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Article

Impact of Preparation Technique on The Synthesis of Cr_2O_3 NPs and Investigation of Cytotoxicity Against the MCF-7 Breast Cancer Cell Line

Weaam A. M.Al-Shammari[1], Reem Khalid Salih[2], Noha Mzher Muteab[3], Osamah Kareem Alwan[4], Assim Maad Mohammed[5]

1. Department of Chemistry, College of Education for Pure Science, University of Diyala, Diyala, Iraq.
2. Department of Chemistry, College of Education for Pure Science, University of Diyala, Diyala, Iraq.
3. Department of Chemistry, College of Education for Pure Science, University of Diyala, Diyala, Iraq.
4. Department of Chemistry, College of Education for Pure Science, University of Diyala, Diyala, Iraq.
5. Department of Chemistry, College of Education for Pure Science, University of Diyala, Diyala, Iraq.

* Correspondence: weaam.ahmed@uodiyala.edu.iq

Abstract: Chemical precipitation method has been used to synthesis of Cr_2O_3 nanoparticles. The lattice parameters and crystallite size were investigated using X-ray diffraction (XRD) research. Transmission electron microscopy (TEM) and field emission scanning electron microscopy (FE-SEM) were used to examine the shape and chemical makeup of the Cr_2O_3 nanoparticles. The biological activity was discovered that the Cr_2O_3 nanoparticles had a major have a biological efficacy, through it was tested for their ability to inhibit the MCF-7 breast cancer cell line.

Keywords: Cr_2O_3 nanoparticles, MCF-7 Breast Cancer, Chemical precipitation, XRD

1. Introduction

Structures and systems on the nanoscale scale—that is, 1 nm to 100 nm (10 to 9 meters)—can have their size and shape altered via nanotechnology [1]. Compared to their bulk counterparts, nanoparticles have larger surface areas, higher reactivity, and more modifiable properties [2]. The advancement of nanoscience and the use of nanoparticles (NPs) in a variety of industries, such as paint, food analysis, biomedicine, and environmental remediation, have been fueled by the aforementioned special qualities [3,4]. Unprecedented levels of understanding and control over matter at the atomic and molecular dimensions are made possible by nanoscale research [5]. Nanoparticle research is being driven by advances in medication delivery and the pursuit of innovative technology applications in bioscience.[6] The science of nanomedicine, which blends nanotechnology with medicine, offers several advantages over conventional cancer treatments, such as multifunctionality, effective drug delivery, and regulated release of chemotherapeutic medications. These benefits are made possible by the special physical and chemical characteristics of nanoparticles (NPs), including their tiny size, large surface area, chemical composition that can be changed, and shape that can be altered.[7] Because of their limited size and shape distribution, extended circulation half-life, rich surface functionalities, and potential for photothermal or photodynamic therapeutic approaches, metal-based nanoparticles are particularly attractive in the field of nanomedicine. The higher density of metal-based nanoparticles allows for faster cellular absorption than non-metallic nanoparticles of the same size, which is advantageous for cancer treatment strategies [8]. Additionally, it has been demonstrated that metal nanoparticles enhance drug transport and targeting, especially when activated with specific ligands that provide controlled deposition into cancer cells [9]. The chemical precipitation is the procedure

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used in this work to synthesize nano Cr_2O_3 particles and it used for MCF-7 breast cancer cell line treatment [10].

2. Materials and Methods

Experimental part

The experimental portion chromium sulfate ($CrSO_4.5H_2O$), sodium hydroxide (NaOH), ethanol, and deionized water are examples of analytically pure materials chemicals (BDH).

