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Synthesis and Evaluation of Oleic Acid Coated Ag-Cu Alloy Doped with MWCNTs

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Abstract:

Electrode is vital component in solar cell which determine the efficiency of solar cell. The aim of present work to propose an efficient and low-cost material for electrode in solar energy area. Herein we synthesized oleic acid (OA) coated Ag-Cu alloy doped with MWCNTs nanocomposite. Oleic acid coated AgCu doped with MWCNTs nanocomposite was characterized through XRD, FTIR for crystal structural and compositional study. SEM was used to examine the surface morphology of prepared nanocomposite. SEM results revealed the successful formation oleic acid coated AgCu NPs on the surface of MWCNTs. Our research provides a path for an easy, productive, and cost-effective process for fabricating electrode composite.

Keywords: **Electrode, MWCNTs, Oleic acid, Nanocomposite**

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I. INTRODUCTION

In 21st century, energy is necessary for economic development and industrial growth around the world, yet global energy consumption is rising as the world's population and energy demands increases. As a result, preservation of energy has become the most essential and challenging subject of the extant era. Also, to match this increase in energy's consumption the world must produce this energy. Therefore, addressing this issue has become a key concern for researchers, scientists, and engineers. Fossil fuels provide most of the energy. Because of rising energy consumption, we will confront a fossil fuel shortfall in the future decades. As a result, the globe is edging closer to a grave energy crisis. Also, non-renewable energy sources are not reliable from environmental point of view causes pollution and dangerous for public health. Renewable sources of energy are an alternative source to the conventional energy sources from environmental viewpoint and low production costs. Among all renewable energy sources solar energy has gain much attention in the past decade. One of the most auspicious and endless renewable energy source is solar energy [1] . Solar energy source is reliable, clean, environment friendly and easy to use [2] . Solar cells play a vital role to provide us the easier way to use the huge source of renewable energy. But there are some limitations for commercialization of solar cells due to the high cost of materials that used as electrode, low conductivity of electrode and the low power conversion efficiency of solar cells [3] .

In order to improve the power conversion efficiency (PCE) of solar cell, the materials that use as electrode in a solar cell should be low in cost, have good stability, and have high electro catalytic activity and electrical conductivity [4] . Platinum (Pt) is a attractive material for electrode application in solar cell because of its superior conductivity and catalytic activity [5] . However, platinum is a rare and expensive noble metal, there is a need to look into Pt-free alternatives for solar cell electrodes [6] . Many scientists have been devoting their research , to several kinds of alternative materials like Carbon materials [7] , Conducting polymers [8] , Metal materials [9],Transition metals [10], Alloy [11] etc. have been explored and introduced to replace Pt.

Among them Ag-Cu alloy gain attention for electrode due to their remarkable catalytic activity [12] and the low cost of the materials. Their low conductivity, on the other hand, is the main drawback that prevents them from being good electrode materials for solar cells [13] . Therefore, an excellent strategy to overcome this issue to incorporate Ag-Cu alloy with additional conductive materials. Multiple-wall carbon nanotubes (MWCNTs) are very effective due to high conductivity of MWCNTs [14] . As a result, Ag-Cu alloy containing MWCNTs will be an excellent candidate as a CE to improve solar cell electrical conductivity. But pure MWCNTs have to instability issues [15]. However, polymers or surfactants such as Sodium Citrate, Oleic Acid, Triton X-100, and others can improve the stability issues of MWCNTs [16] . One of them is the addition of Oleic Acid (OA), which can be quite beneficial for dispersion of MWCNTs through which improve its stability issue.

The purpose of present study is to Synthesis and Evaluation of Oleic Acid Coated Ag-Cu alloy doped with MWCNTs nanocomposite. We are proposing that the synthesized nanocomposite has low cost and has high catalytic activity thus it could be a better choice as electrode for Solar cell application.

II. METHODS AND MATERIALS

A. Chemicals

In the present work, AgCu Nanoparticles were synthesized through chemical reduction method. This method provides several advantages over other methods, such as simplicity, low production cost and easy to scale up to satisfy large-scale production requirements. The precursors used in this experiment were Copper nitrate Cu $(NO_3)_2.3H_2O$ and Silver nitrate ($AgNO_3$) procured from Merck. The reducing agents includes Sodium Polyacrylate ($C_3H_3NaO_2$), and Sodium borohydride ($NaBH_4$) procured from Sigma-Aldrich. Rest of chemical includes MWCNTs, Oleic Acid, O-xylene and acetone all were purchased from Sigma-Aldrich. All the chemicals were used without further purification. Deionized water was used to prepare precursor solutions.

B. Synthesis of Silver-Copper Nanoparticles

AgCu Nanoparticles were synthesized by chemical reduction method. First, aqueous solution of copper nitrate in deionized water (0.6 M in 10mL) was mixed with aqueous solution of Sodium polyacrylate (0.6 M in 10 mL) solution of deionized water. The solution was stirred at 300 rpm at room temperature for half hour. Later, aqueous solution of Sodium Borohydride (1.6 M in 10 mL) in deionized water was added in the solution through injection. After that, aqueous solution of Silver nitrate (10 mL, 2.16 M) was added, and the solution stirred for half hour. After the reaction, a black product was formed which were washed and were dried at 45^0C

temperature for 12 hours before further proceedings.

C. Preparation of Nanocomposite

The nanocomposite was prepared by solution mixing method. In this process, first Silver-Copper NPs were capped by Oleic acid. For Oleic acid capping, we take 3wt % of obtained AgCu nanoparticles in xylene were added into 6 % (v/v) of Oleic acid in xylene solution and mixture was stirred for 1.5 hour at 40^0C. After those Multiwalled Carbon nanotubes was blended into aforementioned solution of Oleic acid Coated AgCu nanoparticles and solution stirred at 300 rpm maintaining temperature 40^0C for 20 minutes. The solution was then sonicated for one and half hours at 40^0C temperature. As a result, solution containing Oleic acid coated AgCu alloy doped with MWCNTs nanocomposite was fabricated. The solution containing nanocomposite was then centrifuged to separate the residuals and after that were washed three times with acetone to get desired Oleic acid coated AgCu alloy doped with MWCNTs nanocomposite and grind to fine powder for further process.

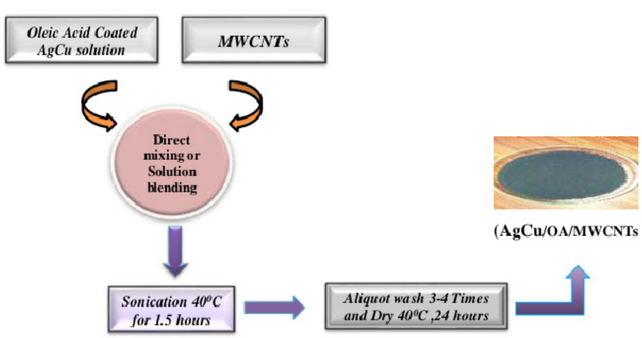

Fig 1: Flow Chart of Fabrication of AgCu/OA/MWCNTs

III. INSTRUMENTS

X-ray data was collected on Bruker D8 Advance Diffractometer with copper tube (λ= 1.5406 A^0) was used for the phase identification of composite with average range 20^0 to 80^0 along with LYNXEYETM detector. FTIR spectrum was recorded using Perkin-Elmer double beam spectrophotometer with 0.5 cm^{-1} resolution operating between 400 to 4000 Cm^{-1}. SEM (JEOL JSM-6490LV) operated at 20 kV equipped with EDX was employed to examine the morphology of the sample. EDX was used to study the elemental composition of nanocomposite.

IV. RESULT AND DISCUSSIONS

D. Phase Identification

XRD analysis of AgCu-OA-MWCNTs nanocomposite was carried out to identify the phase and crystallite size of the given nanocomposite. The diffraction analysis of the nanocomposite is shown in figure below. XRD analysis describes that the prepared AgCu-OA-MWCNTs nanocomposite has polycrystalline in nature The XRD spectrum in Fig. 2. shows the pattern Oleic acid coated AgCu alloy doped with Multiwalled Carbon Nanotube nanocomposite at angle between 20 ^{0} to 80 ^{0}. As seen in Figure 2, the diffraction peaks at Bragg's angles 38.06, 44.17, 64.45 and 77.28 correspond to pure silver with corresponding reflecting planes of (111), (200), (220) and (311) respectively. Also, the diffraction peaks at Bragg's angles 50.89 and 74.18 correspond to pure copper with corresponding reflecting planes of (200) and (220) respectively.

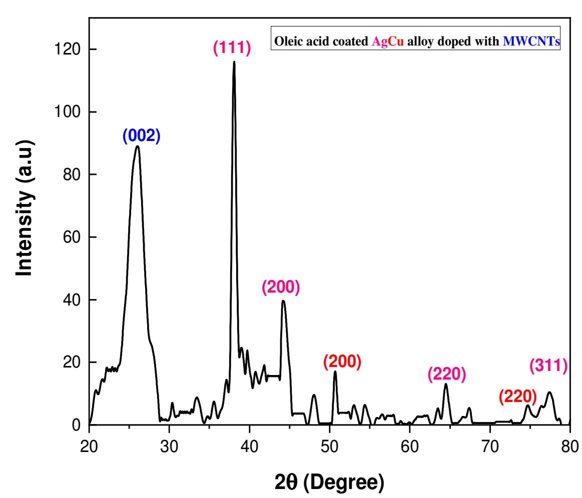

Figure: 2 XRD pattern of Oleic Acid Coated AgCu alloy doped with MWCNTs

The obtained peaks matches with standard peaks and are well agreed with the standard JCPDS results [17] . Also, the lattice plane (002) at 26.38^0 of an angle 2ϴ confirming of multiwalled nature of carbon nanotubes which matches exactly to the JCPDS Card No.00-041-1487 [18] . The sharpness of peaks points to crystalline behavior of the sample. Debye-Scherrer formula was to calculate the crystallite size:

$$D = \frac{0.94\lambda}{\beta COS\Theta}$$

Where, ϴ, λ, β and D corresponds to diffraction angle, wavelength, Full width half maximum, and crystallite size respectively. The crystallite size of the Oleic acid coated AgCu alloy doped with MWCNTs nanocomposite was determined to be 27.33 nm.

E. Compositional analysis

FTIR is a technique used for examining the composition analysis of the composite through observing the bond vibrations of functional groups.

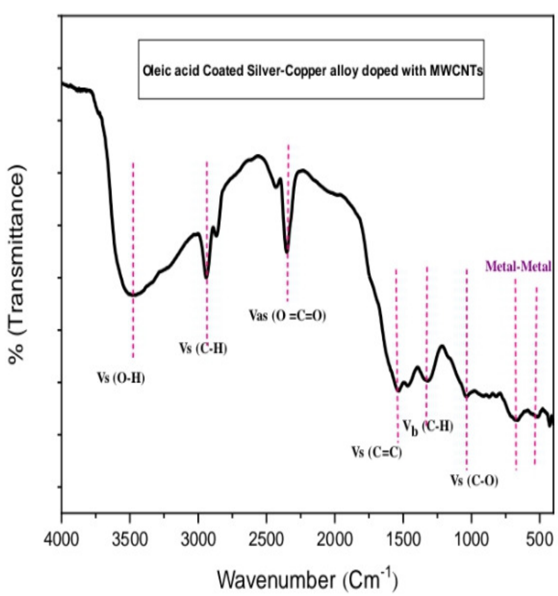

Fig. 3 FTIR Spectra of Oleic acid Coated AgCu nanoparticles doped with MWCNTs

Fig.3 shows the FTIR spectra of oleic acid coated AgCu nanoparticles doped with MWCNTs. The presence of hydroxyl groups is represented by a prominent broad band at 3200–3500cm^{-1}, which is assigned to O–H stretching frequency. The band seen at 2942 cm^{-1} correspond to C–H stretching vibrations in alkane [19] . Carbon dioxide absorbs from the environment, resulting in a medium peak at 346.25cm^{-1} [20] . The sharp signal at 1547.5 cm^{-1} corresponds to mono substitute alkene C=C stretching. C-H (alkane) bending and C-O stretching are shown by the peaks at 1333.75 cm^{-1} and 1041.25 cm^{-1}, respectively [21]. The peaks located at 679 cm^{-1} and 523.75 cm^{-1}which is the indication of the presence of metal to metal (Ag-Cu) bonding [22] .

TABLE 1

FTIR DATA ANALYSIS

Assignments	IR Region (cm^{-1})
(O-H) stretching	3482.5
(C-H) stretching	2942
O=C=O	2346.25
C=C	1547.5
(C-H) bending	1333.75
(C-O)	1041.25
Metal-Metal bond	679, 523.75

The absorption spectra at 1547.5 cm^{-1} confirmed the existence of C=C, indicating the hexagonal shape of the MWCNTs [23] .

F. Surface Morphology

The SEM was used to examine the surface morphology and microstructural properties of synthesized nanoparticles. The SEM image obtained for the pure AgCu alloy synthesized from chemical reduction method is shown in Fig. 4.

From the SEM image of AgCu nanoparticles, it is observed that the synthesized AgCu nanoparticles comprise of high density and compact alignment of uniform AgCu nanoparticles with a wide distribution of particles display almost spherical shape reported in literature [24] . SEM image of AgCu nanoparticles further revealed that a few of the small particles aggregate to make secondary particles due to its high surface energy and extremely small dimension.

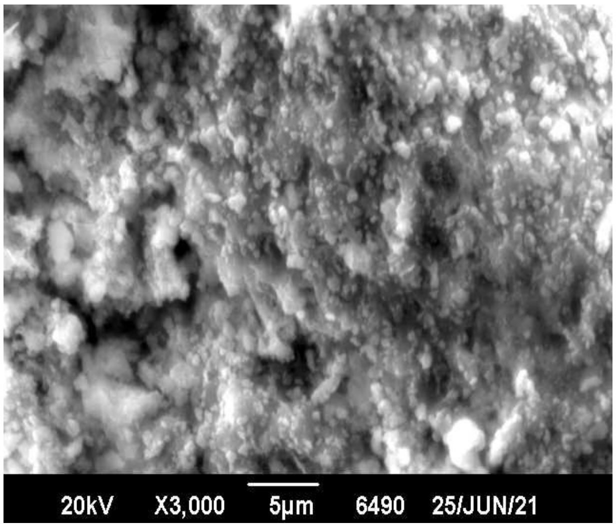

Fig.4 SEM Image of pure Ag-Cu alloy

Fig.5 shows SEM image of AgCu-MWCNTs (1: 0.2) nanocomposite coated by Oleic acid. From the SEM image it is clearly seen that the AgCu NPs and powder of MWCNTs are mixed together uniformly to make its nanocomposite. Voids of intermediate size has been achieved because of solvent evaporation, which can accelerate charge transfer at the interface between AgCu nanoparticles and MWCNT boundaries. This type surface morphology is ideal for the making of electrode material because it will give high surface area. When a substance has a large surface area, it usually has a high conductivity.

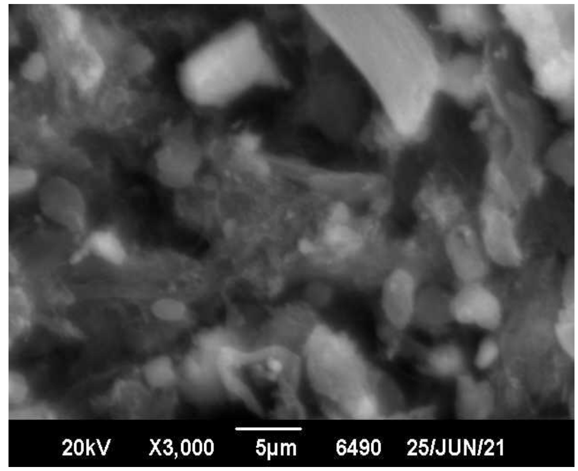

Fig.5 SEM analysis of AgCu-OA-MWCNTs nanocomposite at a magnification of 5µm

V. Conclusions

In present research work, we successfully synthesized Oleic acid Coated Ag-Cu alloy doped with MWCNTs nanocomposite. The crystallite size, composition and morphology are confirmed by characterization of the synthesized nanocomposite by XRD, FTIR and SEM. According to XRD study, the structural behavior of the prepared nanocomposite is polycrystalline in nature. The crystallite size of nanocomposite was determined to be 27.33 nm. The FTIR study revealed that the peaks located at 665 cm^{-1} and 516 cm^{-1} which is the indication the presence of metal to metal (Ag-Cu) bonding. SEM analysis reveals that Oleic acid coated AgCu Nanoparticles are successfully formed on the surface of MWCNTs with Voids of intermediate size has been achieved. This type surface morphology is ideal for the making of electrode material because it will give high surface area. When a substance has a large surface area, it usually has a high conductivity. So, we are proposing that the synthesized AgCu/OA/MWCNTs could be used as electrode material.

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