Reinforce the structural and morphological properties of dental filler using polymer based-graphenenanosheets.

Mohanad Abdul Salam[1, 2],Ehssan Al-Bermany[1*,]
[1]Department of Physics, College of Education for Pure Sciences, University of Babylon, Iraq.
[2]Educational Directorate of Baghdad, Ministry of Education, Iraq.
***Corresponding Email author: mohnadsalam198787@gmail.com**

Abstract:

One of the most important objectives of esthetic restorative dentistry is to provide restorations with structure properties that are comparable to those of natural teeth. Polymer-basedgraphene-nanocomposites significantly impact dental fillerstructure. Graphene oxide (GO) and poly (methyl methacrylate) (PMMA) were used to reinforce commercial hybriddental filling. Developed solution and casting methods were applied to fabricate dental filler-based-polymer-basedgraphene nanocomposites. The structureand morphology ofthe fabricated filling-PMMA/GO nanocomposites were investigated. Fourier transform infrared showed a significant interaction between the filling and the additional materials. An Optical microscope with field emission scanning electron microscopy images demonstrated a considerable change in the morphology of the samples with a homogeneous and fine dispersion of the nanomaterials in the dental filler matrix.

Keywords: GO nanosheets, PMMA, the structural properties.
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Introduction

Dental fillingshave been used extensively for restorations both anterior and posterior during the past three decades[1]. Research shows that secondary caries are a major contributor to the high failure rate. The plaque was shown to build more rapidly on resin composites than on enamel or traditional restorations[2].

In addition, the materials used in composite dental fillings have undergone a series of qualitative and revolutionary leaps from the time they were first developed to the current day[3]. Due to the compound's complexity, these materials covered its makeup and its characteristics [4]. To top it all off, it can't do any harm to the body, break down, or release any poisonous chemicals while in the mouth. It also can't be a breeding ground for germs, thus it has to be antibacterial[5].

Polymers, with their advantageous optical and mechanical qualities and low economic cost, have been introduced as one of the crucial components in the production of dental fillings to alleviate these issues[3,6]. Polymethyl

methacrylate is one such polymer that has found a home in the field of dental science and has been widely successful over the past seven decades(PMMA). Besides its beneficial mechanical-biological features, straightforward manufacturing, and low cost[7]. PMMA has been employed in the production of resin for dentures, -term fix materials, and cement for bones, all of which are advantages for the face and other applications[8,9].

Nanomaterials were recently added into the dental filling's components as a solution to the issues caused by polymers[10]. Graphene oxide nanosheets[11] are one of the most intriguing nanomaterials to find contemporary usage in dentistry. The scientific community is very interested in graphene. In 2004, when it was first discovered by Novoselov et al.[12], It's one of a kind, and it may be used in a broad range of contexts. Graphene and related graphene-derived nanomaterials are becoming increasingly popular in the dental field[13]. Continuous use in dentistry necessitates that these materials be tested to guarantee they produce excellent biocompatibility[14]. Graphene-based materials may be tailored to new uses by altering their chemical and physical properties[13]. Graphene's distinctive and promising features, including its rich functional group, mechanical and optical capabilities, nano-size sheets, and conductivity, are all amenable to tuning in order to either reduce or enhance the material's qualities[9,15]. According to the literature, GO has potent antibacterial properties[16].

On the basis of the foregoing, PMMA and GO have been proposed as promising nanosheets additives for dental filling application. The purpose of this research is to examine the impact of nanoscale materials on the structure and morphologyproperties of commercial dental fillings, which contain materials with micro-scale dimensions. The PMMA used to modify the structure of the filler, and the GO nanosheets used to reinforce the structure of the dental. The efficacy of the latest nano/hybrid dental filler-PMMA/ nanographene dental nanocomposites was characterized using Fourier transform infrared (FTIR) spectroscopy, optical microscopy (O.M) pictures, field emission scanning electron microscopy (FESEM) images.

2- The experimental part

2-1 Materials

The macro particle generated from (Bisphenol A-glycidyl methacrylate) is included in the hybrid filler made by The ShofuInc company Japan.PMMA with 99% purity produced by TuttlingenCompany, China.GO was fabricated by our group using modified Hummer methods [17]flowing the procedure in our previous publication [18]with a pH of around 5.7.