Chemical precipitation technique for Cr_2O_3 preparation

100 mL of deionized water were used to dissolve the 2 grams of chromium salt. To achieve pH = 11, a dropwise addition of NaOH (0.1M) solution was performed while swirling constantly. After a few minutes, chromium hydroxide ($Cr(OH)_2$) precipitated as a light green substance. Until pH = 7, this precipitate is collected and washed many times using ethanol and distilled water. The precipitate was subsequently dried for 10 hours at 80 °C and then calcined for 4 hours at 600 °C to produce Cr_2O_3 nanoparticles (eq. 1).

$$Cr^{+2}\ SO_4^{-2} + Na^{+}\ OH^{-} \longrightarrow Cr(OH)_2 \longrightarrow Cr_2O_3 \qquad (1)$$

Light green Precipitate

3. Results and Discussion

The XRD data for Cr_2O_3 NPs is shown in Figure (1). The average crystallite size of Cr_2O_3 nanoparticles is 41.23 nm, the two theta at (25.10°, 33.57°, 37.13°, 40.05°, 42.14°, 50.24°, 55.31°, 63.15°, and 65.09) corresponding to the (012), (104), (110), (006), (113), (024), (116), (214) and (300) planes, respectively [11]. The obtained values of d-spacing in good agreement with the (JCPDS data file number: 72-3533) and thus confirming the rhombohedral structure of prepared Cr_2O_3 nanostructures. The cell parameters (a = 9.4118 Å, b = 9.4177 Å, and c = 9.4233 Å) with cell volume (835.26 Å3) derived from the XRD data is compatible with the Cr_2O_3 phase [12].

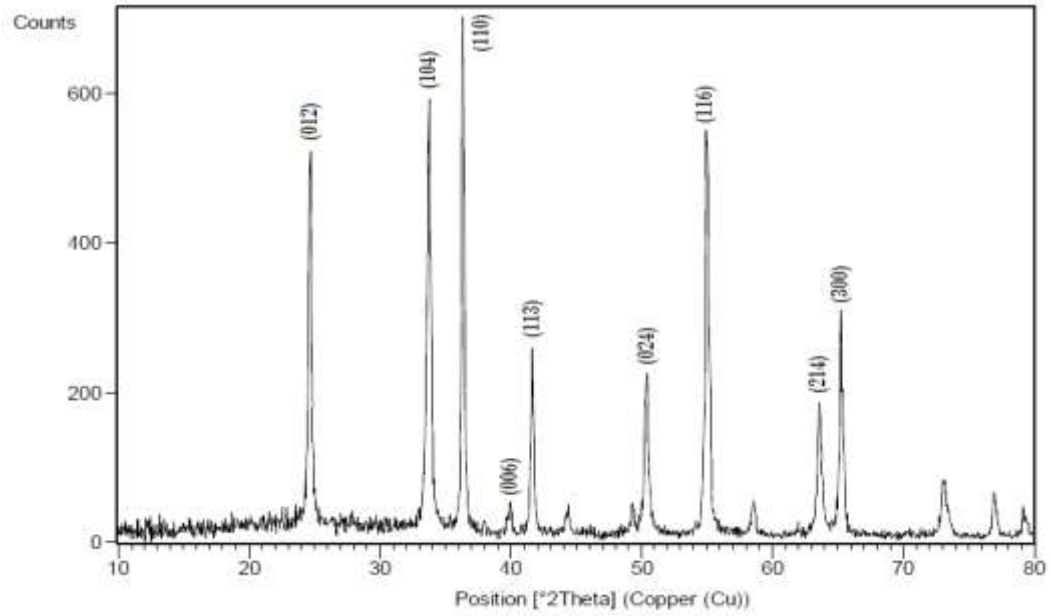

Figure 1. shows the XRD pattern of Cr_2O_3 NPs.

Figures 2 and 3 display FE-SEM and TEM images of the Cr_2O_3 nanoparticles, respectively. The FE-SEM image shown Cr_2O_3 nanoparticles is shaped like spherical and oval particles and were made using the chemical precipitation process, which have an average diameter of 84.04 nm.

Transmission Electron Microscopy (TEM) image of Cr2O3 nanoparticles at magnification (200 nm) is displayed in Figure 3. The nanoparticles vary in size from around 18 to 31 nm , and 23- 42 nm and appear to be heavily agglomerated with diverse morphologies [13].

