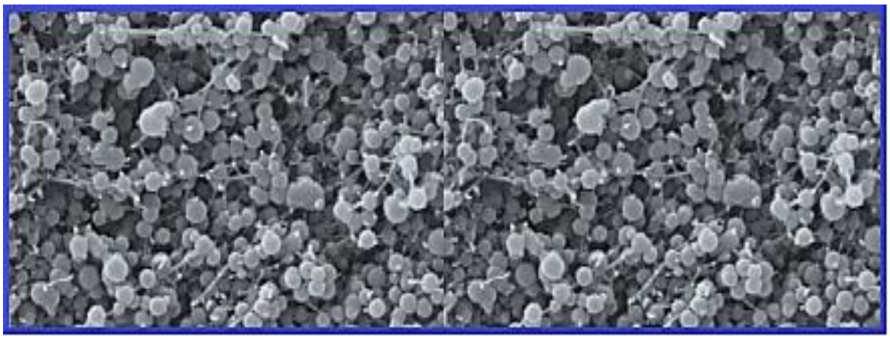
Scanning Electron Microscopy (FESEM) of the new Nano- Azo oxadiazole Compounds (for morphological properties) that publicized in this work that they have a spherical shape also have granular sizes within the nano-scale they have an average size of (42. 09 , 58. 97, 66. 32 ,70. 13) nanometers to [compound {1} , compound {2} , compound {3}, compound {4}] respectively, so the surface part rises also this specific makes it eligible for health applications due to its small granular size , spherical shape within the nano-scale that is applied in health fields as a treatment for many forms of tumors as well as in the manufacturing field(7) , figures (3 , 4):



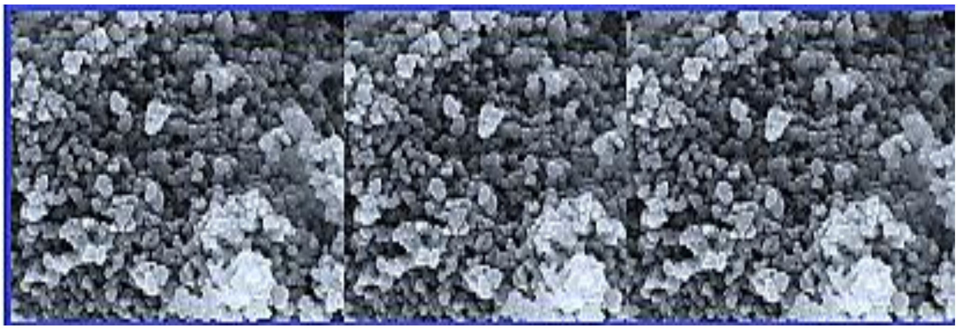
Fig(2): Scanning Electron Microscopy of compound {1}



Fig(3): Scanning Electron Microscopy of compound {2}



Fig(4): Scanning Electron Microscopy of compound {3}



Fig(5): Scanning Electron Microscopy of compound {4}

Adsorption on the surface of nanoparticles

Nano-materials have a wide range of applications that are used to address the problems of environmental pollution, especially water pollution, where heavy metals are the most prevalent at the present time represented by (lead, mercury, zinc, cadmium, nickel), due to their increasing use in industrial activities and the view because of their toxic and carcinogenic nature, they have become a great danger. Nanoparticles and oxides of some metals constitute effective adsorbent materials with high efficiency in treating environmental pollution. Active carbon, silica, and grapheme oxide were used, which proved to be highly efficient due to its unique two-dimensional nature, represented by the presence of Functional aggregates and its large surface area, the method of nanoparticles is one of the most efficient techniques in addressing this problem, as it is due to the small size of these particles and their penetration into the pollution area, and then the adsorption process takes place to obtain a good water purification.