2-2 Fabricated of nanocomposites

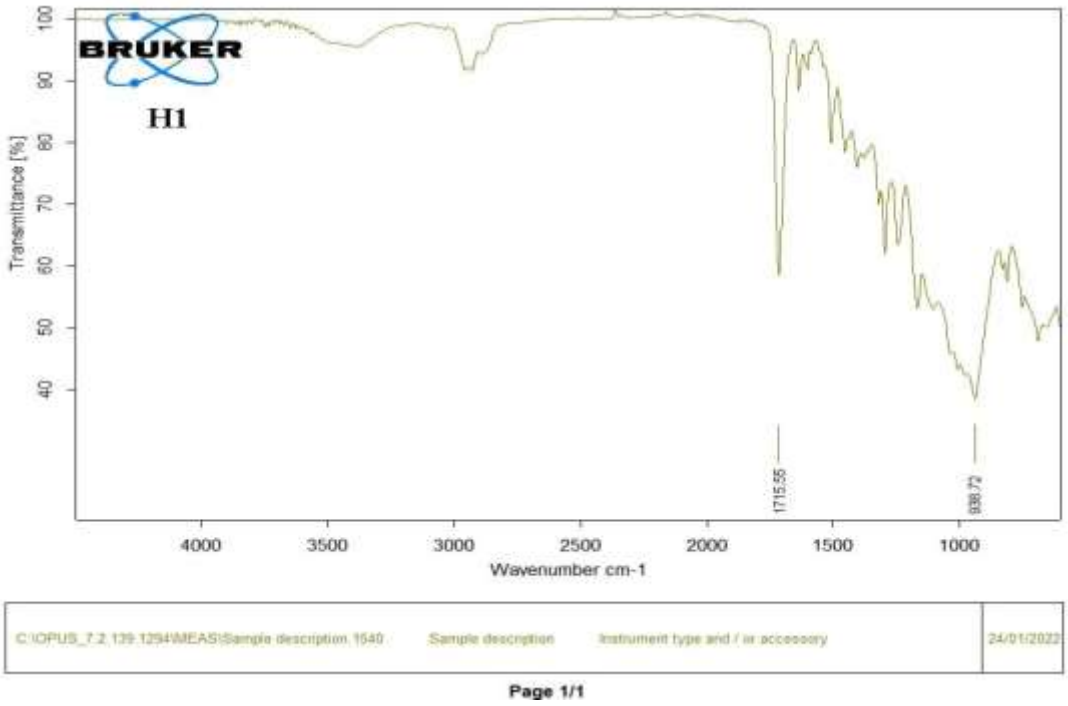
Developed aquatic dissolvingcasting methods were applied to fabricate the dentil filler-polymer-based graphene oxide nanocomposites. Three samples were prepared from both fillers. Briefly, hybrid-filling were fully dissolved separately with a ratio of 100 wt. % in Dimethylformamide (DMF), then PMMA dissolved in DMF using a magnetic stirrer for three hours at 80 ± 2 ºC independently. Thenit was added toeachmodifiedthe fillers samples separately to prepare filler-PMMA samples that were mixed for 3h ata ratio of 3:1 of filler: PMMA to prepper the second samples. Finally, GO was loaded to reinforce the filler- PMMA matrix structure with a ratio of 3:0.9:0.1 of filler: PMMA: GO. Themixersof hybrid filler-PMMA/GO nanocomposites were mixed using a magnetic stirrer for 1 hwithsonication for ten minutes. This procedure was repeated for 3 days until got a homogeneous mixture of thedental nanocomposite.

2.3 Characterizations

TheFT-IR spectraweremeasured by using theFourier transforms infrared model (vertex 70) in the range between(4000-500)cm^{-1} manufactured by Bruker Company Germany, and the imageof optical microscopy (OM)tacked bythe model (Nikon 73346**)**.

4. The Results and Disscusions

Figure (2) illustrates the Fourier Transform-IR spectrum for hybrid dental fillers and the nanocomposites in the range between 500 to 4000 cm^{-1}.The hybrid dental filler curve (H1) exhibited a small feature of the peak at (1715.5, and 938.7)cm^{-1} related tothe stretching vibrations of C=O strong stretching of the ester group and (C-O) related to strong bending. The curve (H2) exhibited a new peaks such as (2950, 1435 and 1141) related to related to C-H medium stretching of the methyl and methylene group [19], the carbon-carbon single bond (C-C) has low absorption, (C-O) related to alkyl aryl ether group, and shifting in the peaks, such as (1715 to 1718), and (938 to 951) cm^{-1}[20]. Whereas, the contribution of GO in the hybrid-PMMA dental filler matrix in the curve (H3) when loading of GO in hybrid dental-PMMA matrix resulted ina new peak at 1242 related to C-H stretching, in addition, it presented a shifting in other some the peaks such as (1718.63 to 1718.63) and (1141 to 1168)cm^{-1}[21].The strong interfacial interaction was responsible for the presence of the new peaks, shifting, and changes in intensity peaks that refers to bonding these materials with a stronger hydrogen bond with dental fillers [22].



