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Influence of SnO_2, MgO, and MnO_3 nanoparticles on Some Physical Characteristics of PVP: CMC films

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Abstract:

In this work, the physical properties of pure composite films "PVP:CMC" impregnated with nanoparticles "SnO_2, MgO, and MnO_3" were investigated. The solution casting method was used to make the films, The solution casting method is considered one of the simple and effective methods for preparing "PVP:CMC" . The material's transmittance and reflectivity were both found to be affected; it was discovered that the electrical conductivity of the produced membranes increases with rising frequency values and that the transmittance tends to decrease in the near-infrared regions. Combining these nanomaterials with "PVP:CMC" films was found to decrease the energy gap and increase the material's absorption in the visible and infrared spectrum. ultraviolet light. The obtained results show that the physical yield of "PVP:CMC" films is greatly affected by the merging of "SnO_2, MgO, and MnO_3" physical discrimination. This makes "PVP:CMC" films viable candidates for numerous applications, including certified sensors and biomedical sensors.

Keywords:
Optical and electrical properties , casting method

Note: The research is not based on a master's thesis or a doctoral thesis.

Introduction:

Nanocomposites have better properties than small and macrocomposites when nanocomposites are incorporated into polymer mixtures [1-3]. Transistors, solar photovoltaics, and energy storage electrodes are just a few of the technical applications for which the organic and inorganic properties of polymers incorporated into nanocomposite mixtures make them suitable [4,5] Nanocomposites based on metal oxide are considered suitable for high-performance materials with new applications because they provide multiple advantages and good mechanical, thermal and barrier properties compared to pure polymeric materials and traditional compounds.[3- 6]. Vinylpyrrolidone monomers are the source of poly vinylpyrrolidone “PVP”, a water-soluble polymer. “PVP” has special properties and can combine with other materials to form stable complexes. [7]. “PVP” is has been used in many applications including personal care applications as a binder, film former, and viscosity enhancer in gels. There is also another water-soluble polymer derived from cellulose, carboxymethyl cellulose (CMC: an anionic water-soluble polymer), which is also used in many industries, including personal care. Food and medicine. “CMC” polymer is used as an emulsifier, thickener and stabilizer in the food industry. [8, 9]. Mixing the materials with polymers “PVP and CMC” leads to the production of compounds with high solubility, stability, and a high ability to form films, and the addition of “SnO_2, MgO, and MnO_3” greatly improves these qualities,

SnO_2 is a semiconductor that possesses a wide energy bandgap (E_g = 3.6 eV) and is known for its inexpensive cost and superior electrical and optical properties. Applications of SnO_2 include gas sensors, solar cells, electronic devices, photocatalysis, and oxidation catalysts [10]. Magnesium oxide “MgO” is used in many applications, including as a pH regulator and a magnesium ion source [10, 11]. “MgO” acts as a crosslinking agent when added to a “PVP:CMC” mixture, enhancing the material’s mechanical strength and water resistance. There are several applications for the resulting “PVP” formulation: “CMC: MgO” [12]. “MnO_3” is an unstable substance that decomposes easily in the presence of moisture and air. [13]. It is used as an oxidizing agent in certain chemical processes, in chemical analysis, and the production of pigments, dyes, and glass stains. Because of its strong reaction, caution must be taken when dealing with it. In this work, the structural, thermal, and optical properties of “PVP:CMC”:”SnO_2, MgO, and MnO_3” were studied and analyzed.

Experimental Procedures

The solution casting method is considered one of the simple and effective methods for preparing “PVP:CMC” composite films. Additional features can also be added by adding “SnO_2, MgO, and MnO_3” . This technique can be used to prepare pure and doped “PVP:CMC” composite films. PVP and CMC should be dissolved in water solvent at a temperature of “60°C”. As a result, equal weight proportions of “SnO_2, MgO and MnO_3”

nanoparticles are added to the solution and a homogeneous solution is formed. The materials are mixed well to ensure that the nanoparticles are evenly distributed throughout the solution, then the mixture is carefully stirred. Time, then pour the mixture on a flat surface and leave it to dry. One way to do this is to spread the solution, for example, on a petri dish or glass dish. A thick layer will then form as the solvent evaporates. The casting plate can be dried more quickly by air drying it at room temperature or by placing it in an oven.

