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Structure Properties of Graphene- polymer Nanocomposite

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ABSTRACT:

In this work graphene-PVA composites samples prepared with different graphene loading (0.2, 0.5, 0.7, 1) gm, where prepared by direct mixing then dried at (60 C°) in an oven. The present work focuses on studying the structural properties of composite, using analysis like X_ray diffraction, SEM and AFM. The results show that the chemical composition has major effect on structural properties, the phase analysis done by X_ray diffraction has confirmed the formation of the expected graphene structure where the crystal size was increased but the X-ray density was decreased when increasing the graphene content in PVA matrix. SEM shows surface image of composite films where the graphene nanoplates can be homogeneously integrated with in PVA matrix. AFM examination shows that the surface roughness decreased with filler increasing.

Key words: graphene oxide, polyvinyl alcohol (PVA), nanocomposite.

INTRODUCTION

Carbon nanotubes (CNT) attracted huge interest with their unique combination of excellent mechanical, electrical and thermal properties [1], CNT have been used for producing polymer fibers with enhanced toughness, and composites that are electrically or thermally conductive at extremely small levels of incorporation [2]. Graphite is a three dimensional carbon material which is certainly abundant. In graphite, sp_2 hybridized carbons are covalently bonded in hexagonal way forming separated sheets named “graphene” and these sheets are bound with the others by van der Waals forces. Graphite has been used in numerous industrial applications for example lubricants [3], and high temperature gaskets [4].

New class of materials consists of two dimensional (2D) crystalline materials have recently been identified and evaluated, the major material in this different category is graphene that consist of single atomic carbon layer. This novel material has a sum of unique properties, which makes it curious for both studies and fundamental future applications; it has a number of extraordinary mechanical and electrical properties. It is considerably very stretchable, and it is stronger than steel. The electrical and thermal conductivity is very high and it can be used as elastic conductor [5]. Graphene is a fast going up star on the skyline of materials science and shortened matter physics, this accurately two dimensional material displays extraordinarily high electronic and crystal quality, in spite of its shortened history, has already discover a abundance of new potential and physics applications, while one can be sure of the actuality of applications just when trade products appear, graphene not needs any more evidence of its significance in terms of essential physics. Due to its uncommon electronic spectrum, graphene has directed to the up growth of a new pattern of “relativistic” reduced matter physics, where quantum relativistic phenomena, several of which are un noticeable in high energy physics, now can be stimulated and verified in table top experiments, however, graphene represents a abstractly new

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materials that are only one atom thick, on this foundation, show new success in to low dimensional physics that has never stop over to surprise and continues to improve a productive ground for applications [6]. Greatest trade produced composites use a polymer matrix material a lot called resin solution, there are numerous various polymers obtainable dependent on the starting raw component, there are numerous broad classes, every with numerous differences, the greatest public are called as vinyl ester, polyester, epoxy, phenolic, polyamide, polypropylene, polyether and others, the reinforcement materials are regularly fibers [7]. The strength of the product is importantly dependent on the reinforcement materials ratio and matrix. Polymer matrix composites are very popular due to their simple fabrication methods and low cost, the high reinforcement capability of some nanoparticles is credited to their high aspect ratio [8], however, it is believed that the need for far lower reinforcement volume fractions stems from the fact that dramatic changes in physical properties of reinforcing particles happen as they leave from microscale classification and approach the nano scale field, the specific interfacial area of nanoparticles can reach upwards of hundreds of (m^2/g), caused in high surface area to volume ratios, this phenomenon results in relatively high interphase content in nano composites [9], many important physical and chemical interactions are run by surface properties, therefore a nano composite can exhibit significantly different properties even at low filler contents when compared to conventional macro and micro composites [10]. 2-D graphene have improved structures and many properties, due to larger specific surface area and higher aspect ratio comparing with other reinforcements, it is sensible to suppose some important development in a range of properties in the composites with graphene as nanofiller, the new success in production of large amount of graphene additional supports the advance of graphene based composite and hybrid materials.