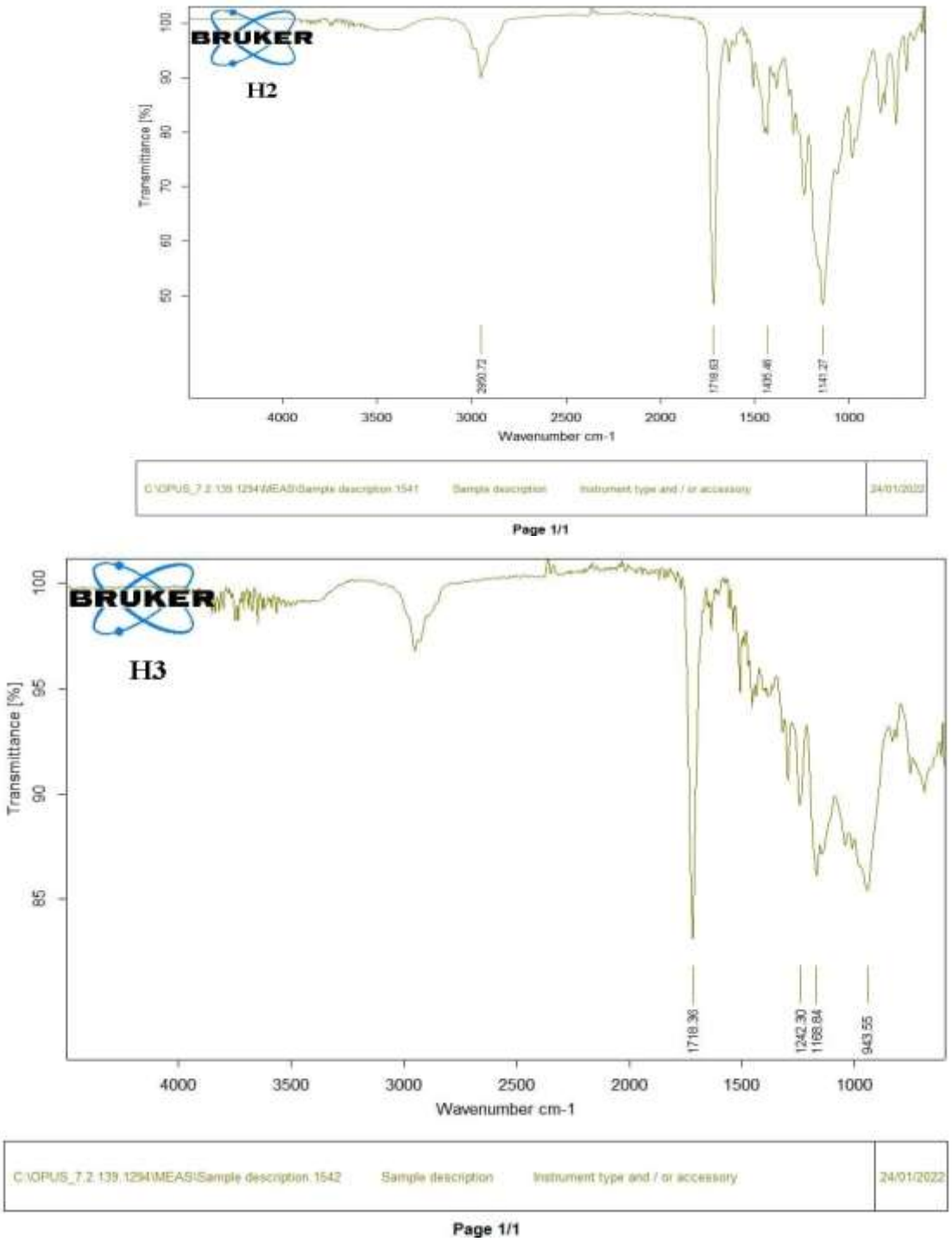


Figure (1). FT-IR spectrum for H1, H2, and H3.

The pictures captured by the optical microscope and displayed in Figure (2) show the surface of the Hybrid dental fillings(H1), as well as their composites (H2, and H3). These pictures showed that dissolved tooth sample for H1 had a very fine uniformity. Alterations in the surface of the samples were observed after the addition of PMMA in H2. The observed changes included

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the presence of certain spherical particles associated with PMMA[23]. This change in the surface of the nanomaterials was related to the bonded among the dental fillers with PMMA. The addition of GO showed a good and fine distribution of GO in the and H3 dental filling in agreement with other findings [24].

