“Physics of Nanostructures for Sustainable Development Goals

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Beni-Suef University

9/2/2024

Outline

- About the presenter
- Definition and Examples
- Physical Properties
  - Size
  - Crystal Structure
  - Melting Point
  - Mechanical Strength
- Optical Properties
  - Surface Plasmons
  - Quantum Confinement Effects
- Electrical Properties
- Health Concerns
- Applications in Energy-Water-

Total publications=138
Total citations=3123
H index=32
FWCI=1.46 Phys.Sci
FWCI=1.55 Eng&Tech

50 M.Sc.and Ph.D. Students
20 Awarded

S.I.El-Dek

PI for 3 projects
CoPI and mem for 3 projects
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30 conferences
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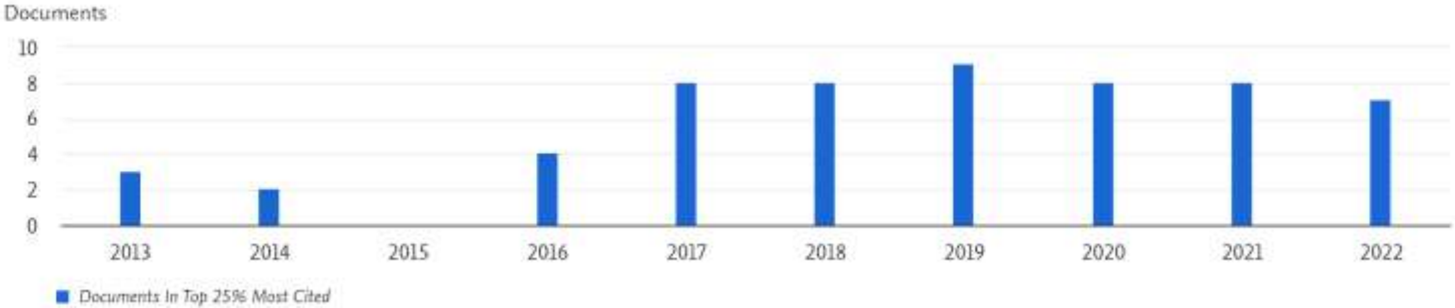

Documents and Field-Weighted Citation Impact

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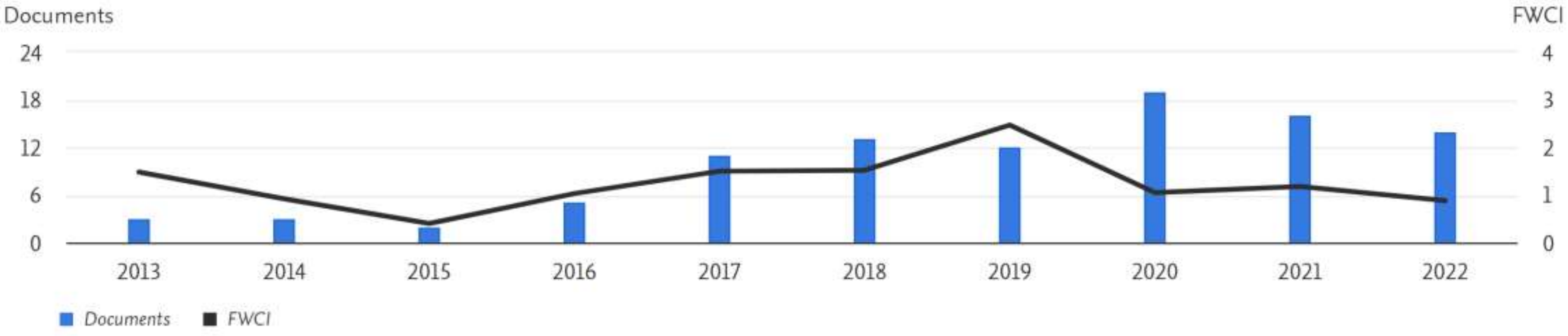


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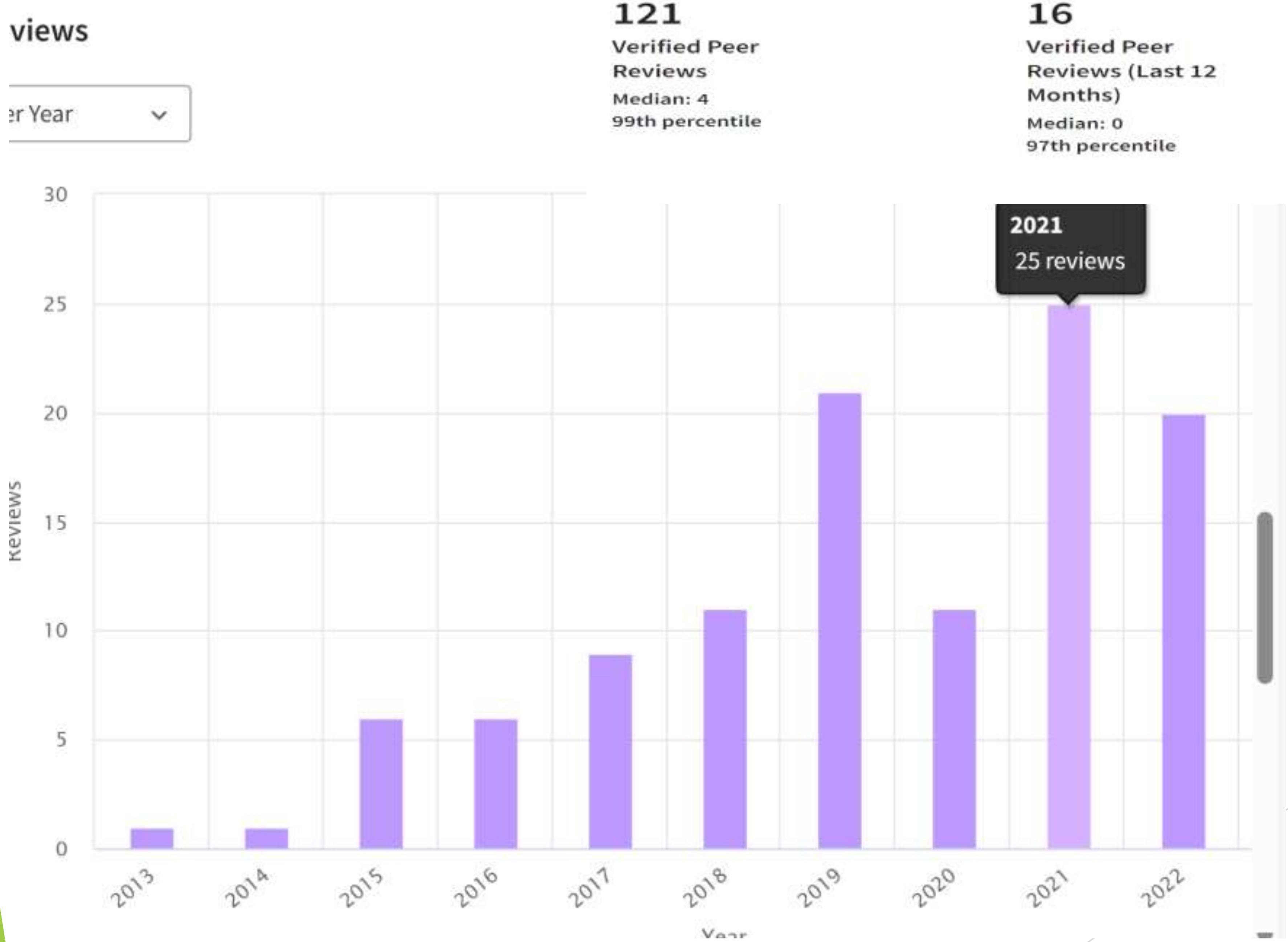
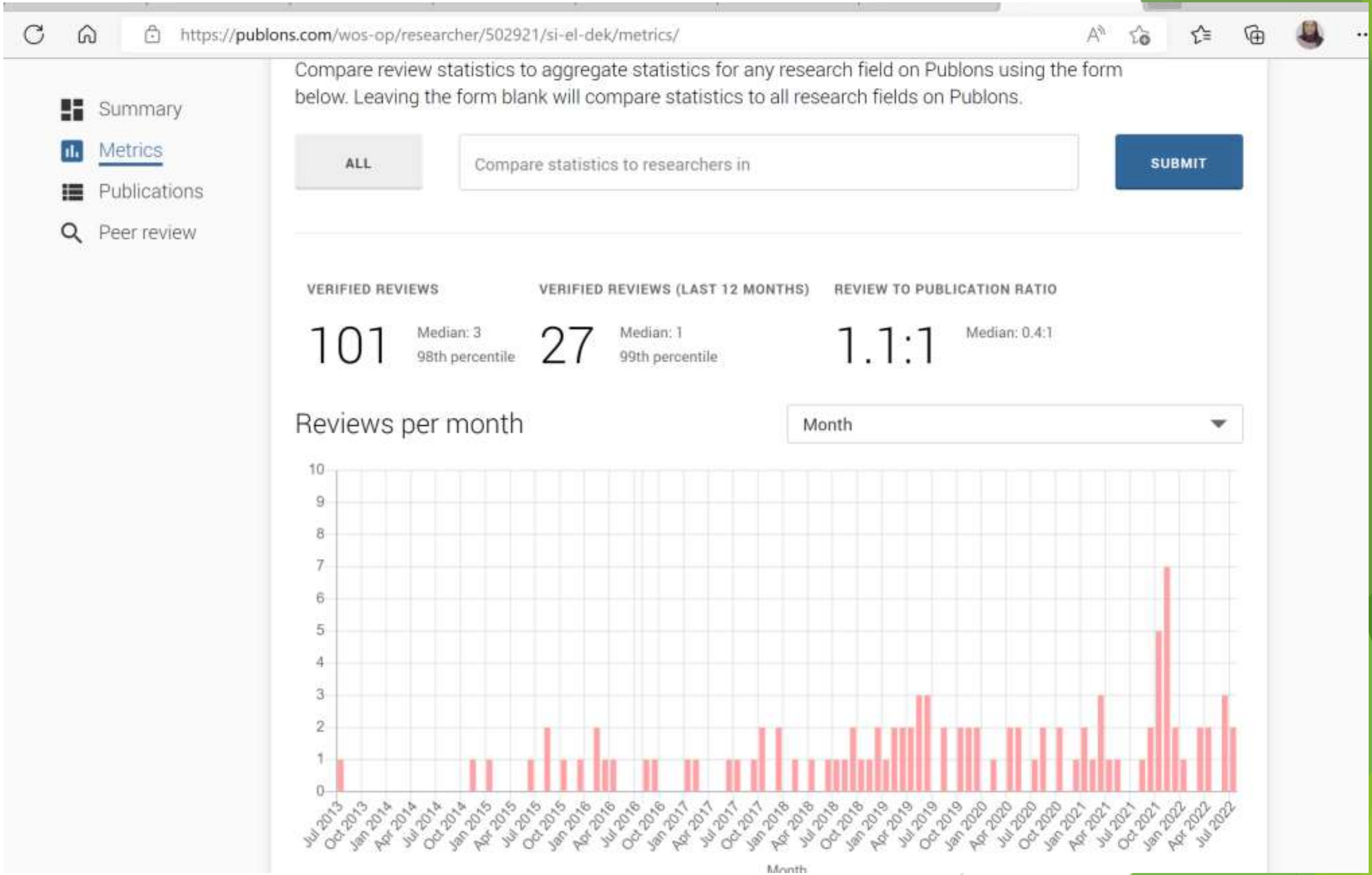
Peer Review Metrics

121
Verified Peer Reviews
Median: 4
99th percentile

16
Verified Peer Reviews (Last 12 Months)
Median: 0
97th percentile

1.2:1
Peer Review to Publication Ratio
Median: 0.3:1

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Reviews per month
Month
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- Summary
- Metrics
- Publications
- Peer review

Verified reviews

(14) Journal of Alloys and Compounds WOS	(14) Journal of Magnetism and Magnetic Materials WOS
(9) Beni-Suef University Journal of Basic and Applie... WOS	(8) Environmental Science and Pollution Research WOS
(6) Journal of Materials Science: Materials in Electr... WOS	(6) Materials Research Express WOS
(6) Physica B: Condensed Matter WOS	(5) Materials Research Bulletin WOS
(4) Journal of Electronic Materials WOS	(4) Nano-Structures & Nano-Objects
(3) Applied Nanoscience WOS	(3) Journal of Physics D: Applied Physics WOS
(2) International Journal of Polymeric Materials and ... WOS	(2) Journal of Semiconductors WOS
(2) Philosophical Magazine Letters WOS	(2) Ultrasonics Sonochemistry WOS
(2) Vacuum WOS	(1) ACS Applied Nano Materials WOS
(1) Applied Clay Science WOS	(1) Desalination and Water Treatment WOS
(1) Elsevier	(1) Emerging Materials Research WOS
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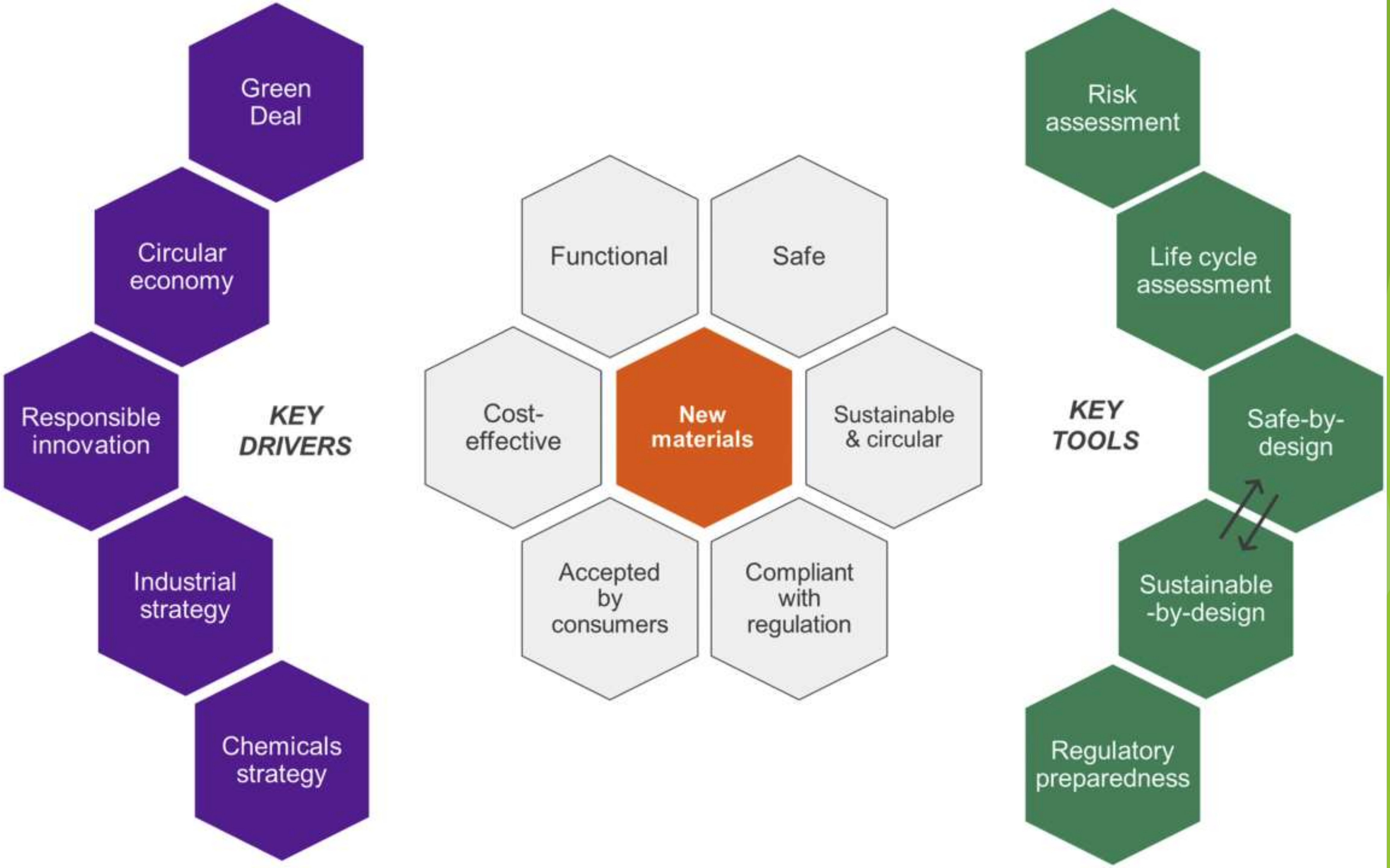
Sustainability
➢ Improve quality of human life
➢ Supporting Eco-system
➢ Maintains
Social
Environment
Economic

Current urgent problems caused by environmental and social stressors addressed by the United Nations' Sustainable Development Goals

Introduction to Nanoparticles and Nanostructures



Green Deal
Circular economy
Responsible innovation
Industrial strategy
Chemicals strategy
KEY DRIVERS
Functional
Safe
Cost-effective
New materials
Sustainable & circular
Accepted by consumers
Compliant with regulation
KEY TOOLS
Risk assessment
Life cycle assessment
Safe-by-design
Sustainable-by-design
Regulatory preparedness

Characterizing Nanomaterials

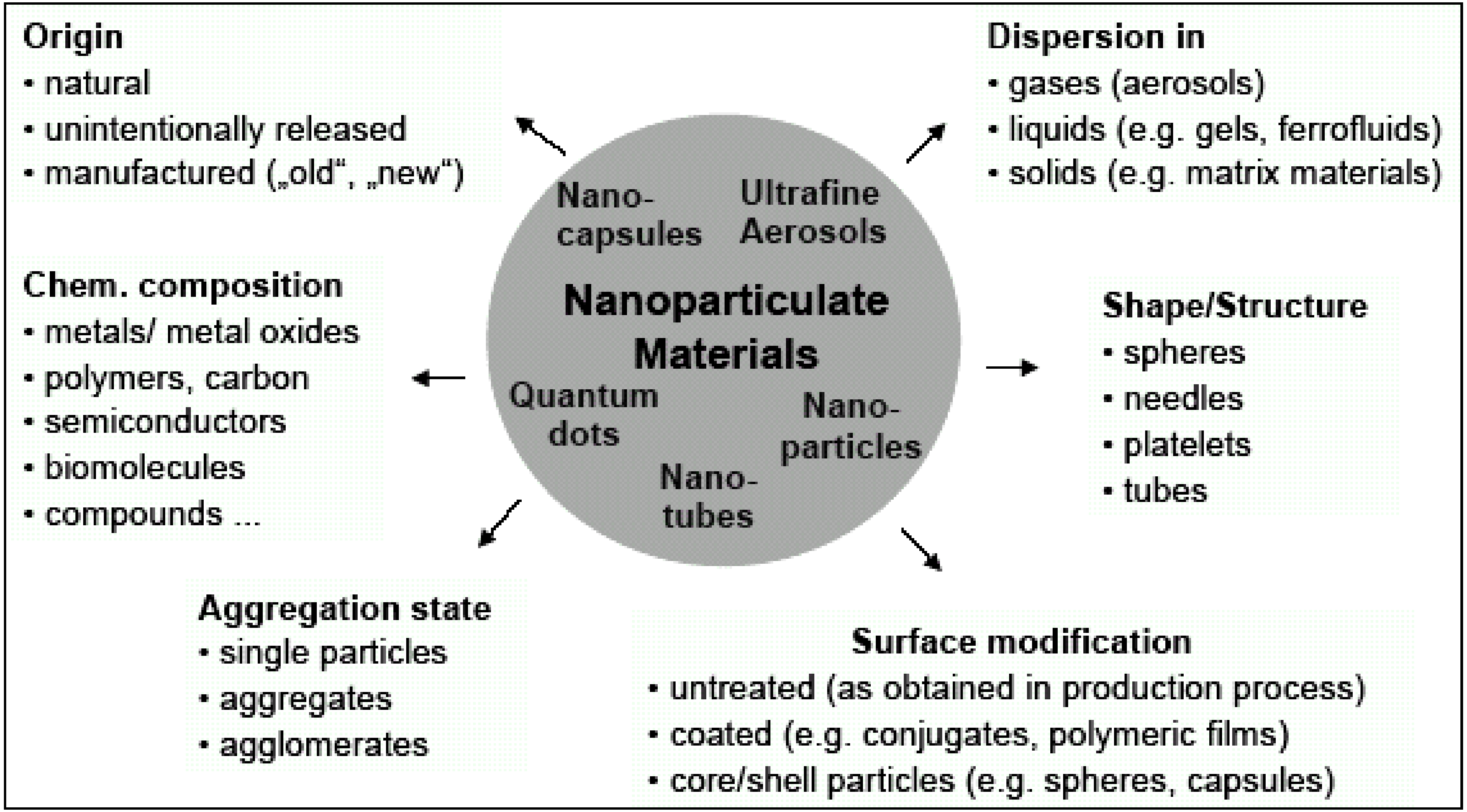
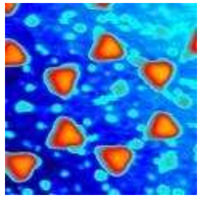
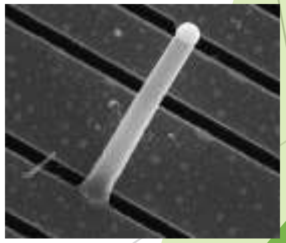


Figure 1: Characterisation parameters of nanoparticulate materials (source: VDI-TZ)

Definition of Nanoparticle

- A structure with at least 1 dimension less than 1 μm.
- Examples:
  - Sphere-like particles
    - Ag nanoparticles, buckyballs
  - Rod-like particles
    - Si & Ni nanowires
  - Tube-like particles
    - Carbon nanotubes
    - TiO_2 nanotubes






Size is a Material Property?

<u>The gold we know:</u>

Material properties don't change with size

- resistivity
- melting point
- optical absorption

<u>The gold we are discovering:</u>

Material properties (such as optical Absorption, shown here) change with the size of the gold nanoparticle.

Outline

- Definition and Examples
- Physical Properties
  - Size
  - Crystal Structure
  - Melting Point
  - Mechanical Strength
- Optical Properties
- Electrical Properties
- Health Concerns

Nanomaterials have unique properties

How can these properties be used to protect the environment?

Properties	Examples
Catalytic	Better catalytic efficiency through higher surface-to-volume ratio
Electrical	Increased electrical conductivity in ceramics and magnetic nanocomposites, increased electric resistance in metals
Magnetic	Increased magnetic coercivity up to a critical grain size, superparamagnetic behaviour
Mechanical	Improved hardness and toughness of metals and alloys, ductility and superplasticity of ceramic
Optical	Spectral shift of optical absorbtion and fluorescence properties, increased quantum efficiency of semiconductor crystals
Sterical	Increased selectivity, hollow spheres for specific drug transportation and controlled release
Biological	Increased permeability through biological barriers (membranes, blood-brain barrier, etc.), improved biocom-patibility

Table 3: Adjustable properties of nanomaterials

Unique Characteristics of Nanoparticles

- Large surface to volume ratio
- High percentage of atoms/molecules on the surface
- Surface forces are very important, while bulk forces are not as important.
- Metal nanoparticles have unique light scattering properties and exhibit plasmon resonance.
- Semiconductor nanoparticles may exhibit confined energy states in their electronic band structure (e.g., quantum dots)
- Can have unique chemical and physical properties
- Same size scale as many biological structures

Examples of Unusual Properties

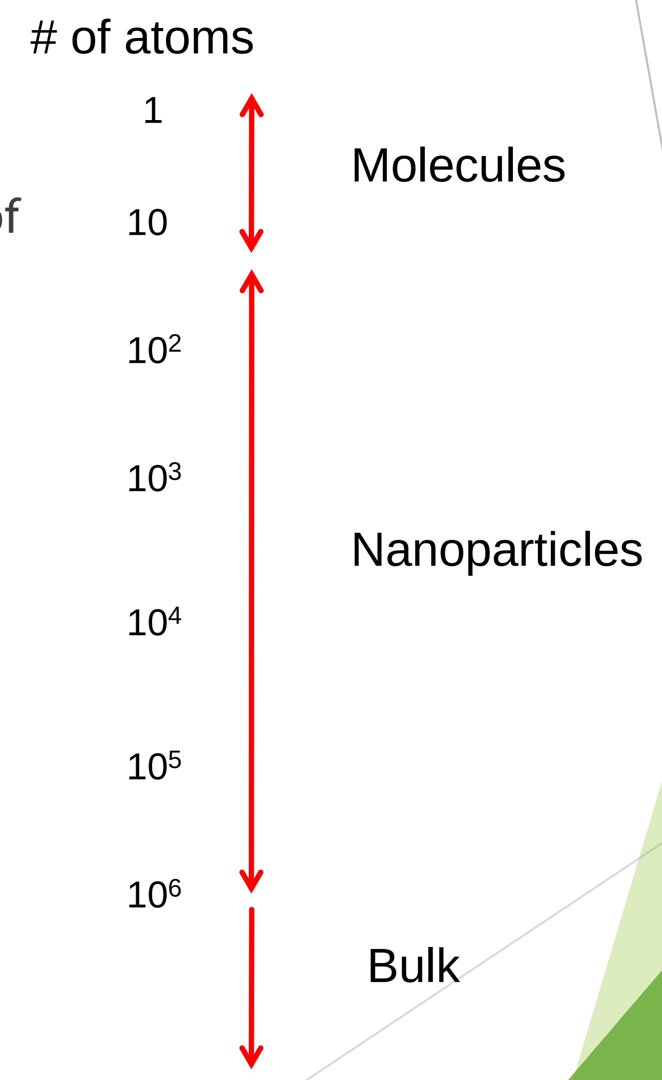
- Lowered phase transition temps
- Increased mechanical strength
- Different optical properties
- Altered electrical conductivity
- Magnetic properties
- Self-purification and self-perfection

Physical Properties of Nanoparticles

- Physical properties of nanoparticles are dependent on:
  - Size
  - Shape (spheres, rods, platelets, etc.)
  - Composition
  - Crystal Structure (FCC, BCC, etc.)
  - Surface ligands or capping agents
  - The medium in which they are dispersed

Size

- Molecules, nanoparticles, and bulk materials can be distinguished by the number of atoms comprising each type of material.
- *Note:* these are very approximate numbers!



Poole, C., Owens, F. *Introduction to Nanotechnology*. Wiley, New Jersey. 2003

Size

- Nanoparticles exhibit unique properties due to their high surface area to volume ratio.
- A spherical particle has a diameter (D) of 100nm.
  - Calculate the volume (V) and surface area (SA)

$$V = \frac{4}{3}\pi r^3 = \frac{\pi D^3}{6}$$

$$V = \frac{\pi(100 \times 10^{-9})^3}{6}$$

$$V = 5.24x10^{-22}m^3$$

$$SA = 4\pi r^2 = \pi D^2$$

$$SA = \pi(100 \times 10^{-9})^2$$

$$SA = 3.141 \times 10^{-14} m^2$$

Poole, C., Owens, F. *Introduction to Nanotechnology*. Wiley, New Jersey. 2003

Surface Area:Volume Ratio

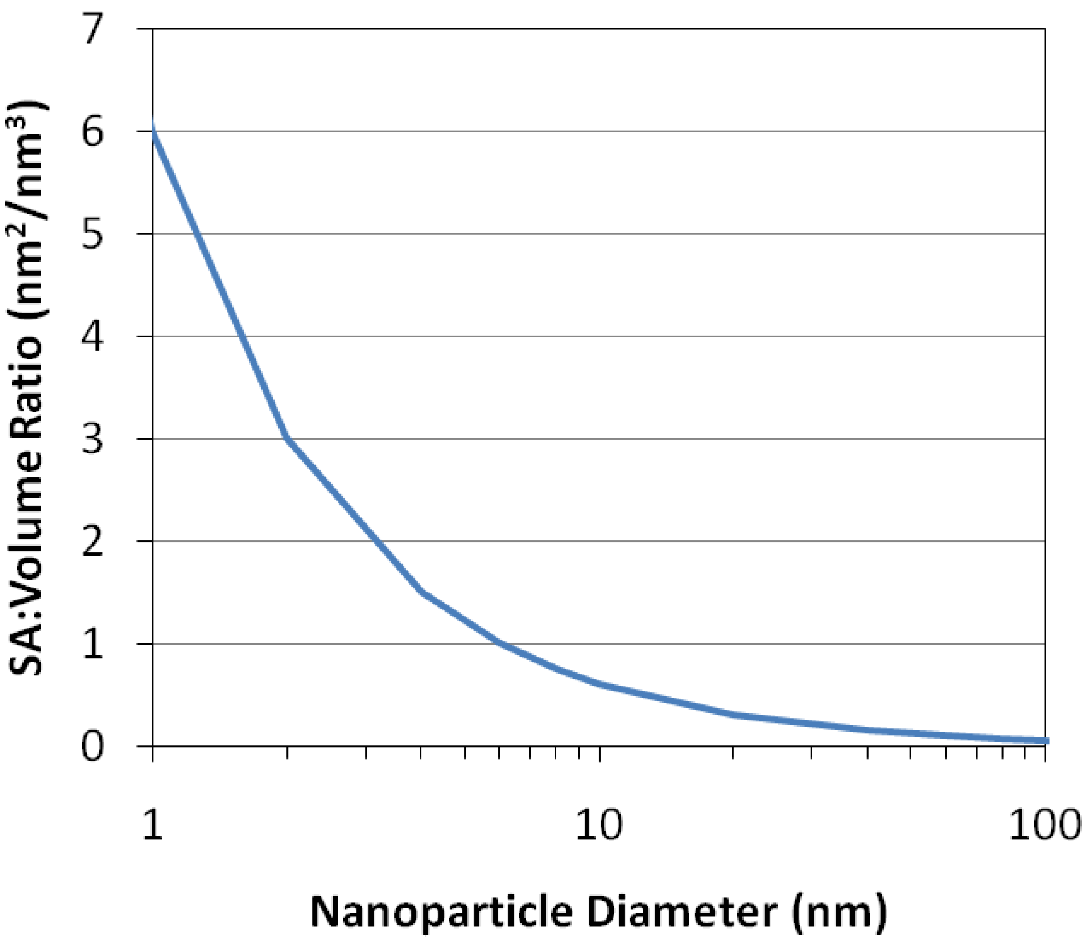
- This gives an approximate surface area to volume ratio of $>10^7:1$ which is significantly larger than a macro sized particle.
- As the surface area to volume ratio increases so does the percentage of atoms at the surface and surface forces become more dominant.
- Generally accepted material properties are derived from the bulk, where the percentage of atoms at the surface is miniscule. These properties change at the nanoscale.

Size

Some example calculations for volume and surface area of nanoparticles. These calculations use nm as unit of length.

Nanoparticle Diameter (nm)	Nanoparticle Diameter (um)	Volume (nm^3)	Surface Area (nm^2)	SA:Vol Ratio (nm^2/nm^3)
1	0.001	0.524	3.14	6
10	0.01	524	314	0.6
100	0.1	523598	31416	0.06
1000	1	5.24E+08	3.14E+06	0.006
10000	10	5.24E+11	3.14E+08	0.0006
100000	100	5.24E+14	3.14E+10	0.00006
1000000	1000	5.24E+17	3.14E+12	0.000006

Surface Area:Volume Ratio



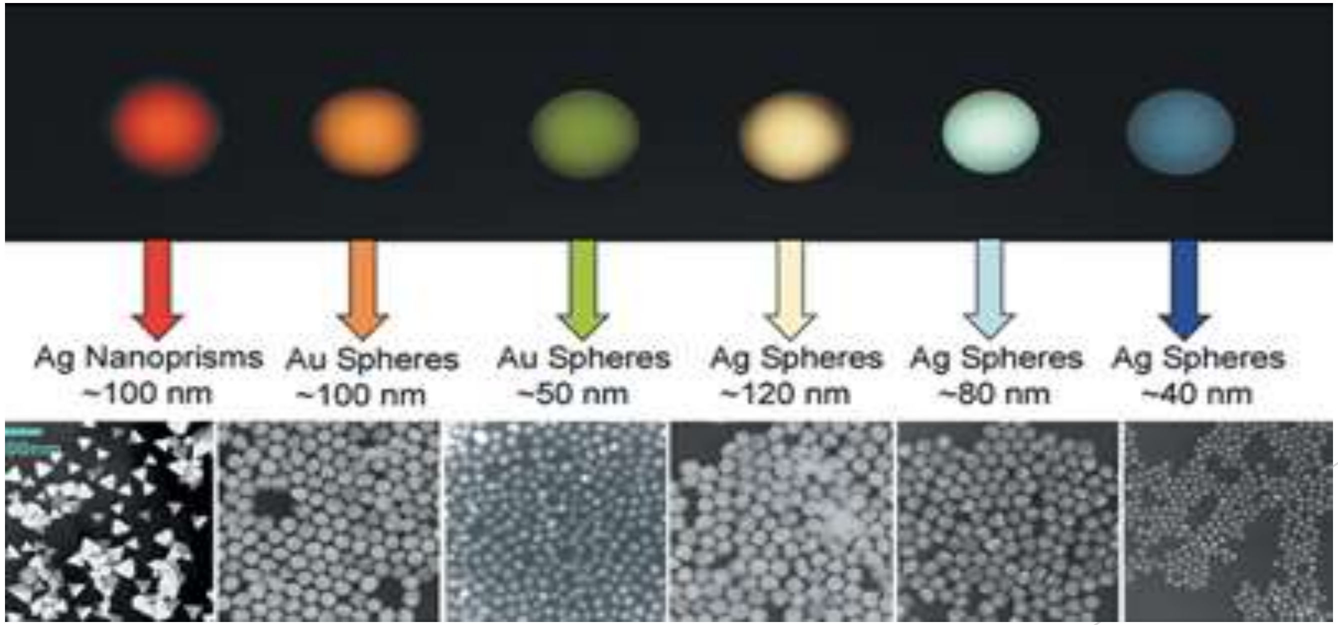
In this graph:
SA = nm^2
Vol = nm^3

SA:Vol Ratio = nm^2/nm^3

The ratio increases dramatically when the nanoparticle diameter drops below about 100 nm

Size

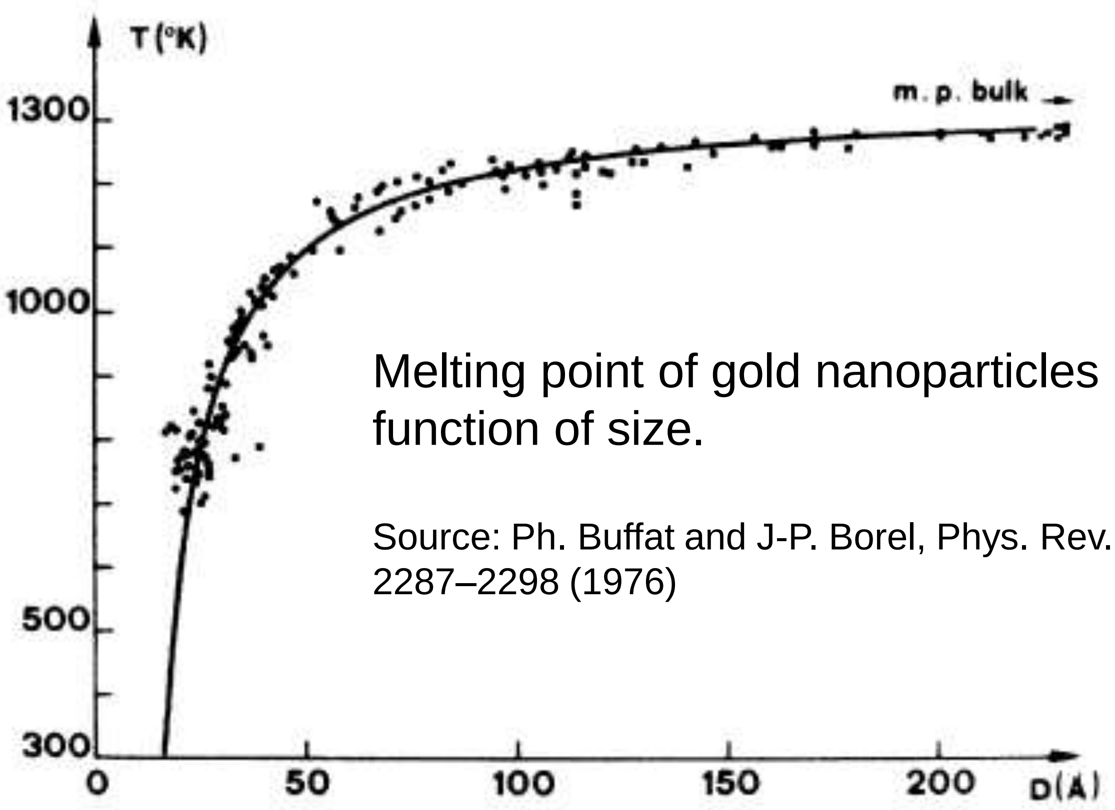
- As the percentage of atoms at the surface increases, the mechanical, optical, electrical, chemical, and magnetic properties change.
  - For example optical properties (color) of gold and silver change, when the spatial dimensions are reduced and the concentration is changed.



Size

Melting point as a function of particle size

- Nanoparticles have a lower melting point than their bulk counterparts



Melting point of gold nanoparticles as a function of size.

Source: Ph. Buffat and J-P. Borel, Phys. Rev. A 13, 2287–2298 (1976)

mp versus Shape

- Particles: May sinter together at lower than expected temperature.
- Rods: Can melt and form spherical droplets if heated too high.
- Films: Thin films can form pin-holes. Continued heating can lead to de-wetting behavior and island formation.

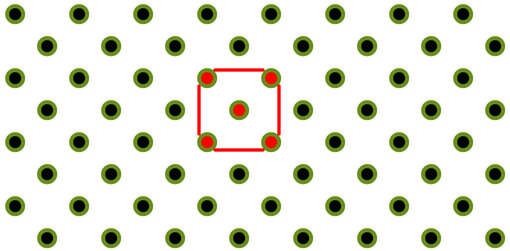
Crystal Structure

- Most solids are crystalline with their atoms arranged in a regular manner.
- This arrangement of atoms impacts the functionality of the material.
- Some solids have this order presented over a long range as in a crystal.
- Amorphous materials such as glass and wax lack long range order, but they can have a limited short range order, defined as the local environment that each atom experiences.

Poole, C., Owens, F. *Introduction to Nanotechnology*. Wiley, New Jersey. 2003

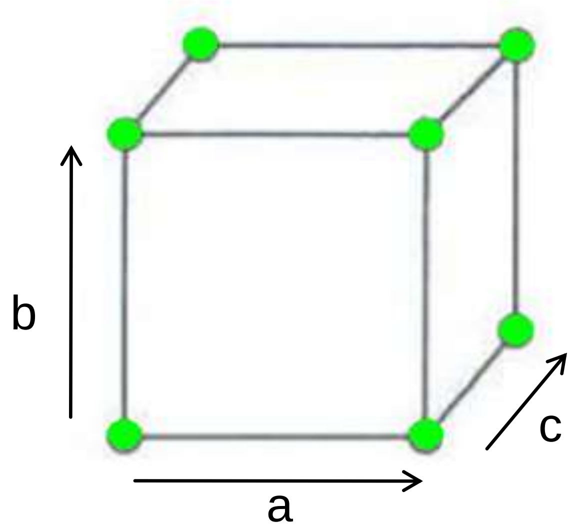
Crystal Structure

- The spatial arrangement of atoms in a crystal lattice is described by its unit cell.
- The unit cell is the smallest possible volume that displays the full symmetry of the crystal.
- Many materials have a “preferred” unit cell.



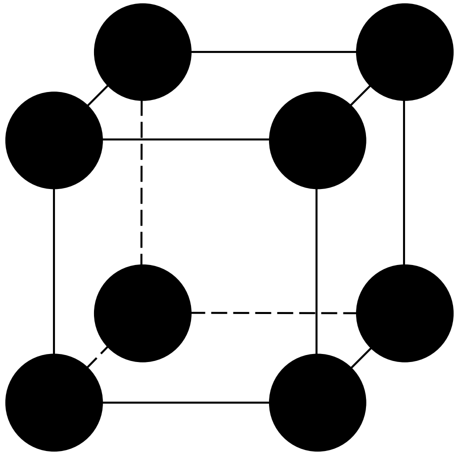
Crystal Structure

- In 3 dimensions, unit cells are defined by 3 lattice constants and 3 angles.
- This leads to 14 Bravais lattices, each having characteristic restrictions on the lattice constants, angles, and centering of atoms in the unit cell.

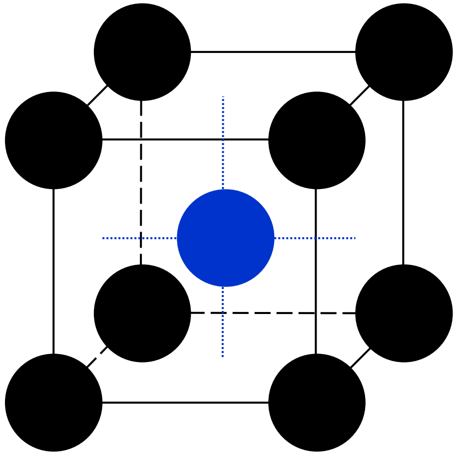


Crystal Structures

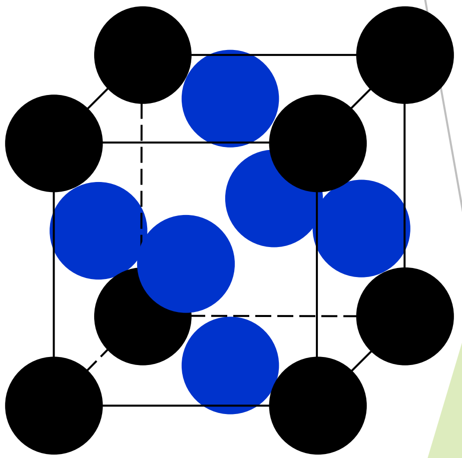
For cubic unit cells, there are three centering types:



Simple Cubic
(SC)



Body Centered Cubic
(BCC)



Face Centered Cubic
(FCC)

Size & Crystal Structure

- Most metals in the solid form close packed lattices
- Ag, Al, Cu, Co, Pb, Pt, Rh are Face Centered Cubic (FCC)
- Mg, Nd, Os, Re, Ru, Y, Zn are Hexagonal Close Packed (HCP)
- Cr, Li, Sr can form Body Centered Cubic (BCC) as well as (FCC) and (HCP) depending upon formation energy

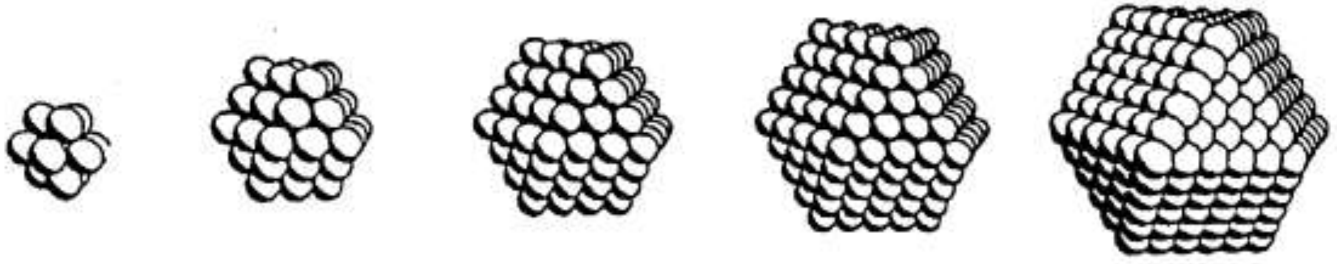
Size & Crystal Structure

- How does crystal structure impact nanoparticles?
- Nanoparticles have a **"<u>structural magic number</u>"**, that is, the optimum number of atoms that leads to a stable configuration while maintaining a specific structure.
- Structural magic number = minimum volume and maximum density configuration
- If the crystal structure is known, then the number of atoms per particle can be calculated.

Poole, C., Owens, F. *Introduction to Nanotechnology*. Wiley, New Jersey. 2003

Close-Packed Magic Number Clusters

Full-shell "magic number" clusters



Number of shells	1	2	3	4	5
Number of atoms in cluster	13	55	147	309	561
Percentage of surface atoms	92	76	63	52	45

- Magic Number = Cluster has a complete, regular outer geometry
- Formed by successively packing layers around a single metal atom.
- Number of atoms (y) in shell (n): $y = 10n^2 + 2$ $(n = 1,2,3\ldots)$
- Maximum number of nearest neighbors (metal-metal hcp packing)
- Decreasing percentage of surface atoms as cluster grows

J. D. Aiken III, R. G. Finke, *J. Mol. Catal.* 1999, 145, 1

Size & Crystal Structure

- For n layers, the number of atoms N in an approximately spherical FCC nanoparticle is given by the following formula:

$$N = 1/3[10n^3 - 15n^2 + 11n - 3]$$

- The number of atoms on the surface N_{surf}

$$N_{Surf} = 10n^2 - 20n + 12$$

Size & Crystal Structure

Number of atoms (structural magic numbers) in rare gas or metallic nanoparticles with face-centered cubic close-packed structure[a]

Shell Number	Diameter	Number of FCC Nanoparticle Atoms: Total	On Surface	% Surface
1	1*d*	1	1	100
2	3*d*	13	12	92.3
3	5*d*	55	42	76.4
4	7*d*	147	92	62.6
5	9*d*	309	162	52.4
6	11*d*	561	252	44.9
7	13*d*	923	362	39.2
8	15*d*	1415	492	34.8
→ 9	17*d*	2057	642	31.2
10	19*d*	2869	812	28.3
11	21*d*	3871	1002	25.9
12	23*d*	5083	1212	23.8
25	49*d*	4.90×10^4	5.76×10^3	11.7
50	99*d*	4.04×10^5	2.40×10^4	5.9
75	149*d*	1.38×10^6	5.48×10^4	4.0
100	199*d*	3.28×10^6	9.80×10^4	3.0

[a] The diameters *d* in nanometers for some representative FCC atoms are Al 0.286, Ar 0.376, Au 0.288, Cu 0.256, Fe 0.248, Kr 0.400, Pb 0.350, and Pd 0.275.

Example Calculations:

How many atoms (N) are in idealized Au NP's with the following diameters?

5 nm Au NP:

With 9 shells, $n = 9$ and

NP diameter = 17d = 4.896 nm

$N = 1/3[10n^3 – 15n^2 + 11n - 3]$

N = 2057

Other Approximate Values

10 nm = 17,900

20 nm = 137,000

30 nm = 482,000

40 nm = 1.1 million

50 nm = 2.2 million

Poole, C., Owens, F. *Introduction to Nanotechnology*. Wiley, New Jersey. 2003

Mechanical Strength

- Calculated values for mechanical strength of idealized xtals = 100 to 1000X than experimental
- Differentiate between wires and nanocomposites
- Transition to higher strength occurs at about 10 microns (above the nanoscale)
- 2 possible reasons:
  - Lower number of defects inside the nanowire
  - Fewer surface defects

Outline

- Definition and Examples
- Physical Properties
- Optical Properties
  - Surface Plasmons
  - Quantum Confinement
- Electrical Properties
- Health Concerns

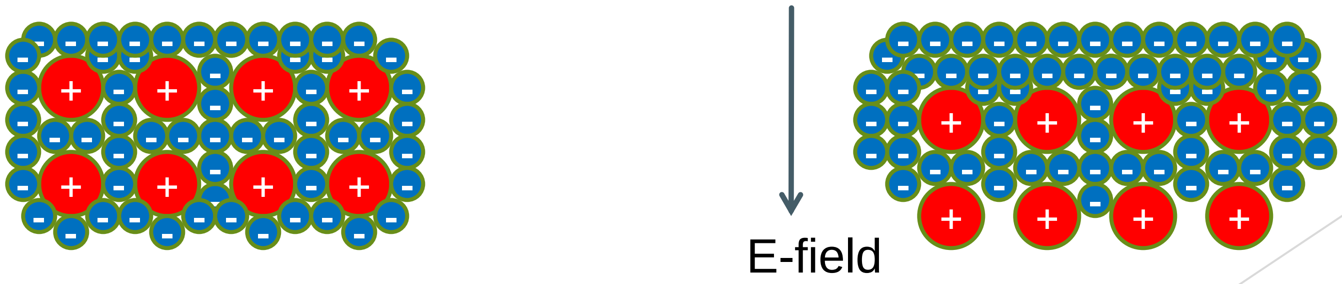
Optical Properties

- The size dependence on the optical properties of nanoparticles is the result of two distinct phenomena:
  - Surface plasmon resonance for metals
  - Increased energy level spacing due to the confinement of delocalized energy states. Most prominent in semiconductors

Poole, C., Owens, F. *Introduction to Nanotechnology*. Wiley, New Jersey. 2003

Optical Properties

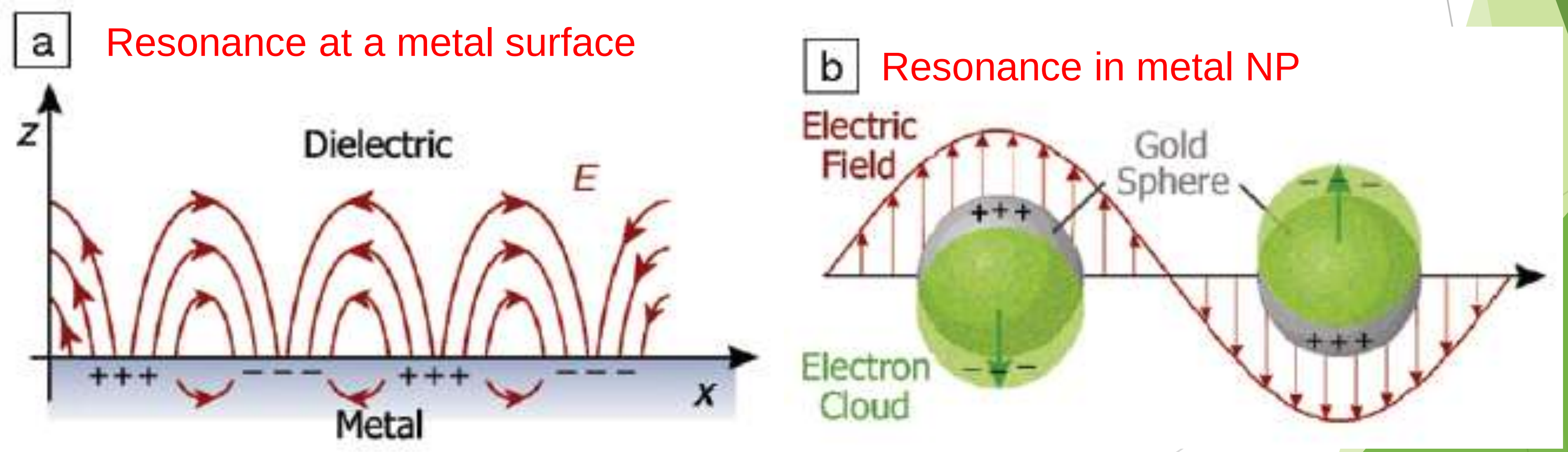
- Surface Plasmons
  - Recall that metals can be modeled as an arrangement of positive ions surrounded by a sea of *free electrons*.
  - The sea of electrons behaves like a fluid and will move under the influence of an electric field



Optical Properties

Surface Plasmons

- If the electric field is oscillating (like a photon), then the sea of electrons will oscillate too. These oscillations are quantized and resonate at a specific frequency. Such oscillations are called **plasmons**.



Source: MRS Bulletin 2005, 30(5), 338.

Optical Properties

- Surface Plasmons
  - Formal definition: Plasmons are the coherent excitation of *free electrons* in a metal.
  - The plasmon resonance frequency (f) depends on particle size, shape, and material type. It is related to the plasmon energy (E) by Planck's constant. E=h*f
  - Surface plasmons are confined to the surface of the material.
  - The optical properties of metal nanoparticles are dominated by the interaction of surface plasmons with incident photons.

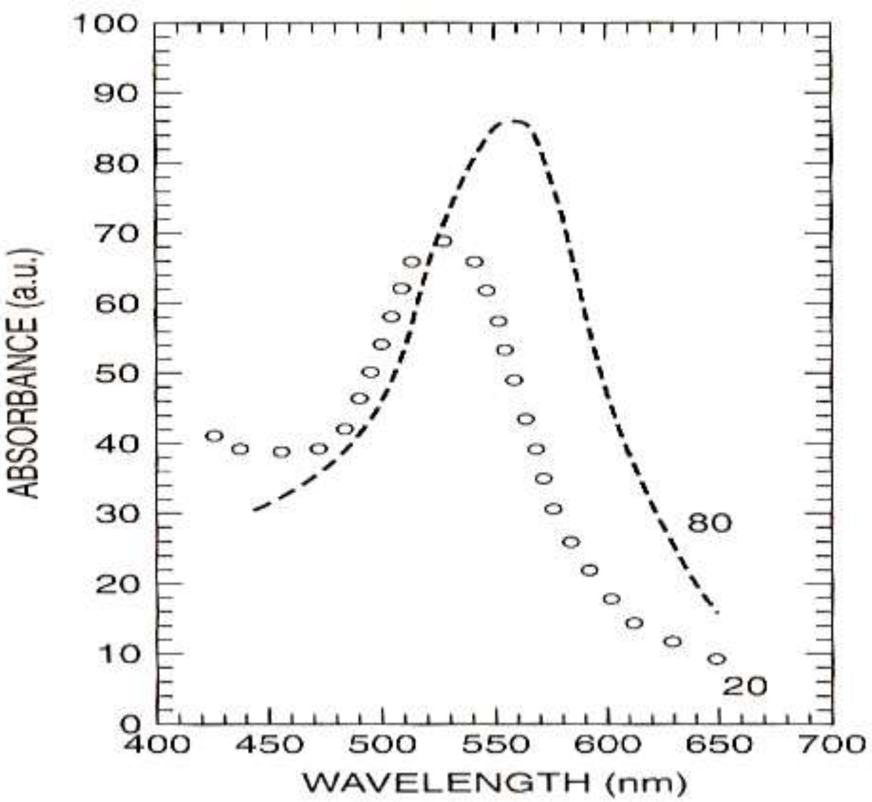
Optical Properties

Surface Plasmons

- Metal nanoparticles like gold and silver have plasmon frequencies in the visible range.
- When white light impinges on metal nanoparticles the wavelength corresponding to the plasmon frequency is absorbed.
- The spectral locations, strengths, and number of plasmon resonances for a given particle depend on the particle’s shape and size.

Optical Properties

- Absorption spectra of spherical Au nanoparticles



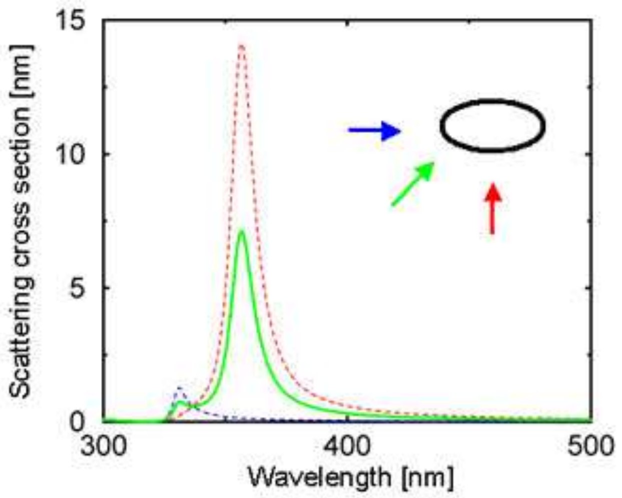
Optical absorption spectrum of 20- and 80-nm gold nanoparticles embedded in glass.
[Adapted from F. Gonella et al., in *Handbook of Nanostructured Material and Nanotechnology*, H. S. Nalwa, ed., Academic Press, San Diego, 2000, Vol. 4, Chapter 2, p.85.]

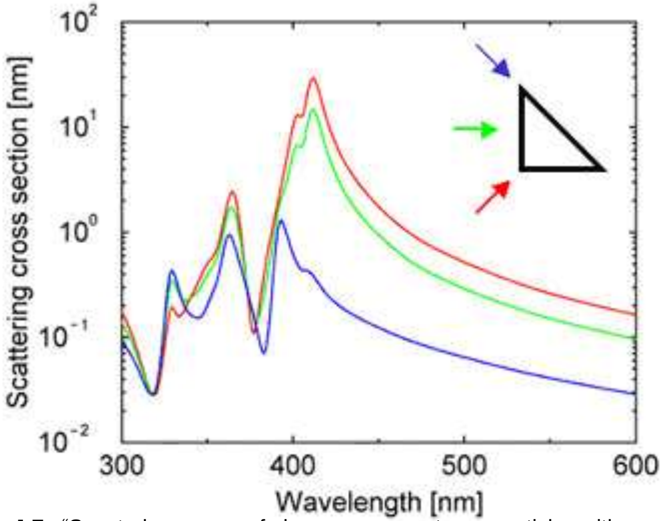
Optical Properties

Surface Plasmons: Shape dependence of absorption spectra

•The amount of light that is scattered into the far field is described by the scattering cross section (SCS). The SCS is plotted against the wavelength of light used to illuminate a particle from a specific angle.

•The arrows indicate the illumination angle, and their colors correspond to the different plot lines.



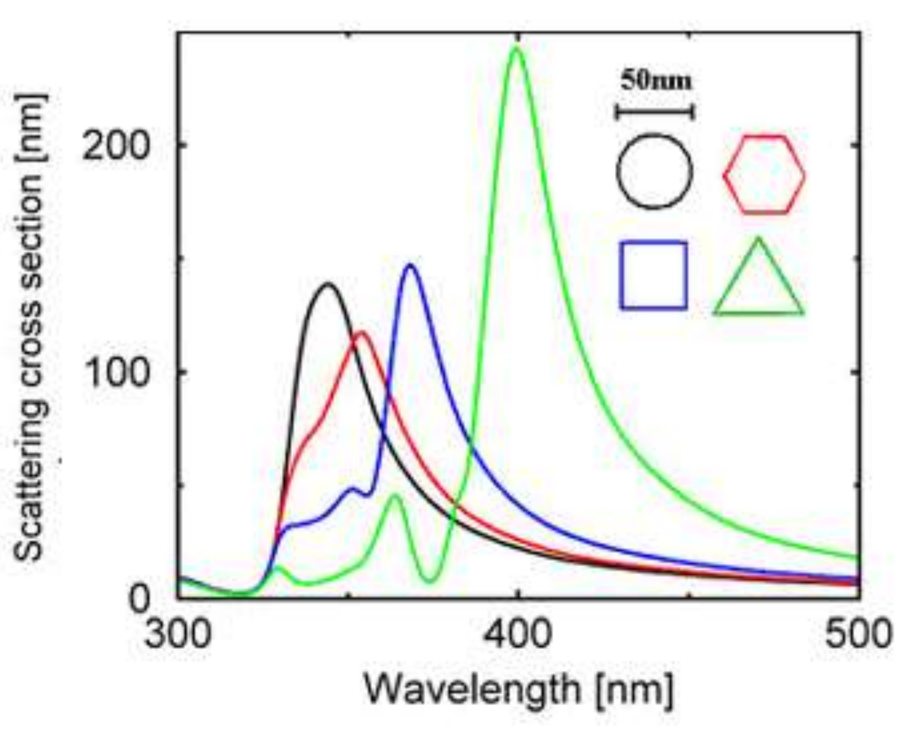


Martin, Olivier J.F. "Spectral response of plasmon resonant nanoparticles with non-regular shape". Optics Express Col. 6. No. 11 May 2000

Optical Properties

Surface Plasmons:
Shape dependence of absorption spectra

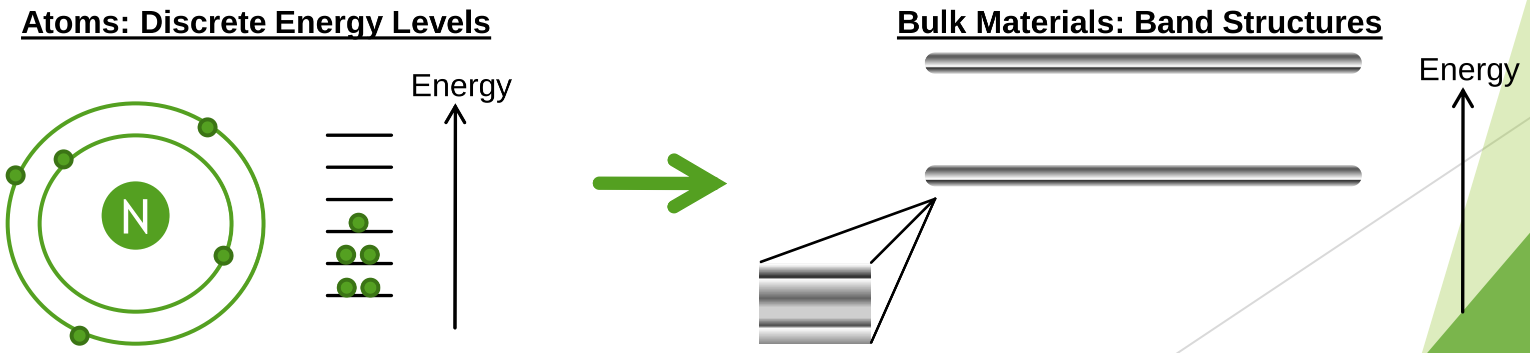
- Triangular shaped nanoparticles produce plasmons with altered frequency and magnitude



Martin, Olivier J.F. "Plasmons". Plasmons. 22 Mar. 2006. Ecole Polytechnique Fédérale de Lausanne. 26 Jan. 2003.

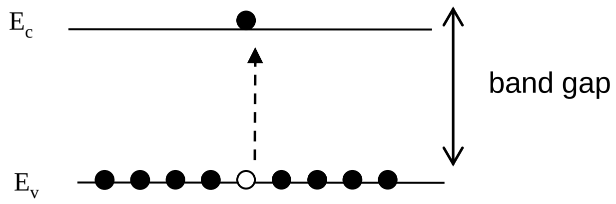
Optical Properties

- Energy levels: from atoms to bulk materials…
  - The Pauli Exclusion Principle states that electrons can only exist in unique, discrete energy states.
  - In an atom the energy states couple together through spin-orbit interactions to form the energy levels commonly discussed in an introductory chemistry course.
  - When atoms are brought together in a bulk material, the energy states form nearly continuous bands of states, or in semiconductors and insulators, nearly continuous bands separated by an energy gap.



Optical Properties

- Energy levels
  - In semiconductors and insulators, the **valance band** corresponds to the ground states of the valance electrons.
  - In semiconductors and insulators, the **conduction band** corresponds to excited states where electrons are a free to move about in the material and participate in conduction.
  - In order for conduction to take place in a semiconductor, electrons must be excited out of the valance band, across the **band gap** into the conduction band. This process is called **carrier generation**.
  - Conduction takes place due to the empty states in the valence band (holes) and electrons in the conduction band.



Electron excited into conduction band

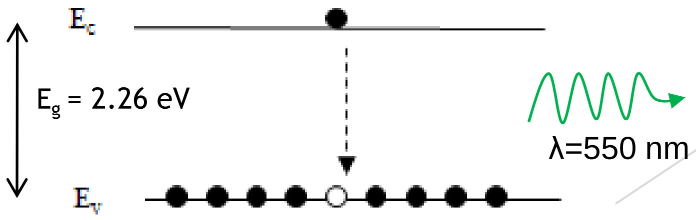
Optical Properties

- Energy level spacing
  - In semiconductors and insulators a photon with an energy equal to the band gap energy is emitted when an electron in the conduction band recombines with a hole in the valance band.
  - The electronic band structure of a semiconductor dictates its optical properties.
  - GaP, a material commonly used for green LEDs, has an intrinsic band gap of 2.26 eV. Carrier recombination across the gap results in the emission of 550 nm light.

$$E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E}$$

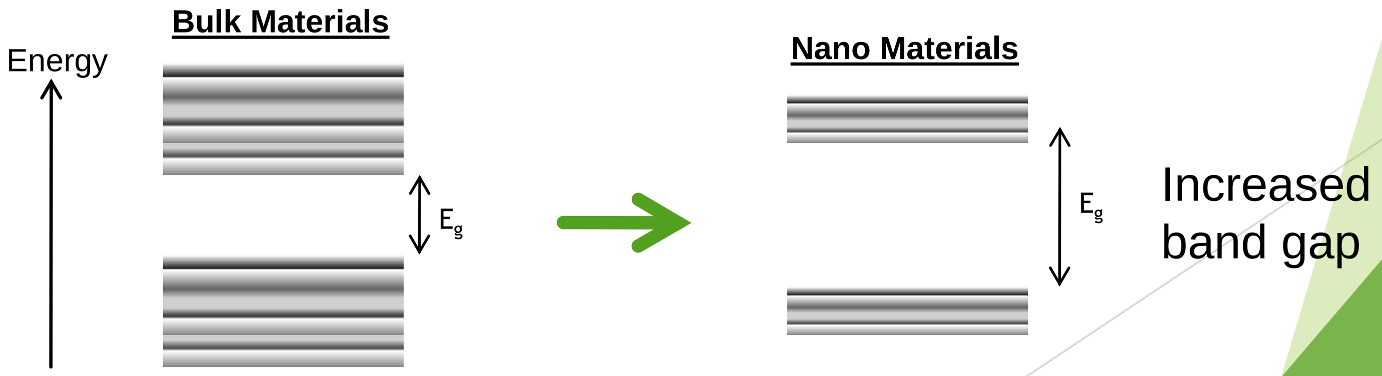
$$\lambda = \frac{(4.136 * 10^{-15}\ \mathrm{eV \cdot s})(2.998 * 10^{8}\ \mathrm{m/s})}{2.26\ \mathrm{eV}}$$

$$\lambda \cong 550\ \mathrm{nm}$$



Optical Properties

- Energy level spacing and quantum confinement
  - The reduction in the number of atoms in a material results in the confinement of normally delocalized energy states.
  - Electron-hole pairs become spatially confined when the dimensions of a nanoparticle approach the de Broglie wavelength of electrons in the conduction band.
  - As a result the spacing between energy bands of semiconductor or insulator is **increased** (Similar to the *particle in a box* scenario, of introductory quantum mechanics.)

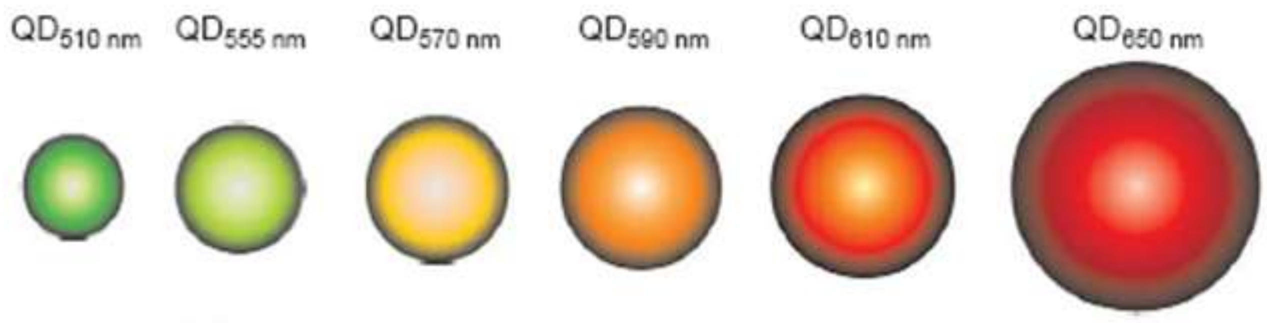


Optical Properties

- Energy level spacing and quantum confinement
  - Semiconductor nanoparticles that exhibit 3 dimensional confinement in their electronic band structure are called **quantum dots.**
  - What does this all mean?
    - **Quantum dots are band gap tunable.**
    - We can engineer their optical properties by controlling their size.
    - For this reason quantum dots are highly desirable for biological tagging.

Optical Properties

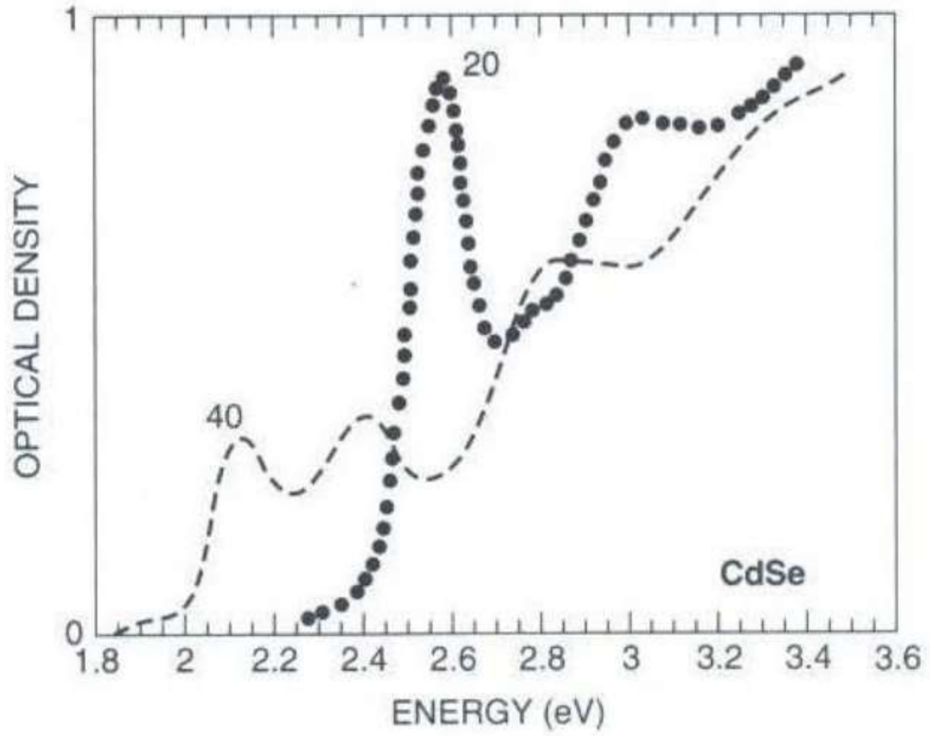
- Energy level spacing and quantum confinement
  - As semiconductor particle size is reduced the band gap is increased.
  - Absorbance and luminescence spectra are blue shifted with decreasing particle size.



Jyoti K. Jaiswal and Sanford M. Simon. **Potentials and pitfalls of fluorescent quantum dots for biological imaging.** TRENDS in Cell Biology Vol.14 No.9 September 2004

Optical Properties

Example: Absorption Spectra of CdSe quantum dots



Optical absorption spectrum of CdSe for two nanoparticles having sizes 20 Å and 40 Å, respectively. [Adapted from D. M. Mittleman, *Phys. Rev.* **B49**, 14435 (1994).]

Outline

- Definition and Examples
- Physical Properties
- Optical Properties
- Electrical Properties
- Health Concerns

Electrical Properties

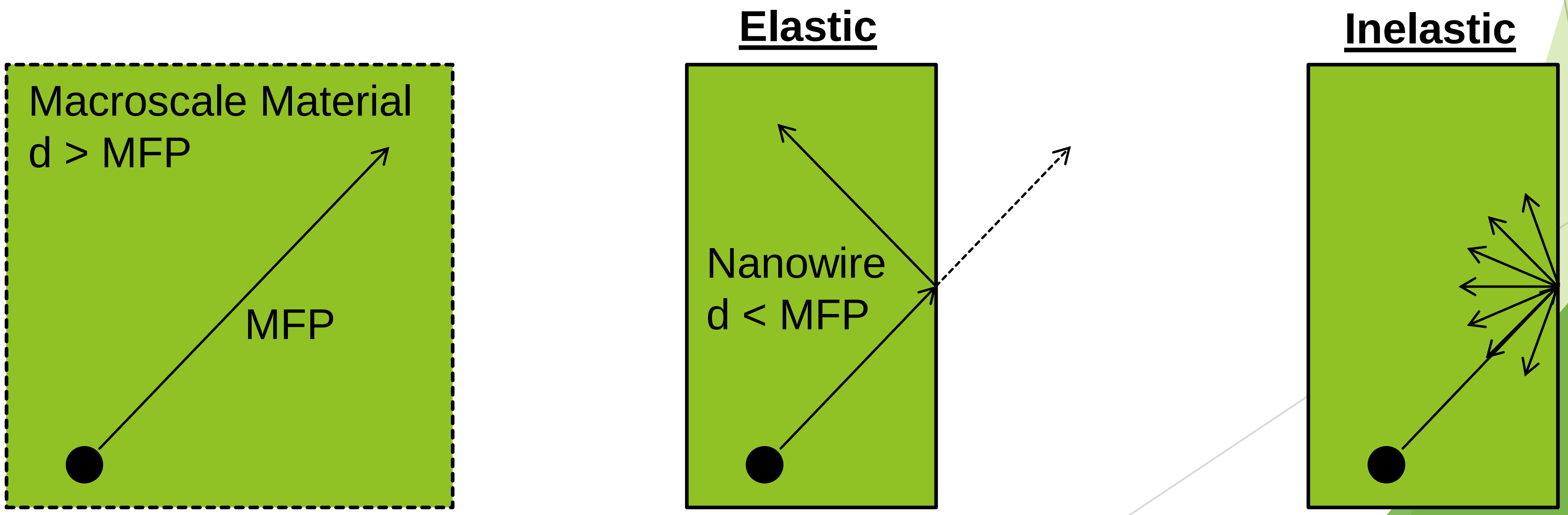
- Effect of structure on conduction
  - If nanostructures have fewer defects, one would expect increased conductivity vs macroscale
- Other electrical effects on the nanoscale:
  - Surface Scattering
  - Change in Electronic Structure
  - Ballistic Conduction
  - Discrete Charging
  - Tunneling Conduction
  - Microstructural Effects

Surface Scattering

- Electrons have a mean-free-path (MFP) in solid state materials.
- MFP is the distance between scattering events as charge carriers move through the material.
- In metals, the MFP is on the order of 10's of nanometers.
- If the dimensions of a nanostructure are smaller than the electron MFP, then surface scattering becomes a factor.

Surface Scattering

- There are two types of surface scattering: elastic and inelastic.
- Elastic scattering does not affect conductivity, while inelastic scattering decreases conductivity.



Outline

- Definition and Examples
- Physical Properties
- Optical Properties
- Electrical Properties
- Health Concerns
-

Potential Health Concerns

- Cause for concern:
  - Nanoparticles are similar in size to many biological structures → easily absorbed by the body.
  - Nanoparticles remain suspended in the environment for extended periods of time.
- Health Impacts of nanoparticles are expected to be dependent on composition and structure.
- We must always try to use green methods and to investigate toxicity in terms of size, shape and concentrations

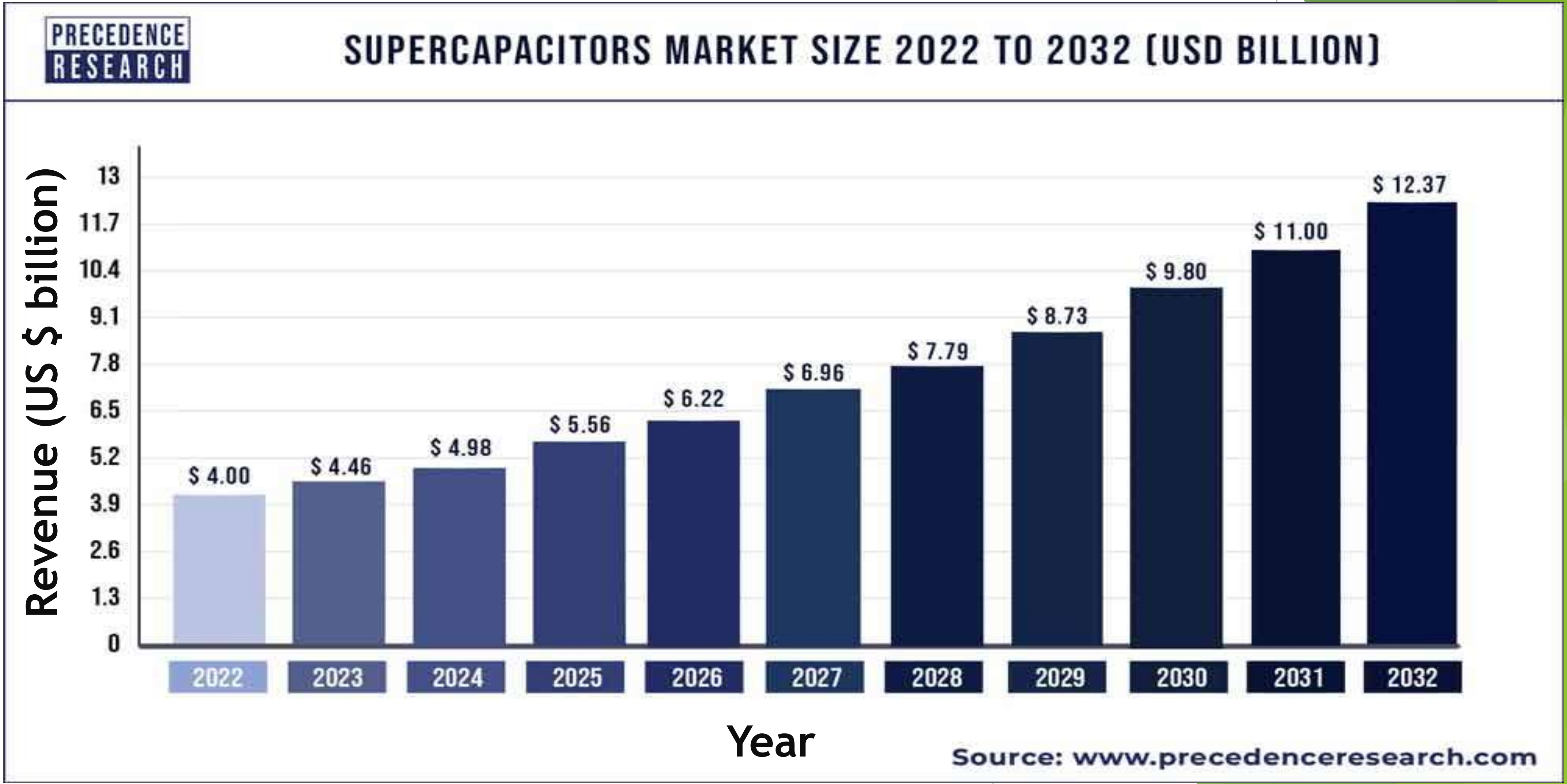
Potential Health Concerns

- The potential health concerns of nanomaterials are largely unknown.
- The EPA has started the National Nanotechnology Initiative which is providing funding to further investigate this issue.

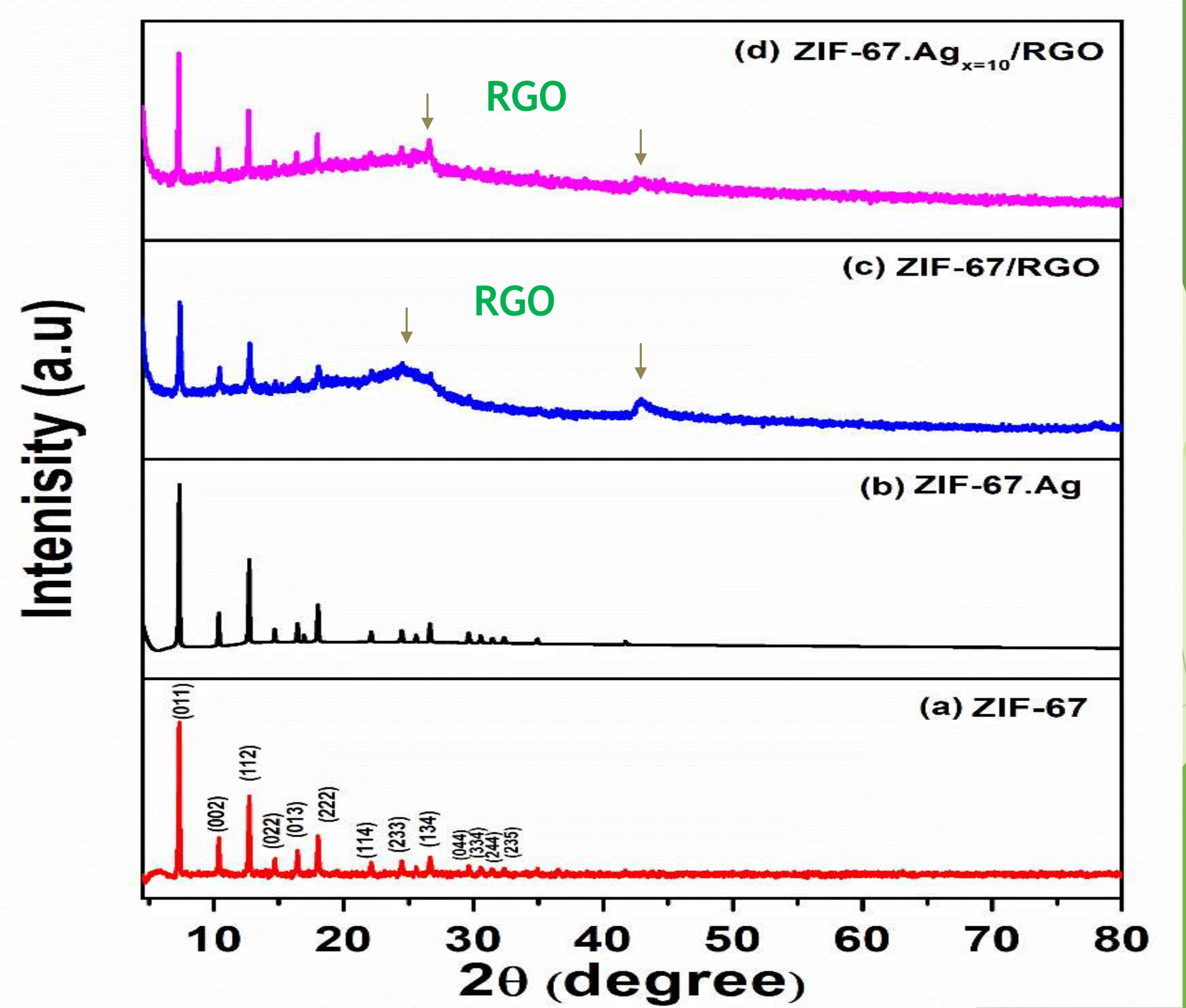
APPLICATIONS

- Energy
- Water
- Waste valorization
- Biomedical Use

SCs Market

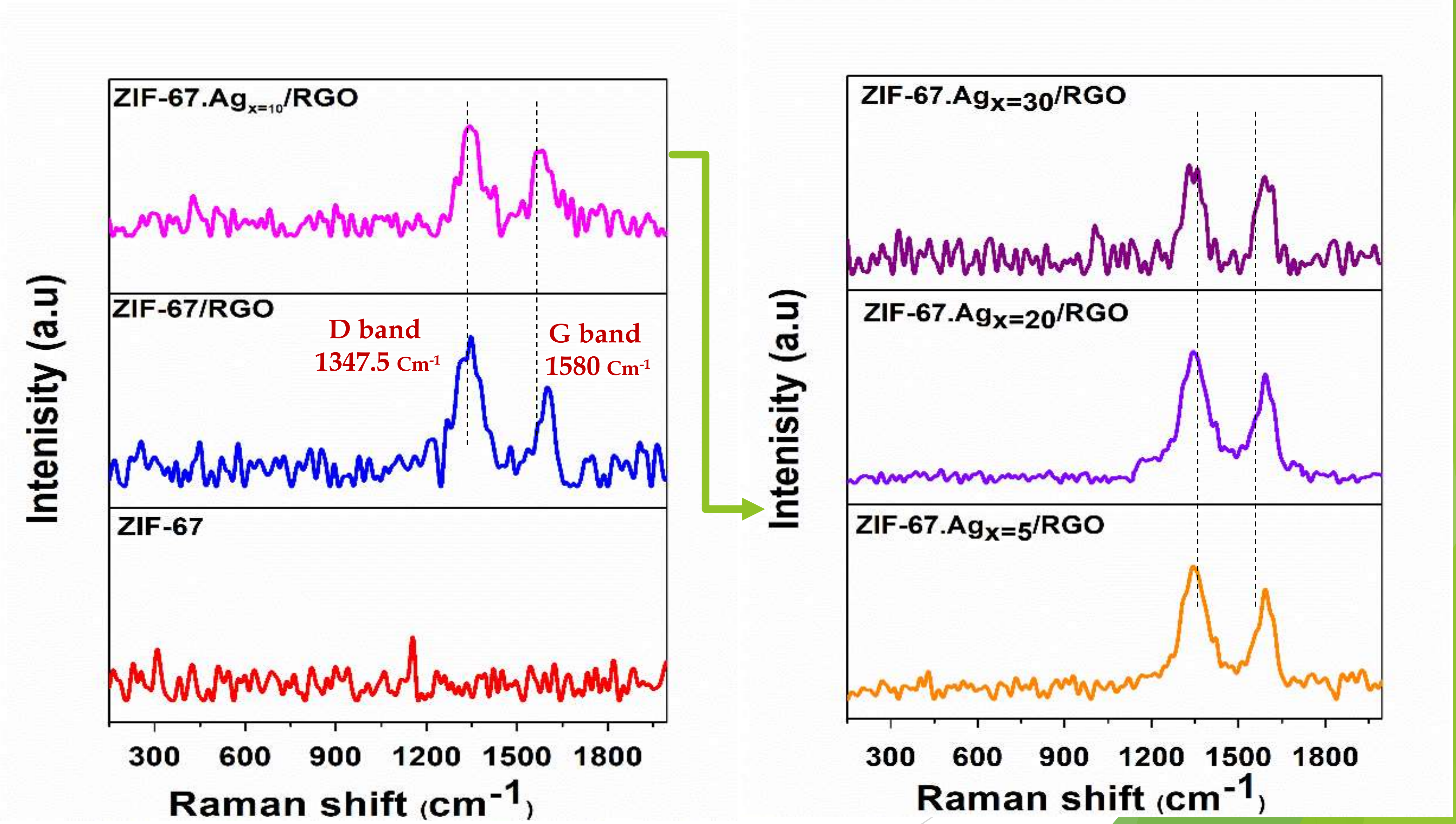

PRECEDENCE RESEARCH
SUPERCAPACITORS MARKET SIZE 2022 TO 2032 (USD BILLION)
Revenue (US $ billion)
13
11.7
10.4
9.1
7.8
6.5
5.2
3.9
2.6
1.3
0
$ 4.00
$ 4.46
$ 4.98
$ 5.56
$ 6.22
$ 6.96
$ 7.79
$ 8.73
$ 9.80
$ 11.00
$ 12.37
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
Year
Source: www.precedenceresearch.com

A XRD

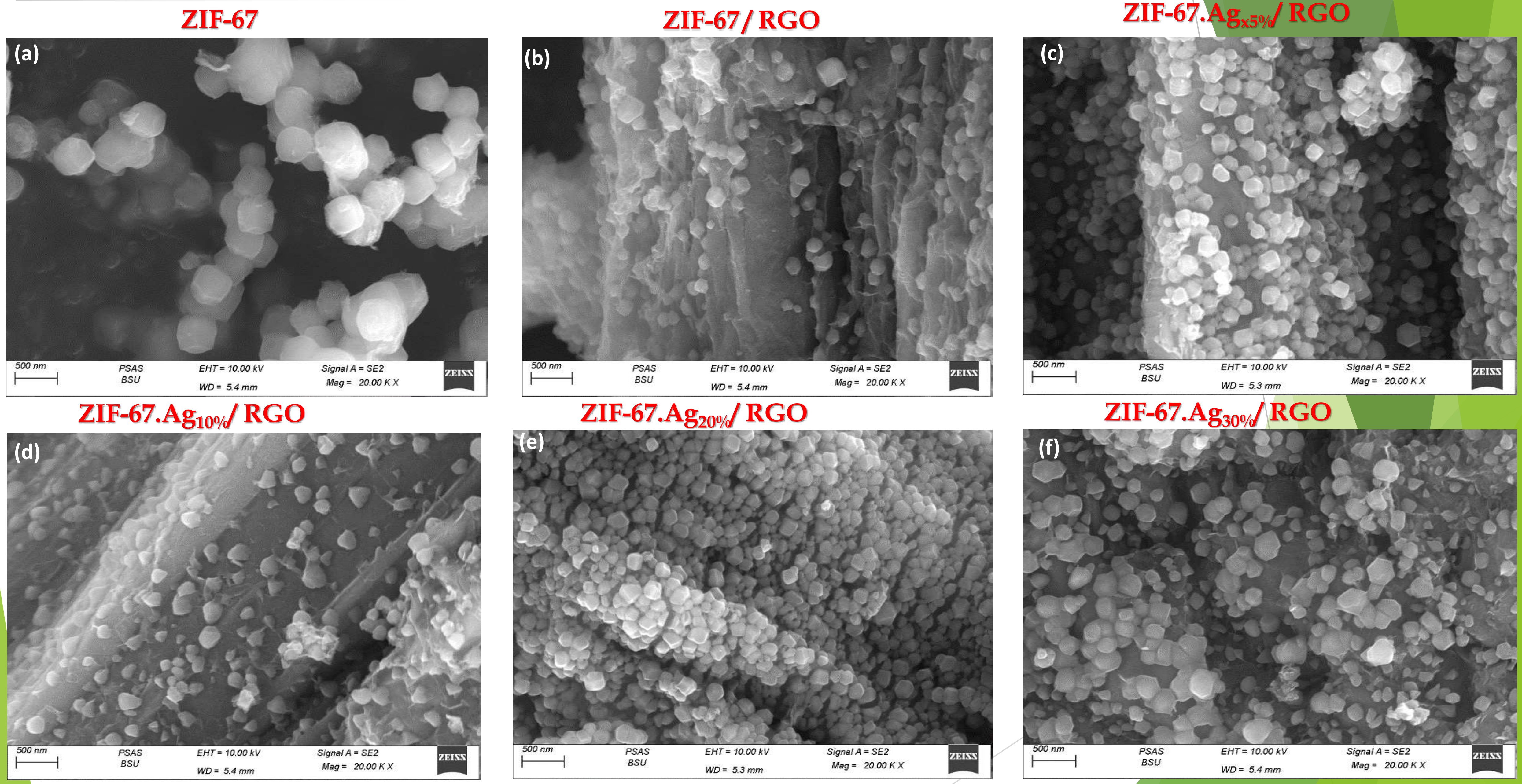


(d) ZIF-67.Ag$_{x=10}$/RGO
RGO
(c) ZIF-67/RGO
RGO
(b) ZIF-67.Ag
(a) ZIF-67
(011)
(002)
(112)
(022)
(013)
(222)
(114)
(233)
(134)
(044)
(334)
(244)
(235)
Intenisity (a.u)
10
20
30
40
50
60
70
80
2θ (degree)

B **Raman Spectroscopy**



C **FESEM**

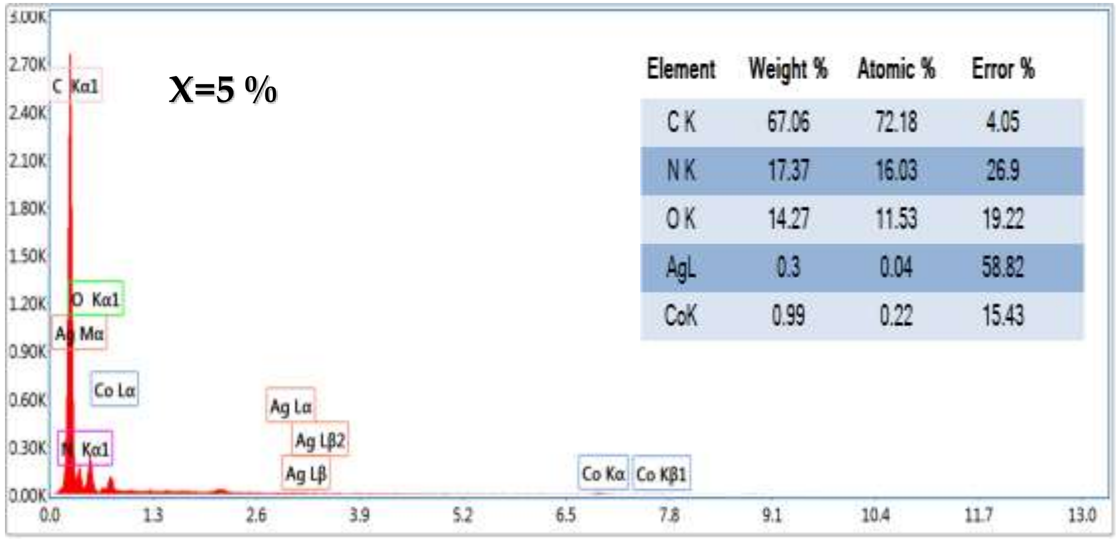


ZIF-67
ZIF-67/ RGO
ZIF-67.Agx5%/ RGO
ZIF-67.Ag10%/ RGO
ZIF-67.Ag20%/ RGO
ZIF-67.Ag30%/ RGO
(a)
(b)
(c)
(d)
(e)
(f)
500 nm
PSAS BSU
EHT = 10.00 kV
WD = 5.4 mm
WD = 5.3 mm
Signal A = SE2
Mag = 20.00 K X
ZEISS

C **EDX**

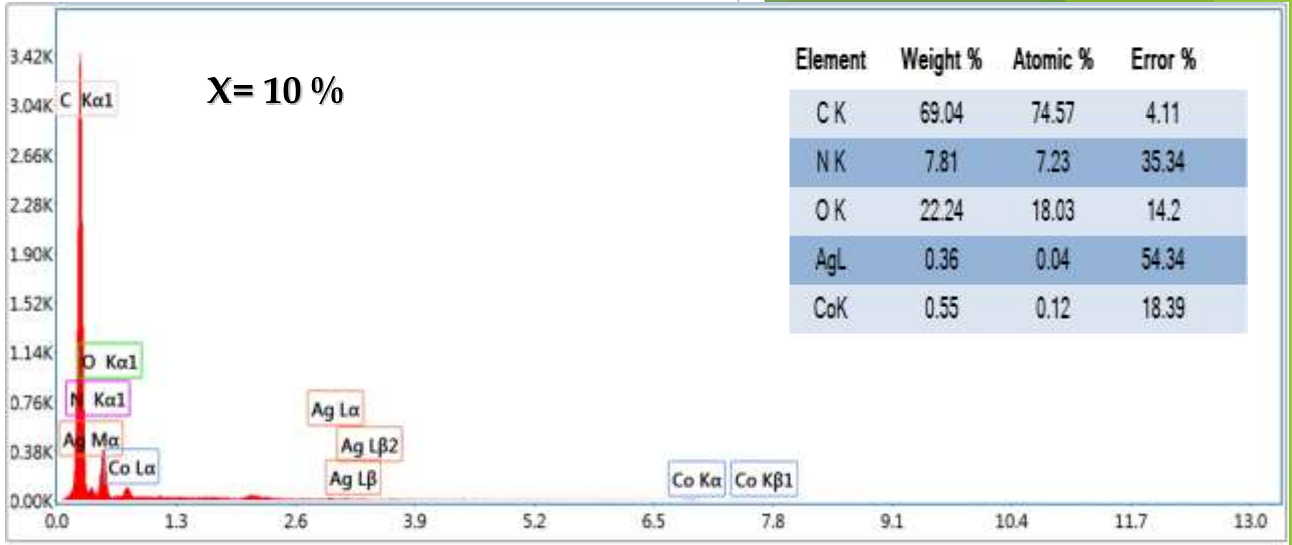
ZIF-67.Ag_x/ RGO

X=5 %



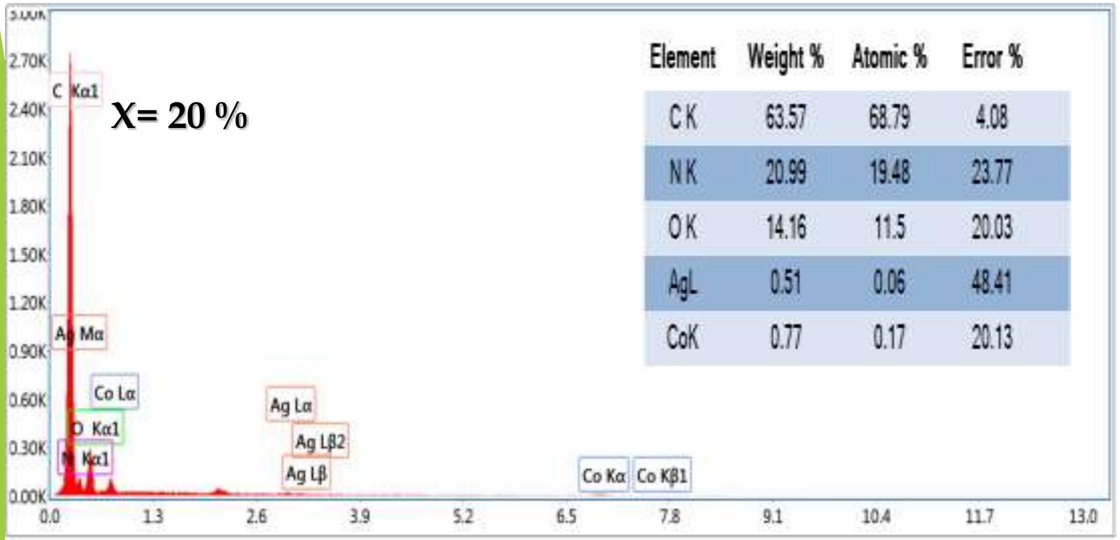
Element	Weight %	Atomic %	Error %
C K	67.06	72.18	4.05
N K	17.37	16.03	26.9
O K	14.27	11.53	19.22
AgL	0.3	0.04	58.82
CoK	0.99	0.22	15.43

X= 10 %



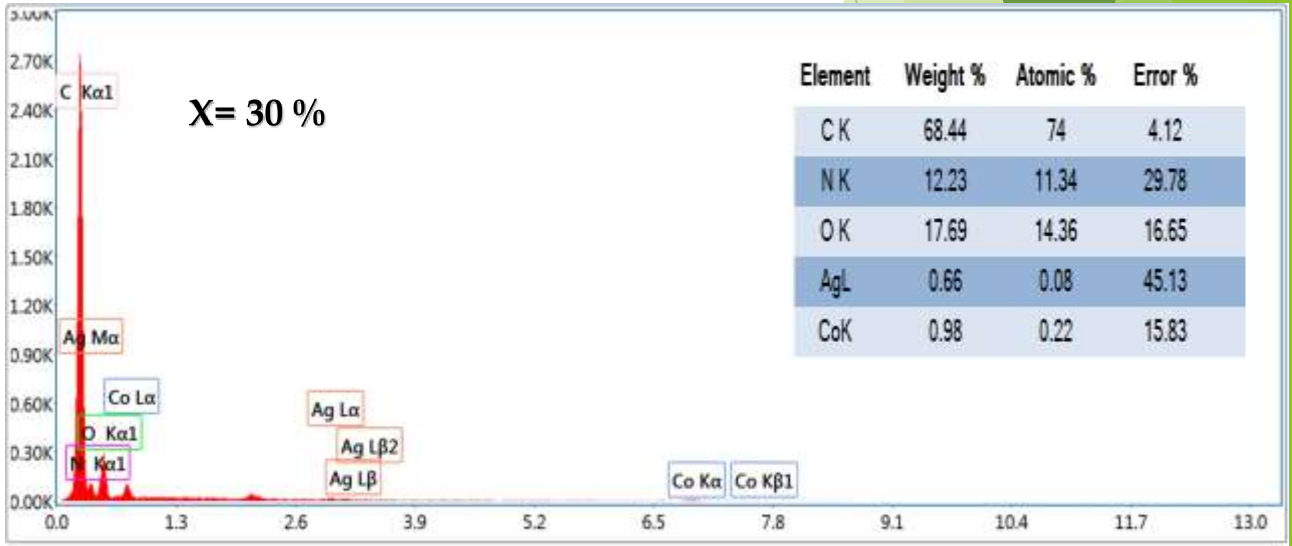
Element	Weight %	Atomic %	Error %
C K	69.04	74.57	4.11
N K	7.81	7.23	35.34
O K	22.24	18.03	14.2
AgL	0.36	0.04	54.34
CoK	0.55	0.12	18.39

X= 20 %



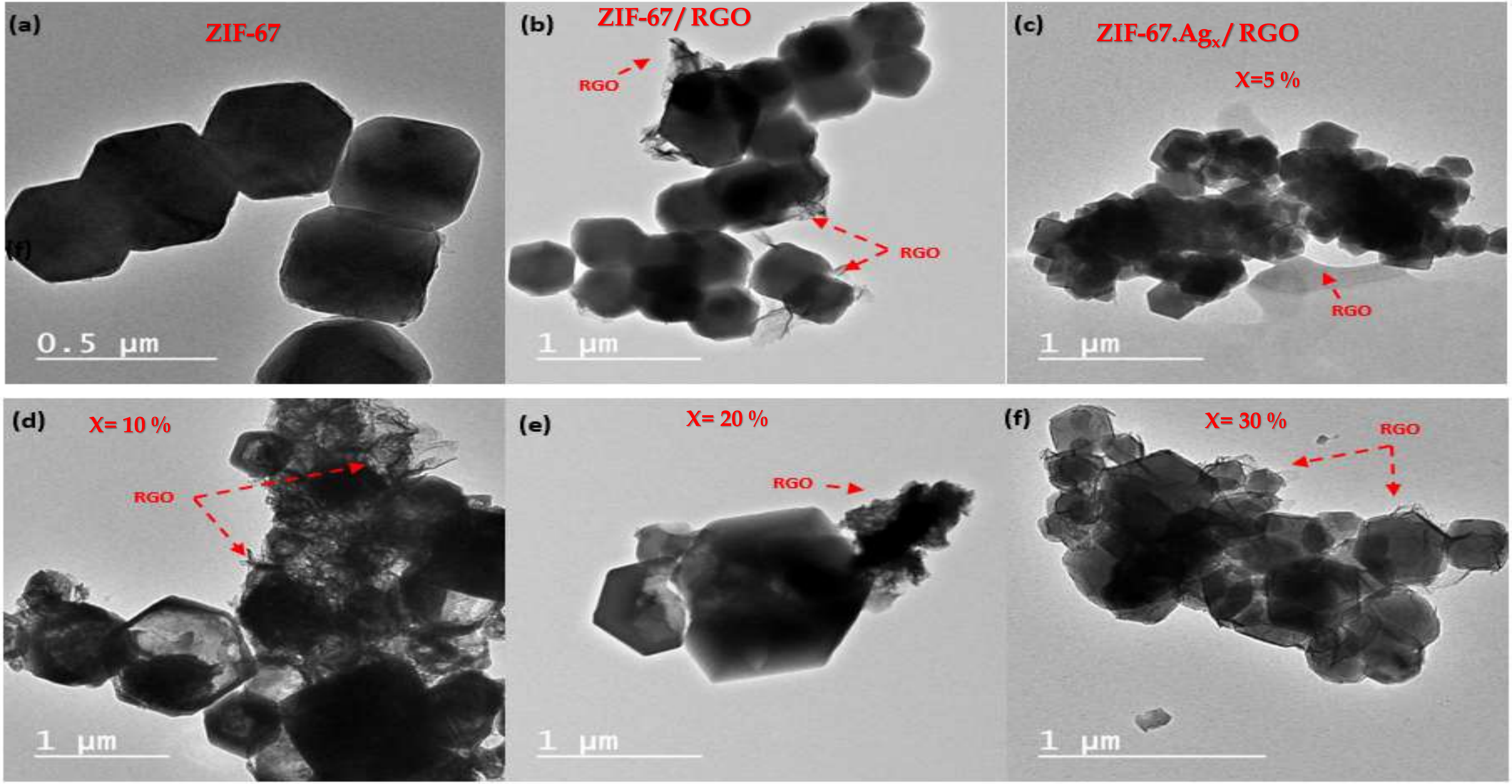
Element	Weight %	Atomic %	Error %
C K	63.57	68.79	4.08
N K	20.99	19.48	23.77
O K	14.16	11.5	20.03
AgL	0.51	0.06	48.41
CoK	0.77	0.17	20.13

X= 30 %



Element	Weight %	Atomic %	Error %
C K	68.44	74	4.12
N K	12.23	11.34	29.78
O K	17.69	14.36	16.65
AgL	0.66	0.08	45.13
CoK	0.98	0.22	15.83

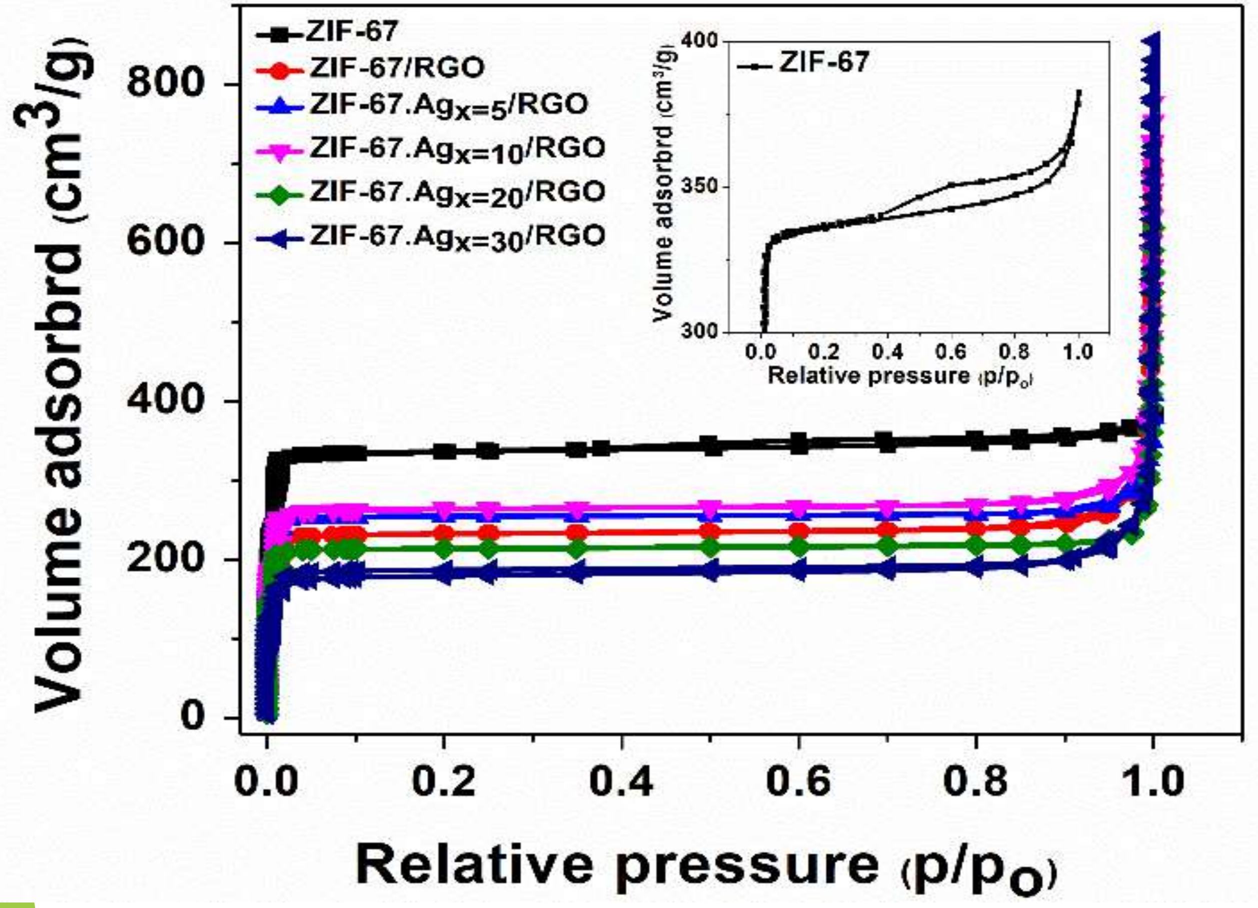
D HRTEM



(a)
ZIF-67
0.5 μm
(b)
ZIF-67 / RGO
RGO
RGO
1 μm
(c)
ZIF-67.Ag$_x$ / RGO
X=5 %
RGO
1 μm
(d)
X= 10 %
RGO
1 μm
(e)
X= 20 %
RGO
1 μm
(f)
X= 30 %
RGO
1 μm

E Surface Area Investigations (BET)

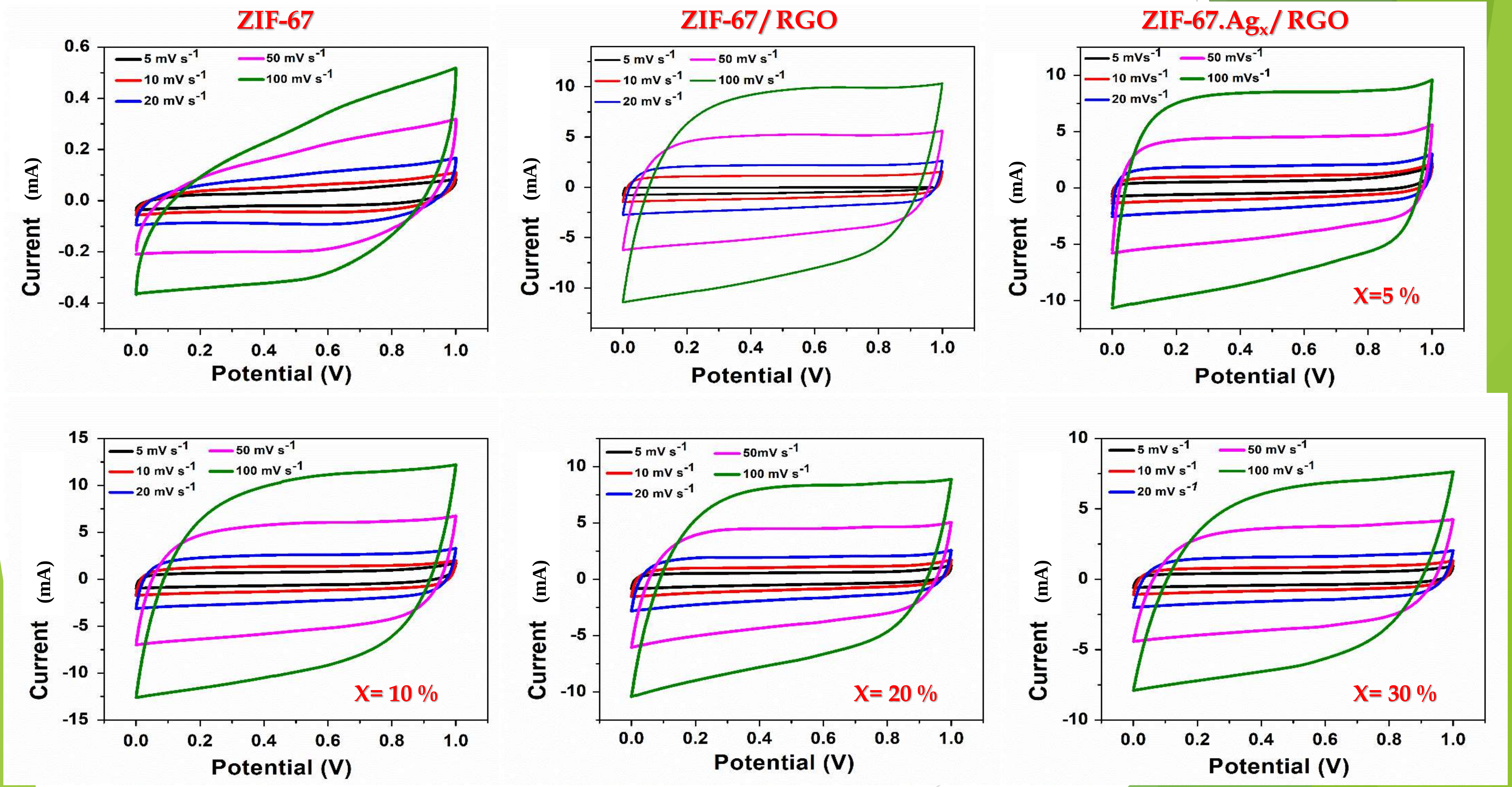
Typical nitrogen adsorption-desorption curves



Composite	S_{BET} (m^2/g)	Pore volume (cm^3/g)	Mean pore diameter (nm)
ZIF-67	1501	0.5786	1.5415
ZIF-67/RGO	1001	0.4942	1.9737
ZIF-67.$Ag_{x=5}$/RGO	1051	0.4796	1.824
ZIF-67.$Ag_{x=10}$/RGO	1105	0.5283	1.912
ZIF-67.$Ag_{x=20}$/RGO	893.5	0.4077	1.825
ZIF-67.$Ag_{x=30}$/RGO	856.3	0.4374	2.04

G Electrochemical Analysis

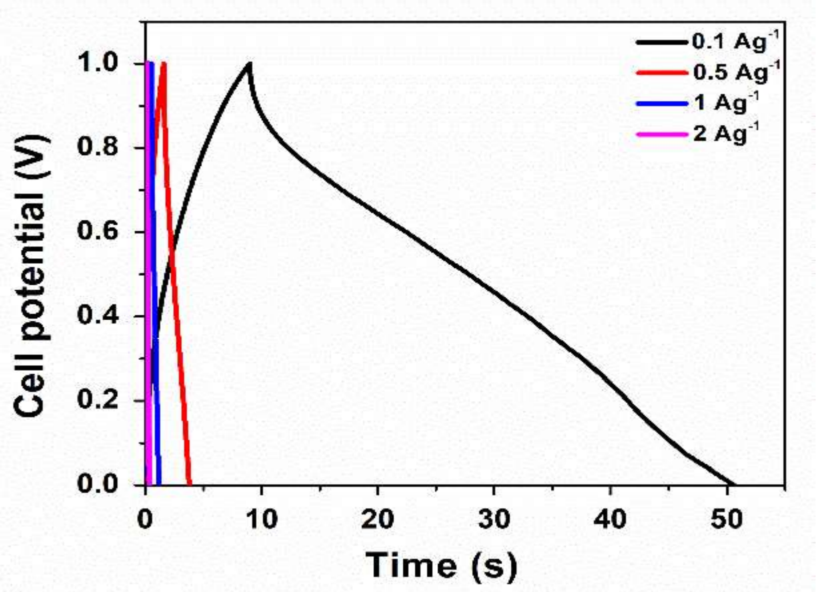
1- Cyclic voltammetry curves (CV)



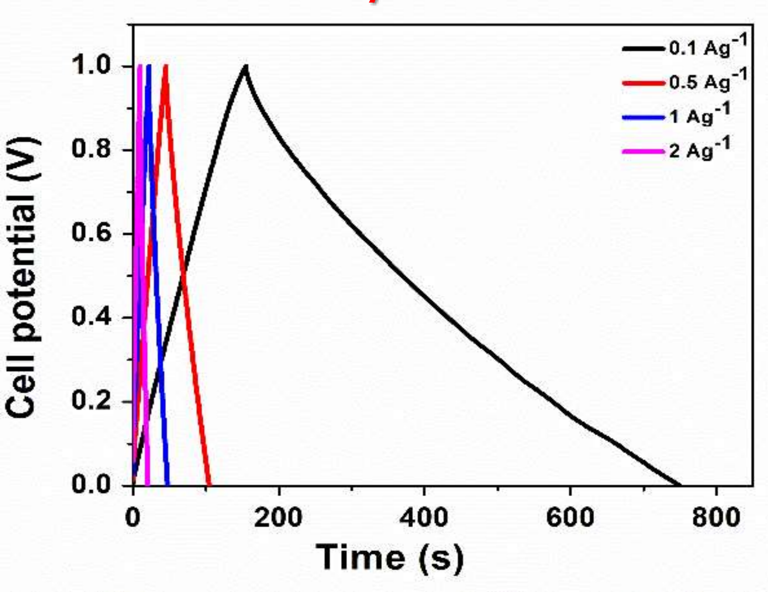
G Electrochemical Analysis

2- Charge-Discharge curves (CD)

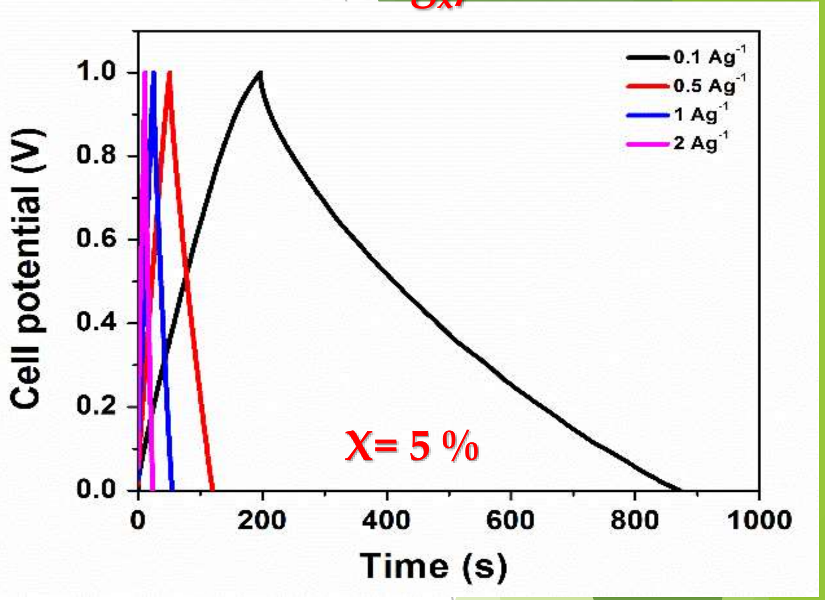
ZIF-67

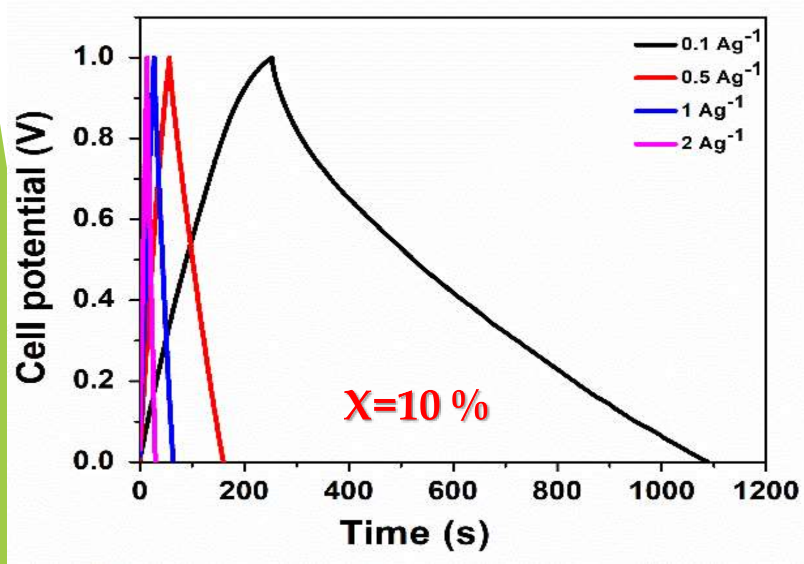


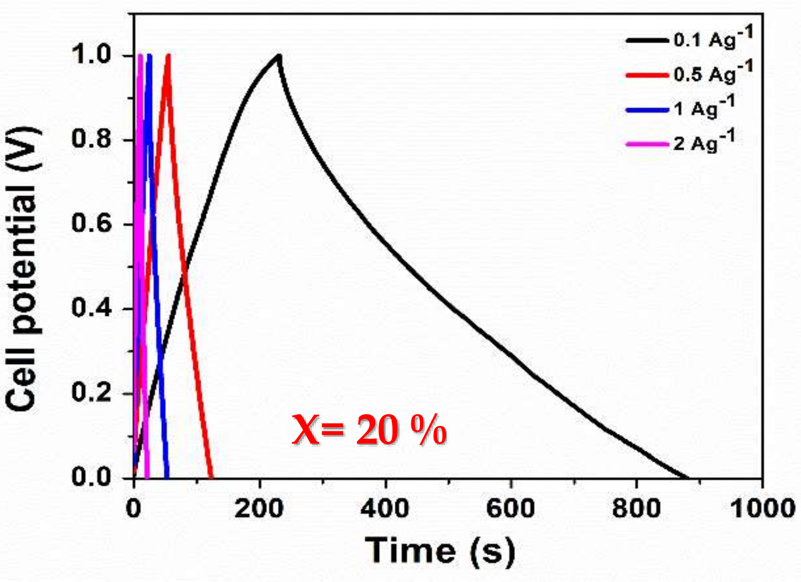
ZIF-67/ RGO

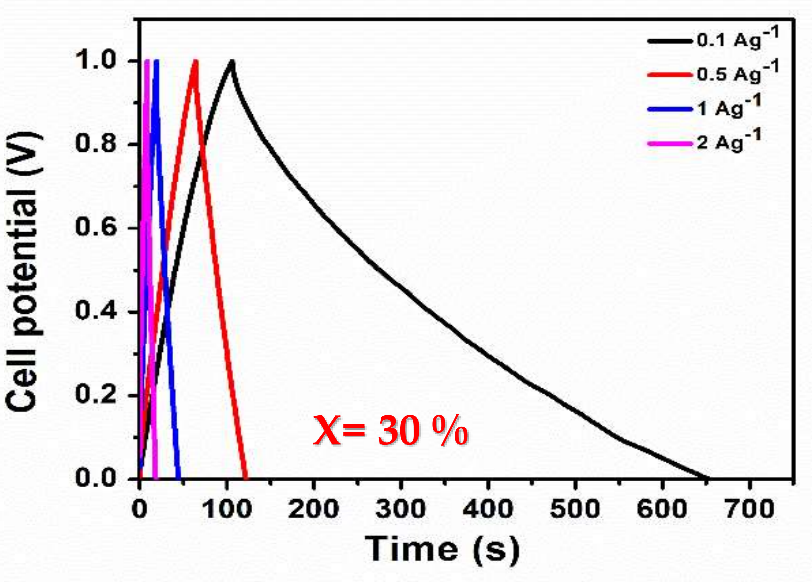


ZIF-67.Ag_x/ RGO









10.3 CiteScore | 9.4 Impact Factor

Journal of Energy Storage 55 (2022) 105443

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Research papers

Silver-substituted cobalt zeolite imidazole framework on reduced graphene oxide nanosheets as a novel electrode for supercapacitors

Fatma M. Ahmed [a,b,*], Ebtesam E. Ateia [a], S.I. El-dek [c], Sherine M. Abd El-Kader [d], Amira S. Shafaay [a]

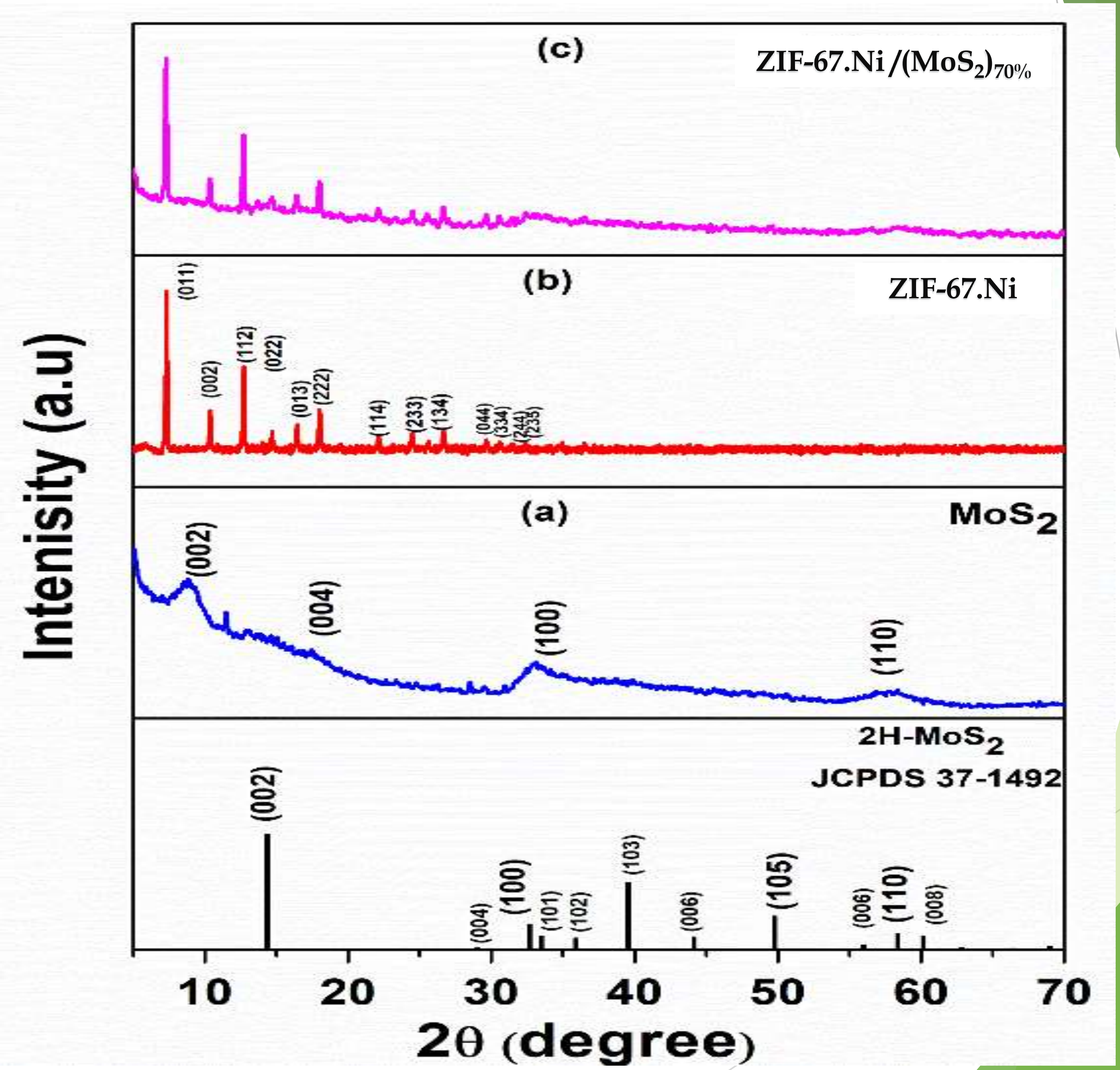
[a] *Physics department, Faculty of Science, Cairo University, Giza, Egypt*

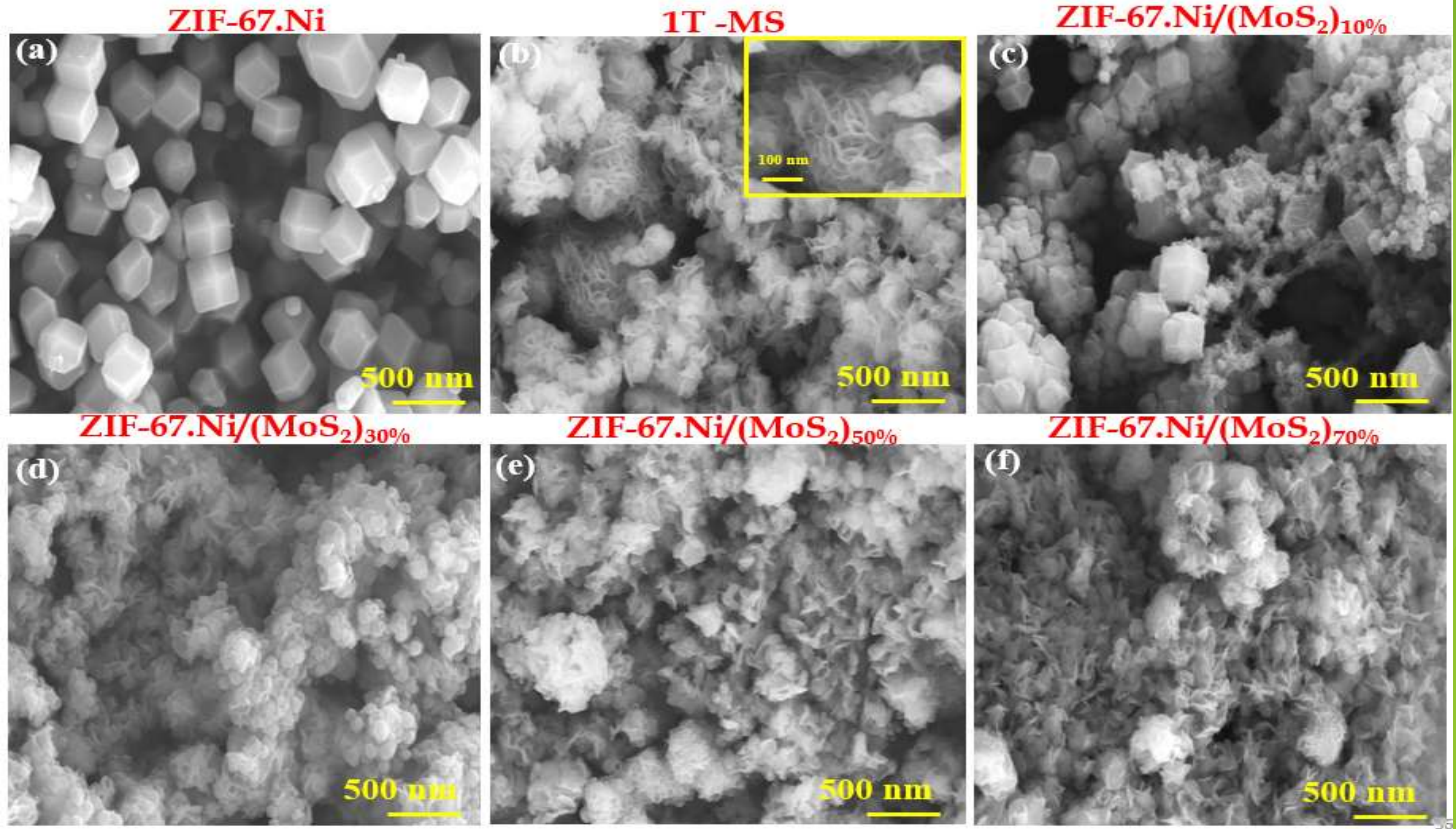
[b] *Nanotechnology Lab, Electronics Research Institute, Cairo 12622, Egypt*

[c] *Materials Science and Nanotechnology Department, Faculty of Postgraduate Studies for Advanced Sciences (PSAS), Beni-Suef University, Beni-Suef 62511, Egypt*

[d] *Computers and Systems Department, Electronics Research Institute, Cairo 12622, Egypt*

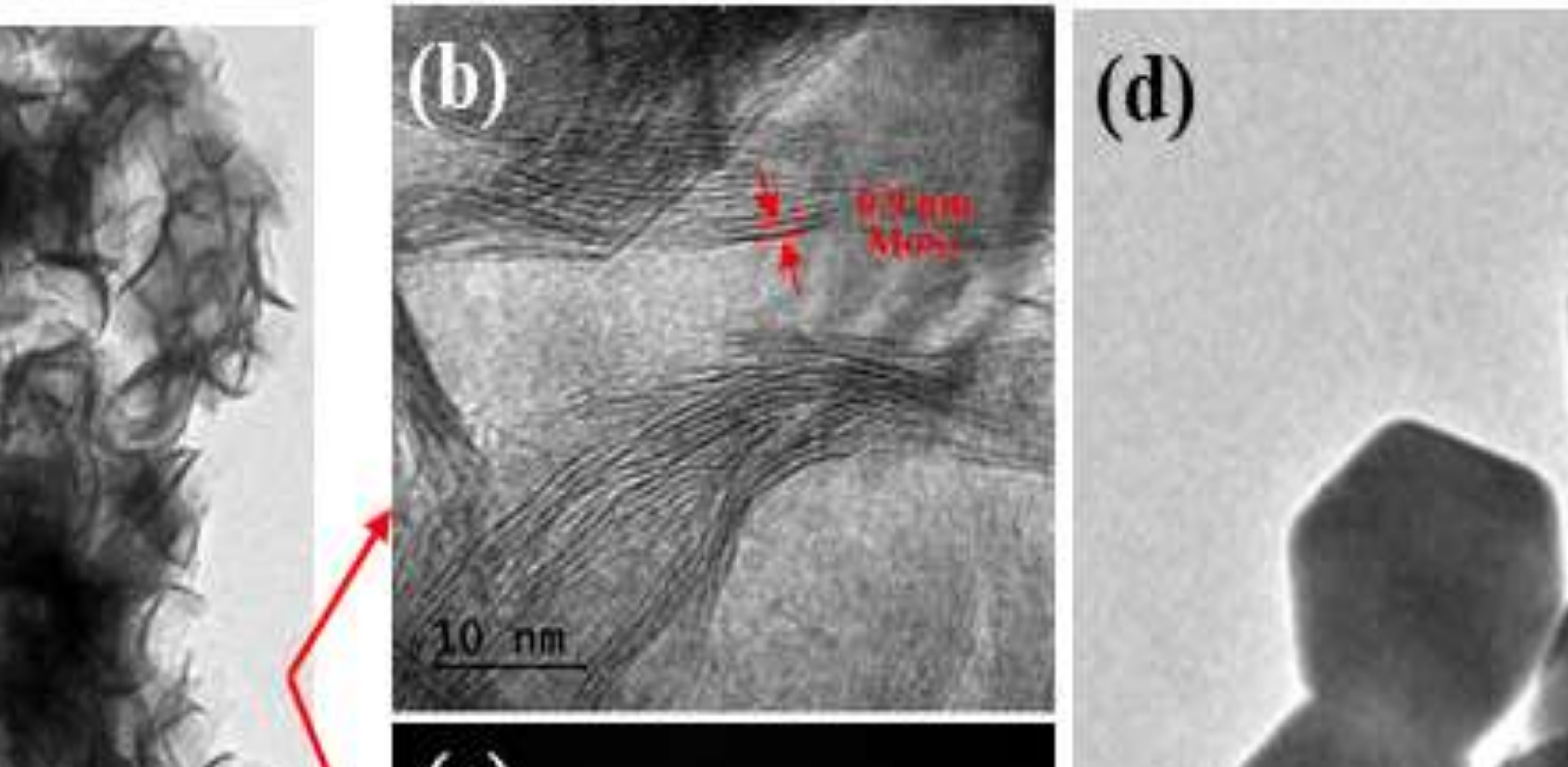
A XRD


(c)
ZIF-67.Ni/(MoS2)70%
(b)
ZIF-67.Ni
(011)
(002)
(112)
(022)
(013)
(222)
(114)
(233)
(134)
(044)
(334)
(244)
(235)
(a)
MoS2
(002)
(004)
(100)
(110)
2H-MoS2
JCPDS 37-1492
(002)
(004)
(100)
(101)
(102)
(103)
(006)
(105)
(006)
(110)
(008)
Intenisity (a.u)
10
20
30
40
50
60
70
2θ (degree)


ZIF-67.Ni
(a)
500 nm
1T -MS
(b)
100 nm
500 nm
ZIF-67.Ni/(MoS2)10%
(c)
500 nm
ZIF-67.Ni/(MoS2)30%
(d)
500 nm
ZIF-67.Ni/(MoS2)50%
(e)
500 nm
ZIF-67.Ni/(MoS2)70%
(f)
500 nm

D HRTEM

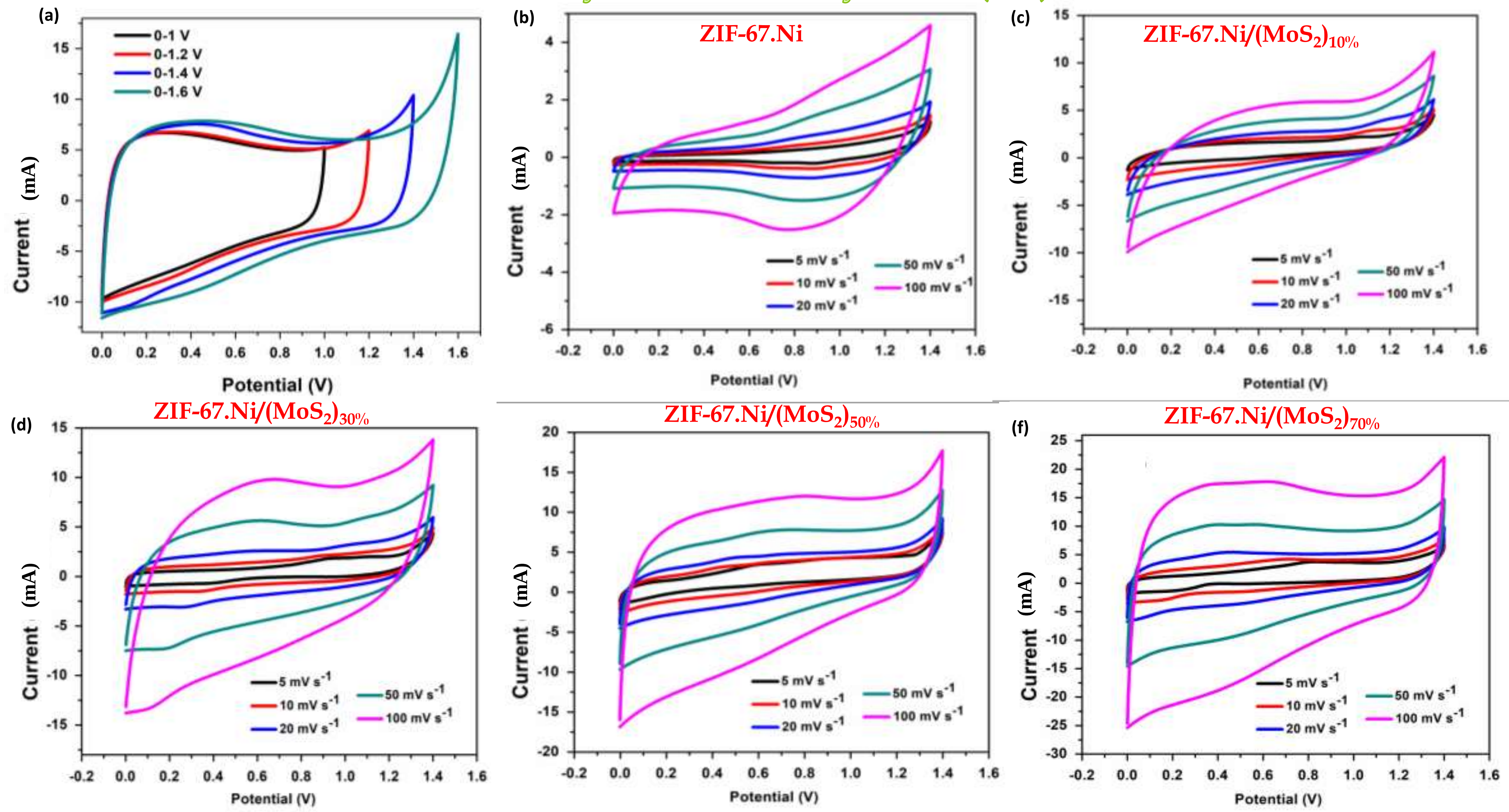
1T –MoS_2



G

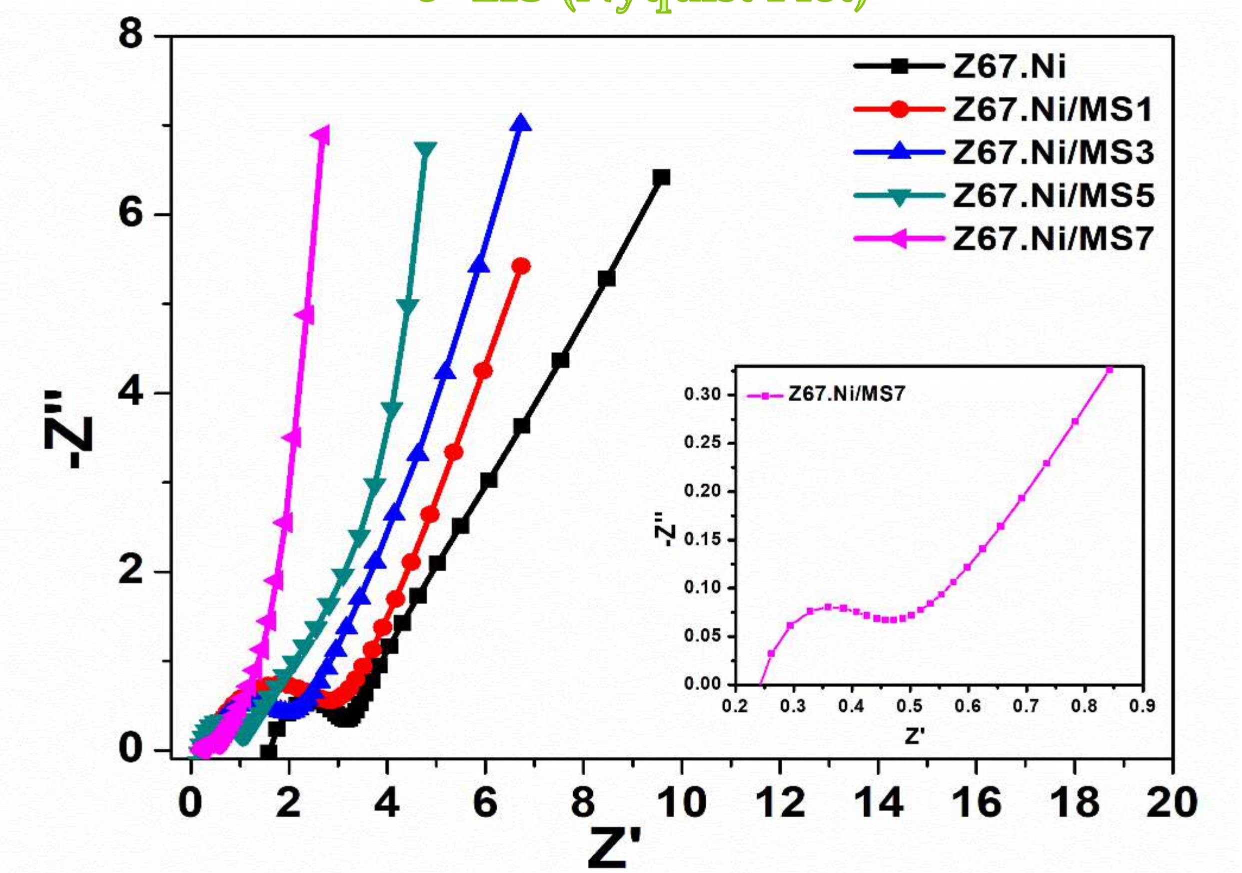
Electrochemical Analysis

1- Cyclic voltammetry curves (CV)



G Electrochemical Analysis

3- EIS (Nyquist Plot)



R (Ω)	ZIF-67.Ni	ZIF-67.Ni/$(MoS_2)_{10\%}$	ZIF-67.Ni/$(MoS_2)_{30\%}$	ZIF-67.Ni/$(MoS_2)_{50\%}$	ZIF-67.Ni/$(MoS_2)_{70\%}$
R_s (Ω)	1.6	0.5	0.4	0.2	0.23
R_{ct} (Ω)	3.16	2.8	2	1.1	0.49
R_p (Ω)	1.56	2.3	1.6	0.9	0.29

10.3	9.4
CiteScore	Impact Factor

Journal of Energy Storage 82 (2024) 110360

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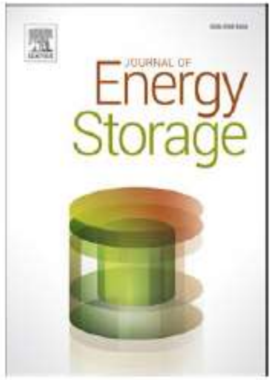


Research papers

Synergistic interaction between molybdenum disulfide nanosheet and metal organic framework for high performance supercapacitor

Fatma M. Ahmed [a,b], Ebtesam E. Ateia [a], S.I. El-dek [c,*], Sherine M. Abd El-Kader [b], Amira S. Shafaay [a]

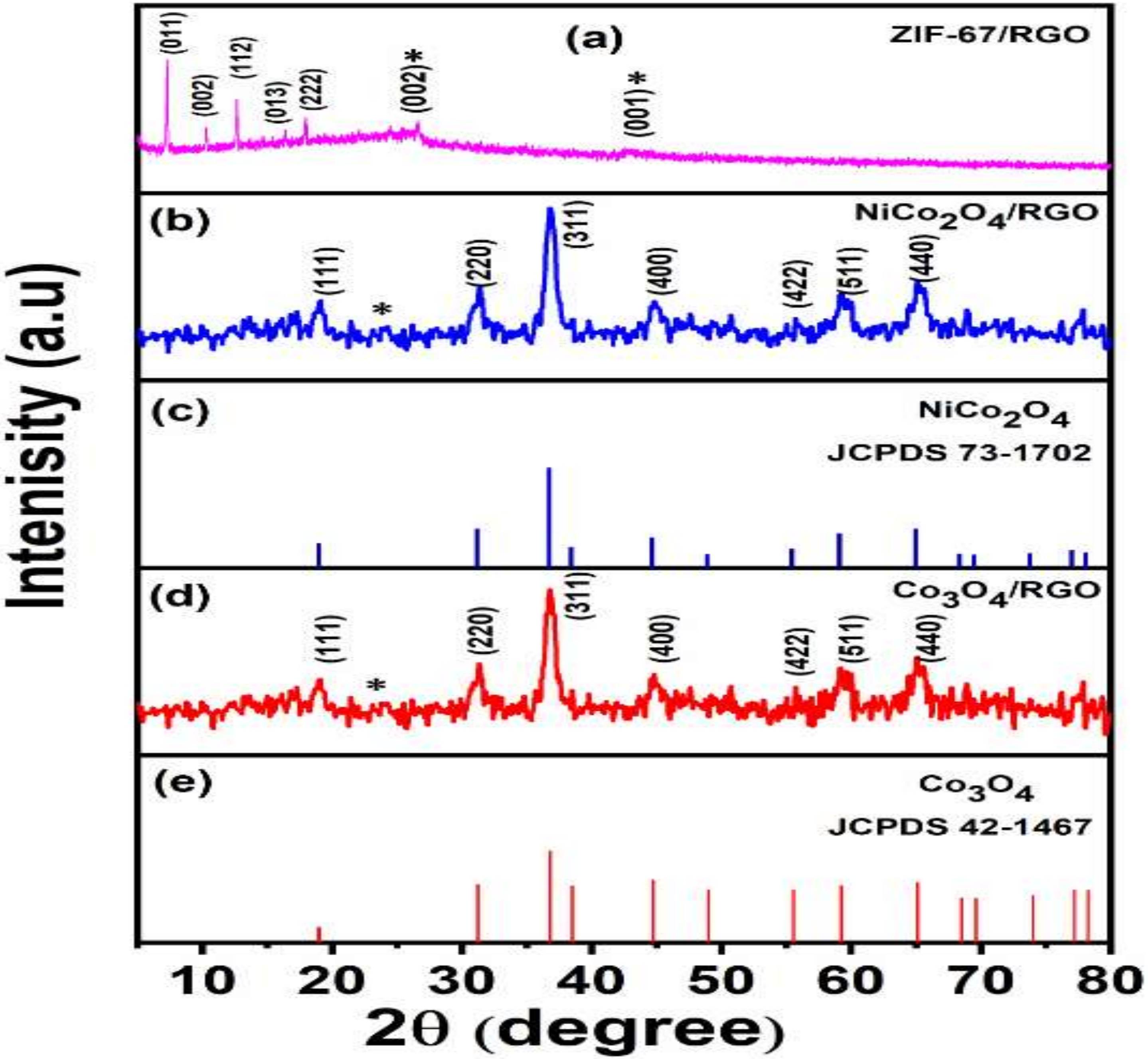
[a] *Physics department, Faculty of Science, Cairo University, Giza, Egypt*

[b] *Electronics Research Institute, Cairo 12622, Egypt*

[c] *CoE Nano Psas, Materials Science and Nanotechnology Department, Faculty of Postgraduate Studies for Advanced Sciences (PSAS), Beni-Suef University, Beni-Suef 62511, Egypt*

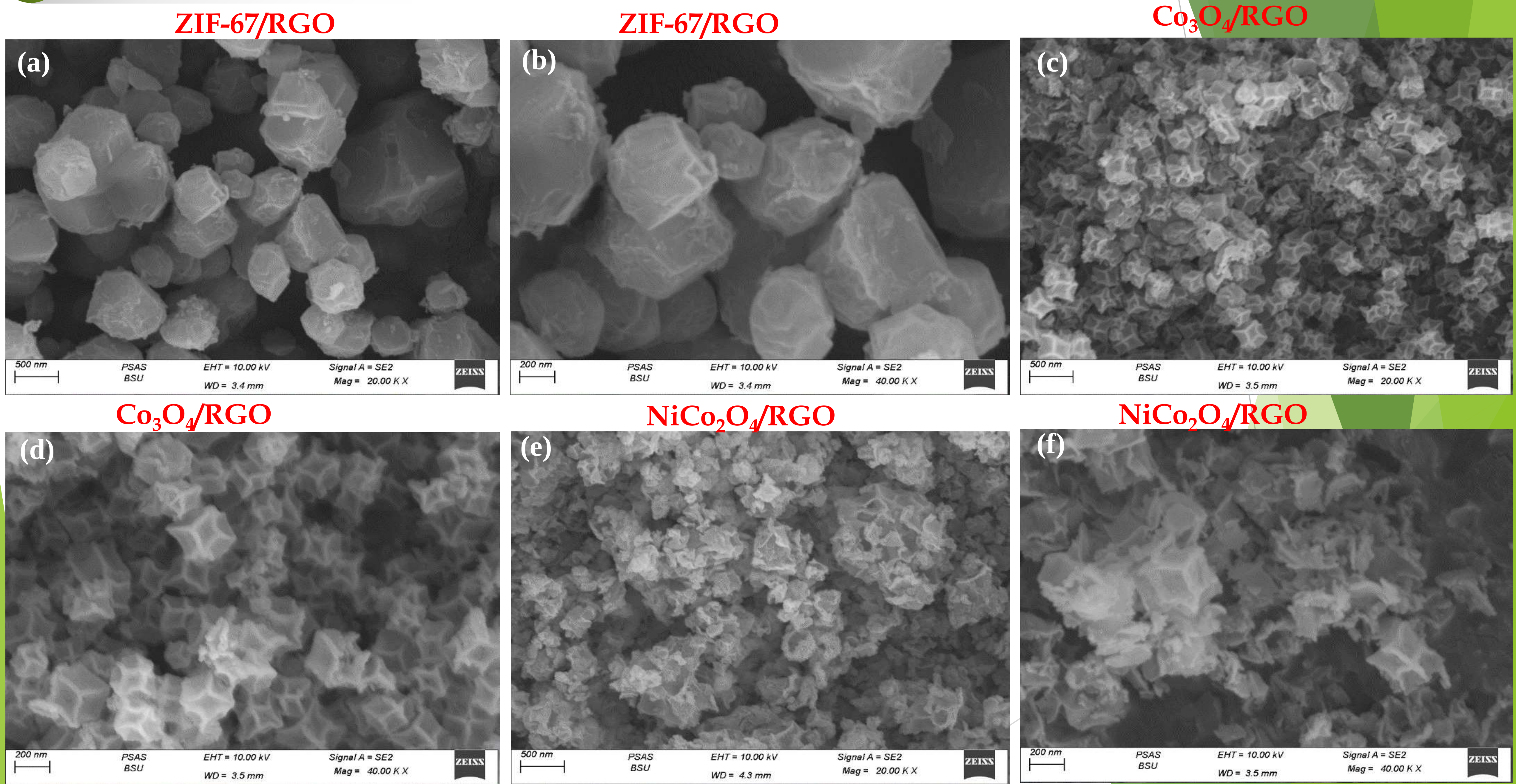
A

XRD



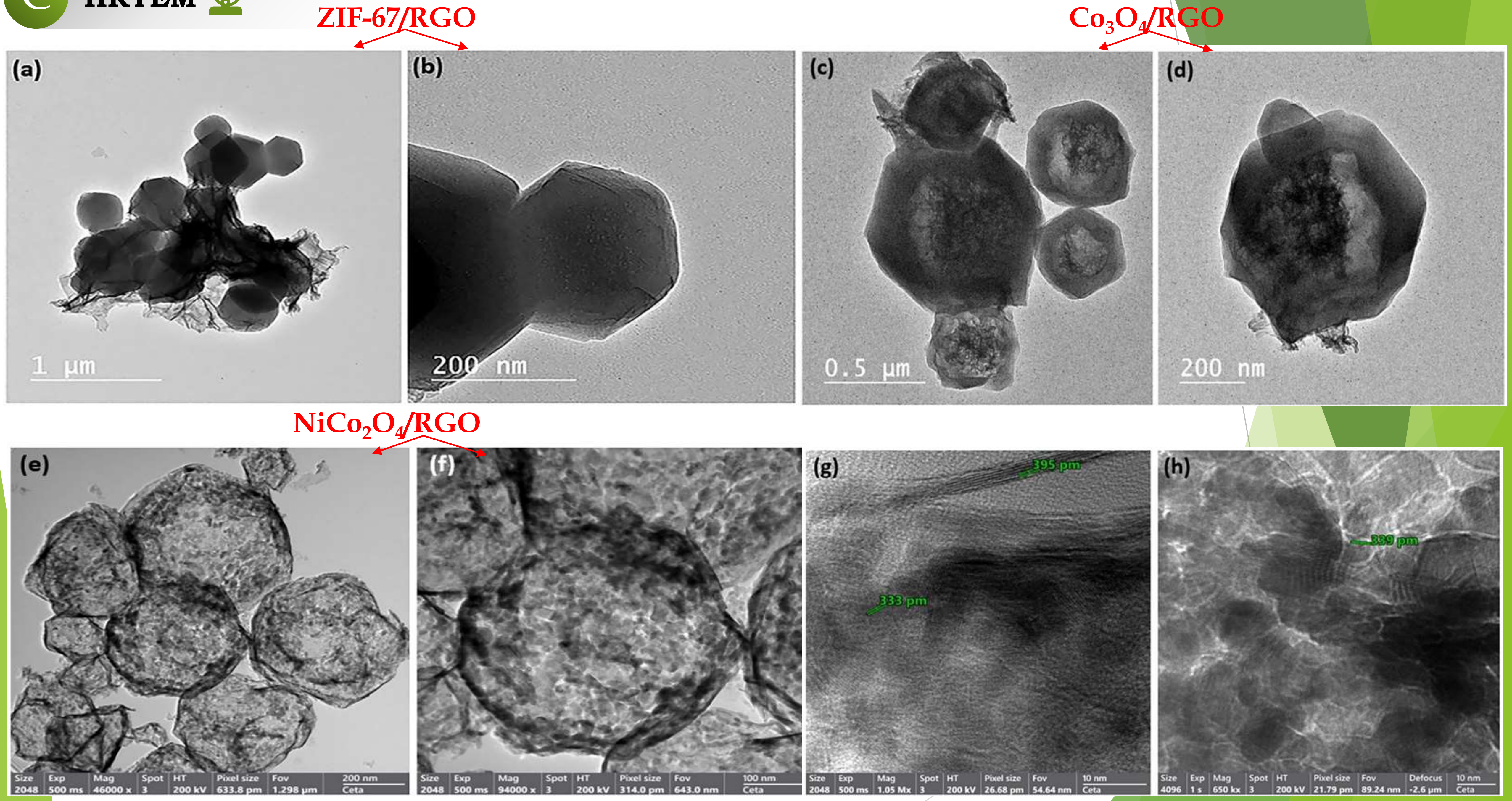
(a)
ZIF-67/RGO
(011)
(002)
(112)
(013)
(222)
(002)*
(001)*
(b)
NiCo2O4/RGO
(111)
*
(220)
(311)
(400)
(422)
(511)
(440)
(c)
NiCo2O4
JCPDS 73-1702
(d)
Co3O4/RGO
(111)
*
(220)
(311)
(400)
(422)
(511)
(440)
(e)
Co3O4
JCPDS 42-1467
Intenisity (a.u)
10
20
30
40
50
60
70
80
2θ (degree)

B FESEM



ZIF-67/RGO
ZIF-67/RGO
Co_3O_4/RGO
(a)
500 nm
PSAS
BSU
EHT = 10.00 kV
WD = 3.4 mm
Signal A = SE2
Mag = 20.00 K X
ZEISS
(b)
200 nm
PSAS
BSU
EHT = 10.00 kV
WD = 3.4 mm
Signal A = SE2
Mag = 40.00 K X
ZEISS
(c)
500 nm
PSAS
BSU
EHT = 10.00 kV
WD = 3.5 mm
Signal A = SE2
Mag = 20.00 K X
ZEISS
Co_3O_4/RGO
$NiCo_2O_4$/RGO
$NiCo_2O_4$/RGO
(d)
200 nm
PSAS
BSU
EHT = 10.00 kV
WD = 3.5 mm
Signal A = SE2
Mag = 40.00 K X
ZEISS
(e)
500 nm
PSAS
BSU
EHT = 10.00 kV
WD = 4.3 mm
Signal A = SE2
Mag = 20.00 K X
ZEISS
(f)
200 nm
PSAS
BSU
EHT = 10.00 kV
WD = 3.5 mm
Signal A = SE2
Mag = 40.00 K X
ZEISS

C HRTEM



ZIF-67/RGO
Co3O4/RGO
NiCo2O4/RGO
(a)
1 μm
(b)
200 nm
(c)
0.5 μm
(d)
200 nm
(e)
Size 2048 Exp 500 ms Mag 46000 x Spot 3 HT 200 kV Pixel size 633.8 pm Fov 1.298 μm 200 nm Ceta
(f)
Size 2048 Exp 500 ms Mag 94000 x Spot 3 HT 200 kV Pixel size 314.0 pm Fov 643.0 nm 100 nm Ceta
(g)
395 pm
333 pm
Size 2048 Exp 500 ms Mag 1.05 Mx Spot 3 HT 200 kV Pixel size 26.68 pm Fov 54.64 nm 10 nm Ceta
(h)
339 pm
Size 4096 Exp 1 s Mag 650 kx Spot 3 HT 200 kV Pixel size 21.79 pm Fov 89.24 nm Defocus -2.6 μm 10 nm Ceta

J Mater Sci

Journal Impact Factor 3.5 (2023)

Energy materials

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Rational construction of a hollow bimetallic porous composite derived zeolite imidazole framework based reduced graphene oxide nanosheets for supercapacitor applications

Fatma M. Ahmed[1,2], Ebtesam E. Ateia[1], Sherine M. Abd El-Kader[2], Amira S. Shafaay[1], and S. I. El-dek[3,*]

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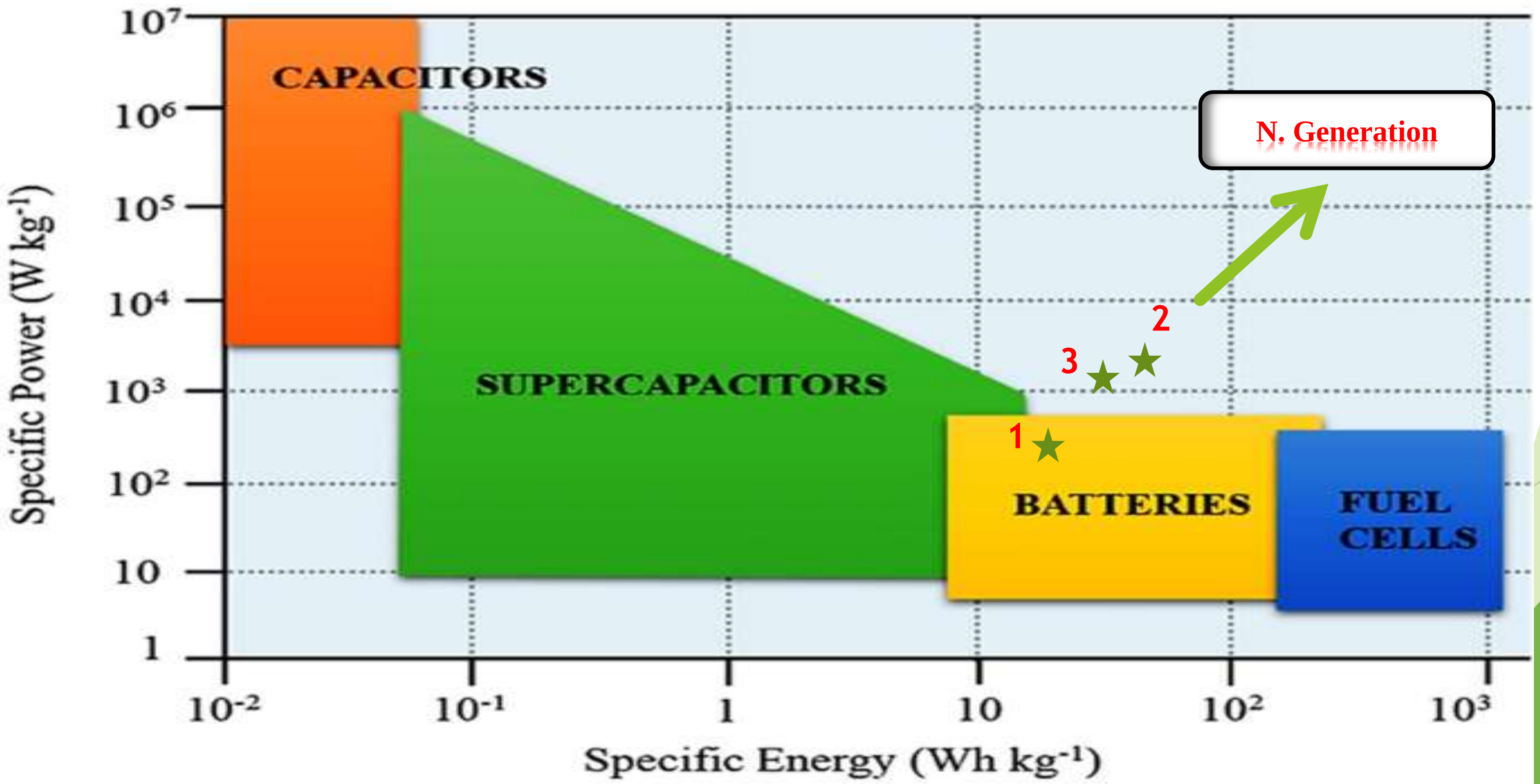
[2] *Electronics Research Institute, Cairo 12622, Egypt*

[3] *CoE Nano Psas, Materials Science and Nanotechnology Department, Faculty of Postgraduate Studies for Advanced Sciences (PSAS), Beni-Suef University, Beni-Suef 62511, Egypt*

5 Conclusion

Group 1	Group 2	Group 3
$(ZIF\text{-}67.Ag_{10\%})_{50\%}/RGO_{50\%}$	$ZIF\text{-}67.Ni/(MoS_2)_{70\%}$	$NiCo_2O_4/RGO$
E=46.38 W h kg^{-1} P=199.7 W kg^{-1} Lifetime=97% (2000)	E=83.98 W h kg^{-1} P=2087 W kg^{-1} Lifetime= 96% (10000)	E=75.54 W h kg^{-1} P=1600 W kg^{-1} Lifetime= 91.7% (10000)

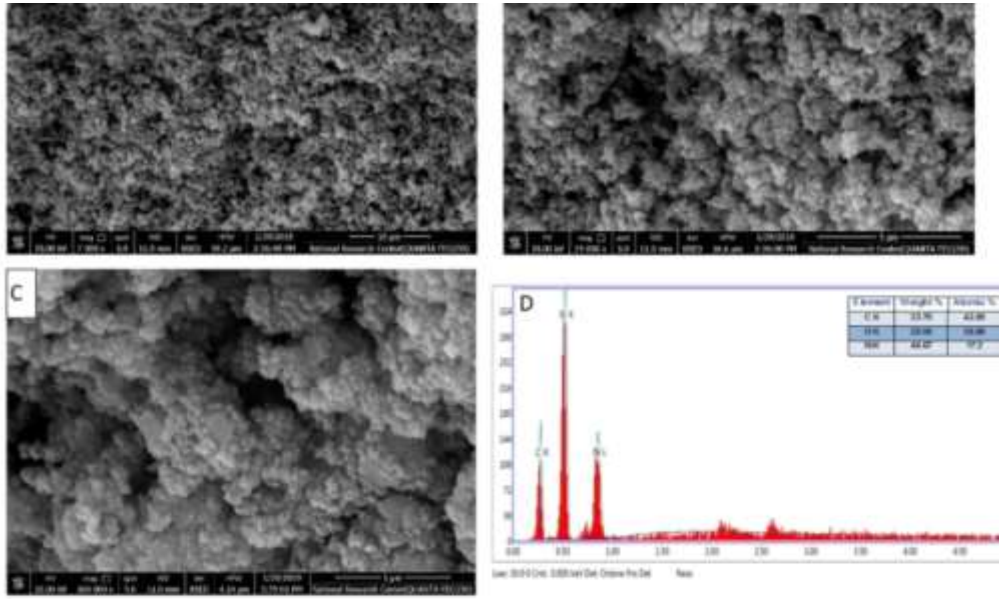


Research | Open access | Published: 09 June 2023

Nickel-gallate metal–organic framework as an efficient antimicrobial and anticancer agent: in vitro study

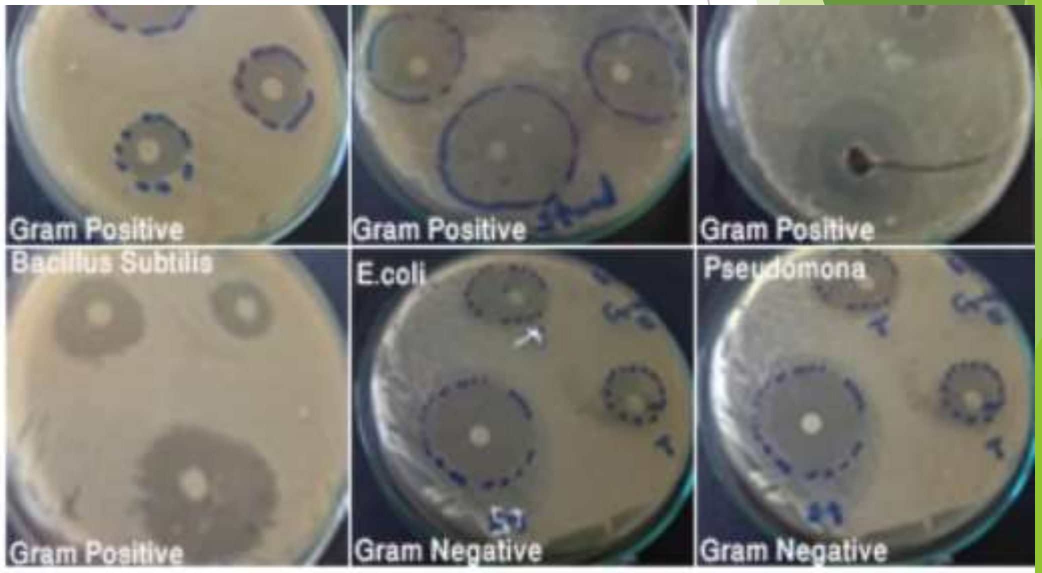
Ahmed. A. G. El-Shahawy, Esam M. Dief, S. I. El-Dek, A. A. Farghali & Fatma I. Abo El-Ela

Cancer Nanotechnology 14, Article number: 60 (2023) | Cite this article



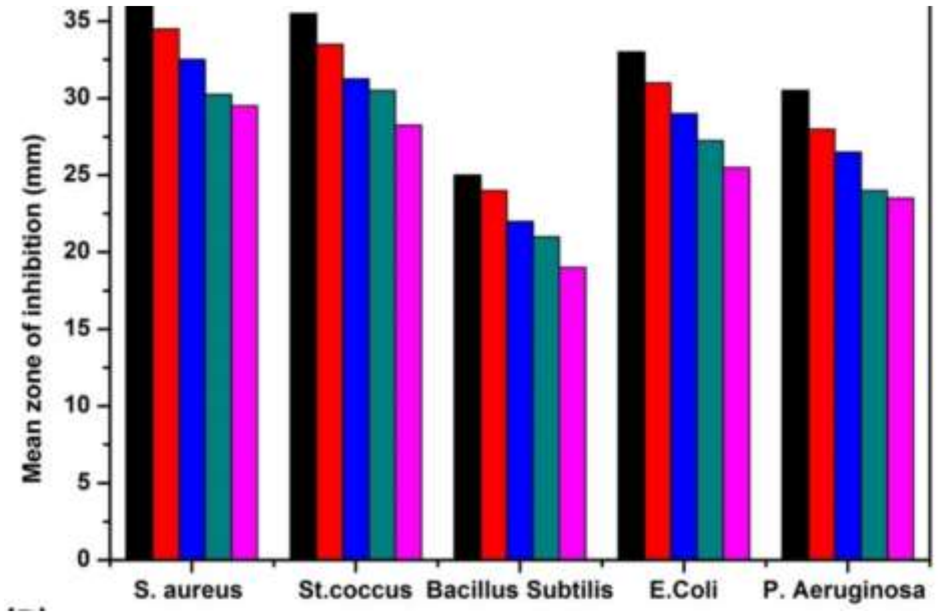
SEM images of Ni-GA MOF nanoparticles (**A**, **B** and **C**). EDX analysis (**D**)

Full size image ›



Images showing the zone of inhibition (mm) Ni-Gallate MOF against different gram-positive and gram-negative bacterial strains

Full size image ›



The as-synthesized Ni-gallate MOF nanostructures have shown high antibacterial activity against both Gram-positive and Gram-negative bacterial species, in addition to a wide spectrum antifungal activity. Furthermore, Ni-gallate MOF was found to inhibit the cancer cell growth in rhabdomyosarcoma (RMS), with an effectiveness quite significant, compared to the reference anticancer doxorubicin.

Electrospun manuka honey@PVP nanofibers enclosing chitosan-titanate for highly effective wound healing

Original Research | Open access | Published: 06 June 2023 | **30**, 6487–6505 (2023)

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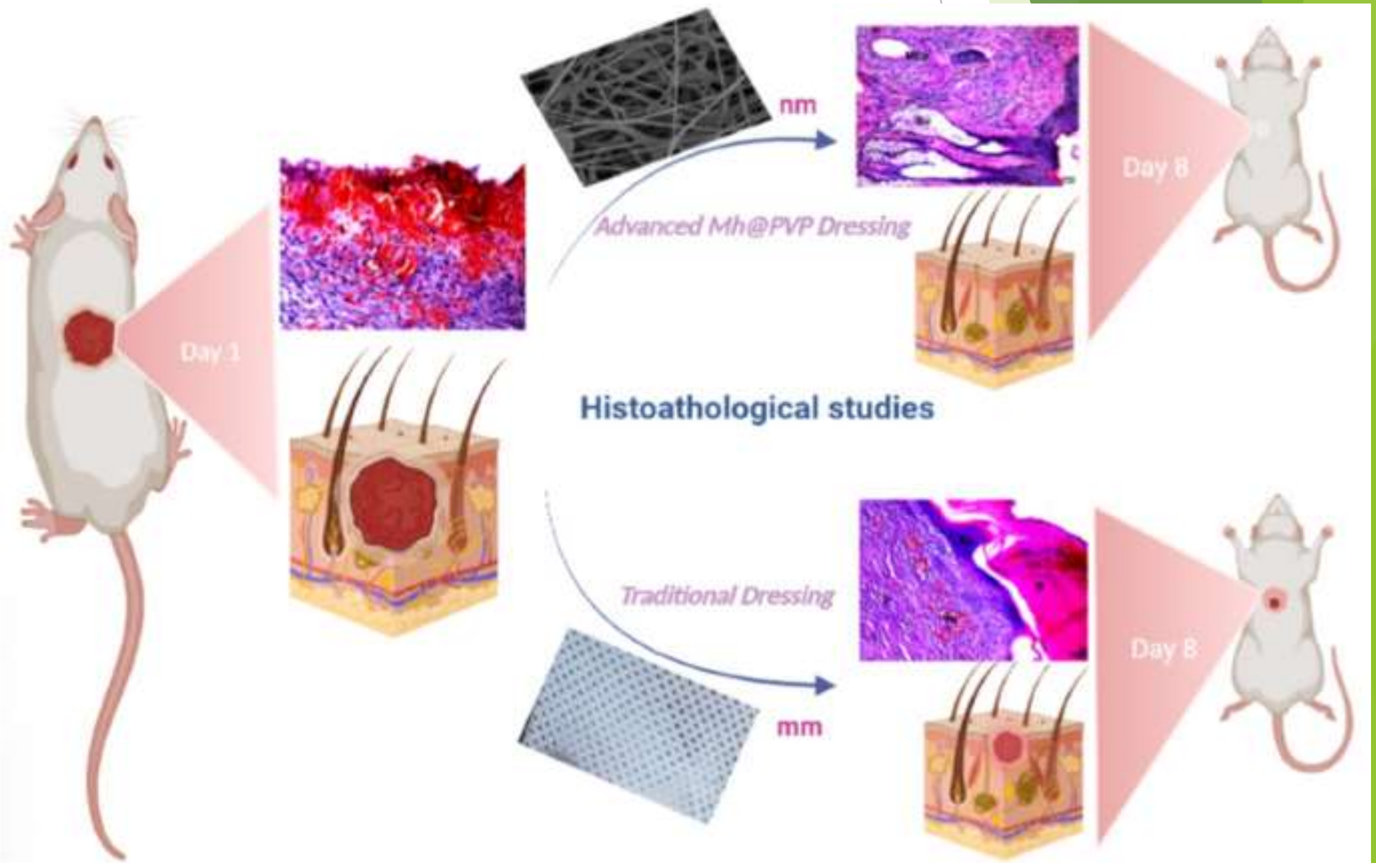
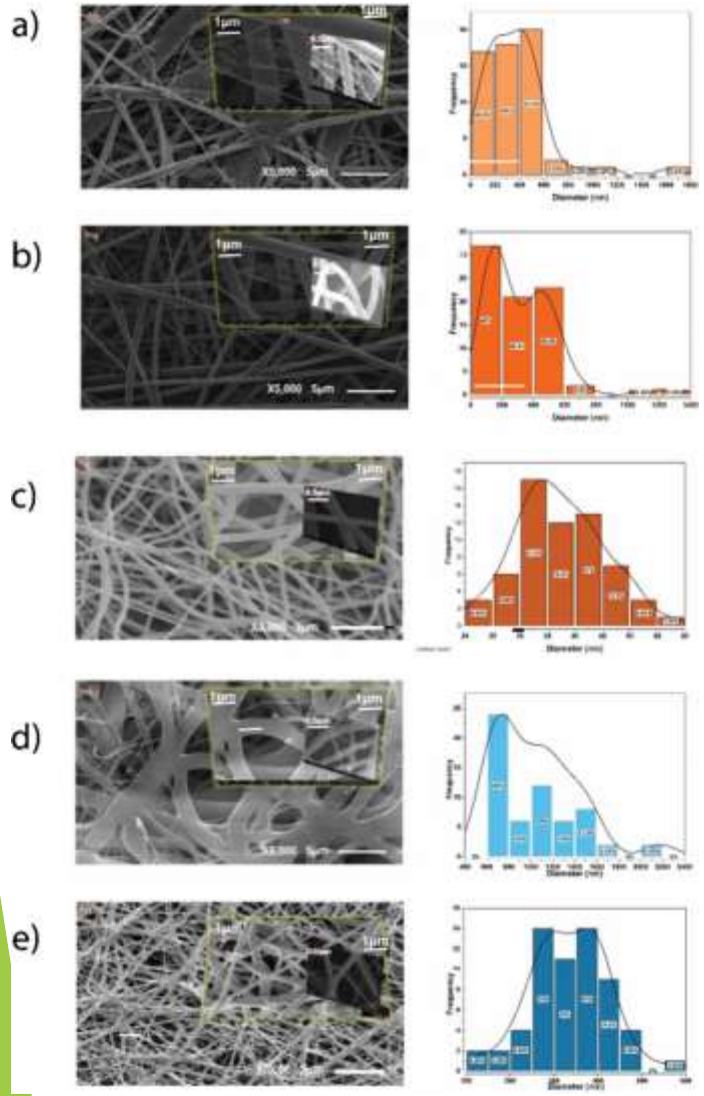
Lamyaa M. Kassem, Ahmed G. El-Deen ✉, A. H. Zaki & S. I. El-Dek ✉





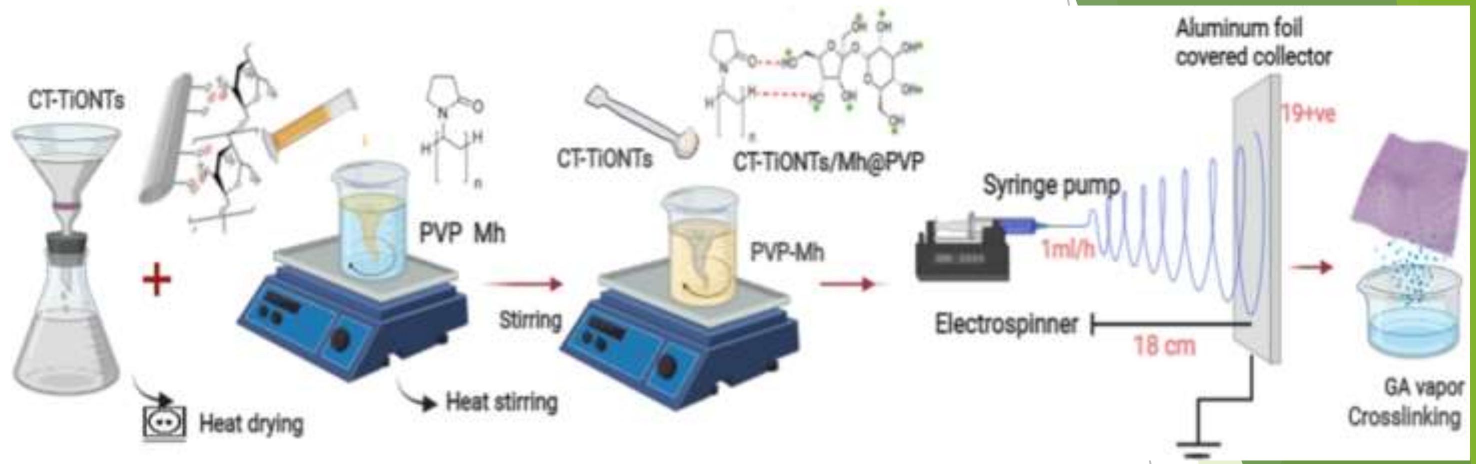
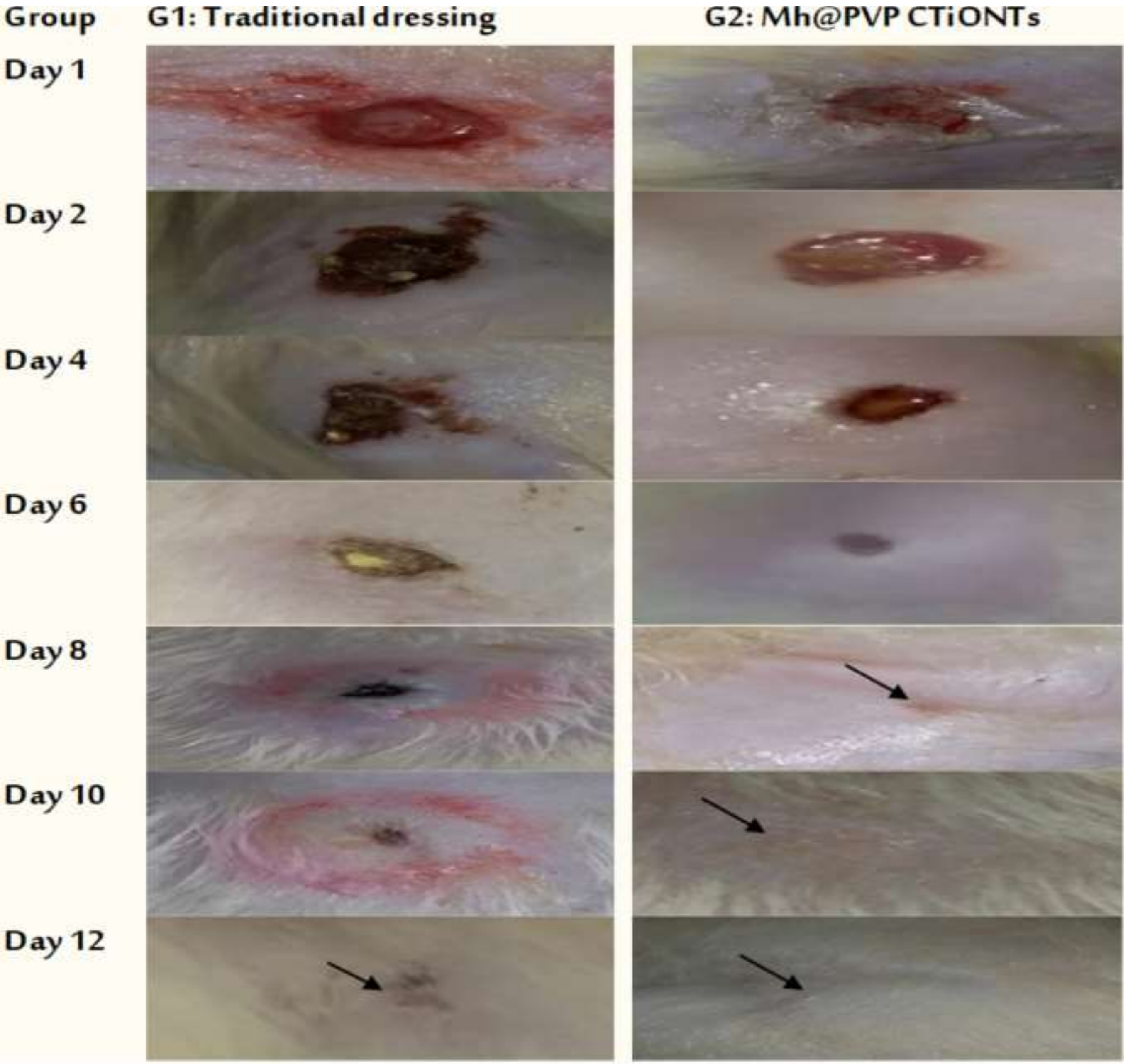


Table 2 Mechanical properties Summary

From: Electrospun manuka honey@PVP nanofibers enclosing chitosan-titanate for highly effective wound healing

Property		Electrospun Naofiberous Scaffold				
		PVP	Mh 15% @PVP	Mh 20% @PVP	Mh 25% @PVP	CT-TiONTs/Mh 15% @PVP
Viscosity (Pa.s)		178	131	108	97	147
Electrical conductivity (μs)		314	572	928	1360	583
Average tensile strength (Newton)	Wet	2.41	2.06	3.24	4.65	2.17
	Dry	3.37	3.85	5.48	6.1	3.79
Water contact angle (Degree)		42.12 ± 1.62°	38.87 ± 1.09°	32 ± 2.37°	24.16 ± 1.4°	36.87 ± 0.43°

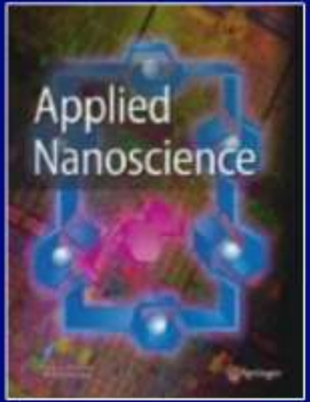
Mh25%@PVP scaffold, **b**: Mh20%@PVP scaffold, **c**: Mh15%@PVP scaffold, **d**: Mh15%@PVP scaffold crosslinked at 50 °C, **e**: Mh15%@PVP scaffold crosslinked at 30 °C.



Using a highly concentrated PVP solution allows for higher manuka honey incorporation while reducing the flattening or beading morphology caused by high honey concentration. SEM images confirmed that PVP with 15% Mh gave the best scaffolds with improved mechanical properties. Applying manuka honey topically helps prevent wound infections, accelerates wound healing, and slows the spread of necrotizing fasciitis. Our studies demonstrated that PVP-Mh dressings improve the quality of wound healing and skin regeneration, resulting in scarless regrowth of hair. By incorporating manuka honey into PVP, electrospun nanofibrous scaffolds gain increased wettability and permeability, allowing them to absorb exudates and retain moisture in the wound bed. Due to the honey's low toxicity, our cell viability studies show that the more honey you use, the more benefits you get.

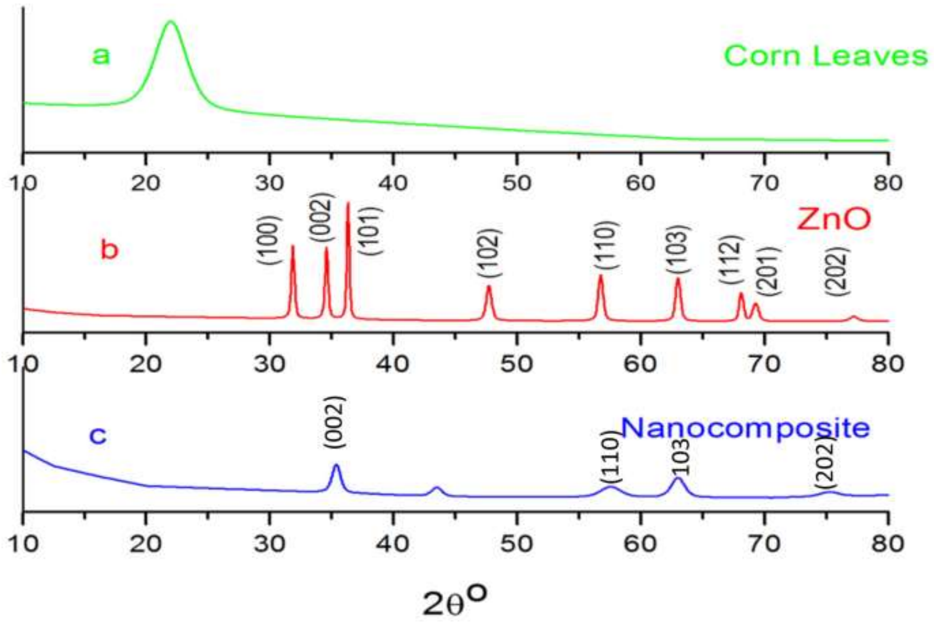
Ecofriendly sustainable synthetized nano-composite for removal of heavy metals from aquatic environment

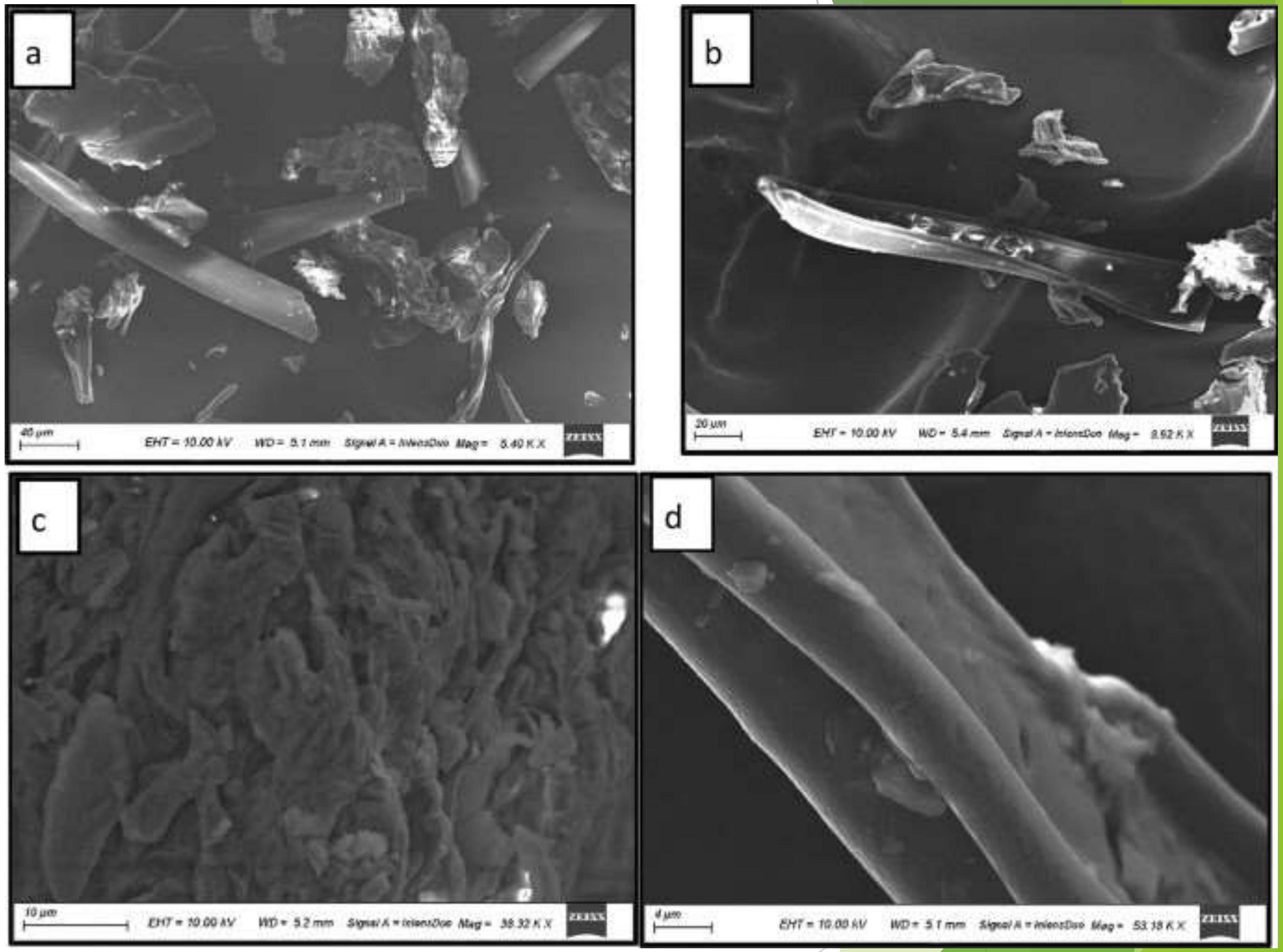
Original Article | Open access | Published: 14 February 2022 | **12**, 1585–1600 (2022)



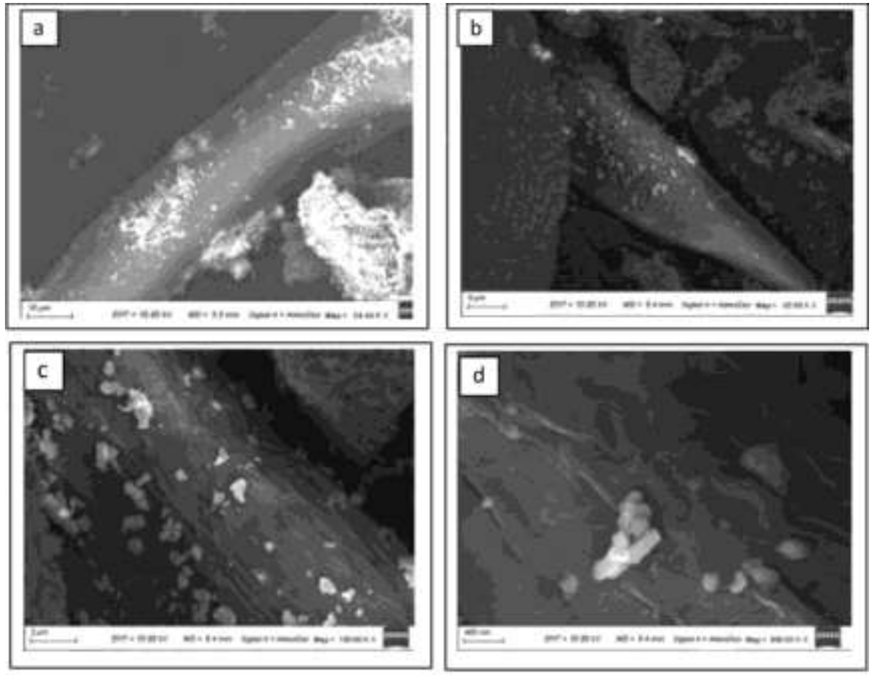
Applied Nanoscience

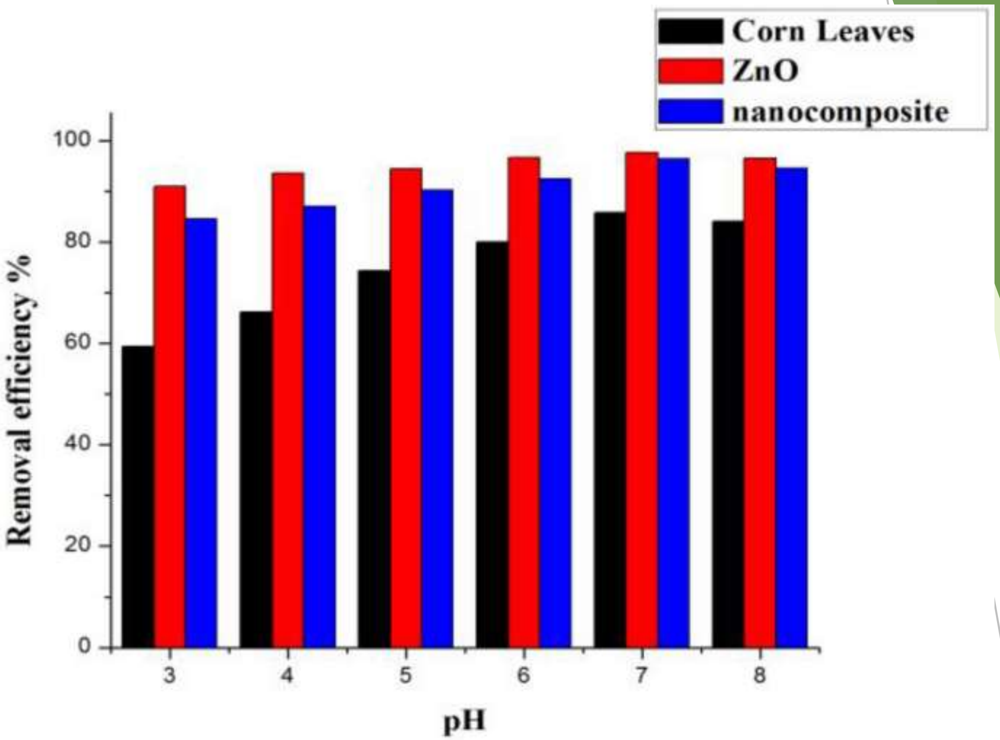
Mohamed Farouz, S. I. El-Dek, Mohamed M. ElFaham & Usama Eldemerdash





FESEM of corn
leaves, **a** 40 μm, **b** 20 μm, **c** 10 μm, **d** 4 μm





Nanoparticles of ZnO possessing nanoparticle size (30 nm) helped to improve the capability of corn leaves through the synthesis of the nanocomposite. It acts as an excellent bio-adsorbent for heavy metals such as Fe and Ni at optimum conditions of pH and adsorption time. The adsorption assessment and validation results showed that the nanocomposite material is competitive compared to the nano zinc oxide. However, the integration of the biomass precursor and the nano zinc oxide resulted in low-cost applicable adsorbent for removal of heavy metals from aquatic environment. However, this approach may help to tackle two problems of agriculture solid waste such as corn leaves and heavy metals removal from the aquatic environment. The results suggest testing the proposed nanocomposite for industrial application.

ELSEVIER

Journal of Magnetism and Magnetic Materials

Volume 544, 15 February 2022, 168681

Research articles

Valorization of industrial iron and zinc sludges for the synthesis of $ZnFe_2O_4$ ceramics

Amira M.M. Amin [a], Yosra M.M. Soliman [a b], S.I. El-Dek [b], Yasser M.Z. Ahmed [a], A.H. Zaki [b]

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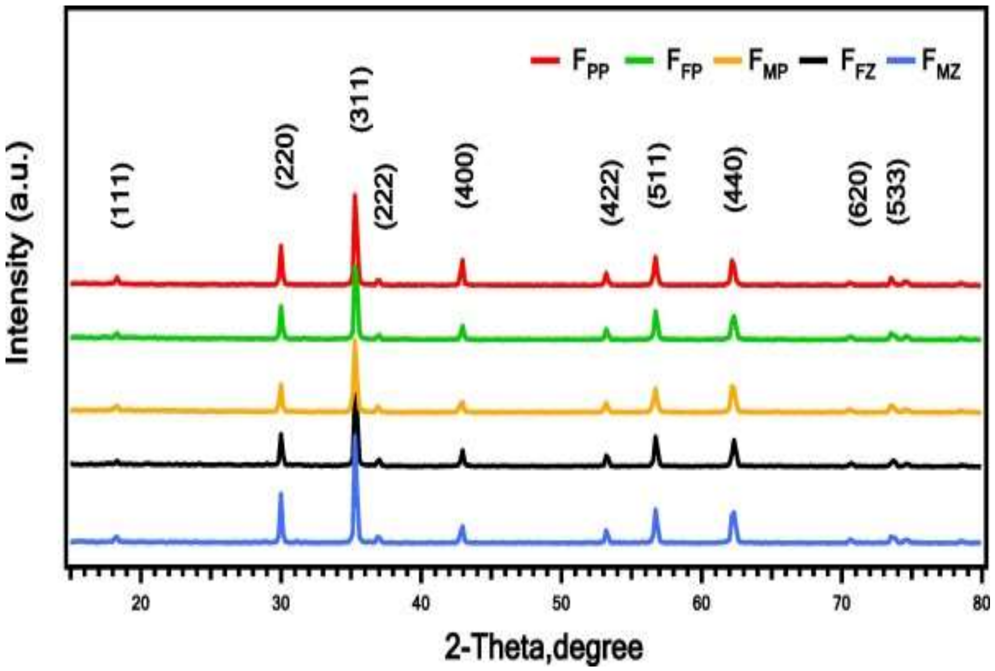
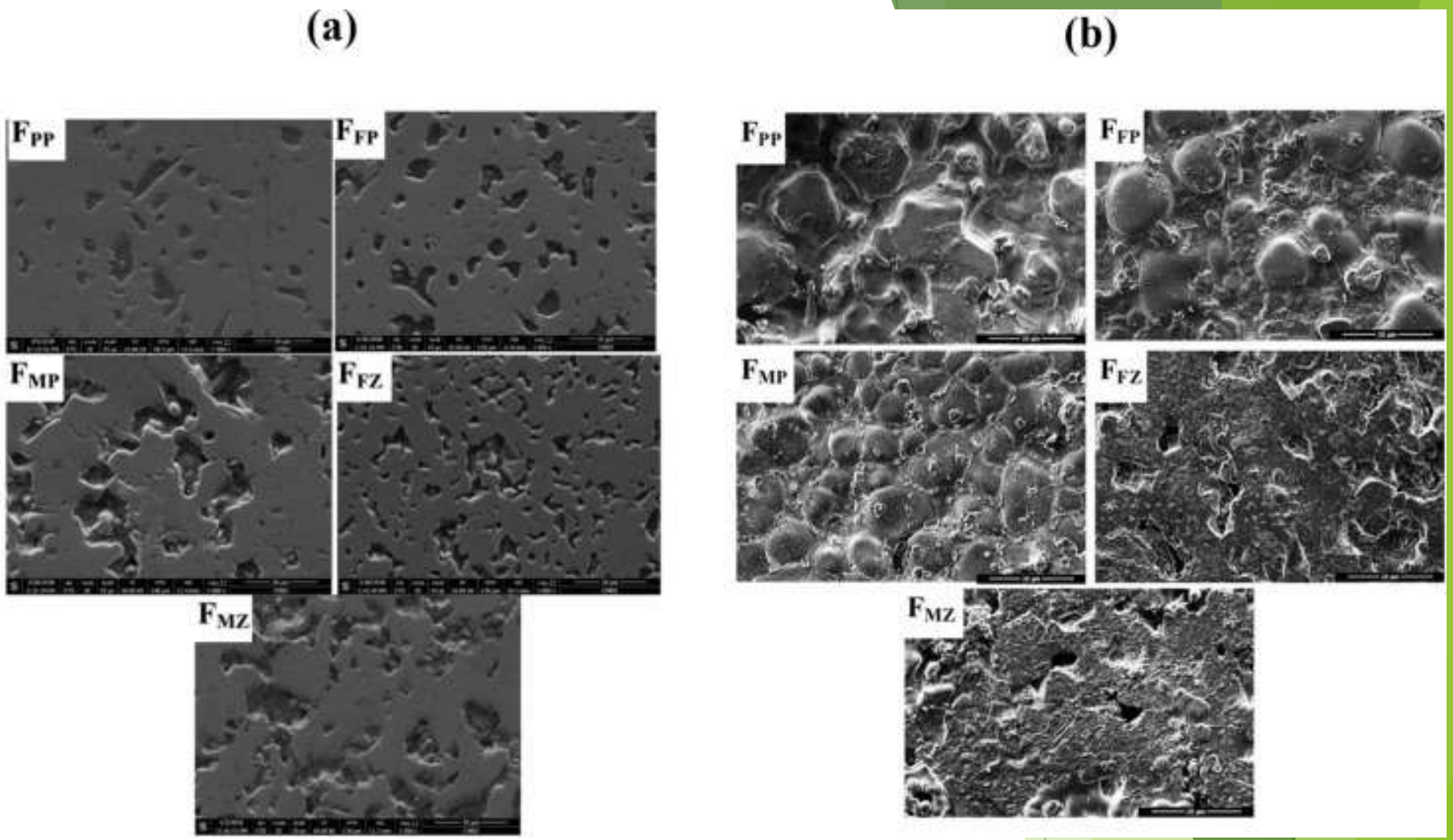
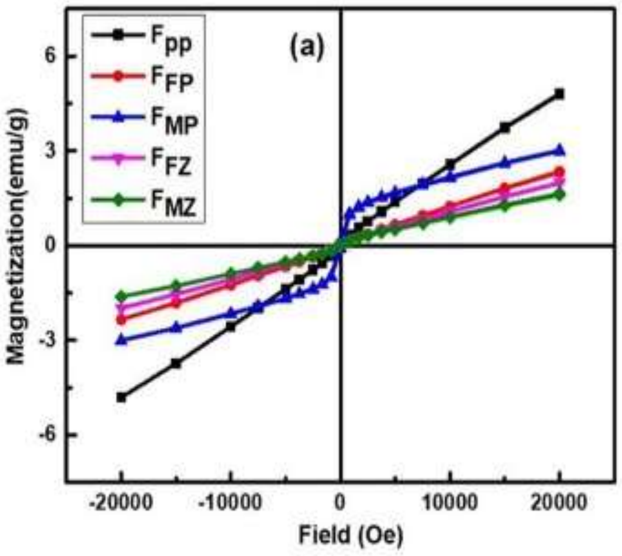
https://doi.org/10.1016/j.jmmm.2021.168681





FESEM of zinc ferrite sintered samples synthesized from different mixtures composition (a) before etching (b)after etching.



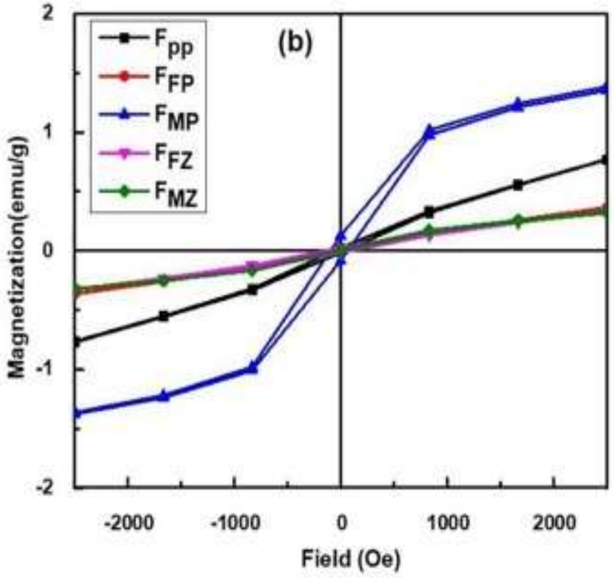


Table 9. The magnetic parameters of zinc ferrite samples at room temperature, saturation magnetization, M_s, coercive field, H_c, remanent magnetization, M_r.

References	Coercivity, H_c [Oe]	Retentivity, M_r [emu/g]	Saturation magnetization, M_s [emu/g]	Samples
This work	49.270	0.020	4.800	F_{PP}
This work	32.910	0.006	2.340	F_{FP}
This work	81.030	0.106	3.000	F_{MP}
This work	118.790	0.021	1.980	F_{FZ}
This work	24.390	0.005	1.630	F_{MZ}
[13]	128	0.830	7.800	–
[58]	221	0.300	2.800	–
[59]	0.001	0.001	1.900	–

The simple and low-cost methodology was successful in preparing $ZnFe_2O_4$ by solid-state reaction using different starting materials including wastes. . The applied technique for the preparation of zinc ferrite by waste valorization is applicable for the production of many types of ferrites.

Toxicology and Industrial Health

Impact Factor: **1.7** / 5-Year Impact Factor: **2.0**

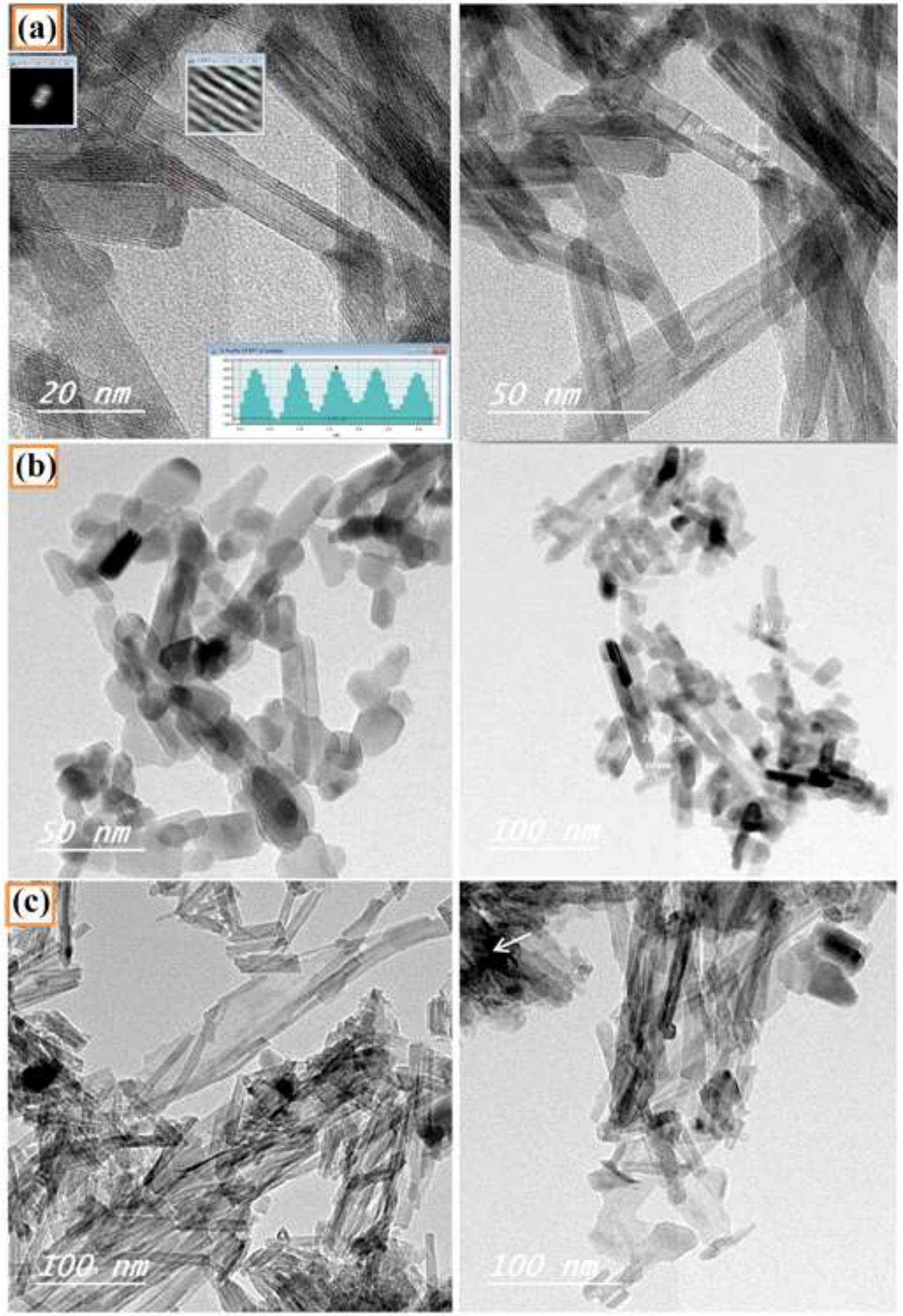
Journal Homepage

Restricted access | Research article | First published online June 18, 2020

Changing the morphology of one-dimensional titanate nanostructures affects its tissue distribution and toxicity

Nahla Kamal, AH Zaki, [...], and SI El-Dek (+2) View all authors and affiliations

Volume 36, Issue 4 | https://doi.org/10.1177/0748233720921693



gure 2. HRTEM images of titanate nanostructures: (a, b) nanotubes, (c, d) nanorods, and (e, f) nanoribbons. HRTEM:

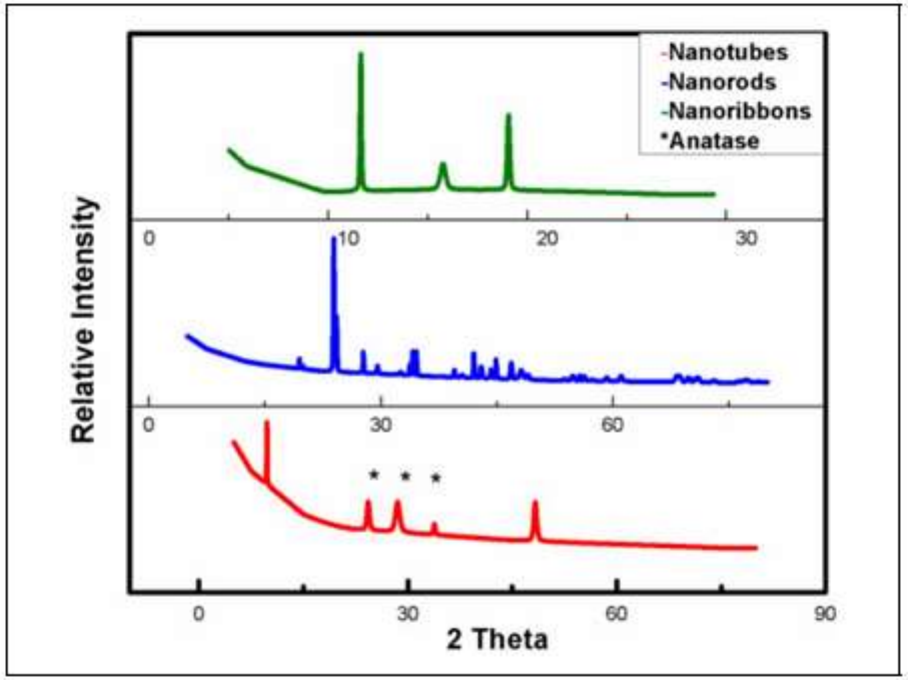


Figure 1. XRD patterns of the prepared titanate nanostructures. XRD: X-ray diffraction.

The nano tubes had the greatest accumulation, and it was the strongest toxic among the three configurations, fol lowed by nanorods and ribbons. The results of this study indicated that the morphology change of TiO2 nanostructures would alter its in vivo distribution and toxicity. The data should be considered in the clinical setting

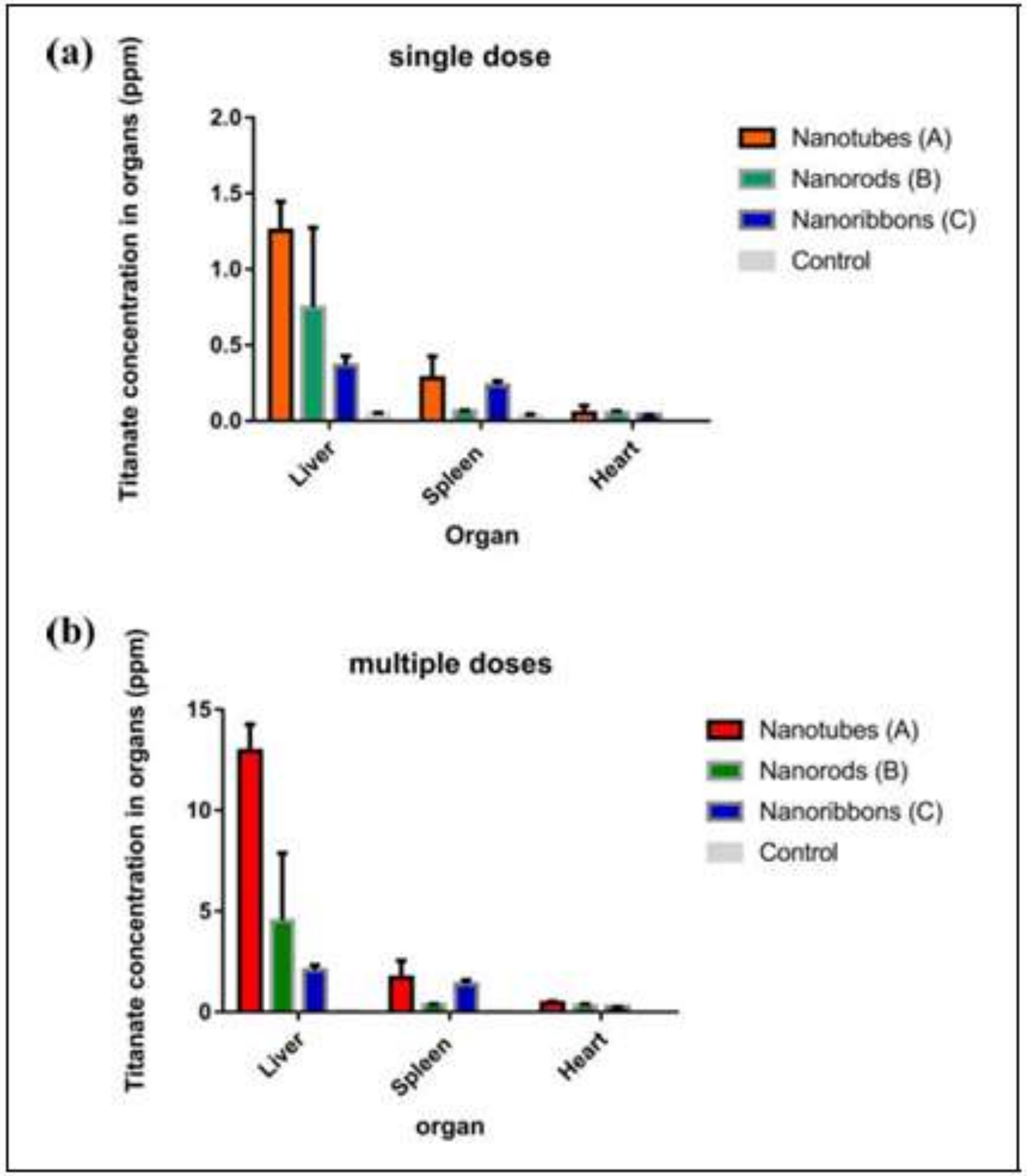


Figure 3. Titanate content in different organs following: (a) single dose and (b) multiple doses administration of different morphologies (mean ± SD). SD: standard deviation.

Royal Society Report
(http://www.nanotec.org.uk/finalReport.htm)

"it is important that claims of likely environmental benefits are assessed for the entire lifecycle of a material or product, from its manufacture through its use to its eventual disposal.

We recommend that lifecycle assessments be undertaken for applications of nanotechnologies."

VDI Report:Technological Analysis
Industrial application of nanomaterials - chances and risks

http://imperia5.vdi-online.de/imperia/md/content/tz/zuknftigetechnologien/11.pdf

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Some Documents to be aware of:

Societal Implications of Nanotechnology (http://nano.gov/html/res/home_res.html)

Chemical Industry R&D Roadmap for Nanomaterials By Design: From Fundamentals to Function (www.chemicalvision2020.org/pdfs/nano_roadmap.pdf

Swiss Re:Nanotechnology Small Matter, Many Unknowns (http://www.swissre.com/)

International Dialogue on Responsible Nanotechnology(http://www.nsf.gov/home/crssprgm/nano/dialog.htm)