Aim of the work

Production of graphene reinforced polyvinyl alcohol (PVA) in different weight% and verifying some physical properties.

Experimental Details:

Materials:

The materials used are polyvinyl Alcohol (PVA): This polymer synthesized by (panreac, didactic, 231375.1218, Barcelona espana) with purity (99.9%) and Graphene powder that synthesized by electro chemical exfoliation method [11].

Sample Preparation

Amount of (PVA) was taken and weight by sensitive balance dissolved with (90ml) of distilled water by using magnetic stirrer at (60 °C) for (1 h) to get a homogeneous and a slimy solution. Then **(**PVA)_graphene mixed with each other with (5:1) mixing ratio, where (0.2, 0.5, 0.7,1) gm of graphene added slowly to (5gm) of (PVA) , the mixture placed in a beaker and stirred by using magnetic stirrer for (30 minute) until we get homogeneous black thick solution. The glass slides was taped on one side to make sure easy removing after drying and the mixture poured on the glass slide then another slide placed on it like a sandwich (Fig 1) then samples dried at (60 °C) in an oven.

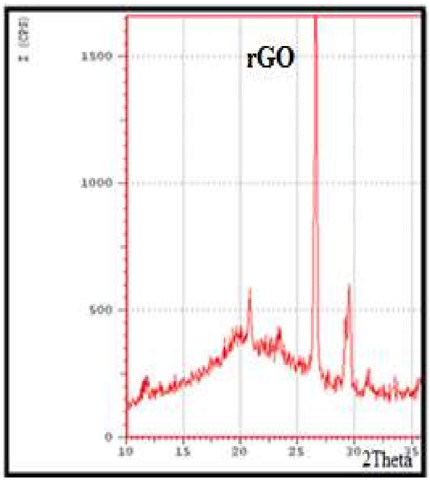
(a) (b)

Figure (1): a, b) The samples.

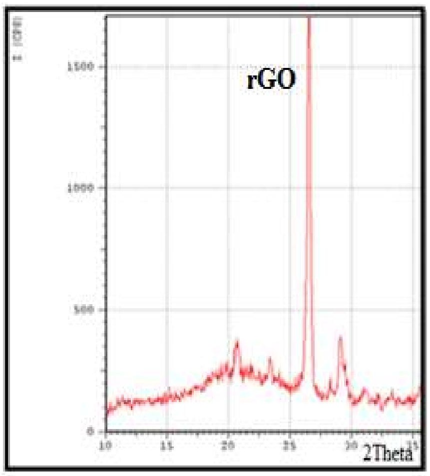
Results and Discussion

X-Ray Diffraction Studies:

The composite film was identified by XRD, (Figure 4-1.a). Reduced graphene oxide (rGO) as in (Fig.4-1) shows three peaks around 22˚, 25˚ and 26.5˚, these XRD results are related to the exfoliation and reduction processes of GO and the processes of removing the oxide groups [12]. the diffraction peak around 24˚with a much broader distribution and a reduced intensity indicates that the graphene nanoparticles GNPs are exfoliated into monolayers [13], In addition to, the carbon atoms existing in the multi-layer of graphene with carbon atom of alcohol which is phenol root in (PVA) caused multiple dispersion to XRD in other molecular level for diffraction angles approaching to (29˚), where the different graphene loading at angles between (20_30˚) specifically about (26˚) [14]. The crystallinity of PVA for the PVA/GNPs nanocomposites increased by the incorporation of GNPs loading with PVA. GNPs was considered to act as the crystallization nucleus for PVA, thus, the micro structure of PVA matrix was affected by adding GNPs.