Results And Discussions

Infrared spectra were used to spread statistics nearby the chemical arrangement and constitutional properties of the {polymer blend} "PVP:CMC", where some special summit appeared that can be he watches in Figure (1) of the {FTIR spectra} of "PVP:CMC". We find that The peak at "23500 cm^{-1}" which agrees to the {-CH-} extending vacillation of the "CMC" mainstay. Similarly, the peak "1650 cm^{-1}" agrees to the {-COO-} stretching vacillation of the {carboxyl} collection in "CMC". The peak "91420 cm^{-1}" agrees to the {-CH-} {bending vibration} of the "CMC" backbone[14,15].

As for the "PVP" peaks: a peak "3400 cm^{-1}", which agrees to the {-NH extending vibration} of the {amide collection} in "PVP" [16, 17].We find that the peak of the {-CH extending vibration} of the "PVP" mainstay reached about "2950 cm^{-1}". The amide collection in "PVP" has a stretching vibration fixed at "1550 cm^{-1} ", which is signified by the peak [18]. Due to the hygroscopic nature of "CMC", the "FTIR" bands of "PVP:CMC" .We notice that there are some overlapping vertices,such as the {-OH-}{stretching vibration of water molecules}. It is important to remember that the specific relation and mixing system used may have an impact on the "FTIR" "PVP:CMC" spectra. Nanoparticle peaks: The "-OH-" stretching vibration of surface hydroxyl groups on SnO_2 nanoparticles is signified "SnO_2, MgO, and MnO_3" nanoparticles is signified by a peak at around "1600-1500 cm^{-1}". an around "1400–1300 cm^{-1}" peak [20, 21].

Moreover, there may be many overlapping peaks among them, such as the {-OH-" stretching vibration of H_2O molecules and the {-CH} stretching vibration of the CMC and PVP backbone [24], also visible in the FTIR spectra of " "PVP:CMC" doped with nanoparticles [22, 23]. It is worth noting that the specific "FTIR" spectra of "PVP:CMC" The messed up one with nanoparticles "SnO_2, MgO, and MnO_3" vary according to the different concentrations of added The messed up one as well as the method that was used in the preparation [25].

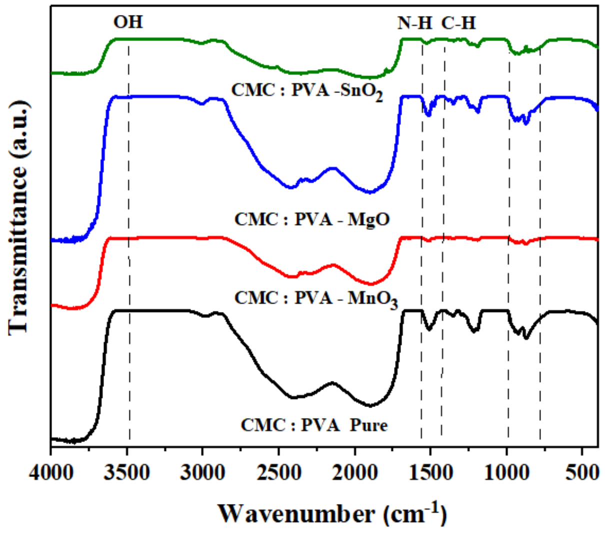

Fig 1. "FTIR for PVP: CMC- SnO_2, MgO MnO_3" Nanocomposite.

When "SnO_2, MgO, and MnO_3" nanoparticles are combined in a mixture "PVP:CMC", It was observed that there was a noticeable effect on the transmission and reflectivity of the resultant material. In particular, The "PVP:CMC" compound doped with these nanoparticles tends to decrease in the "visible and near-infrared" regions. The reason for this decrease in transmittance is due to the enhanced light scattering and absorption exhibited by nanoparticles compared to the polymer mixture [26, 27]. More light is observed to be {reflected from the surface of the material} and {the effect of these nanoparticles} depends on the wavelength of the light "SnO_2, MgO and MnO_3" on transmittance and reflection is observed, where higher condensation of {nanoparticles} lead to intense {scattering and absorption} [28, 29]. Therefore, this ability lead to extra clearly modulation in "transmittance (T%) and reflectivity (R)", as shown in Figure (2).

