Multifunctional Nanoparticles: Perspectives in Health Care

MGMIHS OMICS Research Center

MGM Central Research Laboratory

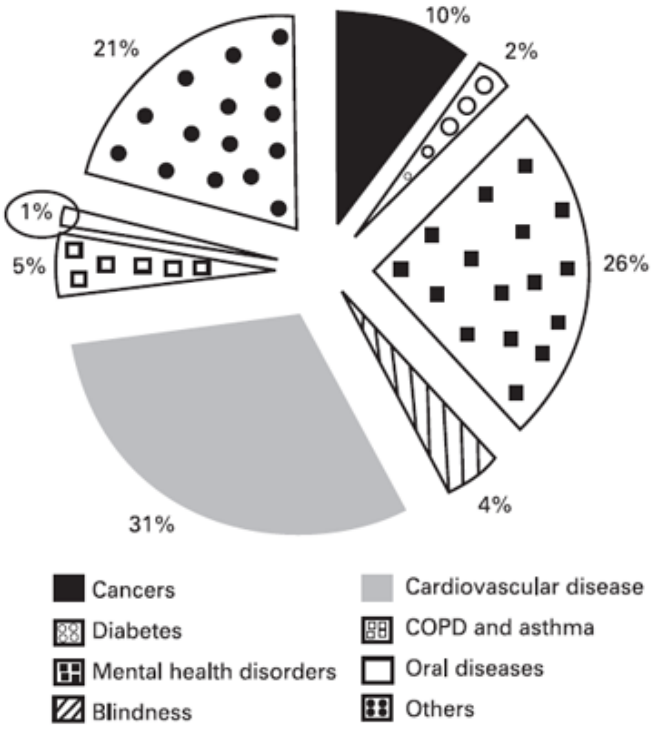


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Technical Director

Important facts

- Global disease burden is showing worrying trend.
- The proportion of the burden of NCDs is expected to increase to 57 % by 2020.
- By 2020, chronic diseases will account for almost three-quarters of all deaths worldwide
- Almost half of the total chronic disease deaths are attributable to cardiovascular diseases; obesity and diabetes.



http://www.ictph.org.in/gip-2009/images
Source ; Google image

Presently India is facing combination of communicable diseases and chronic diseases, with the burden of chronic diseases just exceeding

Factors responsible for disease development

- Poor sanitation and lack of clean water
- Food type
- Interaction with infectious agents
- Errors in genetic makeup
- Accident & injury,
- Living or working in a unhealthy environment
- Unknown factors

Modern dietary patterns and physical activity patterns are risk behaviors that travel across countries and are transferable from one population to another are affecting disease patterns globally

Important contributors in better disease management

- Disease detection techniques
- **Availability of a wide range of vaccines and pharmaceutical/ bio- pharmaceuticals**
- Better sanitation practices
- Availability of adequate food and safe drinking water
- The emerging societal situations and environmental consciousness
- **Interdisciplinary scientific intervention and the basic understanding of etiology of disease**

Vaccines and pharmaceutical/ bio- pharmaceuticals *have played crucial role in diseases management*



Uses of Pharmaceuticals/Biopharmaceuticals

- **Drug target**

- **Mechanism based action**

  - **Receptor based**

    Binding molecule

  - **Enzyme based**

    Enzyme modulator e.g.. Inhibitor

With the understanding of etiology of disease, many potential targets are identified



Disease development with initiation of allied events

- Obesity

Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health, leading to reduced life expectancy and/or increased health problems.

- **Major problems** : (BMI), exceeds 30 kg/m^2
- **Allied events** : **Diabetes , cardiovascular issues**
- **Treatment** : **Multidrug**

- Glaucoma

Glaucoma is known as silent thief of sight is an eye disorder in which the optic nerve suffers damage, if untreated this results into complete blindness.