(a)



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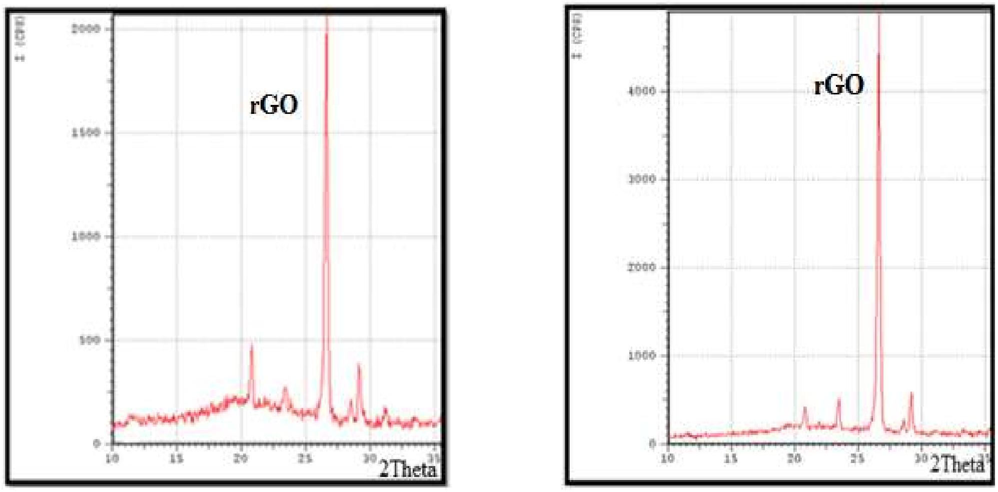


(c) (d)

Figure(2): XRD patterns of graphene-PVA composite with different graphene weights:a) 0.2 gm, b) 0.5 gm, c) 0.7 gm, d) 1 gm.

Also by using Scherer formula [15] :

$$D= 0.9 \lambda /\beta \cos \theta \qquad \ldots (1)$$

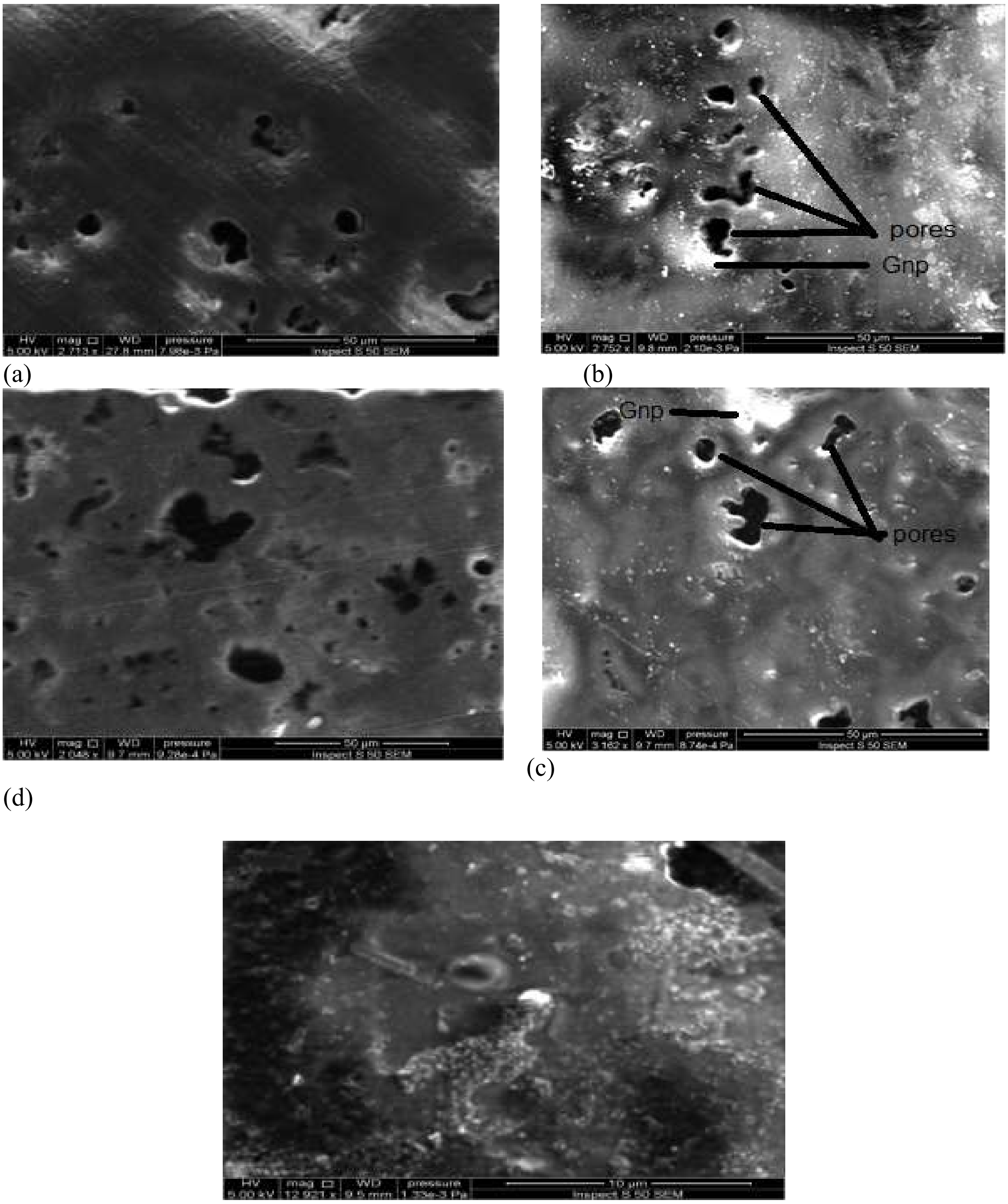
The crystallite size was calculated from full width at half maximum of the peak of highest intensity, it was found that the particle size increased when more GNPs powder added to the PVA matrix and that's due to agglomeration processes.