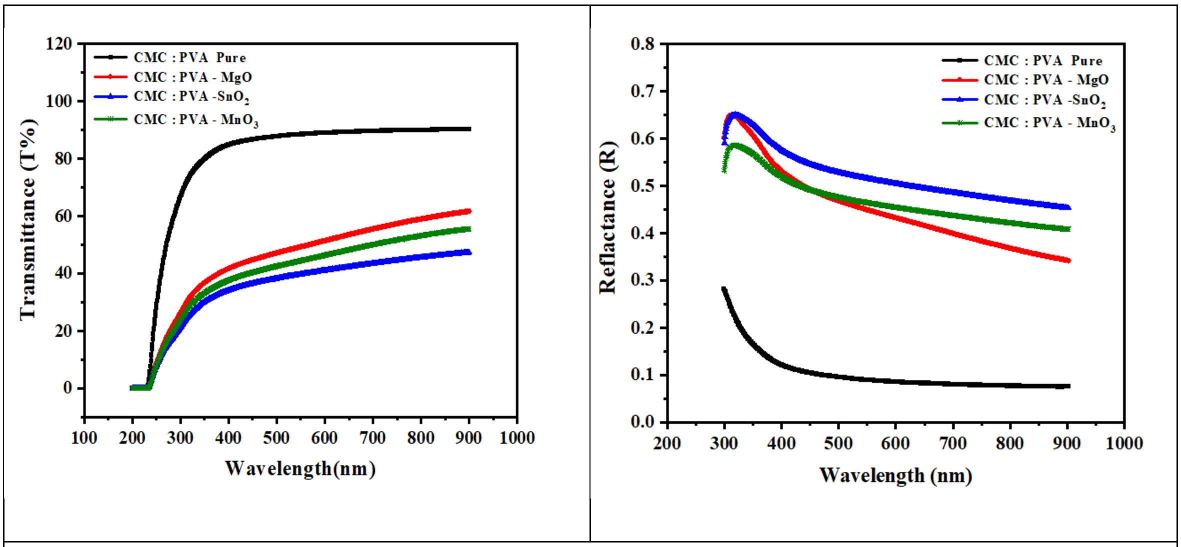

Fig 2. "T% and R" for "PVP: CMC- SnO_2, MgO, MnO_3" Nano composite.

Incorporating nanoparticles "SnO_2, MgO, and MnO_3" into "PVP:CMC" can reduce the energy gap. This decrease is back to the introduction of extra electronic states by the nanoparticles [30]. As a result, this material shows increased by absorption within the "UV-visible" region as shown in Figure 3. It was found that the size of the nanoparticles "SnO_2, MgO, and MnO_3" has a significant impact on the {absorption factor} and "energy gap", and smaller nanoparticles tend to enter A larger number of additional electronic states, leading to more pronounced modulation in the "energy gap" [31]. Furthermore, We observe the significant influence of the surface properties of "MgO" {nanoparticles} on the {energy range} and {absorption coefficient{ and {the appearance of additional electronic states due to surface defects and impurities}, which leads to modulation in {the optical properties of the resulting material} [32]. Therefore, this behaviour can be described according to the next neutralization [33,34]:

$$"\alpha h\upsilon = A\left(h\upsilon - E_g\right)" \quad (1)$$

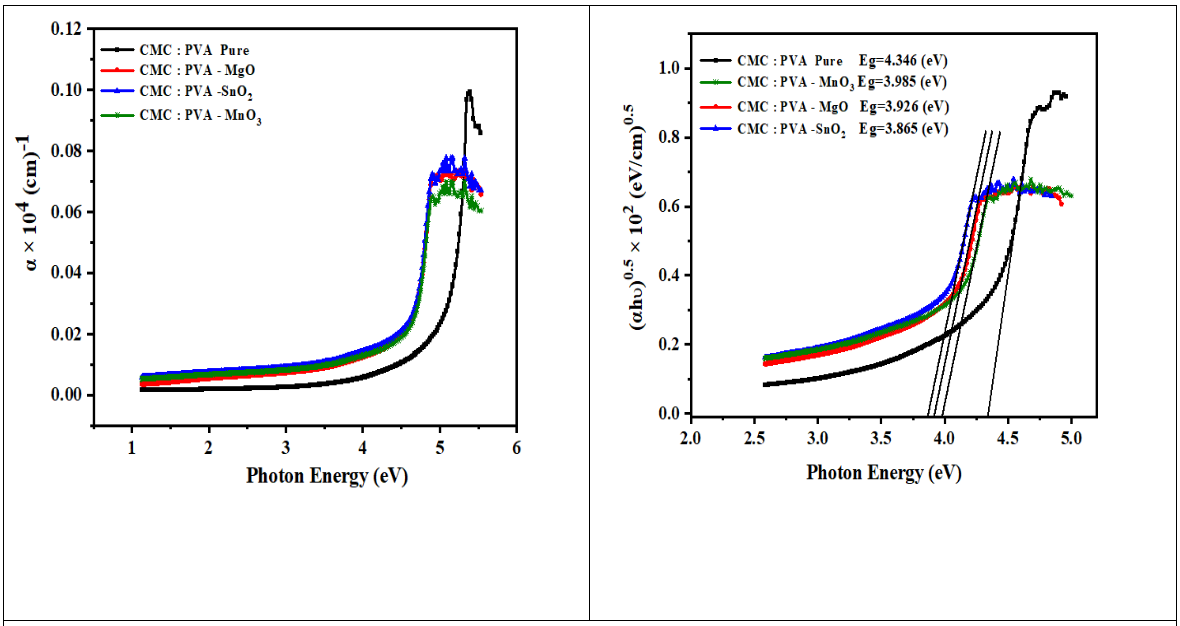

Fig 3. {α and Eg} for {PVP:CMC}- {SnO_2, MgO, MnO_3} Nano composite.

The addition of "SnO2, MgO, and MnO3" nanoparticles to "PVP:CMC" polymers results in an increase in the extinction coefficient in addition to the absorption properties. "SnO2" nanoparticles have a higher refractive index than polymers "PVP, CMC, MgO, and MnO3." As a result, the material's overall refractive index increases when these nanoparticles are added, potentially improving light curvature and producing visual features like light trapping, as seen in Figure 4. The refractive index (n_0) and extinction coefficient (k_0) can be determined using the following formulas. [35, 36]:

$$n_o = \left[\left(\frac{1+R}{1-R}\right)^2 - \left(k_o^2 + 1\right)\right]^{1/2} + \frac{1+R}{1-R} \qquad (2)$$

$$k_o = \alpha\lambda/4\pi \text{ ....} \qquad (3)$$

Where: K : Dielectric constant, α: Absorption coefficient, and λ: wavelength.

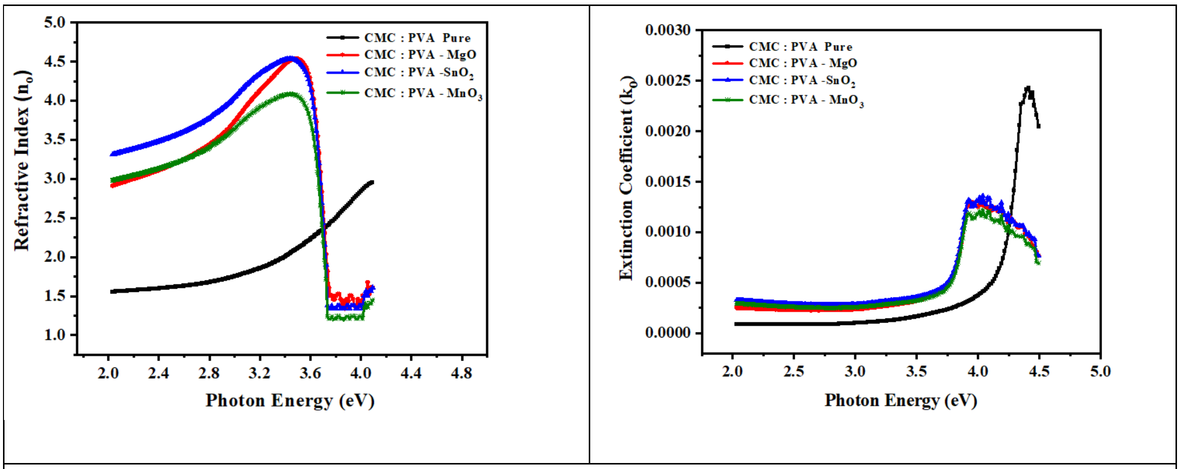

Fig 4. “n_0 and k_0” for “PVP: CMC- SnO_2, MgO, MnO_3” Nano composite.