- **Major problems** : **Blindness progression**
- **Allied events** : **Optic nerve damage , Elevated IOP, Reduction in total antioxidant**
- **Treatment** : **Multidrug**

Multidrug treatment resulted into various side effects



Opportunity for material scientist

- Designing and development of

Multitasking

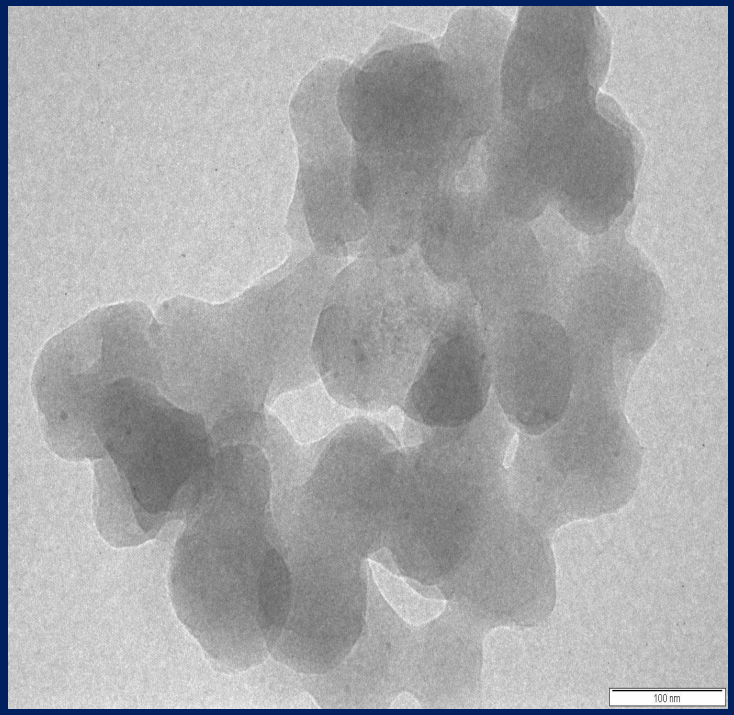
molecules/particles

Therapeutic agents

Disease development with initiation of allied events has inspired material scientist for designing and development of multitasking molecules for better management of diseases

Potential therapeutic agents

- -Molecule
- Multitasking drug candidate
- - Nanoparticle
- Multitasking nanoparticle (1-100 nm)
- - Pico particle
- Multitasking nanoparticle (<1 nm)



Innovation : Mutifunctional nanoparticles

Nano Engineering

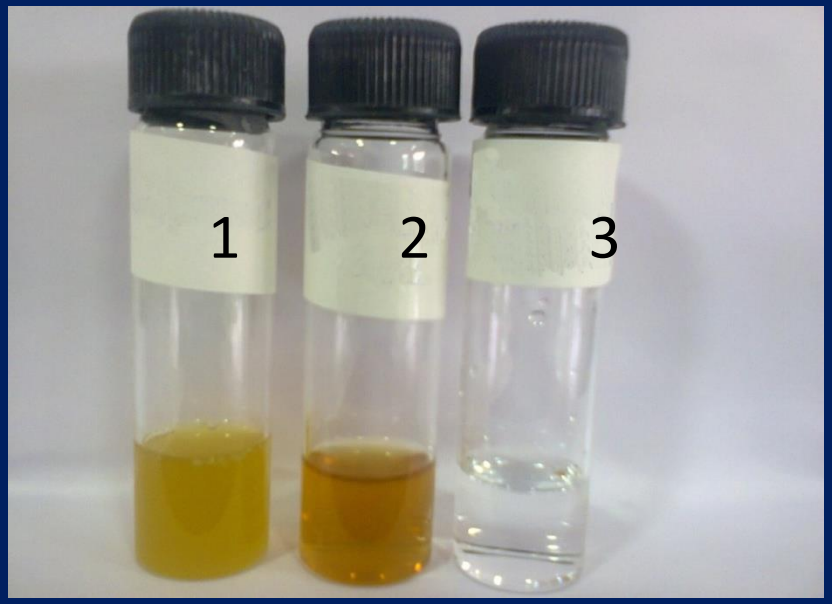
- **Shape**
  Generation of various shapes -Spherical, rod, tubes, cylindrical etc. ((**SEM, TEM**))
- **Size**
  Size from 1nm to 100 nm (SEM, TEM)
- **Exposed group on surface**
  Various groups on nanoparticle surface (FTIR)
  (3473.63cm−1 , 1621cm−1 618.51 cm-1, 717.78 and 3780.89 cm-1)