(Table 1): The particle size of GNPs in PVA with different weight percentages.

PVA/grapheme composite samples	Graphene weight (gm)	Particle size (nm)
A	0.2	40.909
B	0.5	47.582
C	0.7	49.473
D	1	53.790

Scanning Electron Microscope

SEM images (Fig 3) show surface image of composite films containing different weights of graphene, GNPs can be homogeneously dispersed within hydrophilic PVA matrix. The presence of ionic moieties, such as carboxylates in the polymer backbone results in enhanced interfacial interactions between the GNPs and the matrix, whereas its amphiphilic character is responsible for the efficient exfoliation of GNPs by noncovalent approach [16]. This property makes GNPs a potential candidate as filler material in functional polymer composite. As in figure below shows that in pure and other samples have a much rougher texture with increase GNPs loading, the shine area indicate to crystals existing, there is also a much larger number of visible macro pores in the internal structure, these features propose that the graphene may have influenced the packing of macromolecules of the PVA.



(a) (b)

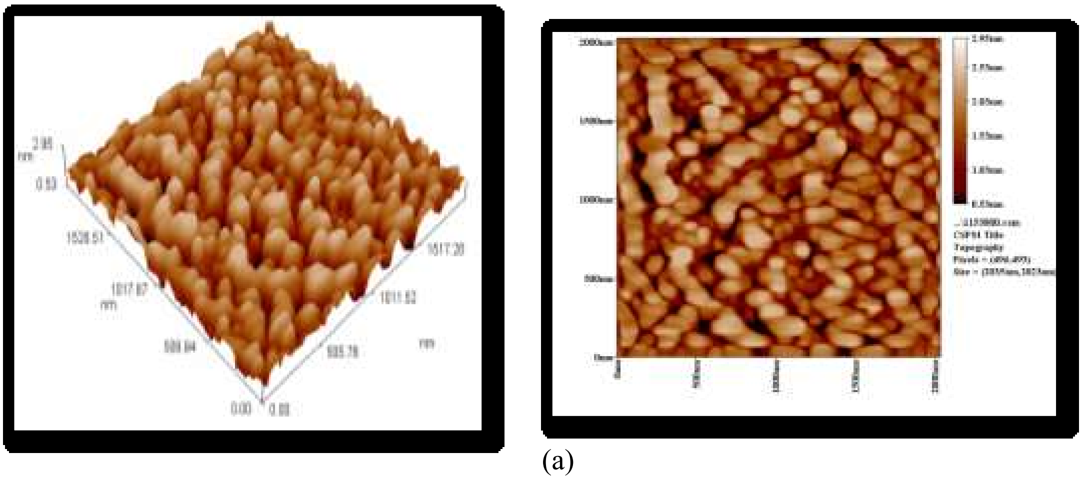
(d) (c)

