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# Synthesis of Mg/AL Layer Double Hydro-oxide and Silver Nano- particle based Green Nanocomposite for Drug Delivery Applications

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Over past few decades, the treatment of various diseases by using nano layers is one of the most challenging tasks. Recently, many modifications have focused on creating rapid findings and effective drug delivery systems to meet the challenge of antibiotic resistance. These carrier vehicles can be of varying sizes, from $10^{-9}$ to $10^{-6}$ meters in size. Different carriers are comprised of different materials, such as liposome, dendrimers, peptides, polymer, and inorganic materials. The purpose of the current research is to synthesize the magnesium (*Mg*) and Aluminum (*Al*) layered double hydroxide silver nano particles (*Ag* Nps) based nano-composite for different drug delivery systems. *Mg/Al* nano layers and silver nano particles were synthesized by co-precipitation method. To access and retrieve the properties, quality and composite performance, and to ensure the work standard, characterization has been performed by XRD, FTIR, FESEM, and Particle Size Distribution. The test results showed that *Mg/Al- Ag* Nps LDH is an effective tool that can be used for different drug delivery application. The synthesized material may achieve better therapeutic efficiency, better biocompatibility, biodegradability, less toxicity, and reduction in dosing frequency.

**Keywords: Green composites, Drug delivery, Nano capsules, Nanomaterial**

## INTRODUCTION

The word *nanomaterial* refers to a material whose structural features have at least one dimension in the nanoscale range (1-100nm) (Correa, Dreaden et al. 2016). As the Greek word for "dwarf" implies, a material may be constructed in one, two, or three dimensions in nano scale. Nanolayers & surface thin films are one-dimensional nanosized, but their other two dimensions are not nanosized, as they are expanded in other dimensions. Nanowires and nanotubes are two examples of nanomaterials that are nanosized in two dimensions, but their aspect is extended that is not in nanosized.

In the nanoparticles, all three dimensions are represented in nanoscale. The characteristics of nanoparticles are completely different from those of normal materials. There are two fundamental aspects of nanoparticles that are responsible for the typical qualities of nanomaterials. The two aspects include high reactivity surface area to volume ratio and the quantum impact (Saifullah and Hussein 2015). When referring to a hybrid inorganic / organic material with at least one dimension in the sub-nanometer range (1-100 nm), the term "nanocomposite" is most often used in nanotechnology (Gisbert-Garzaran, Berkmann et al. 2020, Sindhwani, Syed et al. 2020). Many biological uses are being studied with the organic-inorganic nanohybrid (nanocomposites), notably for medication delivery. When it comes to two-dimensional nanomaterials, inorganic nanolayers stand out due to the fact that they have an endless number of layers and a layer thickness measured in the nanoscale. These inorganic nanolayered materials, layered double hydroxides (LDHs) & layered hydroxide salts (LHS), are used in a variety of biomedical applications, including drug administration and gene transfer, biosensing technologies, and bioimaging. (Alavijeh, Sarvi et al. 2019).

LDHs have a structure similar to brucite *($Mg(OH_2)$)* and are assembled with an interlayer anion, making them one of the layered materials. Some of the divalent cations are exchanged with trivalent ones, resulting in the formation of positively charged sheets in the brucite-like compound as we know that anions, which have a positive charge, fill the interlayer space as catalysts, photocatalysts, electrode, ion adsorbent materials, pharmaceutics, drug carriers, and ion adsorption. A material's performance is influenced by its particle size and distribution. Nanometer-sized particles, such as medication carriers. (Kodama 1999, Kim, Kuk et al. 2007, Lewinski, Colvin et al. 2008, Haase and Schäfer 2011).

It has been very difficult to use nano layers to cure a wide range of ailments. Various innovations have been made to address the issue of antibiotic resistance by developing new methods of finding and delivering drugs. Carrier vehicles may range in size from micro to nano meter in diameter, and they can be made of a variety of compounds (Correa, Dreaden et al. 2016, Lee, Kim et al. 2020). Inorganic nanocarriers of various medications are the focus of our discussion. Using nanolayers for drug delivery allows the medicine to be transported safely and effectively throughout the body. For a long time, pharmaceuticals have been used to help people live longer and better lives. There is a common element to conventional DDS that affects their uncontrollable drug discharge characteristics. Using a concept-controlled approach, sophisticated controlled drug delivery systems are being advocated to address these issues. The experimental failures of standard antibiotic therapies are linked to lengthy discovering procedures, poor access to the infected area, disturbance of the original micro flora, and the significant potential for mutational resistance. One of the most talented techniques to regaining the potency of antibiotics is to combine them with nanoscale level delivery technologies and coat them with silver nanoparticles to achieve greater efficiency and effective. Antibiotics may be protected against enzymatic and physiochemical breakdown by using carriers like this. The purpose of this study is to examine the materials' strength in the finding and treatment of diseases resistant to antibiotics (Saifullah and Hussein 2015, Natarajan, Anitha et al. 2020, Sindhwani, Syed et al. 2020).

Nanolayers based drug delivery system is an efficient drug delivery system, as these nanolayers are basically made-up of inorganic materials. The class of nanolayers which is mostly used is layered double hydroxide (LDH) (Gong, Li et al. 2013, Gisbert-Garzarán, Berkmann et al. 2020). The designed nano-formulation will release the desired drug in a sustained manner at a targeted side. The ability of directed delivery and convenient release of LDHs makes nanolayers based drug delivery more efficient. It is more biocompatible as compared to the free antibiotic drug. Improved efficacy against pathogens because nano-size helps in penetration to the pathogens and silver nanoparticles in formulation will results synergistic effect (Alavijeh, Sarvi et al. 2019).

The drug in medication has a short degradation period, and most of the drug is squandered after interacting with stomach fluids and the remainder is rapidly released when a patient consumes medicine. Consequently, the patient should take more drugs in a day. We chose this issue because we desire a medication carrier that lasts the patient up to 48 hours, lowers dose frequency, and decreases noncompliance. We employ nano-layers with a shorter degradation period, resulting in a longer-lasting drug release. The medication is released in adequate quantities over period in 45-48 hours (Wang and O'Hare 2012).

A new medicine delivery method based on LDH nanolayers is being developed to treat various illnesses. LDH synthesized from *Mg/Al- Ag* Nps might be a useful tool in the future. This technique may achieve improved therapeutic effectiveness, biocompatibility, biodegradability, reduced toxicity, and lower dosing frequency / dosage in the future.

## MATERIALS AND METHODS

In experimental work we used deionized water, $Mg(NO_3)_2$, $Al(NO_3)_3$, $Ag(NO_3)$, $NaBH_4$, Methanol, Ethanol, chemicals for synthesis of the nano composite. These chemicals were purchased from the local chemical market. Aluminum foil used for wrapping the solution which was also purchased from the local market. Glass wares and magnetic hot stirrer plate were available in the Biochemistry Laboratory of Department of Biomedical Engineering, MUET Jamshoro, Sindh, Pakistan.

The preparation of the nanocomposites done by direct method called co-precipitation method. This approach is carried out commonly for direct one-pot synthesis of LDHs with diversified species of divalent and trivalent cations and various several anions extending from $Cl^-$, $NO_3^-$, $CO_3$ which are inorganic ions. The aqueous solution is mixed with both divalent and trivalent cations along with the anions which are intercalated in co-precipitation method while we increase pH by adding basic solution. The co-precipitation is more effective technique as compared to others because interjected of anions is easily and effectively carried out through this. By using super saturation, confirmation of cations co-precipitations done. Application of thermal heat after co-precipitation achieves optimal output and upgrades sample crystallinity. Thermal treatment is performed through aging the solution at temperature between 25 °C to 100 °C. It is possible to alter it by hydrothermal methods where the sample is exposed to extreme pressures of 10-150MPa and extreme temperatures in autoclave bombs with a time interval of a few hours (Yadollahi, Namazi et al. 2015).

### Synthesis of Nanocomposites

Firstly, for the synthesis of *Mg/Al* layered doubled hydroxide, we want 2 moles of sodium hydroxide (*NaOH)* (reducing agent) solution. In the laboratory we prepared a normal standard solution of *NaOH* by mixing 40g of sodium hydroxide and 500ml of deionized water in a beaker, place the beaker over the magnetic stirrer machine, this results in a suitable solution of *NaOH*. Furthermore, we prepared a 1 mole solution of the two compounds, namely magnesium nitrate hexa hydrate (*Mg*

*$(NO_3)_6.6H_2O$*) and aluminum nitrate non hydrate (*$Al(NO_3)_3.9H_2O$*).

*40g of NaOH + 500ml of deionized water = 2moles NaoH normal standard solution*

Take magnesium nitrate hexahydrate and aluminum nitrate non- hydrate in a proportion of 1:4, dissolve it in 500ml of deionized water in a beaker and then stirrer it for few minutes in a magnetic stirrer machine for the colloidal solution to be prepared. Immediately cover the beaker with aluminum foil. Satisfy the burette with *NaOH* solution and set this burette over the colloidal solution hanged with the help of the burette stand, open the tap of burette so that reducing agent drop by drop is added in a colloidal solution. As the *NaOH* is added to a solution, it changes the PH of the solution, *Mg/Al* LDH is formed by raising the pH to 9.7 by the addition of reducing agent of 2 moles drop wise. Then we collected the jelly like substance through the filter paper, after collecting gelatin like substance. Pour this gelatin like substance in a centrifuge tube. In the centrifuge machine, put these centrifuge tubes in opposite direction. Right Away place this material in the oven for 48 hours at 60·C. In last obtained material crushed in mortar and pestle to get Mg/Al nano composites as shown in Figure 1 and Figure 2 (a-j)

**Material characterization**

Characterization is a major function in accessing and retrieving the properties, quality, and performance of a composite, and is thus an important step in assuring the standard and success of work. So, for Characterization we performed XRD, FTIR, FESEM, Particle Size Distribution.

**X-Ray Diffraction (XRD)**

It is a non-corrosive testing method, which is used to examine the structural properties of crystalline materials. XRD examination, is used to detect the crystalline levels present in a substance and thereby uncover chemical composition information (Azároff 1974).

**Field Emission Scanning Electron Microscope**

Scanning electron microscopy with field emission (FE-SEM) is a cutting-edge technique for capturing images of the microstructure of various materials to analyze the particles anatomy (Vermeulen 2005).

**FTIR (Fourier Transform Infrared)**

FTIR is a technique for obtaining an infrared spectrum of a solid, liquid, or gas's absorption or emission by which we can analyze the chemical properties of the materials (Doyle 1992, Jackson and Mantsch 1995, Movasaghi, