

# The compare for structural, mechanical and thermal properties between poly (vinyl alcohol) and graphene /poly (vinyl alcohol) nanocomposites

<sup>1</sup>Salah M. Abd Ul Aziz, <sup>2</sup>Zainab Karam Hassoon

## **Abstract:**

*Graphene/polymer nanocomposites have created escalated attention because of their extraordinary properties. There are two main components for property improvements Interface interactions and scattering among the polymer matrix and graphene. In graphene/ poly (vinyl alcohol) (PVA) nanocomposites, as a rule, gets more huge property improvements than neat (PVA) as indicated by the previous literature. The improved properties of polymer nanocomposites as contrasted with neat polymers are just carried out in powerful interfacial adhesion and the existence of well-scattered nanoparticles.*

*In this research, nanocomposite films were synthesised dependent on poly (vinyl alcohol) (PVA) filled with fine well-scattered graphene nanoparticles. The prepared films were distinguished by Fourier transform infrared spectrum (FT-IR) and X-ray diffraction (XRD) analysis. When incorporating graphene with the neat (PVA) the elongation and tensile strength at break arrive maximum qualities, indicating increments by 34% and 212, respectively.*

**Keyword:** Graphene , Polyvinyl alcohol , Stress, Strain

## **I. Introduction**

Poly (vinyl alcohol) (PVA) is an ordinarily water-dissolvable polymer which has so good translucence (1), biodegradability (2), barrier properties (3), toughness (4), and biocompatibility (2), and has been broadly utilized in different fields, for example, packaging industry (5), biosensors (6) and biomedicine (2). Polymeric materials possess amazing chemical and physical characteristics and because they are lightweight, cheap they are used as an alternative to conventional materials (7). Endeavours are

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<sup>1</sup> Lab Department of Sciences / basic education college /University of Sumer/ Thi-Qar / Iraq.

<sup>2</sup> Ministry of Education / Thi- Qar Directorate/ Thi-Qar/ Iraq.

directed to create different polymeric nanomaterial collections and to comprehend their key standards to be used in different fields of designing and science.

In the polymer matrices and through the incorporating little amounts of nanofillers can easily adjust the mechanical, structural, electrical and optical properties of polymers (8). The nanoscience improvement in polymeric materials which contains in any event one-measurement in nanoscale have huge consideration in scientific materials research of cutting edge materials (9). Polymeric nanomaterial composite has been widely used in various fields with extraordinary regard for biological and medicinal applications. It is therefore of great importance among the categories of nanocomposite substances (10). In the polymer matrix, the geometric and physical properties were improved by adding nanomaterials that cause the surface region to rise in volume proportion (11). As of late, researchers are concentrating on producing polymer nanocomposites for the motivations behind use in organic applications (2).

## **II. Experimental**

### **Synthesis of graphite oxide (GO)**

Graphite oxide (GO) was set up by an altered Hummers' strategy from flake graphite. Firstly, Sulfuric acid (200 ml), peel graphite (5 g) and Sodium nitrate (5 g) were put in a glass beaker and completely cooled to 2–5 °C in an ice shower. Potassium permanganate  $\text{KMnO}_4$  (25 g) was gradually added within 10 minutes after 20 minutes of mechanical stirring. The blend was additionally mixed for one hour at 5–10 °C and after that warmed to 40 °C. And then, 200 ml from water was trickled to the blend and the temperature of the material reactant blend was preserved at (90–100 °C) for half an hour. When 800 ml of water, the resulting viscous mud is diluted and to reduce the unreacted oxidation hydrogen peroxide is added until the mud turns into a golden yellow color. Finally, after washing with hot deionized water and using diluted hydrochloric acid and centrifuge, Graphite oxide is obtained graphite oxide.

### **Synthesis of Graphene**

From the procedure of chemical reduction of graphite oxide compound graphene was obtained. A plausible part of hydrazine hydrate ( $\text{H}_6\text{N}_2\text{O}$ ) ((1:1) in mass proportion) was included in GO watery arrangement together with mechanistic blending. Chemical reduction process should occur for 8 hours during three days at a temperature between (95 – 100 °C), and finally, from using device centrifugation and cleaning with deionized water can get graphene. By using a vacuum oven at 60 °C part from the GO and graphene were dried for 24 h for characterization.