(e)

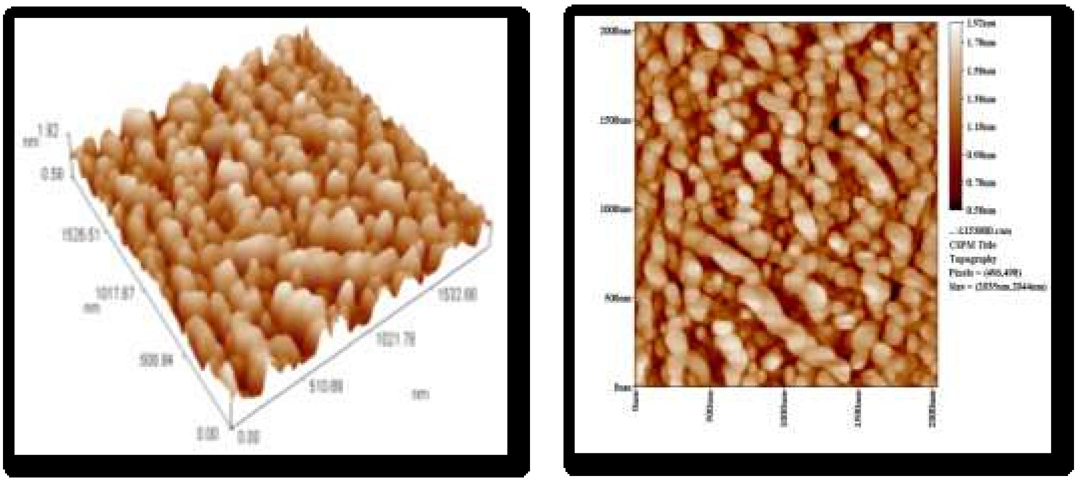
Figure (3): SEM images of composite film with different graphene wt%: a) pure PVA, b) 0.2 gm, c) 0.5 gm, d) 0.7 gm, e) 1 gm.

Atomic Force Microscope

The atomic force microscope is used to image surface structures on a nm or even sub-nm level. AFM used for topographical imaging, the grains in the sample can be viewed from the two dimensional and three dimensional AFM images of the sample and also used to look at the structure of composite sample as the top layer (Fig 4).


2.95
nm
0.53
1526.51
1017.87
nm
508.94
0.00
0.00
505.76
1011.52
1517.28
nm
2000nm
1500nm
1000nm
500nm
0nm
CSPM Title
Topography

(a)


1.92
nm
0.50
1526.51
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508.94
0.00
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510.89
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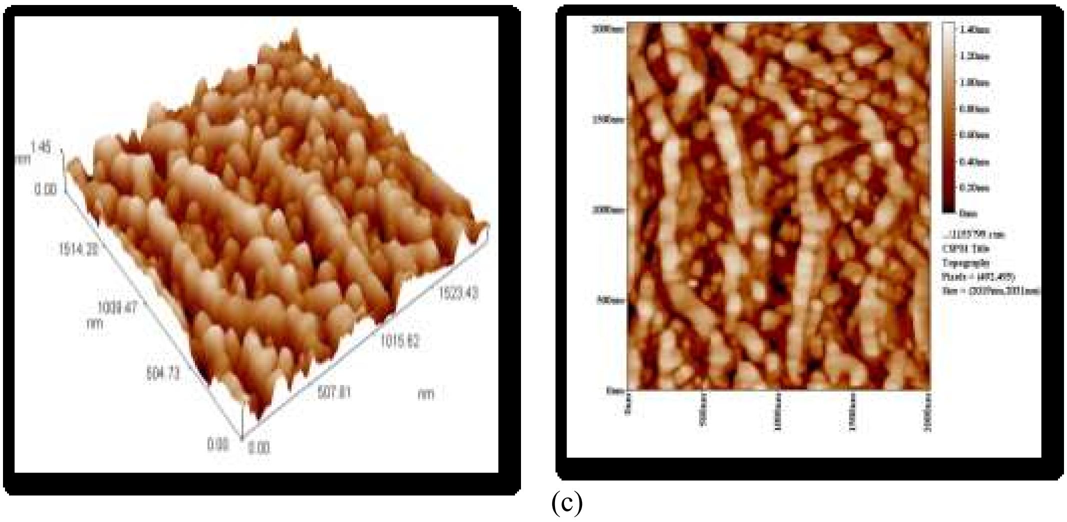
CSPM Title
Topography

(b)


1.45
nm
0.00
1514.20
1009.47
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504.73
0.00
0.00
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1523.43
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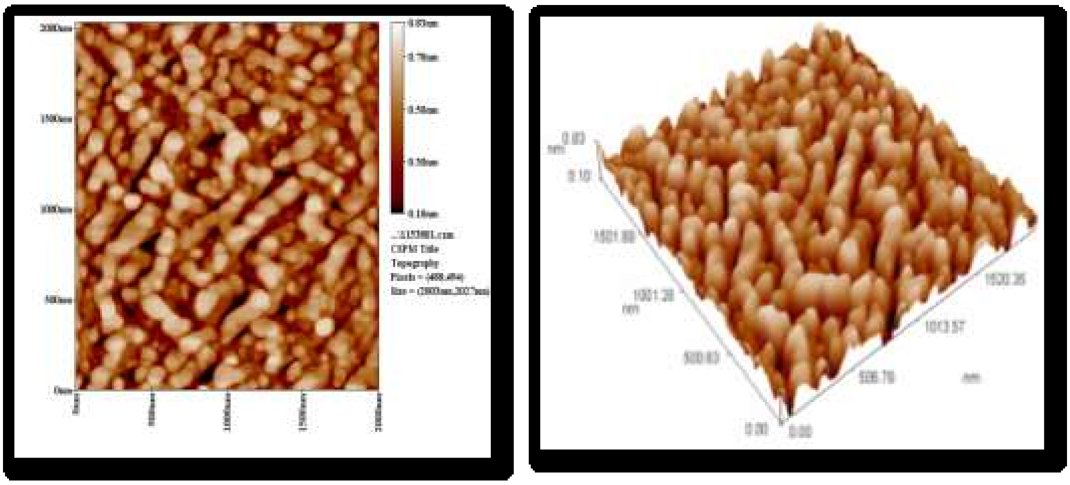
CSPM Title
Topography

(c)



(d)

Figure (4): Surface morphology 3D image of AFM for composite samples with different weights of GNPs: (a) 0.2 gm, (b) 0.5 gm, (c) 0.7 gm, (d) 1 gm.

Table(2): Roughness and Grain size of composite.

Sample	Roughness (nm)	Grain size (nm)
a	0.391	77.39
b	0.209	77.68
c	0.261	78.71
d	0.126	90.24

The mean grain size and roughness were increased with graphene percentage. The mean particle size achieved by using deby-scherrers formula (1), were smaller than the dimension of grains noticed in AFM images showing these grains probably an aggregate of many crystallite or may be due to AFM was the surface morphology of coalesced grains which gave the particle size.

CONCLUSION:

Graphene-PVA nanocomposite prepared by direct mixing, the synthesized composite is characterized by XRD, SEM and AFM. From the X_ray diffraction pattern, it can be observed that the particle size of powder resulted in nano range about of (47.5 nm). The morphology of composite surface showed by (SEM) that shows a minimum rougher texture. (AFM) used to image surface structure and surface forces, the grain size results increased with graphene percentage increasing.

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