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Preparation of Copper Nanoparticles Using Different Media by Pulsed Laser Ablation and Study of Their Physical Properties

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ABSTRACT

In this study, copper nanoparticles (CuNPs) were prepared using the pulsed laser ablation method, and the study was conducted under the effect of changing the liquid medium (ethanol, deionized water, distilled water) with a number of pulses (700p/s) and using a (Q-switched Nd-YAG) laser. At a wavelength of 532nm and an energy of 100mJ, the results of the samples prepared in a medium (ethanol, distilled water, deionized water) showed the average radii of CuNPs (58.3, 61.6, 46.1 nm, respectively) with a spherical shape. The spectrum of copper at (3250 $cm^{-1}$to 3550 cm^{-1}) is mainly due to the expansion of (O-H) the clear hydroxyl group and under the conditions of the three solvents (ethanol, deionized water, distilled water). The XRD results showed that the CuO nanoparticles are free of impurities and crystallized High and the crystallite size was calculated at 2theta (20.094, 19.949, 38.045) nm for the samples in (deionized water, distilled water, and ethanol), respectively.

Keywords- copper nanoparticles, pulsed laser ablation, different media.

I. INTRODUCTION

Man took the path to the use of nanomaterials extensively during the previous years and in various industries, due to their very small size, which gave them properties not found in their counterparts of larger size [1]. Therefore, man has striven in the manufacture of nanomaterials, and this field has clearly developed. Nanoparticles are small solids whose size ranges from 1-100 nanometers [3,2]. Nanoparticles have different physical and chemical properties and others similar to their large-sized counterparts [4]. Nanoparticles are prepared in two ways[3]. The first method (construction) is from the bottom. To the top, where nanomaterials are prepared from very small materials, where the physical forces work on the self-assembly of the valve units to obtain stable structures of a larger size (nano). As for the second method, it is a process of demolition from top to bottom and depends on stable structures of large size and using multiple methods The material is fractionated into small nanoparticles [5]. Among the methods used is the pulsed laser ablation method, which is the method of exposing the material to a high-energy pulsed laser and is considered the most effective way to obtain nanoparticles [2,4] where the laser beam interacts with the target that leads to the volatilization of the material particles and the formation of plasma that is deposited on the base and forms membranes. kind [7,6].

II. THEORETICAL METHODS

Experimental PLAL method and preparation of CuNPs. The target is copper with high purity (99%), where a copper strip was made with dimensions (1 cm, 1 cm, 2 mm). The copper piece was cleaned first with ethanol and then immersed in liquid ethanol medium, where the copper slide was placed in a beaker containing The organic solvent was in the amount of (5ml) and the height of the liquid above the sample was (4ml). The study included a change in the liquid medium, where the process was repeated three times,

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each time only the liquid medium was changed. The media used in this study (ethanol, distilled water, deionized water) at A fixed number of pulses (700 p). The target was bombarded using a (Q-switched Nd-YAG) laser with a fixed excision energy of 100mJ and a wavelength of 532nm at a repetition rate (5HZ). By this bombing, a colloidal solution containing nanoparticles was obtained inside and in three media. Different (CuNPs suspended in ethanol medium, CuNPs in distilled water, CuNPs in deionized water).

III. RESULTS AND DISCUSSION

Field Emission Scanning Electron Microscopy (FESEM)

Figure 1 represents the FESEM topographes with three different magnifications of the prepared Cu nanoparticles attained through distalled water. It can be clearly percieved from the figure that the prepared Cu nanoparticles in distilled water have compact nanoparticles with some agglomirations. The diameter of the obtained Cu nanoparticles in distilled water ranges from 35nm to 90 nm with mean diameter of 61.6 Figure 2 demonstrates the prepared Cu nanoparticles using deionized water as the main solvent of this experiment. A clear agglomeration morphology of the addressed nanoparticles in deionized water can be observed. This could be due to the fact of the drop casting on glass slide procedure prior to the FESEM analysis test. As for the Cu nanoparticles in water, it can be noticed that the range of the measured diameter is ranging from 20 nm up to 90 nm, with mean diameter of 58.3 nm Subsequently, Figure 3 illustrates the morphological characteristics of the Cu nanoparticles in EtOH. In particular, the attained Cu nanoparticles showed fine nanoparticles formation, this can be clearly evidenced through the diameter distribution from 30 to 70 nm. Additionally, the utilized EtOH resulted in small nanoparticles diameter (46.1 nm). However, the formation of film-like morphology is mainly to the drop casting process, as stated previously

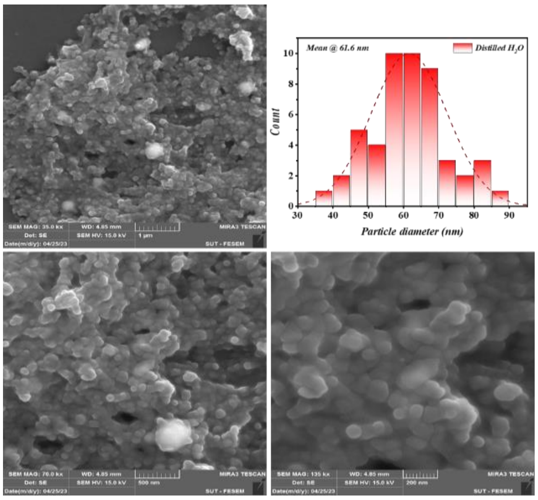

Figure 1: FE-SEM topographies of Cu nanoparticles in distilled H_2O

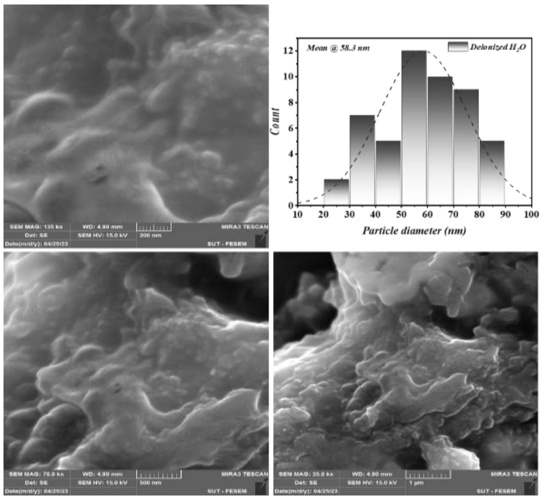

Figure 2: FE-SEM topographies of Cu nanoparticles in deionized H_2O

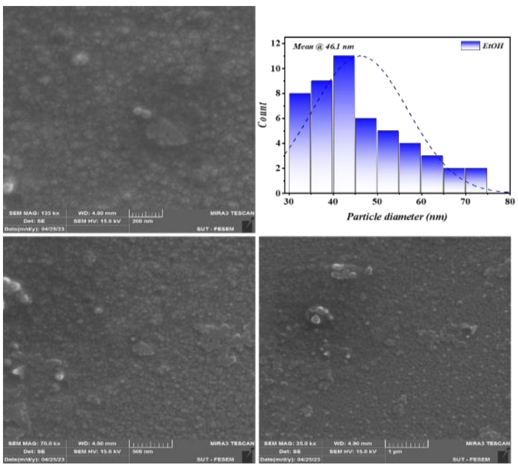

Figure 3: FE-SEM topographies of Cu nanoparticles in EtOH

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X-ray Diffraction

The X-ray diffraction patterns of the preparation CuO nanoparticles at different solvent type (EtOH, distilled H_2O, and deionized H_2O) are shown in Figure 4 which can be indexed to the single-phase structure of CuO (JCPDS No. 48-1548); in which three distinctive peaks were obtained. These outcomes were found to be in a good accordance with previously published research [8, 9]. It can be clearly noticed that there were no impurities perceived in the X-ray diffraction results; this indicates the purity and high crystallinity of the prepared CuO nanoparticles, with respect to the utilized solvent. However, it can be observed that higher peak intensity was attained using both deionized and distilled H_2O, while EtOH utilization during the preparation process demonstrated a decrease in the peak intensity. In accordance with Equation (1),

$$D = \frac{K\lambda}{\beta\, cos\theta} \quad (1)$$

The crystallite size at 2θ 35.6 were estimated to be 20.094, 19.949 and 38.045 nm for samples prepared in deionized H_2O, distilled H_2O, and EtOH respectively. The addressed data of the are presented in Table 1

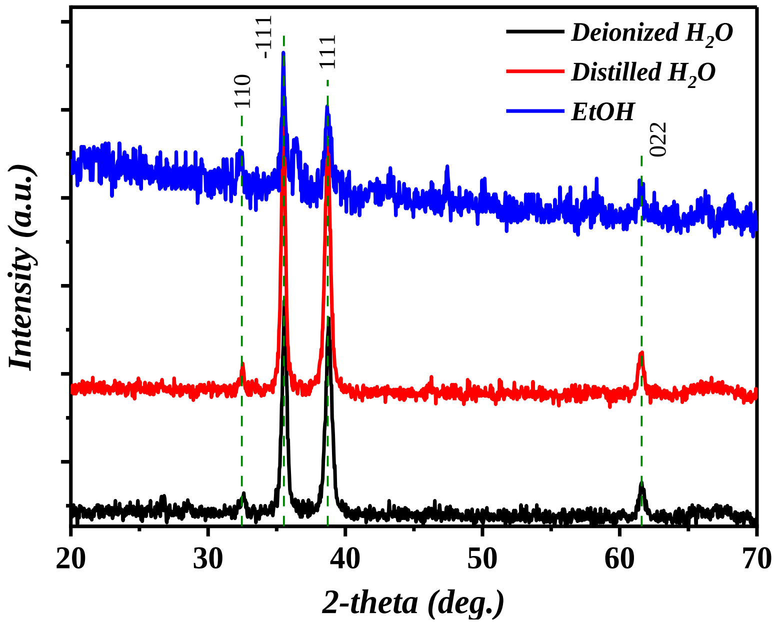

Figure 2: X-ray diffraction of the prepared CuO nanoparticles using EtOH,

Table 1: In-depth X-ray diffraction parameters of the CuO nanoparticles

Sample	2θ (deg.)	FWHM (deg.)	Crystallite size (nm)
Deionized H_2O	35.509	0.416	20.094
Distilled H_2O	35.576	0.419	19.949
EtOH	35.977	0.220	38.045

Fourier-Transform Infrared Spectroscopy

The Fourier transform infrared spectroscopy analysis for the prepared Cu nanoparticles under the effect of three different preparation solvent, EtOH, distilled H_2O, and deionized H2O, are illustrated in Figure 5 Generally, the un-expected broad band noticed between 3250 to 3550 could be mainly attributed to the clear stretching of hydroxyl groups; this was perceived for the prepared Co samples under all three solvent conditions, EtOH, distilled H_2O, and Deionized H2O. Another two noticeable bands at around 2950 and 2845 are obtained from the stretching, symmetric and asymmetric, of group and terminal groups and, respectively [10]; such observation was only observed under the effect of EtOH preparation condition. Continuously, other absorption bands of carboxylate coordination and metals located at around 1700 cm-1 for asymmetric stretching; this was accompanied with another peak at around 1400 in the EtOH spectrum [11]. However, under the preparation condition for Co using both distilled H_2O and deionized H_2O, the addressed peak (1400) was not found. In the meanwhile, the symmetric stretching of was located at around 1080 and 820 using EtOH as the main solvent. In the range below 800, the observed absorption bands are caused by stretching vibrations and [12]. This was perceived under the effect of three different conditions.

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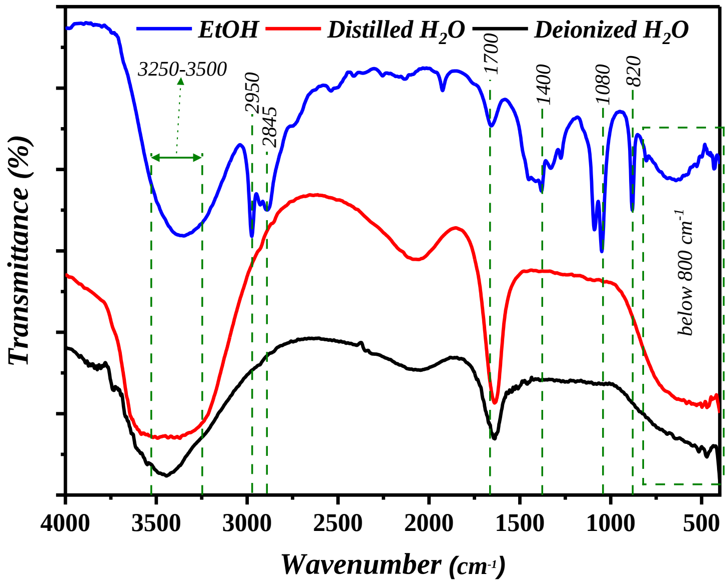

Figure 5: FT-IR spectra of the prepared Cu nanoparticles using EtOH, distilled H_2O, and deionized H_2O

IV. CONCLUSION

It is expected that the method will serve as a basis for the production of (CuNPs) and it was concluded that the best medium for preparing nanoparticles is absolute ethanol with a concentration of (99%). Pulsed laser ablation is considered one of the best methods for obtaining stable and active nanoparticles because it is a safe and environmentally friendly method. The results showed that (CuNPs) nanoparticles have excellent properties and grow in a liquid medium and are a potential candidate for photon diodes and biomedical development.

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