- **Dissipation factor:** It is one of the most significant variables that has a significant and direct impact on {the applications of polymeric composite materials}. It is {the dissipation factor} “tanδ” is It known as a measurement of the ratio of the weak energy to the total energy crossing through dielectric materials, and its relationship is directly related to the amount of energy dissipated at “25 °C” in the insulating material. With a range of “1-5 MHz”, the dissipation coefficient values of the prepared films were calculated. The “dissipation factor” “tanδ” for single films “PVP:CMC” containing nanoparticles with equal weight ratio of “SnO_2, MgO and MnO_3” is shown here as a assignment of frequency in Figure (5), while here the dissipation factor values “tanδ” show a decrease for all fabricated and reinforced films with increasing Value. Frequency, according to the results obtained. As a result of the movement of these diodes, we find that the amount of charge carriers decreases with increasing frequency values. As a result, more energy is required for the dipoles to relax, resulting in lower values of the dissipation factor “tanδ”. [37,38] .

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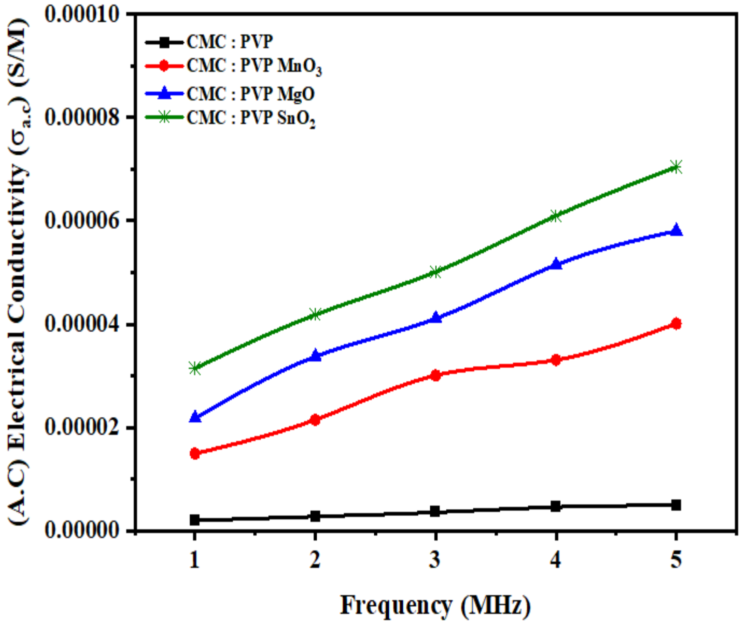

Fig 5. Dissipation Factor for {PVP: CMC}- {SnO_2, MgO, MnO_3} Nano composite.

- **AC electrical conductivity:** The "AC electrical conductivity" “σa.c” of all that have been manufactured films was studied as a function of the frequency of the applied electric field within the range “1-5 MHz” and at room temperature “25 °C”. Whereas, the AC conduction behavior “σa.c” of individual films “PVP:CMC” prepared with identical weight ratios of “SnO_2, MgO, and MnO_3” nanoparticles is shown in Figure (6) as a function of decreasing frequency factor “tanδ”.

Based on the data, we find that all manufactured single and reinforced membranes have "AC" electrical conductivity values "σa.c" that rise with rising frequency values. This is due to the fact that when frequency values grow, the produced membranes become more electrically polarized, which increases the quantity of charge carriers between neighboring levels. It was discovered that, generally speaking, the electrical conductivity of polymeric and semiconductor materials increases noticeably with frequency.[39], Using the following equation, the A.C. electrical conductivity has been determined:

$$\sigma_{a.c} = w\, \varepsilon'' \varepsilon o \qquad (4)$$

Where $\sigma_{a.c}$: a.c electrical conductivity, w: angular frequency, ε": dielectric constant and εo: permittivity of free space.

The dissipation factor "tanδ" is calculated to find the ratio of the energy dissipated in the test material to the energy applied to the sample. It was found that it increases with the inclusion of "SnO2 NPs" for all manufactured films "CMC:PVP" in the total circulation [40].

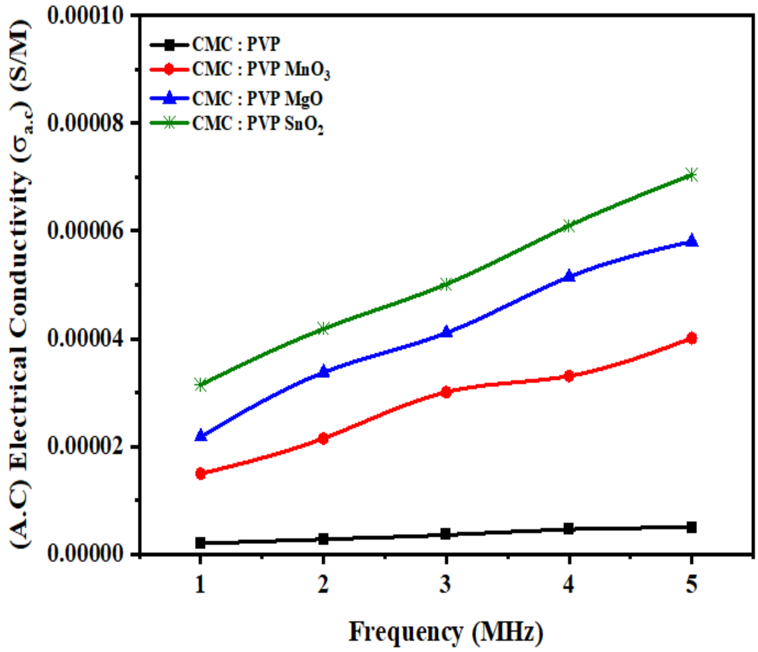

Fig 6. {AC electrical conductivity} for {PVP: CMC} – {SnO_2, MgO, MnO_3 } Nano composite.

Conclusion:

An improvement was found in the {mechanical force}, {thermal stability{, and {surface morphology: of the material} as a result of adding nanoparticles in equal weight ratios "50% of PVP, SnO_2, MgO, and MnO_3 " to the solution. Through casting, "50% CMC", . Furthermore, the optical qualities of the mixture can be improved, resulting in improved light transmission and reflection quality. The electrical properties of the blend "PVA:CMC" can also be improved by increasing its conductivity. Therefore, adding nanoparticles to polymeric mixtures greatly enhances their properties and makes them suitable for many uses, including biomedical devices, sensors, and optoelectronics. To obtain the properties required for specific applications.

Further Work

we can conduct further research to improve the nanoparticle size and concentration as well as the processing parameters.

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تأثير الجسيمات النانوية SnO2 و MgOو MnO3على بعض الخصائص الفيزيائية لأغشية CMC: PVP

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مستخلص البحث:
في هذه الدراسة تم تحضير أفلام مركبة (CMC:PVP) النقية والمشوبة بالجسيمات النانوية من SnO_2 وMgO وMnO_3 باستخدام طريقة الصب بالمحلول، وتمت دراسة الخواص الفيزيائية للأفلام المركبة. تم الحصول على تأثير على كل من النفاذية والانعكاس للمادة، ووجد أن النفاذية تميل إلى الانخفاض في المناطق القريبة من الأشعة تحت الحمراء. وقد وجد أن دمج هذه المواد النانوية مع أفلام PVP:CMC يقلل من فجوة الطاقة، فتظهر المادة زيادة في الامتصاص في المنطقة المرئية من الأشعة تحت الحمراء. فوق بنفسجي. بشكل عام، تشير النتائج إلى أن دمج التمييز الجسدي SnO_2 وMgO وMnO_3 يؤثر بشكل كبير على المحصول المادي لأفلام PVP:CMC، مما يجعلها مرشحة واعدة للتطبيقات بما في ذلك أجهزة الاستشعار الطبية الحيوية المعتمدة.

الكلمات المفتاحية :مركب (CMC:PVP)، الخواص البصرية والكهربائية، طريقة الصب بالمحلول.
ملاحظة : هل البحث مستل من رسالة ماجستير او اطروحة دكتوراه ؟ كلا