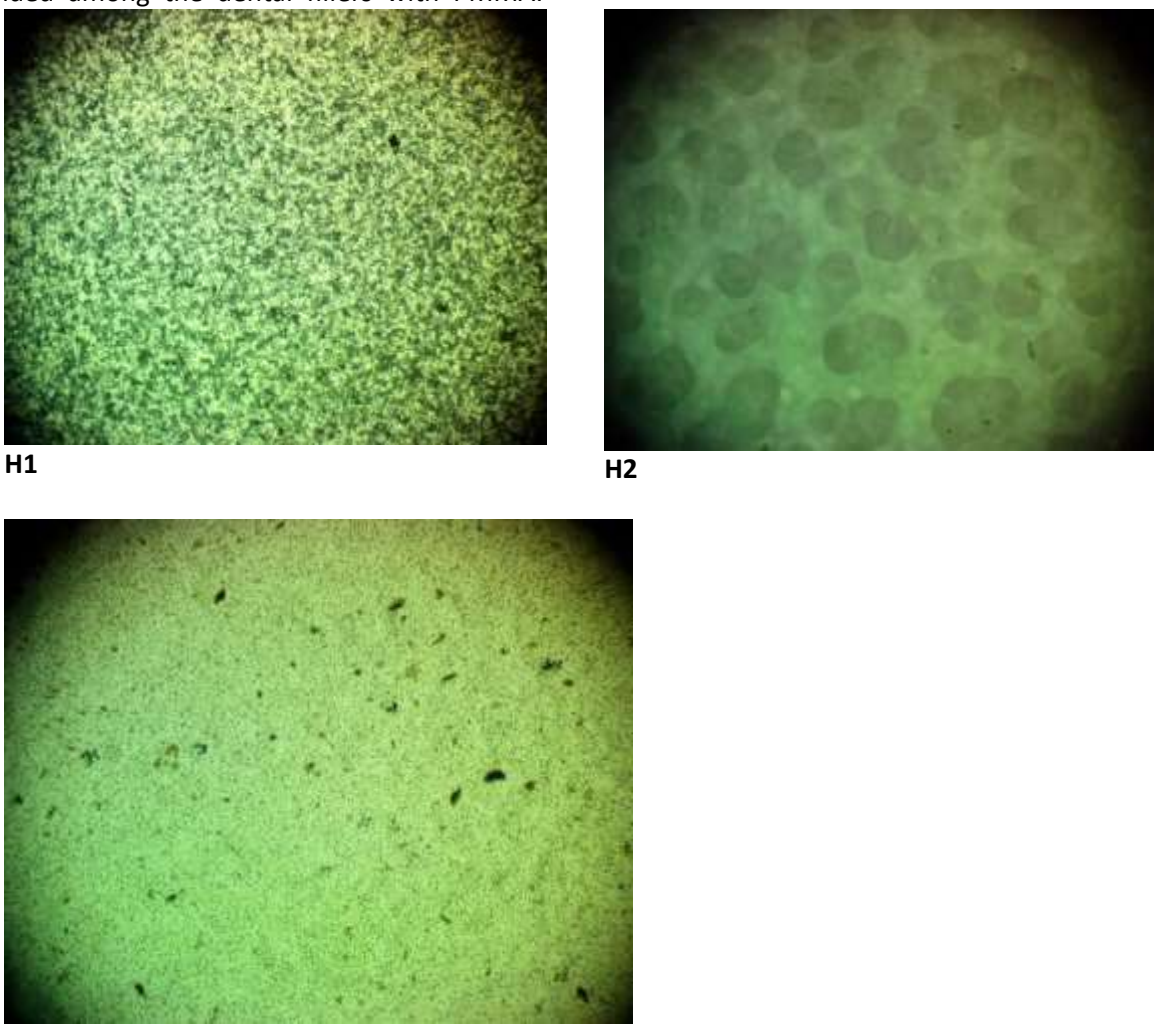
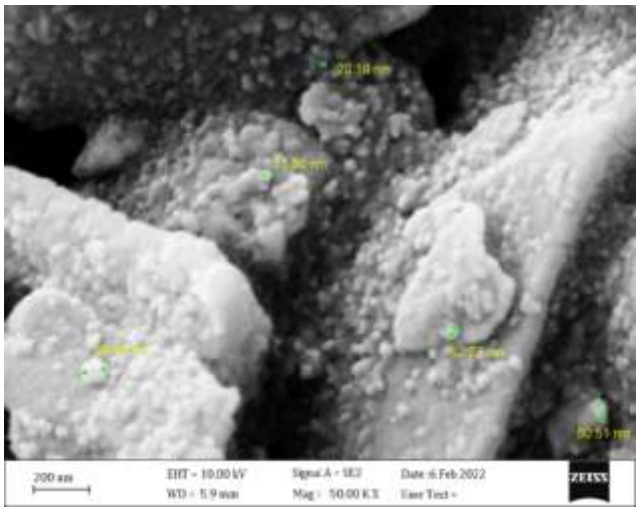
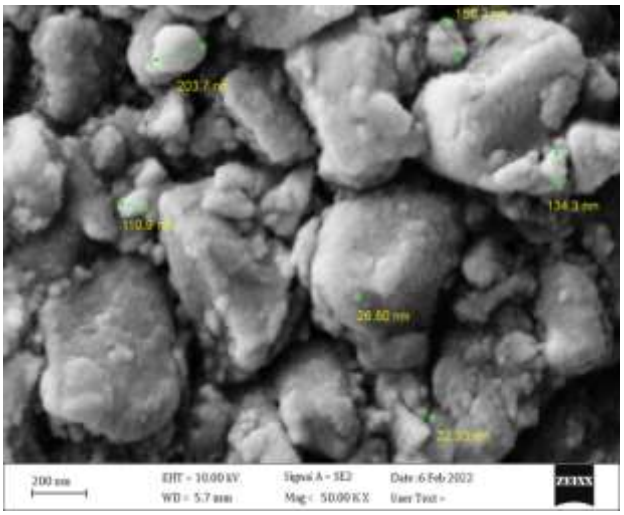


