# A Surfactant Role on The Polyethylene Glycol (PEG) Nanoparticles by Sol-Gel Method

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**ABSTRACT**

This study investigates the role of surfactants in the synthesis of polyethylene glycol (PEG) nanoparticles via the sol-gel method. Surfactants significantly influence nanoparticle size, distribution, and stability by acting as stabilizing and templating agents. By varying surfactant type and concentration, improved colloidal stability, reduced agglomeration, and enhanced dispersibility were achieved. These findings highlight the potential of surfactant-assisted PEG nanoparticles for applications in drug delivery and biomedical engineering, offering precise control over nanoparticle properties.

**Keywords:** Nano particles, Sol-gel, surfactant, PEG

## 1 Introduction

Nanotechnology has revolutionized various scientific fields, offering advanced solutions for applications ranging from drug delivery to materials science. Among polymer-based nanoparticles, polyethylene glycol (PEG) nanoparticles have garnered significant attention due to their biocompatibility, chemical versatility, and potential for surface functionalization. PEG nanoparticles are widely used in drug delivery systems for their ability to enhance solubility, stability, and bioavailability of therapeutics while minimizing immunogenicity and toxicity effects [1]. The sol-gel method is a highly effective technique for synthesizing PEG nanoparticles, offering precise control over size, morphology, and structural properties. However, challenges such as particle agglomeration and inconsistent size distribution remain significant hurdles. Surfactants, as stabilizing and templating agents, play a pivotal role in overcoming these challenges by reducing surface energy and stabilizing nanoparticle dispersion during synthesis [2]. In this study, we investigate the influence of various surfactants on the properties of PEG nanoparticles synthesized via the sol-gel method. By tailoring surfactant type and concentration, we aim to optimize nanoparticle characteristics such as size, stability, and functional performance. These insights are crucial for enhancing the efficiency of PEG nanoparticles in biomedical and industrial applications [3-6].

## 2 Materials and Methods

### 2.1 Synthesis of PEG nanopowder

The synthesis of PEG nanoparticles by microwave irradiation method was carried out as follows. First, a 0.1 M of hydroxyl solution was prepared by dissolving PEG with in deionized water. Then pH of the solution was maintained at 8 by adding liquid ammonia solution drop wise. The resulting product was filtered and washed with double distilled water and ethanol until it became free from impurities. The precipitate was irradiated for 5 minutes in household microwave (radiation frequency 2.45 GHZ,


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Power up to 1 KW) with convection mode, giving a white product. Finally, the sample was as prepared by annealed temperature at 300 °C for 4 hours.

## 2 Results and Discussion

### Morphological and microstructural analysis

### 3.1 X-ray diffraction

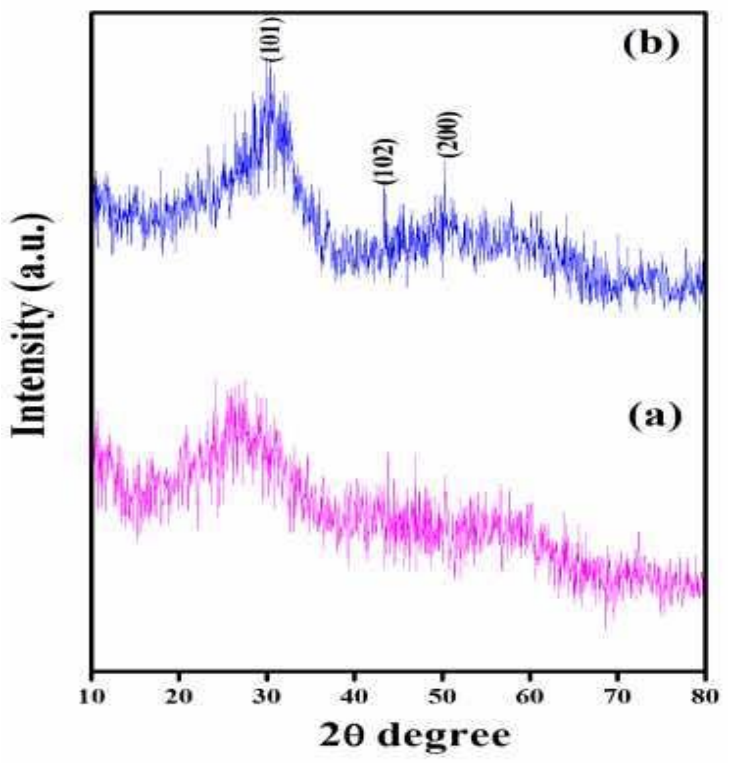


**Figure. 1:** *XRD patters of (a) Sample-A; (b) Sample-B*

XRD patterns of Sample-A and Sample-B are shown in Fig.1. The diffraction pattern of Sample A (Fig. 1a) confirms the amorphous peaks in polycrystalline nature. The sample heated at 300 °C (Sample-B) (Fig. 1b) XRD pattern exhibited the formation of tetragonal phase crystal structure and indexed the following miller indices (101), (102) and (200). The observed diffraction planes were well matched with the (JCPDS 89-7710). The average crystallite size of Sample-B was calculated and found to be 56 nm. The lattice constants of Sample-B were calculated as a=3.6183 and c=5.0162.

### 3.2 Fourier transform infrared spectroscopy

The formation PEG functional group from the hydroxyl group was also confirmed from FT-IR analysis. The FT-IR spectrum of PEG nanocomposites for Sample-A and Sample-B are shown in Fig.2. Samples (A&B) show the presence of as-prepared PEG and annealed nanocomposites. Fig. 2(a) shows the typical FT-IR spectrum in broad sharp peak at 3441 $cm^{-1}$, 3294 $cm^{-1}$ and 3255 $cm^{-1}$ are the characteristic of a non-associating O- H stretching vibration which indicates the presence of free hydroxyls. In Fig. 2(b) shows is prominent peak of 1381 cm-1 region corresponds to O-H bonding, peak in the region of 1566 $cm^{-1}$ may be due to the adsorbed moisture and in the 3950 $cm^{-1}$, 3902 $cm^{-1}$, 3757 $cm^{-1}$, 3402 $cm^{-1}$ region is attributed to stretching of O-H groups, characteristic of a highly hydrated compound.

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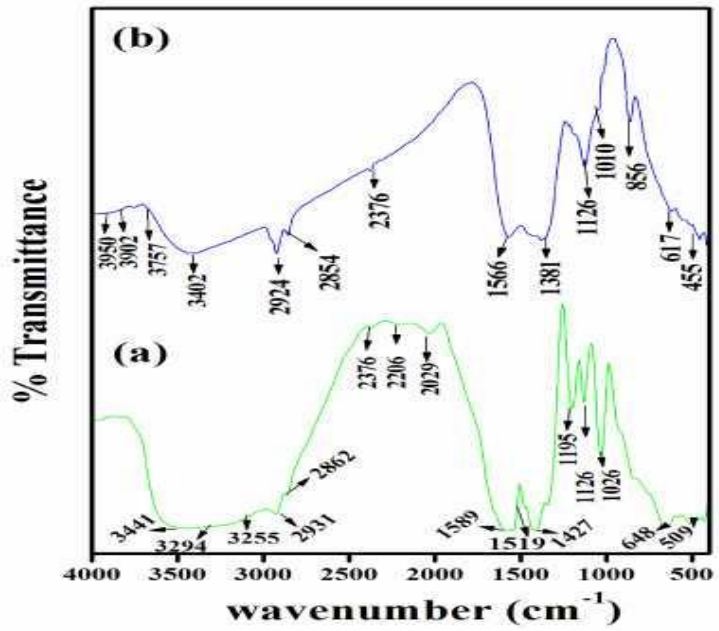


**Figure. 2:** FT-IR spectrum of PEG nanocomposites (a) Sample-A; (b) Sample-B

Samples (A&B) is absorption peaks at 2931 $cm^{-1}$, 2924 $cm^{-1}$, 2854 $cm^{-1}$, 2862 $cm^{-1}$, 2376 $cm^{-1}$, 2026 $cm^{-1}$ and 2029 $cm^{-1}$ are attributed to C-H stretching vibrations. The absorption peaks at 1589 $cm^{-1}$, 1519 $cm^{-1}$ and 1427 $cm^{-1}$ correspond to the vibrational mode of O-H stretching of absorbed water. The absorption peaks at 1195 $cm^{-1}$, 1126 $cm^{-1}$, 1026 $cm^{-1}$ and 1010 $cm^{-1}$ are assigned to C-N primary amine. The peak located at 856 $cm^{-1}$, 648 $cm^{-1}$ 617 $cm^{-1}$, 509 $cm^{-1}$ and 455 $cm^{-1}$ are due to the stretching vibrations.

### 3.3 Surface morphology

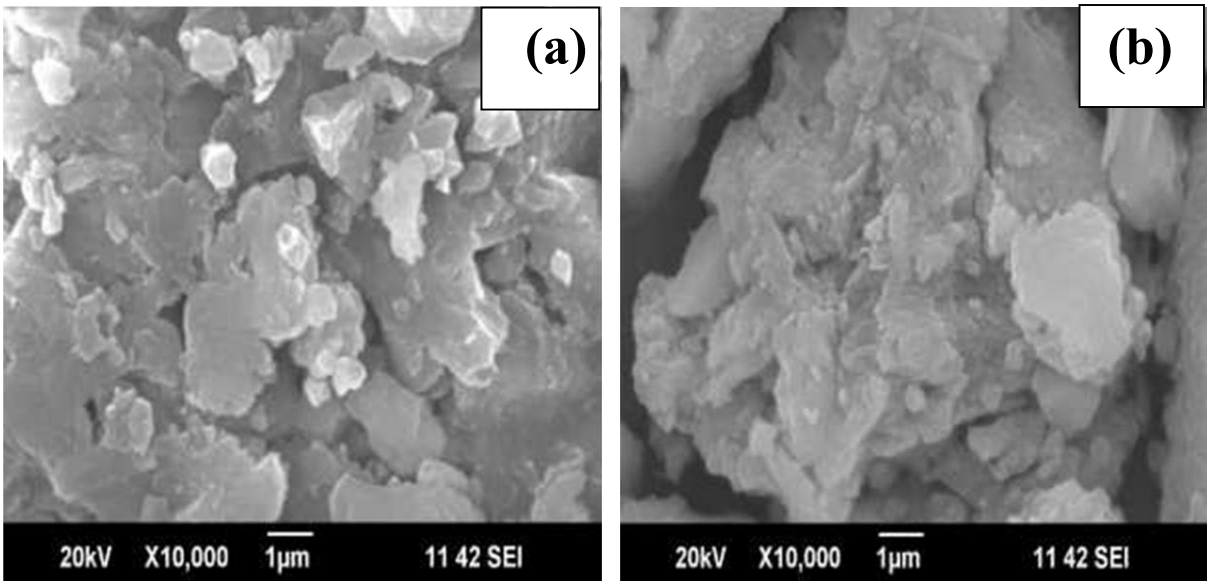


**Fig. 3:** SEM micrograph of PEG nanocomposites (a) Sample-A and (b) Sample-B

The morphology of the synthesized nanocomposites was analysed by scanning electron microscope (SEM). A typical micrograph of Sample-A and Sample-B is shown in Figure.3. SEM images also show that the synthesized samples are composed by the agglomeration of the smaller crystallites. Therefore, the temperature circulation is uniform and is transferred to the materials inside, making a volatile effect followed by energetic growth of the gases to form PEG with good polycrystalline nature.

### 3.4 EDS spectrum

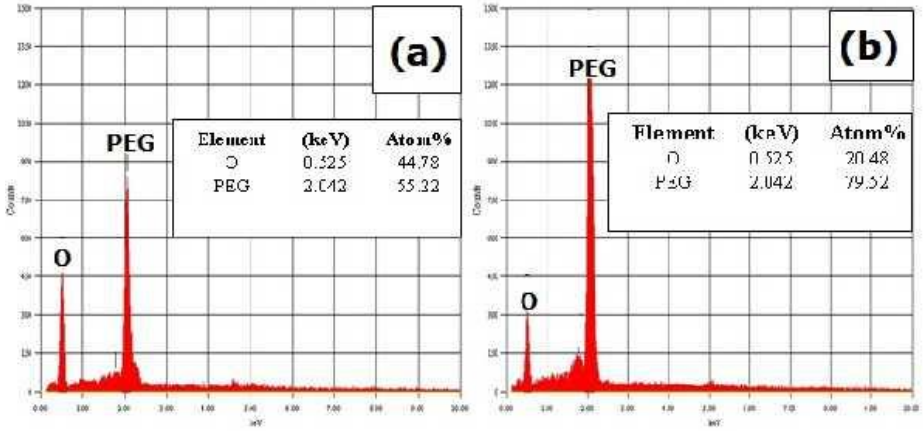


**Figure. 4:** EDS spectrum of PEG nanocomposites (a) Sample-A; (b) Sample-B

The spectrum of the synthesized nanocomposites was analyzed by Energy dispersive spectrum (EDS). A typical spectrum of Sample-A and Sample-B is shown in Figure.4. This spectrum is performed to investigate the elemental composition of PEG nanostructures. EDS analysis confirms that the presence of PEG nanostructures.

### 3.5 TEM study

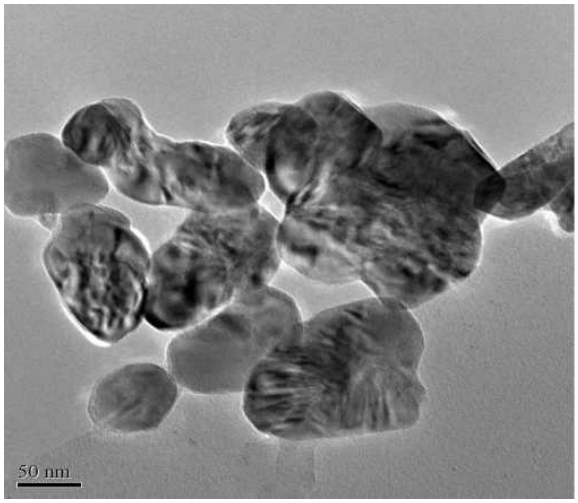


**Figure. 5:** TEM micrograph sample of PEG nanocomposite

TEM typical micrograph sample is shown in Fig.5. TEM image also show that the synthesized samples are composed by the agglomeration of the smaller crystallites and nearly with spherical shaped crystalline nature. The average particle size is 43-60 nm.

## 4 Conclusions

The surfactant of PEG nanocomposites was prepared in chemical precipitation method. This work aims at carrying a different morphology obtained by using the surfactant. The average particle size of the PEG nanocomposites predicted from XRD result is consistent with the observed particle size from TEM micrograph (43-60 nm). The SEM images confirms that the agglomeration of the smaller crystallites. The EDS analysis confirms that the presence of PEG structures. Thus, the simple synthesis

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route is a quiet interesting feature and cost-effective approach to produce PEG nanoparticles for optical and photocatalytic applications.

## 5 Declarations

### 5.1 Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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