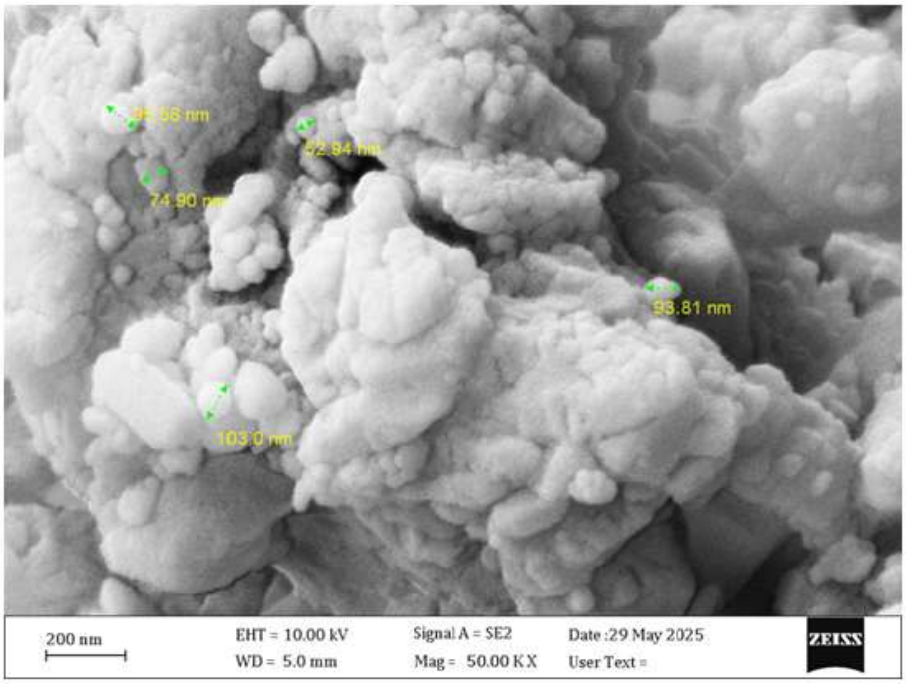

Figure 2. FE-SEM image of Cr_2O_3 nanoparticles

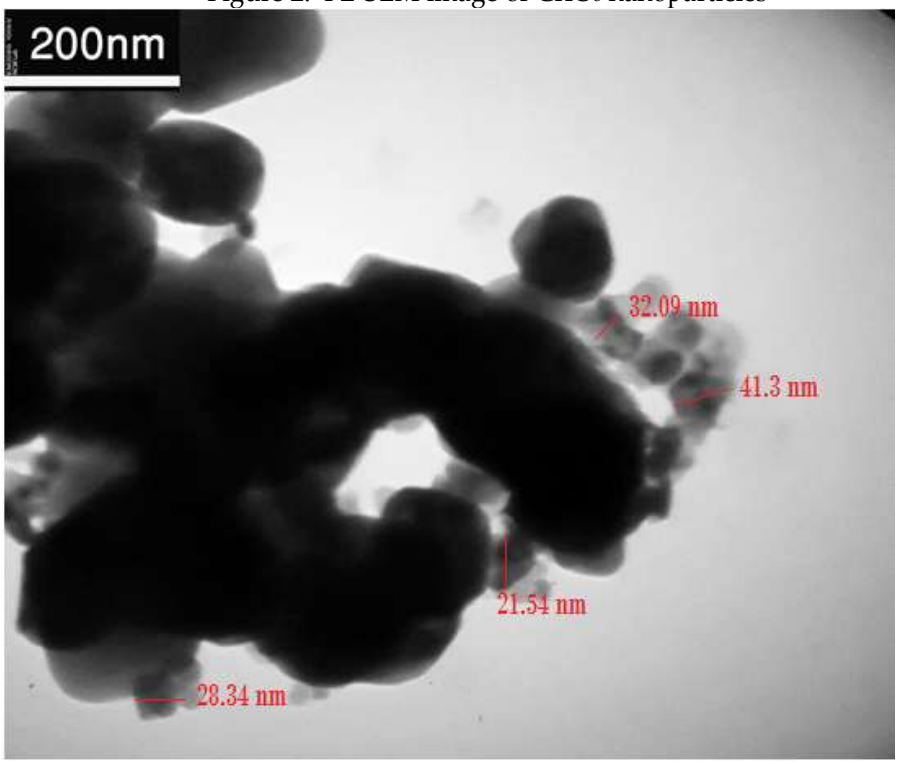

Figure 3. TEM image of of Cr_2O_3 nanoparticles.

Examine the MCF-7 breast cancer cell lines cytotoxicity.

The impact of the Cr_2O_3 NPs on MCF-7 cancer cells, which are often utilized in cancer research, was evaluated in a study [14], [15]. The cells were exposed to a range of Cr_2O_3 NPs concentrations at 48 hours, including 15, 30, 60, 120, and 240 μg/mL. For Cr_2O_3 nanoparticles, the IC50 value—which indicates the quantity that inhibits or kills half of the cancer cells—was determined to be 123.6 μg/mL. The results of the Cr_2O_3 nanoparticles showed that the material had a concentration-dependent impact, with higher concentrations causing more cancer cell killing, shown figure 4 and table 1

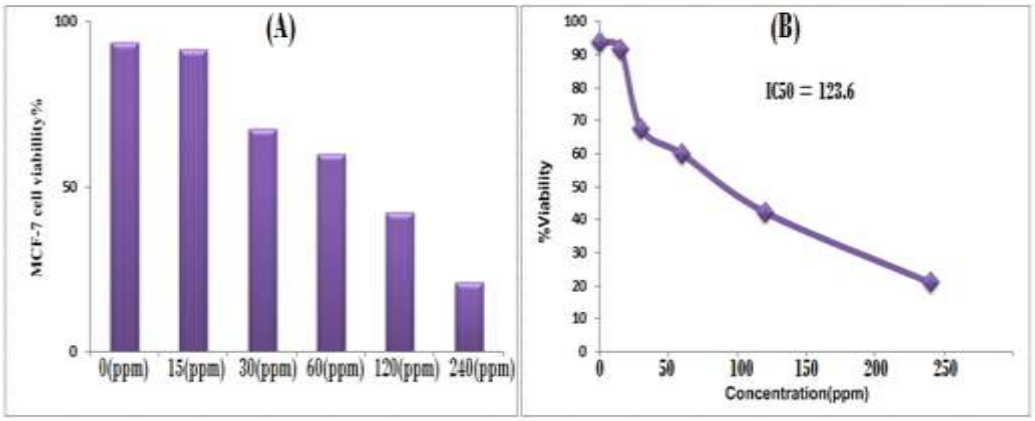

Figure 4. (A) Illustrates the percentage of cancer cell killing, and (B) shows the IC50 for the Cr_2O_3 NPs prepared using chemical precipitation.

Table 1 displays the concentrations of Cr_2O_3 NPs, the percentage of cancer cells killed, and the vitality of the cells.

Concentration (μg/mL)	Cell Death (%)	Cell Viability (%)
15	18.6135	81.3865
30	43.0357	56.9643
60	51.9849	48.0151
120	77.8742	22.1258
240	90.0563	9.9437

4. Conclusion

Chemical precipitation method was the technique used in this investigation to successfully synthesize of Cr_2O_3 NPs. Cr_2O_3 NPs were verified by a many methods (XRD, FE-SEM, and TEM). The XRD spectra verified the comfirm of Cr_2O_3 NPs phase type generated as an orthorhombic crystal system. By FE-SEM and TEM technique the size and form of the Cr_2O_3 nanoparticles was validated. Cr_2O_3 shown strong anticancer properties against human breast cancer cell lines in a concentration Cr_2O_3 nanoparticles-dependent manner, according to the results.

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