(Halogen compound ,C–S linkage, Phenol ring, Aromatic ring, Hydroxyl compound, N-H stretch)

Manipulating the shape ,size and exposed groups of nanopartcle, multifunctional nanoparticles can be generated

Synthesis of mutifunctional nanoparticles

- **Physical**
- **Chemical**
- **Biogenic**



Generally nanoparticles synthesized by physical and chemical methods, however, most of the techniques are complex, expensive and hazardous.



Biogenic Synthesis of mutifunctional nanoparticles : Challenges and opportunity

- Generally slow process

- Customization for generation of specific nanoparticle is very difficult

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- Ecofriendly

- **Use of biological materials, mild environment, green process**

- Possible nontoxic nanoparticles

Biological (plant materials, microbial metabolites etc.

Generally slow process and customization for generation of specific nanoparticle is major challenge

Nanobiotechnology program at MGMIHS OMICS

- Biogenic synthesis of various metallic nanoparticle
- Biofabrication of antimicrobial nanoparticle
- Biofabrication of anti-oxidant nanoparticles
- Biofabrication of enzyme modulating nanoparticle
- Biofabrication of fluorescent nanoparticles
- Hypothesis driven generation of pure nanoparticles
- Development of multifunctional nanoparticles



Center is promoting proteome driven green synthesis of nanoparticles

Biogenic synthesis of nanoparticles

- UV-Vis spectrophotometeric observation:

Biological systems	Ag NP	Mg NP	Ca NP	Fe NP	Ce NP	SiO_2	ZnS	CuSO4 NP
MGM-OMC-P1	Y	Y	Y	Y	Y	Y	Y	Y
MGM-OMC-P2	Y	-	-	-	Y	Y	-	-
MGM-OMC-P3	-	Y	-	Y	-	Y	Y	-
MGM-OMC-P4	Y	-	-	-	Y	Y	-	-
MGM-OMC-P5	Y	Y	-	-	-	-	-	-
MGM-OMC-P6	-	-	-	Y	Y	-	-	-

Key : Y = Presence of nanoparticles

Biogenic synthesis of nanoparticles

- UV-Vis spectrophotometeric observation:

Biological systems	Ag NP	Mg NP	Ca NP	Fe NP	Ce NP	SiO_2 NP	CuSO4 NP
MGM-OMC-P7	-	-	-	-	Y	-	-
MGM-OMC-P8	-	-	-	-	-	-	-
MGM-OMC-P9	-	-	-	Y	Y	Y	-
MGM-OMC-P10	Y	-	-	-	Y	-	Y
MGM-OMC-P11	-	-	-	-	-	-	-
MGM-OMC-P12	-	Y	-	-	-	Y	-
MGM-OMC-P13	-	-	-	-	-	-	-

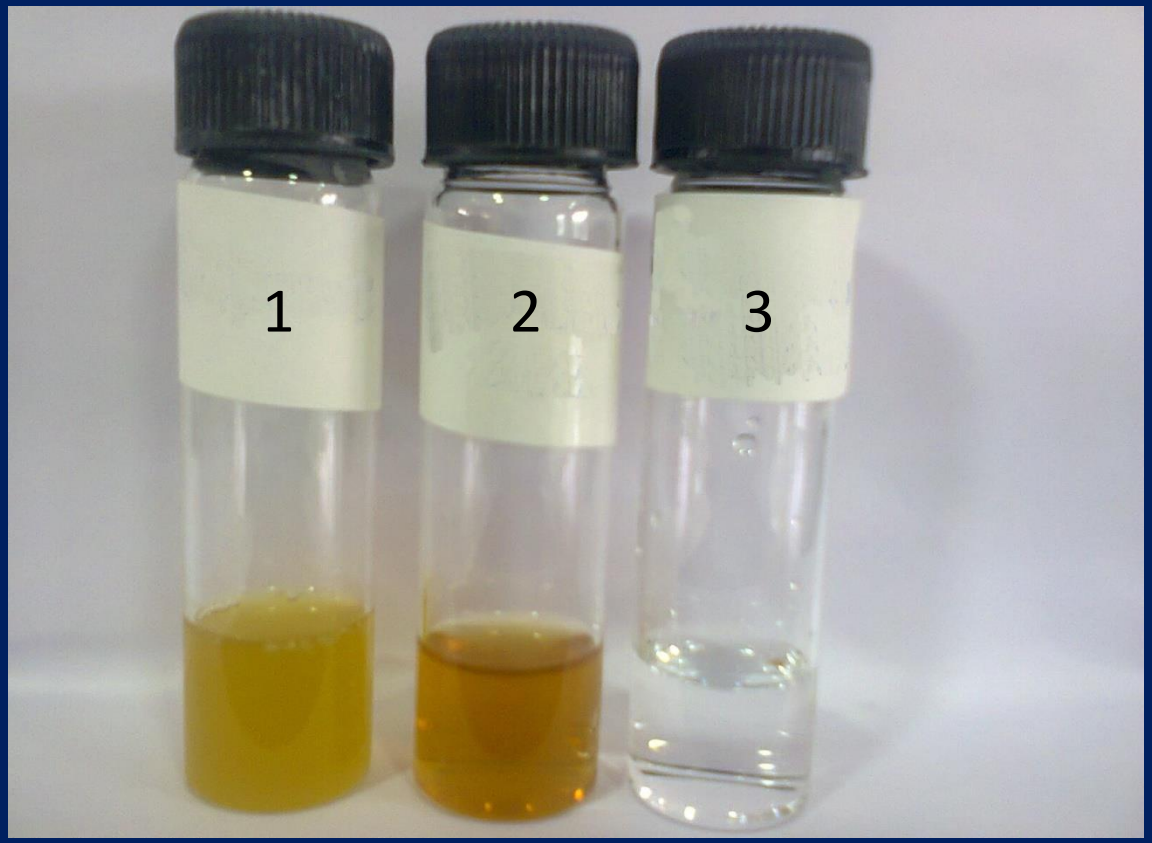
Biogenic synthesis of nanoparticles

- UV-Vis spectrophotometeric observation:

Biological systems	Ag NP	Mg NP	Ca NP	Fe NP	Ce NP	SiO_2 NP	ZnS NP	CuSO4 NP
MGM-OMC-P14	-	-	-	-	Y	Y	-	-
MGM-OMC-P15	-	-	-	-	Y	Y	Y	-
MGM-OMC-P16	-	-	-	Y	Y	-	-	-
MGM-OMC-M1-L	Y	-	-	-	-	-	-	-
MGM-OMC-M1-A	Y	-	-	-	-	-	-	-
MGM-OMC-P2	-	-	Y	-	Y	-	-	-
Total systems	7	4	2	5	11	8	3	2

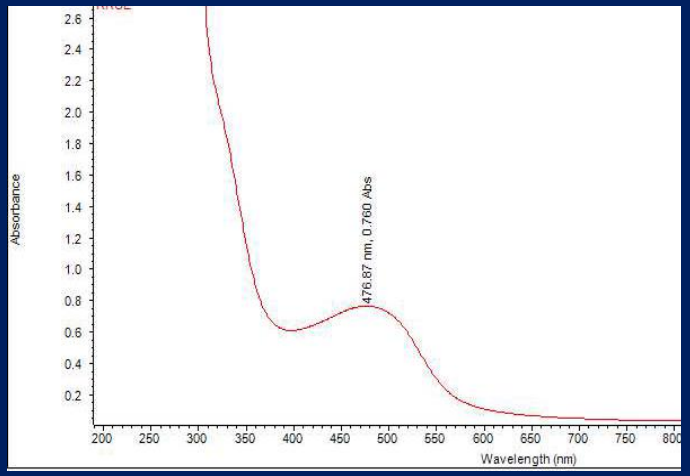
Biogenic synthesis of nanoparticles

Visual observation



Observation & Results

- UV-Vis spectroscopy :

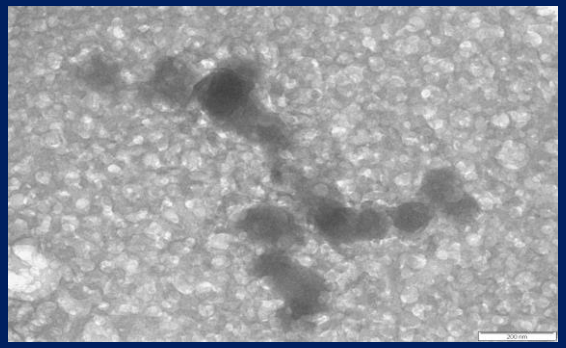


MGM-OMC-NP1

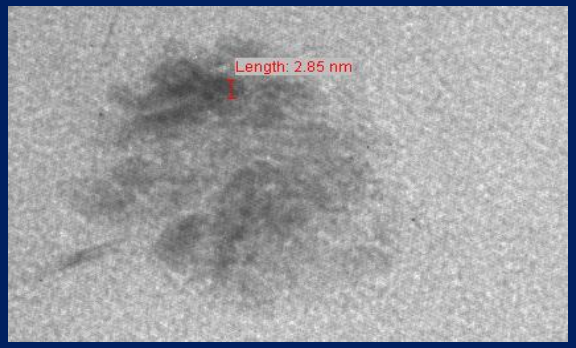
Nanoparticles	Peak (UV-Vis Spectroscopy) (nm)
MGM-OMC-NP1	476.87
MGM-OMC-NP2	395.00
MGM-OMC-NP3	391.00
MGM-OMC-NP4	389.00
MGM-OMSI-NP1	399.00
MGM-OMZ-NP1	386.00

Characterization of nanoparticles

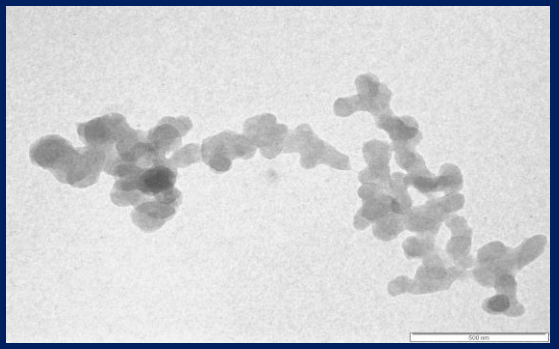
Transmission Electron Microscopy (TEM)



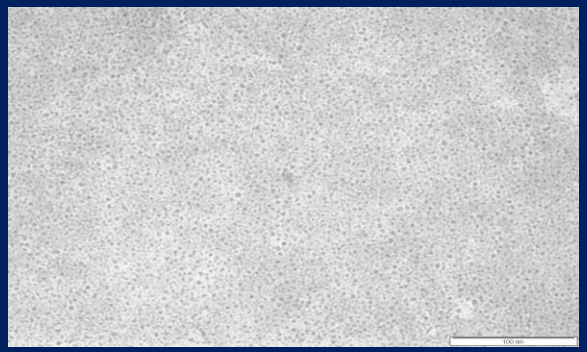
MGM-OMC-NP1
(90-100 nm)



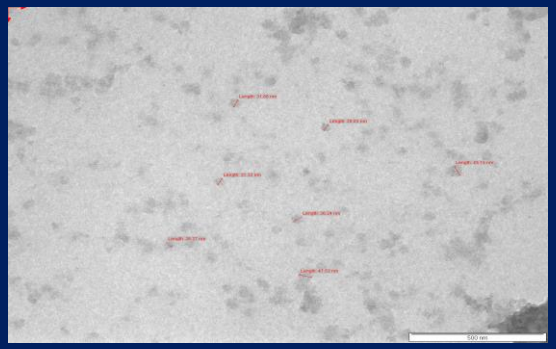
MGM-OMC-NP2
(2-4 nm)



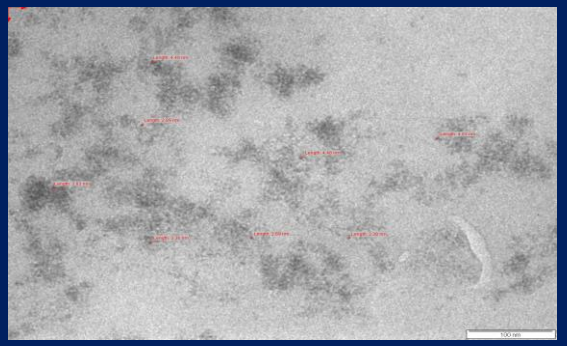
MGM-OMC-NP3
(65-88 nm)



MGM-OMC-NP4
(2-4 nm)



MGM-OMSI-NP1
(2-4 nm)



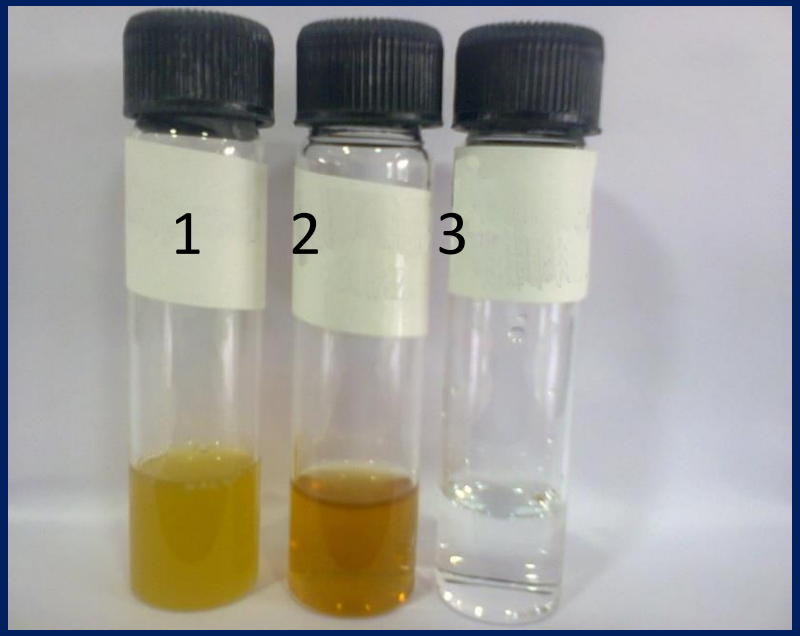
MGM-OMZ-NP1
(2-4 nm)

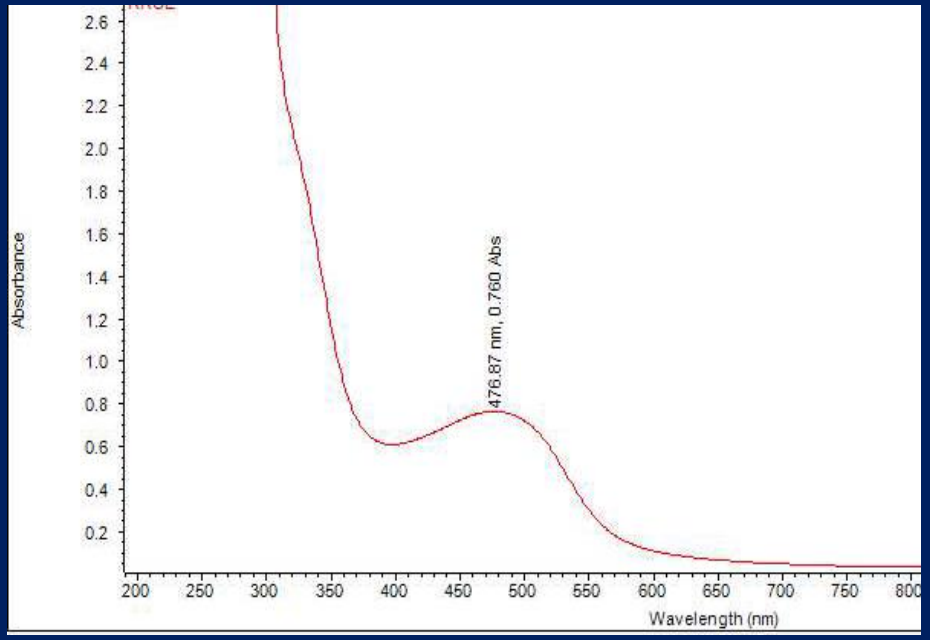
Bifunctional CeO2NPs : Potential anti-glaucoma agent

- **- Enhanced antioxidant activity**
- **- Inhibition of carbonic anhydrase**

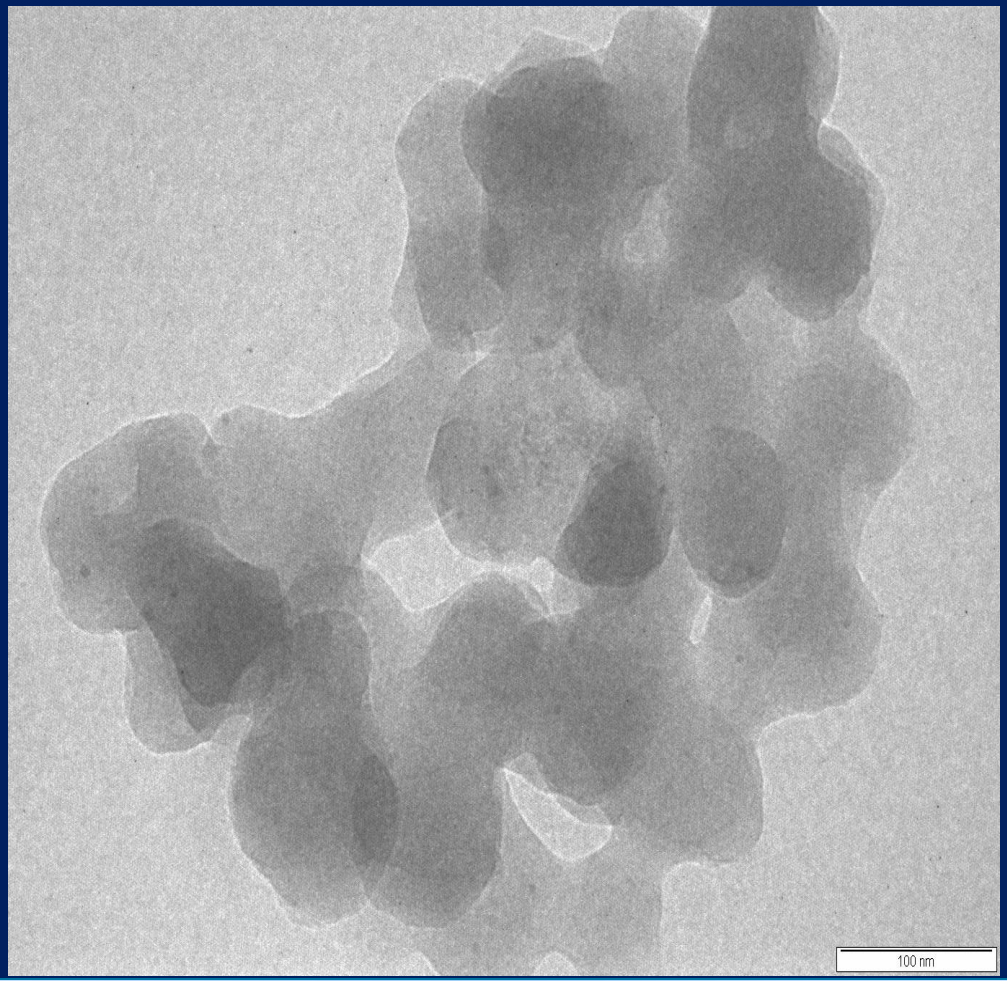
The goal of medical treatment is to obtain 24-h IOP control with minimum concentration and number of medications, as well as minimal local and systemic effect

Biogenic Synthesis of bifunctional CeO2NPs cerium nanoparticle





Biogenic Synthesis of mutifunctional CeO2NP



TEM - Size 65-88 nm

Biogenic Synthesis of bifunctional CeO2NPs

FTIR data analysis

Protein might be responsible for the synthesis of cerium nanoparticles

Clue for the synthesis of cerium nanoarticles

Biogenic Synthesis of bifunctional CeO2NPs

Protein has been identified for the synthesis of CeO2NPs

Antioxidant activity of generated CeO2NPs

Sr.No.	Sample	% Inhibition of NBT reduction
1.	Control	0.00%
2.	CeO2	20.96%
3.	Extract	59.24%
4.	Protein	40.76%
5.	OMC –NP3	74.53%
6.	OMCP-NP3	75.96%

Antioxidant activity of generated CeO2NPs

Sr.No.	Sample	% DPPH radical scavenging
1.	Control	0.00%
2.	CeO2	5.88%
3.	Extract	53.59%
4.	Protein	28.43%
5.	OMC –NP3	63.76%
6.	OMCP-NP3	81.37%

Antioxidant activity of generated NPs

Sr.No.	Sample	Catalase activity (U/ml)
1.	CeO2	3.67%
2.	Extract	2.29%
3.	Protein	2.75%
4.	OMC –NP3	7.57%
5.	OMCP-NP3	8.95%

Carbonic anhydrase inhibitiry activity of generated cerium nanoparticles

Sr.No.	Sample	% Inhibition
1.	Control	0.00%
2.	CeO2	4.30%
3.	Extract	23.66%
5.	OMC –NP3	100.00%



Perspectives of generated bifunctional cerium nanopartcles

Nanoparticle size : 65-88 nm

Nanoparticle size : Spherical

Major Exposed group (FTIR) : aromatic ring, -NH stretch

Antioxidant activity : Amplified

Mimics :Catalase like activity

Carbonic anhydrase :Inhibition

It can be used in those disease situation where there is amplification of carbonic anhydrase activity with diminished antioxidant activity



Conclusion

- Disease development along with allied events are major concern in disease management.
- Multitasking molecules represent potential candidate as therapeutic agent for management of disease with allied events.
- In recent year various nanopartcles have gained importance as advanced nanomaterials for their multifunctinality.
- Cerium oxide is potential candidate for generation of multifunctional nanoparticles .
- The presentation highlighted the biogenetic method for generation of multifunctional nanoparticles with enhanced antioxidant activity with carbonic anhydrase inhibitory activity and their perspectics in disease management including glaucoma.



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Thank you