Figure (2). The OM images of H1, H2, and H3.

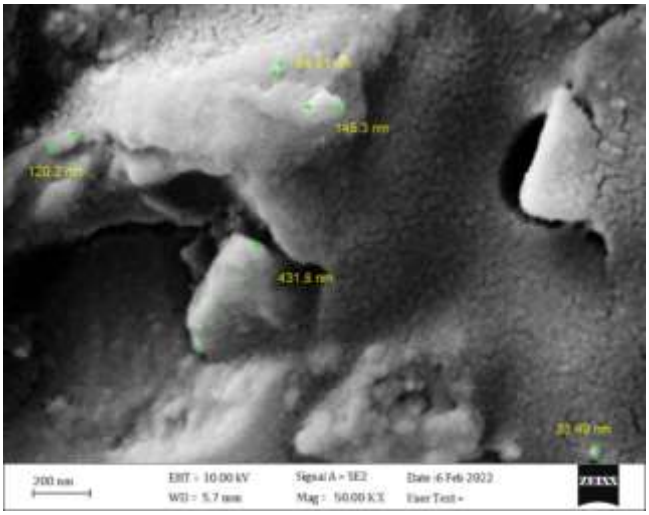
Figure 5 is a representation of the SEM pictures of the surface morphology of each sample, with the magnifications set at 200 nm. It clarified the composition of the nano-filling as gritty particles and rough with cavities surface form. The hybrid filling the surface topography of the sample were depicted in the images that can be seen in Figures 5 H1. The loaded PMMA demonstrated coverage of the majority of particles and filling the gaps between the filler components. In addition, the surface of the samples displayed minute fissures on the surface that were connected to the nature of the PMMA, as is obvious in the image (H2). It is evident from the photographs that the GO was a significant factor in the creation of a significant difference. This is due to the fact that GO possesses a large number of stretching bonds, which make it possible to attach the molecules closely to one another and overcome surface fissures (H3), in agreement with other reports [15,19].



H1



H2



H3

Figure (3).SEM images with two magnificationsof the surface morphology of H1, H2, and H3.

This change in the morphology of the surface of the filler is related to the impact of long chains of polymer molecules, which have covered the most and bonded the filler partials components, in addition to filling the gaps between the filler particle. This change in morphology of the surface of the filler is related to the impact of long chains of polymer molecules. whereas the functional groups of GO give it the ability to form a stronger interfacial interaction to create strong bonds among fillers, polymer molecules, and GO nanosheet, as that strongly presented in the FTIR results that showed strong new peaks in addition to shifting of other peaks in agreement with another finding. This demonstrates well working together between the filler particles and polymer[22,25].

5. Conclusion

In this study, the method was successfully prepared for the hybrid filling-PMMA/ GO dental nanocomposite fillers. The FTIR demonstrated the distinctions between the functional groups of each component. Also, FTIR is showinga strong impactand good interfacial interaction between the fillers and the

reinforcement materials (PMMA and graphene nanosheets). The optical microscopy images revealed a homogeneous sample and fine dispersion of GO, which provided improvements in the morphology properties as significantly confirmed by SEM images.

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