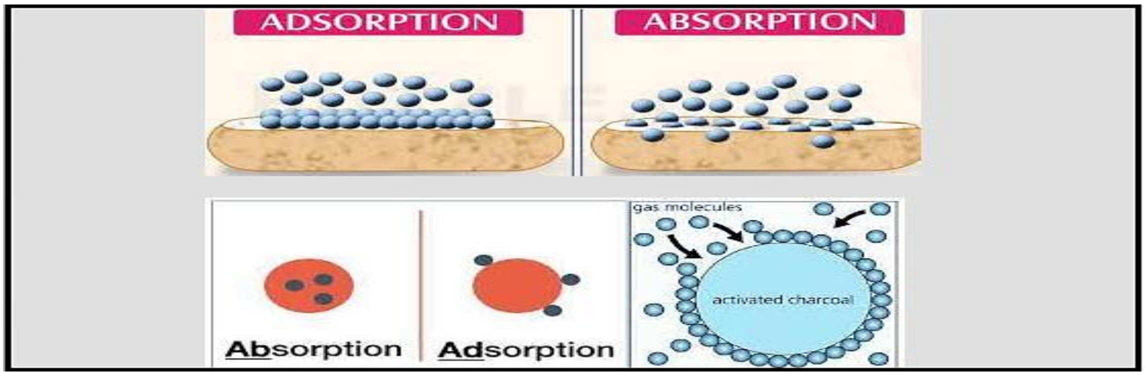


Fig. 6: Mechanism of Absorption and Adsorption of Nano- Materials

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In simple terms, adsorption is "the gathering of a substance on the surfaces of the particles of an adsorbent substance" (Reynolds and Richards, 1996). Adsorption is found in many natural physical, biological and chemical systems, and is widely used in industrial applications such as: water purification using activated carbon or synthetic resins for the purpose of purifying a medium, liquid or gas[1-3]. The processes of adsorption, ion exchange (adsorption), and (absorption) are considered as sorption processes. Valachrp is a comprehensive term that includes absorption and adsorption.

Similar to surface tension, adsorption is a consequence of surface energy[4].

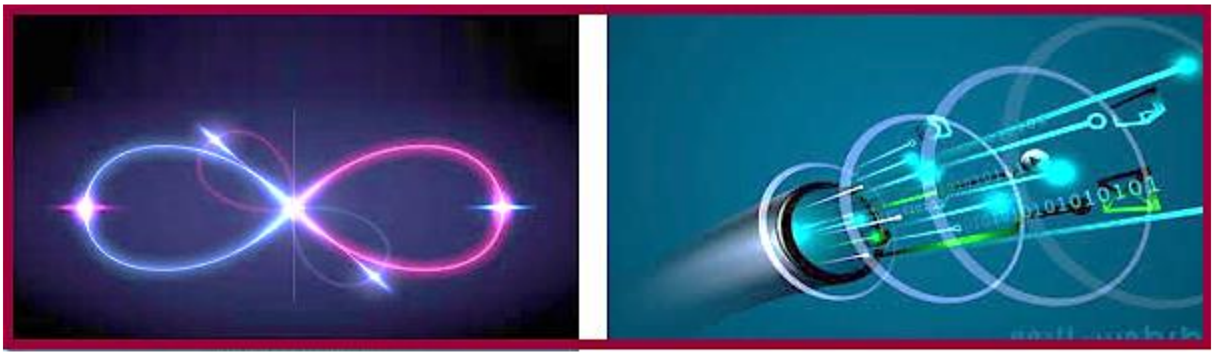

Fig. 7: Adsorption by Nano-photons and Nano-lasers

In solids, all atoms are bonded together (whether ionic, covalent or metallic bonds) and the atoms at the core of the material are surrounded by other atoms of the same kind. But the atoms on the surface of the "granules" of the adsorbent material are not completely surrounded by atoms of the adsorbent, and thus can attract other adsorbents, as happens with a catalyst where the catalyst activates the interaction of materials on the surfaces of the adsorbent [5-7]. Adsorbents are typically used in the form of spherical granules, rods, or briquettes, and are found with hydrodynamic blocks with diameters ranging from 0.5 to 10 mm. They must have high abrasion resistance, high thermal stability and porosity, and this makes the surface subject to adsorbent capture large, and thus high surface adsorption capacity. The adsorbents must also have a distinct structure which enables the rapid transfer of gaseous vapors[8]. Most synthetics fall into one of three categories:

- Oxygen-containing compounds — usually aqueous, polar, including substances such as silica gel and zeolite.
- Carbon-based compounds — usually hydrophobic and non-hydrophobic, including materials such as activated carbon and graphite.
- Polymer composites — polar or nonpolar materials in a perforated polymer matrix.

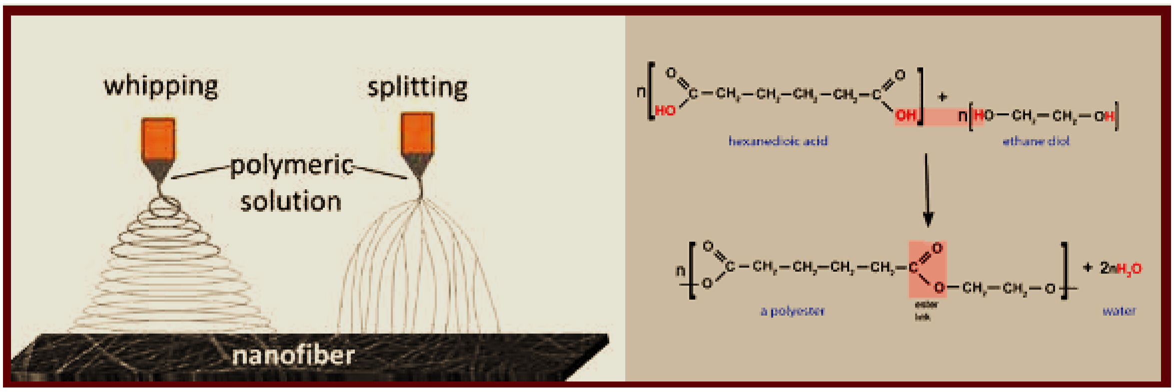

Fig. 8: Adsorption by Nano- Polymers

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Adsorption on Nano Dyes :

Dyes are colored materials that can bind in some way to the materials to be dyed and give them bright colors, so that they are not affected by washing, light, oxygen, acids and bases. These dyes have the advantage of giving strong absorptions in the visible region due to the availability of conjugate systems, and the non-localization of pi electrons in their composition. [17] The reason for the colored compound is due to the presence of certain functional groups in it, which leads to making it colored, as they are known as chromophores, and they mean color bearing groups and include groups (-C=C-, -C=S , -C=O, -N=O,-NO2 ,-N=N-) As for the one that increases the intensity of the color, it is called the auxiliary group, or the auxo-chromes, which mean color depths, and they are electron motive groups, and they have another importance, as The molecule is given an acidic or basic character, thus increasing its ability to bind to adsorbent surfaces. [18] These dyes are produced annually in large quantities and in many types estimated at (10000) types that differ in their composition and components, and they are widely used in various industrial processes. Therefore, industrial waste water contains high concentrations of these dyes. [19] Industrial dyes are one of the common types of water pollutants due to their high solubility in water, and industrial wastewater needs chemical treatment to remove dangerous chemicals to comply with legal limits so that it can be discharged to public sewage networks or to surface water [20]. Removing these pigments from wastewater and making them usable, while continuing to develop new technological systems to remove organic pollutants present in water, such as pigments and heavy metals from their aqueous solutions, for example (adsorption, filtration, sedimentation, ion exchange and other methods) [21]. Adsorption can be defined as the phenomenon of gathering a gaseous or liquid substance in the form of molecules, atoms or ions on a specific substance called an adsorbate, and the surface on which adsorption occurs is called an adsorbent [22-24]. Although adsorption is one of the old techniques, it has the importance of what makes any industry nowadays indispensable in its applications and use. It is used in the petroleum, dyes and food industries such as oils, dairy and other industries that cannot be listed here. [25-27] Adsorption studies showed the existence of two types of adsorption, namely, physical adsorption, sometimes called Vander Waals adsorption, and chemical adsorption, and the bonding occurs in it in a form similar to chemical bonds. This adsorption is characterized by specificity, i.e. the occurrence of this adsorption requires the presence of a specific surface, certain conditions, and requires activation energy and occurs at temperatures exceeding the boiling point of the adsorbent material [28], and it occurs in one layer on the surface, i.e. it is uni molecular. With regard to physical adsorption, the adsorbed molecule is bound to the surface by weak forces that are similar to the Vander Waals forces, and this adsorption is sometimes called natural adsorption, and it is not characterized by non-specificity and in its occurrence tends to temperatures lower or close to The boiling point of the adsorbent material, and it does not need activation energy, and adsorption is in the thickness of several layers (Multi molecular adsorption).

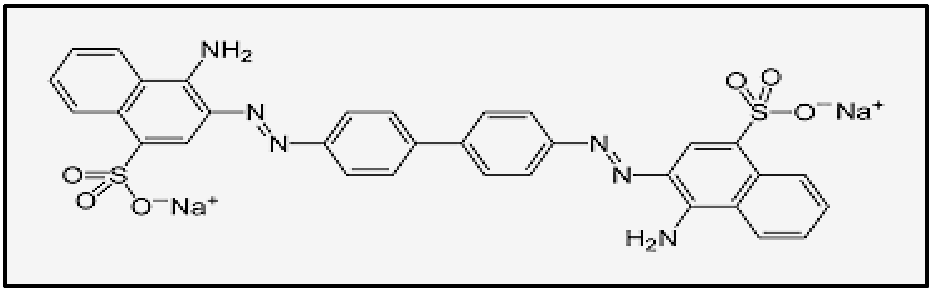

Fig 9: Adsorption on Surface of Chemical Compounds as example

Activated carbon

Crystal Clear app kdict.png Main article: Activated carbon ., Activated carbon is a highly porous, solid, amorphous substance consisting of intrinsic crystals with a graphite lattice, usually prepared in small granules or powder. It is considered cheap and not rare.

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But a major drawback is that it is flammable activated carbon can be made from carbonaceous materials, including coal (bitumen, sabituminous, and lignite), peat, wood, or husks (eg coconut). The process consists of two stages, carbonization and activation. The carbonization process includes drying and then heating to separate the by-products, including tar and other hydrocarbon raw materials, as well as to remove any gases generated. The carbonization process is completed when the material is heated from 400 to 600 ° C in an atmosphere isolated from oxygen so that its combustion does not occur. The carbon granules are then "activated" by exposing them to an oxidizing agent, usually water vapor or carbon dioxide at high temperatures. This oxidizing agent burns the pore-blocking materials formed during the carbonization process, producing a porous structure in graphite. The size of the pores formed in graphite during the activation process depends on the time during which the activation process takes place. The higher the activation time, the larger the pore sizes. A common type of hydrated carbon, which is made from bitumen (bituminous) due to its hardness, high corrosion resistance, porosity, and low manufacturing cost. However, its uses are worth testing to use the appropriate type. Activated carbon is used for adsorption of organic and non-polar adsorbents and is also commonly used for waste gas treatment (and water treatment). It is one of the most widely used features. Its benefit mainly comes from the possibility to control the pore size and the effective surface area when manufacturing activated charcoal.

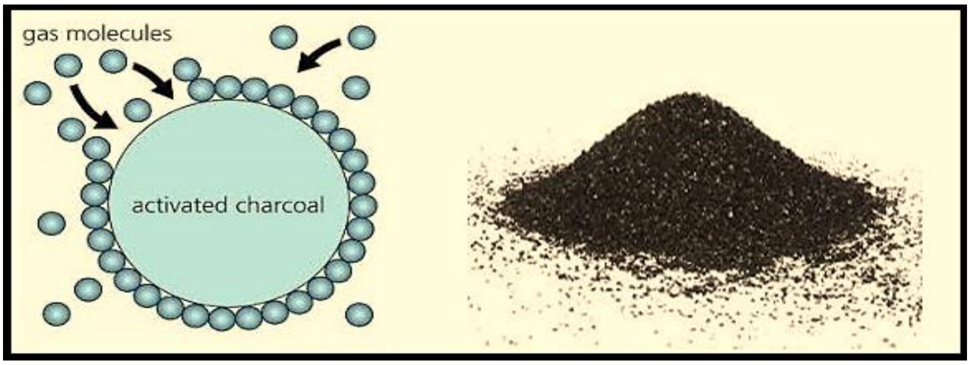

Fig. 10: Adsorption on activated charcoal surfaces as example

Adsorption on Silica gel

Crystal Clear app kdict.png Main article: Silica gel , Silica gel is chemically inert, non-toxic, polar and stable in structure (up to 400°C) in a curable amorphous form 2. It is prepared by reacting sodium silicate with sulfuric acid, which is followed by a series of processes to treat it such as cornering, pickling, etc. This results from the different pore size distributions in it. Silica is used for drying process air (such as oxygen, natural gas) and adsorption of heavy (polar) hydrocarbons from natural gas[9,10].

Adsorption on Zeolite:

It may be natural or synthetic zeolite, containing silicates and aluminum, highly porous as well as releasing water at high temperatures. Zeolite is polar in nature. It was made by hydrothermal synthesis of sodium alumino-silicate or by another silica source in an autoclave followed by ion exchange with some cations (Na+, Li+, Ca2+, K+, NH4+). Channel diameters in zeolite granules typically range from 2 to 9 Å (200 to 900 µm). The ion exchange process is tracked by drying the crystals, which can be rotated with a cling agent in the form of macro-porous beads. Zeolite is also applied in the air drying process, which removes carbon dioxide from natural gas[11-13], removes carbon monoxide from petroleum refining gases, air purification, and purifies petroleum products. Non-polar (silicates) zeols are also made from aluminum-free silica or by purifying aluminum-containing zeolites from aluminum . Aluminum is purified from zeolite by treating it with water vapor at high temperatures, above 500°C. This high temperature breaks the bonds between aluminum and oxygen, and the aluminum atoms are released from the zeolite[14-16].

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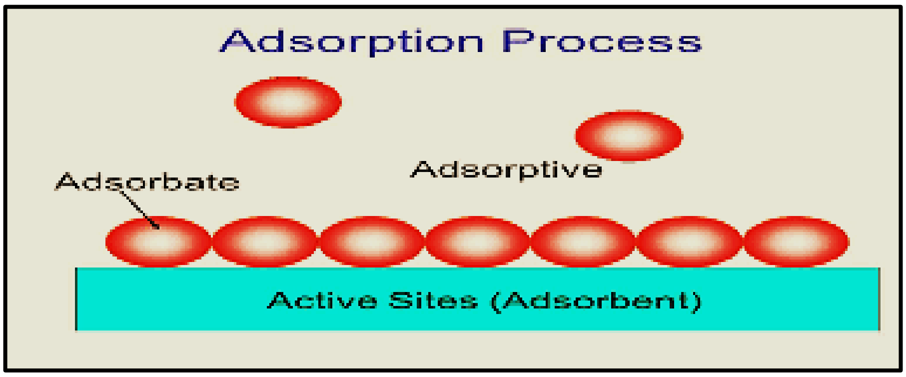

Fig 11: Chemical Adsorption on Surface

Factors affecting the adsorption process:

1- The nature of the adsorbed gas: the gases that are easy to liquefy are more adsorb-able, and the adsorption increases with the increase in the critical temperature of the gas. The adsorption process increases with increasing gas pressure (concentration), and the rate of increase is rapid at first, then gradually slows down as the surface is covered with gas particles.

2- The nature of the adsorbent surface: If the surface area is large, the adsorption efficiency is large.

Charcoal and silica gel are good adsorbents because they have a porous structure that increases the surface area.

3- Temperature: The amount of gas adsorbed is inversely proportional to the temperature.

Increasing the temperature of coal from 350 - 1000°C increases its surface activity.

More information about adsorption

Adsorption is one of the most important fields in surface chemistry, as adsorption and the auxiliary factor have now become two very important scientific branches, and hardly any of the existing industries in our time is devoid of benefit from them, and the industries of petroleum, oils, dairy and dyes are a good example of the importance of Adsorption and auxiliary action in its growth and development. The utilization of adsorption applications is not limited to the industrial aspect, but also extends to other aspects, the most important of which are environmental pollution, medical fields and what is related to them in terms of treating poisoning cases and preparing drugs. This phenomenon becomes clear in the process of gathering a substance in the form of molecules, atoms or ions on the surface of another substance. Examples of adsorption are many. We mention the adsorption of acetic acid on animal coal, in which acid particles collect on the surface of coal particles, and hydrogen adsorption on the surfaces of some metals such as nickel and iron. The material that undergoes adsorption on the surface is called the adsorbate, and the surface on which it is adsorbed is called the adsorbent. Adsorption may be limited to the formation of one partial layer on the adsorbing surface, and then it is called Unimolecular Adsorption. Adsorption sometimes includes the formation of several molecular layers on the adsorbing surface, and the process is then called multimolecular adsorption. Adsorption is usually accompanied by a decrease in the free energy (ΔG) of the adsorbent surface, and a decrease in the entropy (ΔS) because the molecules that suffer adsorption become restricted due to their attachment to the surface atoms, and thus lose some of their degrees of freedom compared to the state they were in Before adsorption, the decrease in the free energy ΔG and the entropy ΔS simultaneously results in a decrease in the heat content (ΔH)) according to the thermodynamic relationship that links the three quantities together at a given temperature:

$$\Delta G = \Delta H - T\Delta S$$

The term (sorption) is used to describe every type of material taking or storage by the external surface of solid (adsorption) and liquid (absorption) materials as well as by the internal surface of porous solids or liquids. Adsorption is a separation process in which the liquid phase is in contact with the phase of solid porous particles that has a selective property to take or store one or more of the components in the liquid phase. As the fluid does not dissolve in the solid, but sticks to the surface and balance occurs between the adsorbed fluid and the adsorbent fluid. Which remains in the depth of the fluid phase, and adsorption is a basic property of the material possessing forces of attraction between molecules, as the force field near the surface of the solid material creates a low potential energy and as a result, the density of molecules near the surface is generally greater than the mass of gas. The many important applications of adsorption It depends on the selectivity, i.e. the difference in the response of the surface to the different components. The substance that undergoes adsorption on the surface of the solid is called (adsorbate). The material that performs adsorption is called (adsorbent surface). Adsorption is one of the most economical separation methods, especially when the concentrations of substances that must be removed from the liquid phase are very few. It is the most widely used technique for separating particles in the oil, natural gas, petrochemical, chemical and environmental processes industries. The attractive force causing adsorption is generally weak compared to the chemical bonds and by increasing the temperature of the adsorbent material or decreasing the partial pressure of the adsorbent material (or the concentration in the liquid), the adsorbent material can be released from the surface. The process of liberation or reactivation step is an important step in the process, where the activation process first allows the extraction and separation of the adsorbents and then it allows reuse of the solid for several cycles. In a few cases, the adsorption is impractical and the adsorbent must be removed by thermal solution or reaction Other chemical or simply solids disposal.

The molecules in adsorption are distributed between two phases, the first in the solid phase, while the other is in the liquid or gas phase, the opposite of the adsorption process in which the solute molecules spread from the gas phase to the liquid phase, and the molecules spread in adsorption from the fluid phase to the surface of the solid, forming a well-defined adsorbed phase. The adsorbent material used in gas separation is used to remove small amounts of compounds from the gas mixture, and a common example is drying the gases to prevent corrosion and condensation or to prevent an unwanted side reaction. Adsorption is effective in removing few compounds from the liquid phase and is used to extract compounds or substances harmful to health from industrial influence. There is a difference in each process of distillation, absorption and extraction between the properties that are separated. In the distillation process, there is volatility, absorption, solubility, and extraction coefficient of distribution. As for the adsorption separation process, it depends on one component that is more prepared for adsorption than the other. The process of separating ordinary paraffin from branched distillation requires a large number of stages due to the relative low volatility of the two compounds. Where it is preferable from an economic point of view to use an adsorbent that separates based on the difference in the molecular diameters of the two compounds. For example, the regular pentane and isopentane have diameters * (0.489 nm) and (0.558 nm), respectively, when an adsorbent with a pore size (0.5 nm) is used for a mixture For gases, small particles will diffuse through the surface of the adsorbent and remain there, while large particles are excluded. The remaining particles in the solid can be recovered by lowering the pressure or raising the temperature. Adsorption occurs when the dispersed particles remain in the fluid phase for a period of time by forces from the near surface. The surface represents a total gap in the composition of the solid, and the atoms at the surface have remnants of intermolecular forces that are not saturated with the surrounding atoms as in the structure of the body. These residual forces, or Van der Waals forces, are common to all surfaces and the only reason these solids are so special is that they can be made into highly porous forms, giving an increase in internal space. Next, the outer surface contributes moderately to the total, even when the surface is finely divided. The adsorption based on Van der Waals forces is physical in nature because the forces are weak and adsorption can be easily reversed. The amount of heat generated in physical adsorption is similar in value to the heat of condensation, and when the heat is not dispersed by cooling, the volume of the solid material will decrease with increasing temperature.

It is appropriate to think that adsorption occurs in three stages, when the concentration of the adsorbent increases, first a single layer of molecules is formed on the surface of the solid material. The number of layers formed can be determined by the size of the pores. Finally, for adsorption from the gas phase, capillary condensation occurs, as the capillaries are filled with the condensed adsorbent and its vapor pressure reaches a critical peak relative to the size of the pores. Molecules are attracted to surfaces as a result of two types of forces: dispersion and repulsion (called Van der Waals forces), which result in the molecule or surface group having a permanent dipole, quadrupole, or net electric charge. Dispersion forces are always present and in the absence of any strong force will determine equilibrium behavior as in adsorption of molecules with a non-polar dipole or quadrupole moment on non-oxidizing carbon. If the surface is polar, it will present an electric field that induces the dipole moment in the molecule with a non-permanent dipole and through this Polarization increases adsorption. By analogy, a molecule with a permanent polar moment will polarize the non-polar surface, thus increasing the attraction. The attraction to a polar surface and molecules with a permanent dipole moment is strong, as is the adsorption of water on hydrophilic adsorbents. Similar to the polar surface, a molecule with a permanent dipole moment will be attracted more strongly than a similar molecule [48]with a weak moment. Example: Nitrogen adsorbs more strongly than oxygen on the surface zeolite.

- The adsorption process is exothermic (and similar to condensation).
- The reverse desorption process is endothermic (similar to evaporation).
- Low temperature and high pressure are preferred in the adsorption process.
- High temperature and low pressure are preferred for reversing desorption.

Types of adsorption:

Adsorption is classified according to the type of bond into:

A- Physical Adsorption or Physi-sorption

It occurs when the inter-molecular forces or Van der Waals forces of attraction between the molecules of the fluid and the surface of the solid are greater than the forces of attraction between the molecules of the fluid itself. As the molecules of the fluid stick to the surface of the adsorbed solid, equilibrium occurs between the adsorbed fluid and which remains in the fluid phase. No change in electrons is observed. Or rather, intermolecular attraction occurs between the preferred energy site and therefore does not depend on the electronic properties of the molecules involved. Physical adsorption is characterized by interference energies equal or similar to the heat of condensation. The adsorbed material is trapped on the surface by relatively weak Van der Waals forces and several layers of molecules can form with approximately the same adsorption temperature. Heat of adsorption for physical adsorption It is slightly per mole (Kcal/mole). Therefore, this type of adsorption is stable only at temperatures below 150 ° C, and physical adsorption allows its use by a continuous process.

B- Chemical Adsorption or Chemi-Adsorptions on Surface of Nano-Compounds

The chemical interaction between the adsorbent fluid includes the solid adsorbent substance, and in most cases the adsorption is irreversible and it is difficult to separate the adsorbent substance from the adsorbent fluid. The adsorbent material is similar or equal to the strength of chemical bonds and in tens of kilocalories per mole) and accordingly it is much stronger and more stable at high temperatures than physical adsorption and generally only a single layer of molecules is formed. Most applications of adsorption in separation and purification processes depend on physical adsorption, while heterogeneous catalysts generally include chemical adsorption of the reactants. Chemical adsorption is sometimes used to remove impure substances present in small quantities, where a high selectivity is achieved. Although chemical adsorption is not widely used as in physical adsorption, there are several applications in processes that are important for chemical adsorption to purify gases, including: Removal of mercury: As small amounts of mercury in natural gas are known to cause corrosion to the surfaces of aluminum heat exchangers in low-temperature cold box units in LNG plants, and mercury can be removed for such units by using effective carbon containing sulfur and that Mercury reacts with sulfur to form mercury sulfate.

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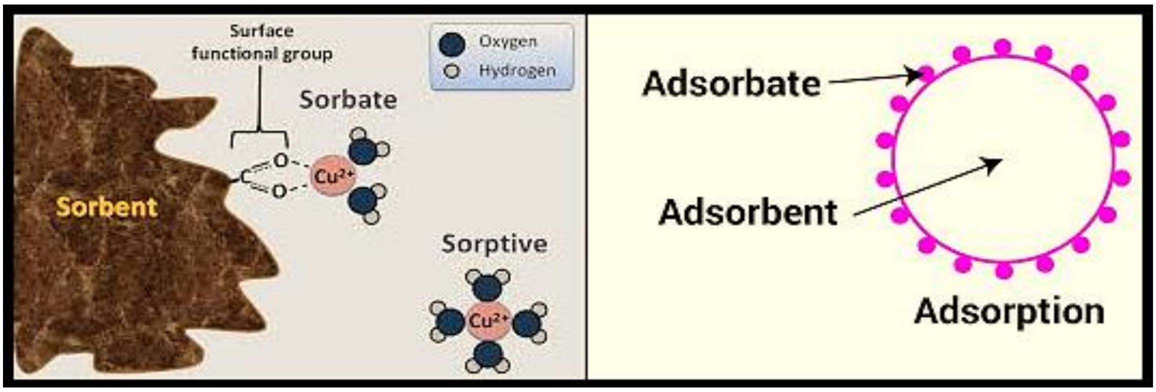

Fig. 12: Mechanism of Chemical Constituents in Soils

CONCLUSIONS

Adsorbents are typically used in the form of spherical granules, rods, or briquettes, and are found with hydrodynamic blocks with diameters ranging from 0.5 to 10 mm. They must have high abrasion resistance, high thermal stability and porosity, and this makes the surface subject to adsorbent capture large, and thus high surface adsorption capacity. The adsorbents must also have a distinct structure which enables rapid transfer of gaseous vapors.

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