Silver Nanoparticles

INTRODUCTION

Recent advances in nanoscience and nanotechnology radically changed the way we diagnose, treat, and prevent various diseases in all aspects of human life. Silver nanoparticles (AgNPs) are one of the most vital and fascinating nanomaterials among several metallic nanoparticles that are involved in biomedical applications. AgNPs play an important role in nanoscience and nanotechnology, particularly in nanomedicine. Although several noble metals have been used for various purposes, AgNPs have been focused on potential applications in cancer diagnosis and therapy.

SYNTHESIS

Synthesis of AgNPs Using Physical and Chemical Methods

Generally, the synthesis of nanoparticles has been carried out using three different approaches, including physical, chemical, and biological methods. In physical methods, nanoparticles are prepared by evaporation-condensation using a tube furnace at atmospheric pressure . Conventional physical methods including spark discharging and pyrolysis were used for the synthesis of AgNPs . The advantages of physical methods are speed, radiation used as reducing agents, and no hazardous chemicals involved, but the downsides are low yield and high energy consumption, solvent contamination, and lack of uniform distribution.

Chemical methods use water or organic solvents to prepare the silver nanoparticles . This process usually employs three main components, such as metal precursors, reducing agents,

CHARACTERISATION

The physicochemical properties of nanoparticles are important for their behavior, bio-distribution, safety, and efficacy. Therefore, characterization of AgNPs is important in order to evaluate the functional aspects of the synthesized particles. Characterization is performed using a variety of analytical techniques, including UV-vis spectroscopy, X-ray diffractometry (XRD), Fourier transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), dynamic light scattering (DLS), scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM). Several qualified books and reviews have presented the principles and usage of various kinds of analytical techniques for the characterization of AgNPs