### **Preparation polyvinyl alcohol solution**

The polyvinyl alcohol (PVA) powder with Molar mass 30000 g/mol is gradually mixed with double deionized water to keep away from the of agglomerates, when it temperatures was rises, the viscosity increases and the tendency to form agglomerates increases. When the powder is completely

scattered the mixture is warmed to the temperature at that the PVA turns out dissolved liquid going from (80°C to 90°C), this relies upon the evaluation of PVA utilized. Blending proceeds with such temperature into the polymer is completely solubilized. Contingent upon the evaluation of material and productivity of the excitation technique this can set aside some effort to accomplish. Leave the polyvinyl alcohol (PVA) solution to cool at room temperature.

### Nanocomposite Preparation

To prepare PVA/graphene nanocomposites, gradually added (10 g) from polymer PVA in 100 ml from deionized H<sub>2</sub>O at 95 °C in a graduated cylinder for beaker for while stirring the solution to prepare the aqueous polymer solution. At that point, graphene fluid suspension (in 60 ml deionized H<sub>2</sub>O) was gradually added into the polymer (PVA) solution which has been previously prepared. Finally, the mixing was thrown onto glass plates and dried at 50 °C in a vacuum stove for two days to shape level films which were stripped off and additionally warmed at 80 °C for two days to evacuate remaining water.

## III. Results and discussion

### Structure and morphology

#### X-RAY Diffraction analyses

XRD can more often than not be utilized to decide the build of nanocomposite materials. Figure (1) demonstrates for the XRD examples of graphite oxide and graphene. The regular diffraction peak of graphite oxide is appeared at around  $2\theta = 10^\circ$  (Figure 1 a). In the case of graphene, the crest at  $2\theta = 10^\circ$  vanish (Figure 1 b), Graphene demonstrates an ordinary expansive follow with an evident vanishing of the distinguishing peaks, which indicates that graphite oxide is conversion to graphene, Which largely corresponds to previous results, showing long-range irregularities in graphene (12).

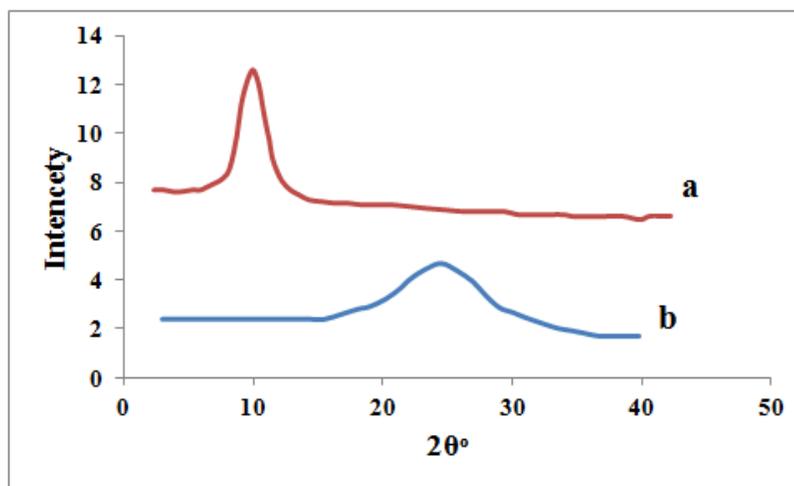


Figure (1) X-RAY Diffraction analyses the curve (a) for graphite oxide and the curve (b) for graphene.

Figure (2) demonstrates the test XRD examples of neat polymer PVA and graphene/PVA nanocomposites. Figure (2 a) show the diffraction peak of polymer poly(vinyl alcohol) was situated within  $2\theta = 19.5^\circ$ . In the case when graphene is joined with PVA, the test XRD examples for the graphene/PVA nanomaterial composites (figure 2 b) just demonstrate the characteristic peak and the diffraction top from polymer PVA of graphene vanishes, that suggests peeling for graphene in the polymer PVA network. Also, graphene/PVA nanocomposites have a bigger and sharper peak from neat polymer PVA, so the consolidation of graphene noticeably improves the crystallinity of PVA, so the consolidation of graphene noticeably improves crystalline properties for polymer PVA, that straightforwardly impacts the graphene / PVA nanocomposites characteristics (13). The expanded crystallization of graphene / PVA nanocomposite may be because graphene is able to arrange and shackle the polymer chain.

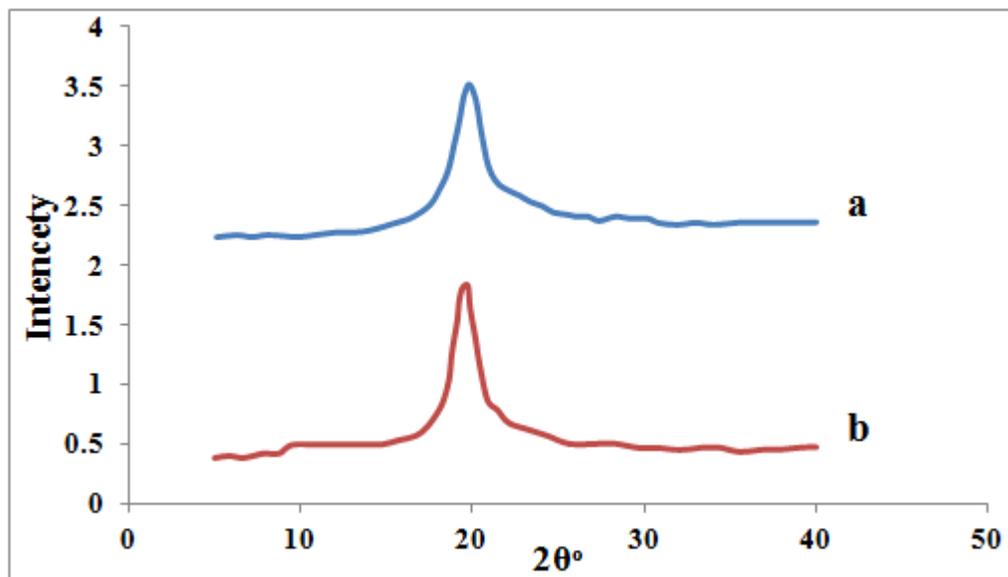


Figure (2) X-RAY Diffraction analyses the curve (a) for the polyvinyl alcohol (PVA) and the curve (b) for graphene / PVA nanocomposites.

#### Fourier transform infrared spectrum (FT-IR) analysis

To determine the interaction between the graphene and PVA matrix analysis of FTIR spectra was used. As appeared in Figure (3), in the graphene/PVA nanocomposite, the C-O extending peaks  $1100\text{ cm}^{-1}$  of were very weak contrasted with the C-O extending peaks for the neat polymer PVA, which indicates the getting of associations between the graphene and polymer PVA matrix (14). The presence of the vibration of the hydroxyl symmetric extension in PVA that causes a strong and broad absorption at  $(3000 - 3700)\text{ cm}^{-1}$  in the polymer PVA spectrum. The bands that lie at  $(1000-1200)\text{ cm}^{-1}$  are ascribed to the

extending vibration for the C-O and but the peaks lie at (2800– 3000)  $\text{cm}^{-1}$  are expected to be  $-\text{CH}_2$ . The alteration for hydrogen bonding works on change wavenumbers for vibration O-H (15).

The separation of hydrogen bonding among hydroxyl set in polymer PVA molecules causes the movement of O-H vibration waves in graphene / PVA nanocomposites to smaller sizes contradicting pure PVA (14, 16). The hydrogen bonds between PVA molecules may be broken by the incorporation of graphene /PVA nanoparticles leading to reduced hydrogen bonds between the PVA matrix. Simultaneously, the graphene and a hydrogen bond among the polymer PVA matrix is shaped when the hydrogen bond among polymer PVA atoms is broken which, first, a key factor for property improvements, and second, diminish the hydrogen bonds between the polymer PVA molecules.

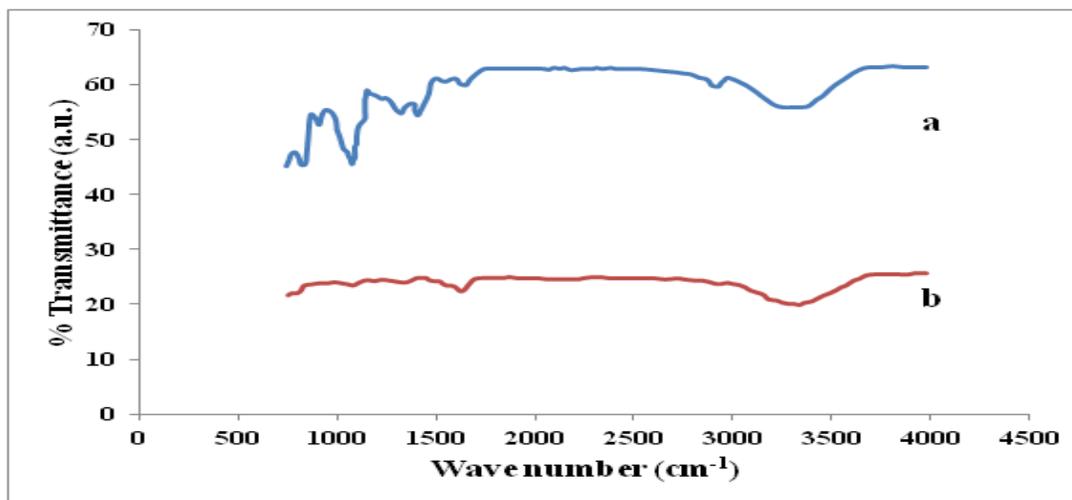
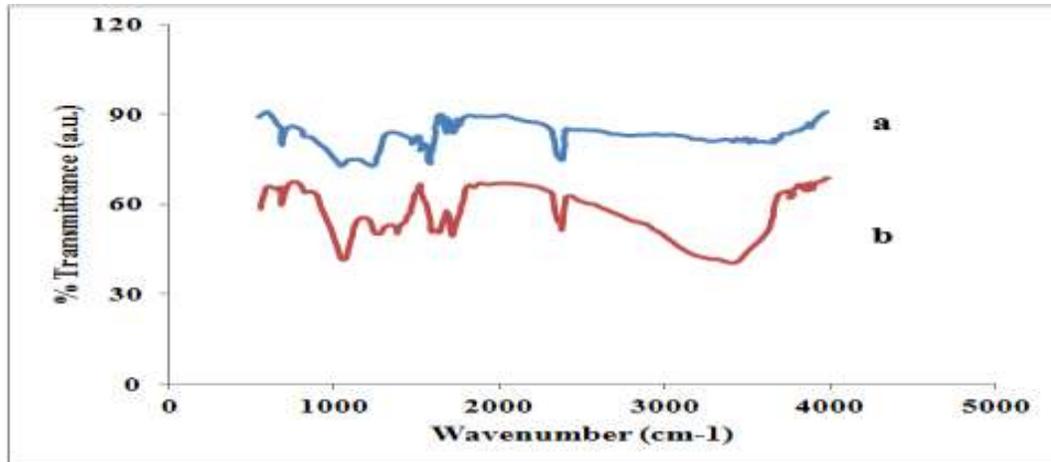


Figure (3) FTIR spectra of the curve (a) for the polyvinyl alcohol (PVA) and the curve (b) for graphene /PVA nanocomposites.

The specimens were distinguished utilizing different systems, for example, Fourier transforms infrared spectrum (FT-IR). In Figure (4a) have appeared the FT-IR analysis pattern for graphene possesses a feature peak within (1610)  $\text{cm}^{-1}$  a result of the aromatic (C=C) skeletal oscillations. All peaks for the graphene spectrum are weakly contrasted to the graphite oxide spectrum. The FT-IR example of graphite oxide, which is appeared in Figure (4b), uncovers the existence of the oxygen including functional gatherings. The peaks at 1630, 1380, 1071 relate to C-C extending method of the  $\text{sp}^2$  carbon skeletal system, C-OH extending, C-O-C extending oscillations, separately, whereas peaks situated within 3440 and 1730  $\text{cm}^{-1}$  compare to O-H extending oscillation and C-O extending oscillations of the COOH gatherings, respectively (17).

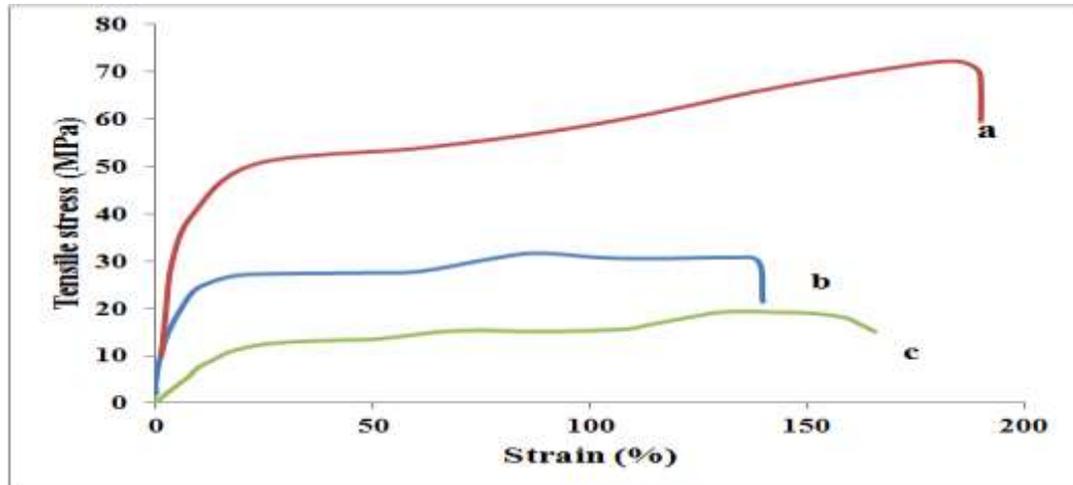


**Figure (4) FTIR spectra of the curve (a) for graphene and the curve (b) for graphite oxide.  
Stress –strain behaviors**

stress-strain conduct for the graphene/PVA nanocomposites, PVA and graphene have appeared in Figure (8). As figure 8(a, b and c) displays, the tensile strength for of graphene, graphene/PVA nanocomposites and PVA respectively. Mechanical behaviour changes greatly when graphene is added to the polymer PVA matrix. In Figure 8(b), when incorporating graphene with the neat (PVA) the elongation and tensile strength at break arrive maximum qualities, indicating increments by 34% and 212, respectively.

The strong interplay between graphene, polymer (PVA) and homogenous spread for graphene matter in the polymer PVA can be attributed to the main reason for improving the properties for graphene / PVA nanocomposites especially mechanical properties. Matching for the results obtained by Zhang and co-workers,(18). If a large quantity from the graphene matter is added to the graphene / PVA nanocomposite compound, the distance between the nanoparticles of the graphene will be very tiny in which the nanoparticles are easily susceptible to stacking with each other readily because Van der Waals' strong strength and the particles accumulate together by agglomerates. As additional agglutination may lead to nanoparticles clumping together, which reduces the productivity of improving mechanical properties, while graphene can be diffused into the polymer PVA matrix by less than 1%, which leads to a marked improvement in mechanical properties.

The polymer PVA non-toxic and scentless has brilliant film-shaping, adhesive and emulsifying properties as is known. The PVA has high elasticity and tensile strength, just as great oxygen and smell obstruction properties (19). Nevertheless, these characteristics depend on moisture. The existence of water, which Works on reduces tensile strength and as a plasticizer, but increases tear strength and the elongation (20). This seriously constrains the use of PVA.



**Figure (5) Typical stress–strain curves of the curve (a) for graphene , the curve (b) for graphene/PVA nanocomposites and the curve (c) for the polyvinyl alcohol (PVA).**

#### **Thermal behavior**

In addition, to describe the thermal properties of graphene / PVA nanocomposites, a thermal examination (TGA) is used. As appeared in Figure (6), graphite oxide isn't thermally steady and begins to lose mass after raising the temperature even beneath 100 °C. This might be because of an enormous number of oxygen-including efficient gatherings, for example, carboxyls, epoxides and hydroxyls on the graphite oxide. At the point where the thermally unstable oxygen efficient gatherings are expelled, the graphite oxide is then converted into graphene, improving thermal properties, and graphene becomes more thermally stable.

Thus the thermal properties are improved and the graphene/PVA nanocomposites display more various thermally stable. PVA and graphene/PVA starts to break down from 260 °C and the most extreme weight reduction for neat PVA happens at 304 °C and the greatest weight reduction for graphene/PVA nanocomposites happens at 402 °C. These outcomes indicate that when incorporating graphene into the polymer PVA matrix delay the thermal degradation of polymer PVA in the graphene / PVA nanocomposites.

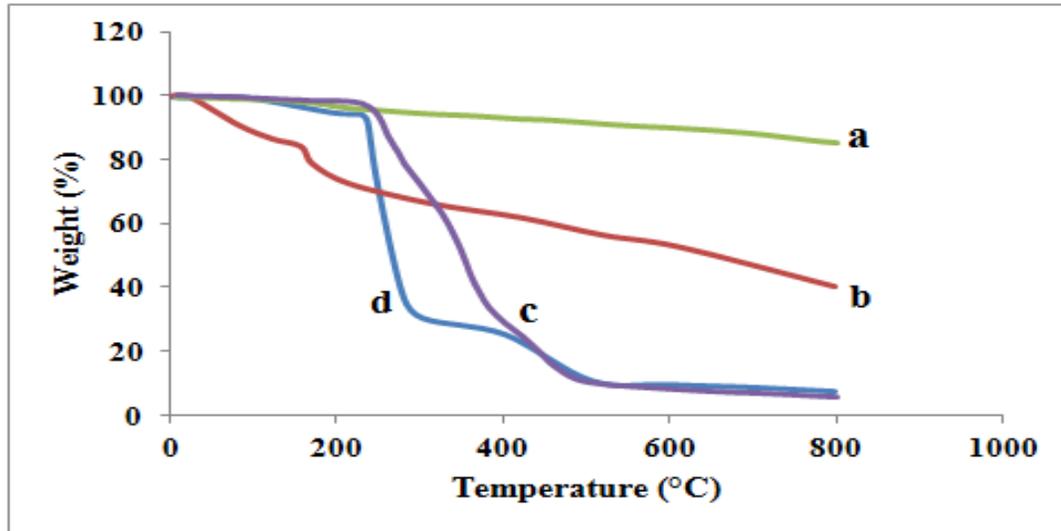


Figure (6) TGA curves of the curve (a) for graphene , the curve (b) for graphite oxide, the curve (c) for graphene /PVA nanocomposites and the curve (d) for the polyvinyl alcohol (PVA).

#### IV. Conclusions

From X-RAY Diffraction analyses in the case of graphene, the crest at  $2\theta = 10^\circ$  vanish (Figure 1 b), Graphene demonstrates an ordinary expansive follow with an evident vanishing of the distinguishing peaks, which indicates that graphite oxide is conversion to graphene, showing long-range Irregular in grapheme. In the case when graphene is joined with PVA, the test XRD examples for the graphene/PVA nanomaterial composites just demonstrate the characteristic peak and the diffraction top from polymer PVA and the peak diffraction for graphene vanishes, that suggests peeling for graphene in the polymer PVA network. So adding graphene to a PVA polymer significantly improves the PVA crystal, which directly affects the properties of graphene/ PVA nanocomposites.

The hydrogen bonds between PVA molecules may be broken through the combination of graphene nanoparticles with polymer PVA molecules leading to reduced hydrogen bonds among the polymer PVA network. When incorporating graphene with the neat polymer PVA the elongation and tensile strength at break arrive maximum qualities, indicating increments by 34% and 212, respectively. Can be attributed to the main reason for improving the mechanical characteristics for nanocomposites the strong interplay between graphene, polymer PVA and homogenous pervasion for nanoparticle graphene in the polymer PVA network.

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