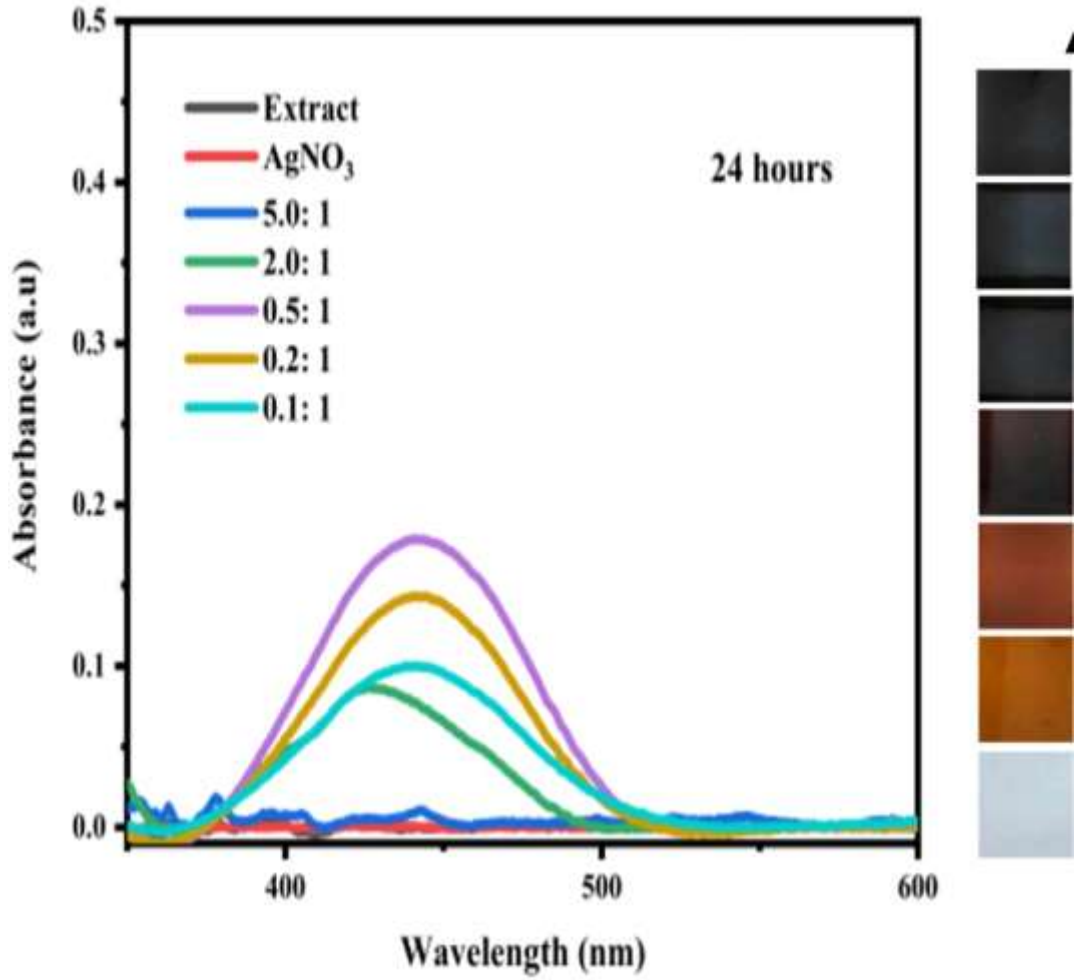
CHARACTERIZATION TECHNIQUES :-

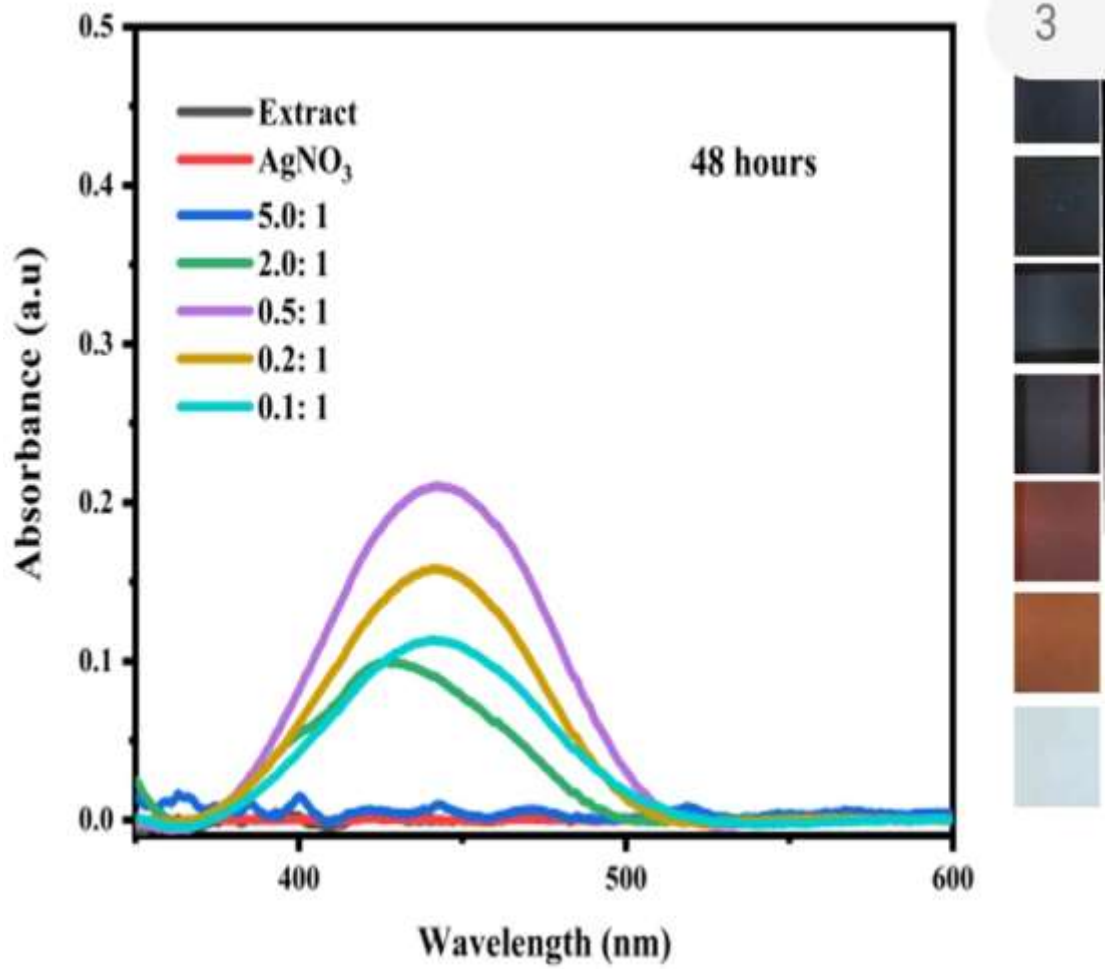
- UV – VIS spectroscopy
- XRD
- Scanning electron microscopy
- Transmission electron microscopy

UV VIS SPECTROSCOPY

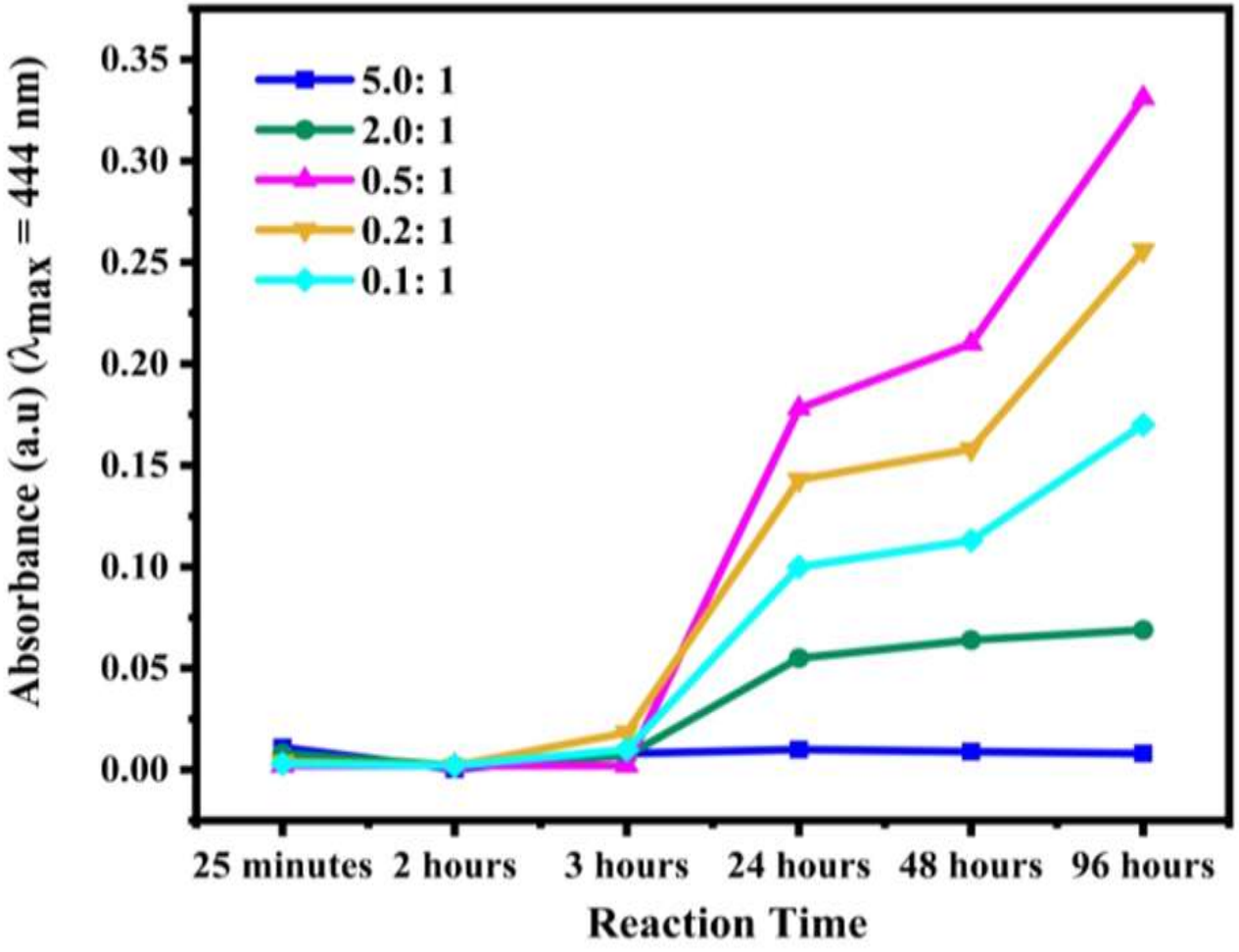
- UV-vis spectroscopy is a very useful and reliable technique for the primary characterization of synthesized nanoparticles which is also used to monitor the synthesis and stability of AgNPs . AgNPs have unique optical properties which make them strongly interact with specific wavelengths of light . In addition, UV-vis spectroscopy is fast, easy, simple, sensitive, selective for different types of NPs, needs only a short period time for measurement, and finally a calibration is not required for particle characterization of colloidal suspensions . In AgNPs, the conduction band and valence band lie very close to each other in which electrons move freely. These free electrons give rise to a surface plasmon resonance (SPR) absorption band, occurring due to the collective oscillation of electrons of silver nano particles in resonance with the light wave . The absorption of AgNPs depends on the particle size, dielectric medium, and chemical surroundings . Observation of this peak—assigned to a surface plasmon—is well documented for various metal nanoparticles with sizes ranging from 2 to 100 nM. The stability of AgNPs prepared from biological methods was observed for more than 12 months, and an SPR peak at the same wavelength using UV-vis spectroscopy was observed.

GRAPHS:


Extract
AgNO3
5.0: 1
2.0: 1
0.5: 1
0.2: 1
0.1: 1
24 hours
Absorbance (a.u)
Wavelength (nm)
0.0
0.1
0.2
0.3
0.4
0.5
400
500
600


Extract
AgNO3
5.0: 1
2.0: 1
0.5: 1
0.2: 1
0.1: 1
48 hours
Absorbance (a.u)
Wavelength (nm)
0.0
0.1
0.2
0.3
0.4
0.5
400
500
600

GRAPHS



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XRD:

- X-ray diffraction (XRD) is a popular analytical technique which has been used for the analysis of both molecular and crystal structures , qualitative identification of various compounds , quantitative resolution of chemical species , measuring the degree of crystallinity , isomorphous substitutions , particle sizes , etc. When X-ray light reflects on any crystal, it leads to the formation of many diffraction patterns, and the patterns reflect the physico-chemical characteristics of the crystal structures. In a powder specimen, diffracted beams typically come from the sample and reflect its structural physico-chemical features. Thus, XRD can analyze the structural features of a wide range of materials, such as inorganic catalysts, superconductors, biomolecules, glasses, polymers, and so on . Analysis of these materials largely depends on the formation of diffraction patterns. Each material has a unique diffraction beam which can define and identify it by comparing the diffracted beams with the reference database in the Joint Committee on Powder Diffraction Standards (JCPDS) library. The diffracted patterns also explain whether the sample materials are pure or contain impurities. Therefore, XRD has long been used to define and identify both bulk and nanomaterials, forensic specimens, industrial, and geochemical sample materials.

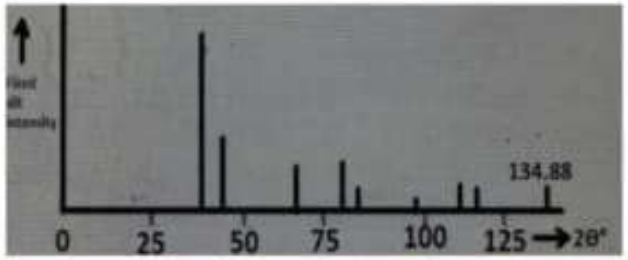
- XRD is a primary technique for the identification of the crystalline nature at the atomic scale. X-ray powder diffraction is a nondestructive technique with great potential for the characterization of both organic and inorganic crystalline materials . This method has been used to measure phase identification, conduct quantitative analysis, and to determine structure imperfections in samples from various disciplines, such as geological, polymer, environmental, pharmaceutical, and forensic sciences. Recently, the applications have extended to the characterization of various nano-materials and their propertieS. The working principle of X-ray diffraction is Bragg's law. Typically, XRD is based on the wide-angle elastic scattering of X-rays. Although XRD has several merits, it has limited disadvantages, including difficulty in growing the crystals and the ability to get results pertaining only to single conformation/binding state . Another drawback of XRD is the low intensity of diffracted X-rays compared to electron diffractions .

GRAPHS

PDF #040783, Wavelength = 1.54056

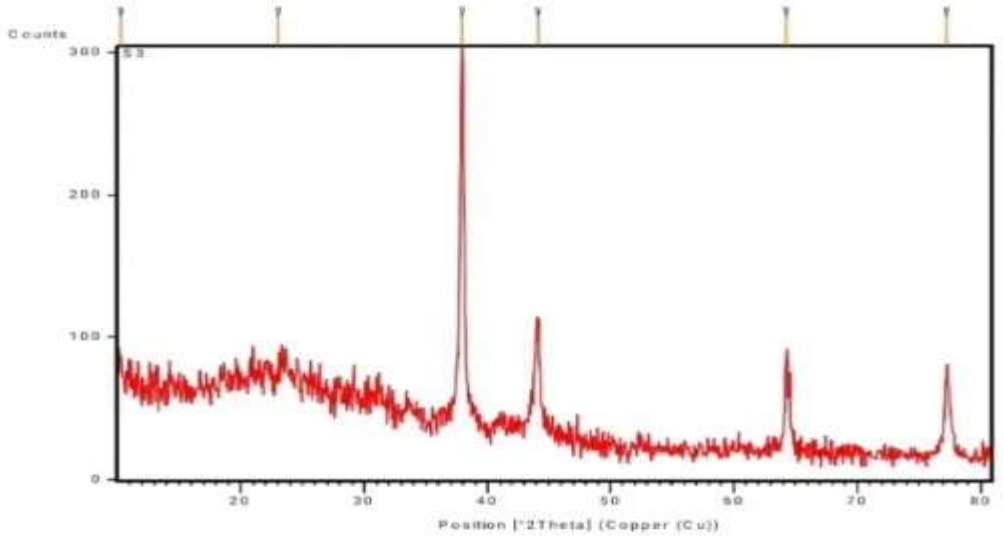
04-0783	Quality 1
CAS Number :	7440-22-4
Molecular Weight:	107.87
Volume[CD]:	68.23
Dx:10.501	Dm:10.500
Sys:	Cubic
Lattice:	Face-centered
S. G.:	Fm3m[225]
Cell parameters:	
a = 4.086	b e
α	β γ
SS/FOM:	F9=65(.0153, 9)
I/Icor:	5.20
Rad:	CuKa1
Lambda:	1.54056
Filter:	Ni
d-sp	
Mineral Name:	Silver,3C syn

Ag
Silver
Ref: Swanson, T ntge, Natl Bur. Stand. (U.S.) Circ.559,I, 23 (1953)



2θ	Int-f	h	k	l
38.116	100	1	1	1
44.277	40	2	0	0
64.426	25	2	2	0
77.472	26	3	1	1
81.537	12	2	2	2
97.888	4	4	0	0
110.49	15	3	3	1
114.92	12	4	2	0
134.88	13	4	2	2

Main Graphics, Analyze View: (Bookmark 2)

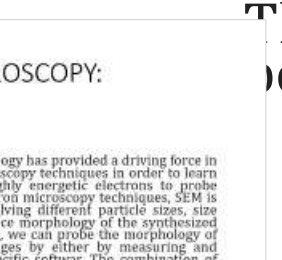


Peak List: (Bookmark 3)

Pos. [°2Th.]	Height [cts]	FWHM Left [°2Th.]	d-spacing [Å]	Rel. Int. [%]
10.3118	18.20	0.5904	8.57875	6.93
23.0586	10.80	3.1488	3.85722	4.11
37.9509	262.66	0.3444	2.37092	100.00
44.1954	82.90	0.2460	2.04934	31.56
64.2615	62.59	0.1968	1.44953	23.83
77.2219	62.64	0.2952	1.23542	23.85

SCANNING ELECTRON MICROSCOPY:

- Recently, the field of nanoscience and nanotechnology has provided a driving force in the development of various high-resolution microscopy techniques in order to learn more about nanomaterials using a beam of highly energetic electrons to probe objects on a very fine scale . Among various electron microscopy techniques, SEM is a surface imaging method, fully capable of resolving different particle sizes, size distributions, nanomaterial shapes, and the surface morphology of the synthesized particles at the micro and nanoscales. Using SEM, we can probe the morphology of particles and derive a histogram from the images by either by measuring and counting the particles manually, or by using specific softwar. The combination of SEM with energy-dispersive X-ray spectroscopy (EDX) can be used to examine silver powder morphology and also conduct chemical composition analysis. The limitation of SEM is that it is not able to resolve the internal structure, but it can provide valuable information regarding the purity and the degree of particle aggregation. The modern high-resolution SEM is able to identify the morphology of nanoparticles below the level of 10 nm.


OSCOPY:

ogy has provided a driving force in
scopy techniques in order to learn
ghly energetic electrons to probe
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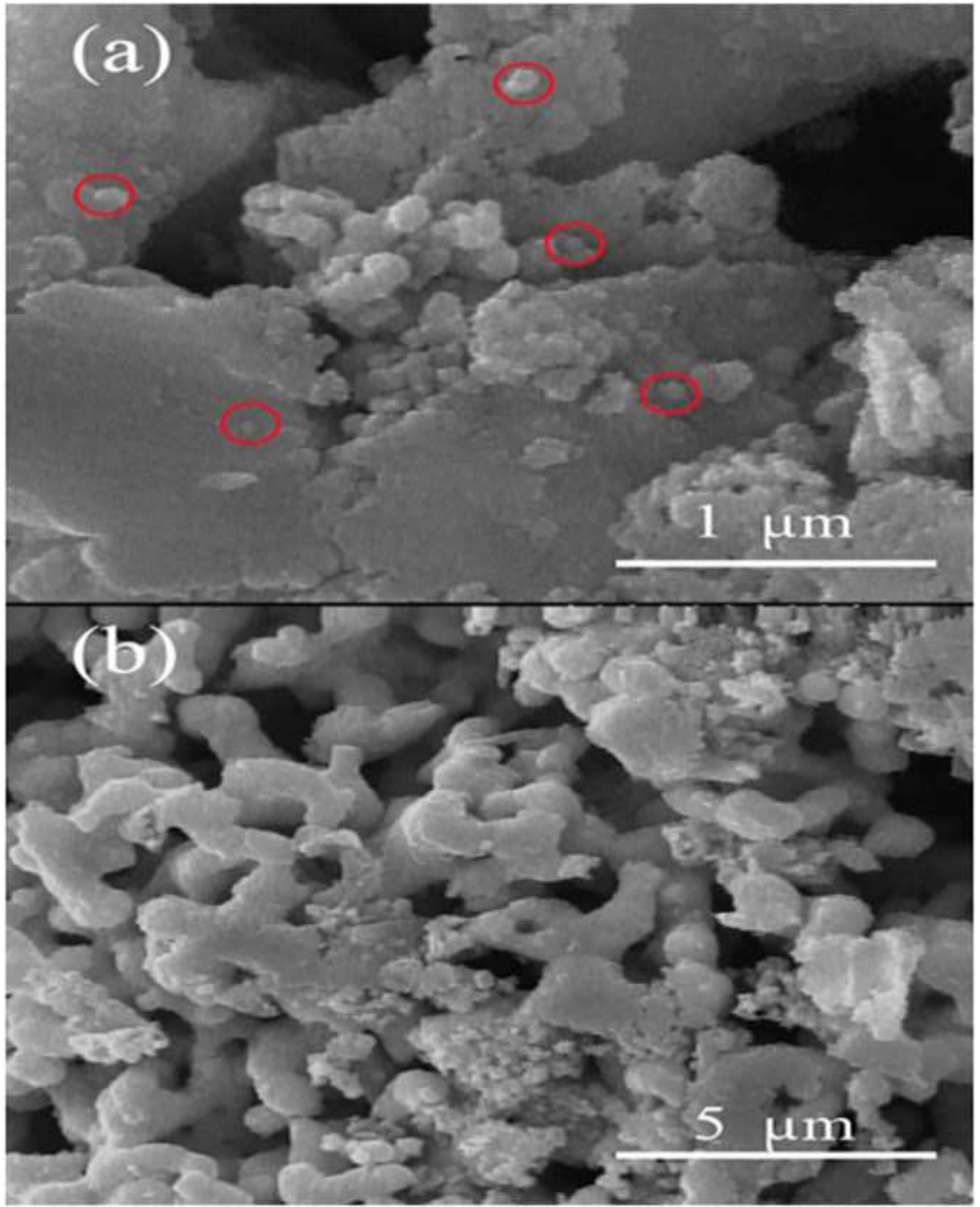
ce morphology of the synthesized
, we can probe the morphology of
ges by either by measuring and

RESULTS OF SEM:

- In order to investigate the morphology of the as-prepared products, SEM images were recorded for each sample. Figure belowshows the SEM images of Ag-N300 in two different magnifications. In Fig a small nanoparticles with the size of less than 100 nm are detectable which are shown in red circles. However, from Fig b it is clearly observed that the sample consists of highly agglomerated nanoparticles, which have formed large aggregates with diameter of 400 nm to 2.5 µm

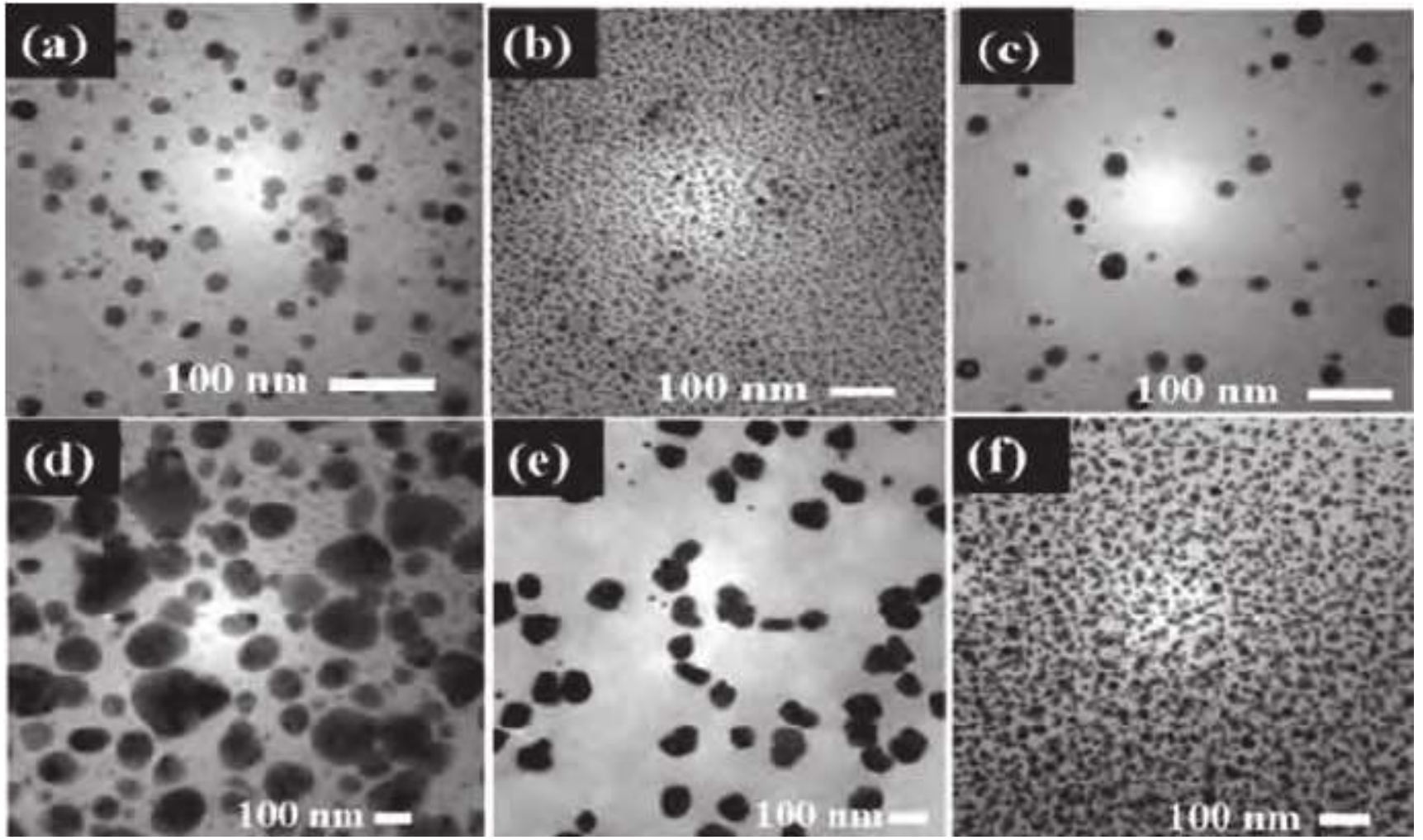
SEM IMAGES:



TRANSMISSION ELECTRON MICROSCOPY:

- TEM is a valuable, frequently used, and important technique for the characterization of nanomaterials, used to obtain quantitative measures of particle and/or grain size, size distribution, and morphology . The magnification of TEM is mainly determined by the ratio of the distance between the objective lens and the specimen and the distance between objective lens and its image plane . TEM has two advantages over SEM: it can provide better spatial resolution and the capability for additional analytical measurements . The disadvantages include a required high vacuum, thin sample section , and the vital aspect of TEM is that sample preparation is time consuming. Therefore, sample preparation is extremely important in order to obtain the highest-quality images possible.

TEM IMAGES

- 

APPLICATIONS

- Due to their peculiar properties, they have been used for several applications, including as antibacterial agents, in industrial, household, and healthcare-related products, in consumer products, medical device coatings, optical sensors, and cosmetics, in the pharmaceutical industry, the food industry, in diagnostics, orthopedics, drug delivery, as anticancer agents, and have ultimately enhanced the tumor-killing effects of anticancer drugs . Recently, AgNPs have been frequently used in many textiles, keyboards, wound dressings, and biomedical devices .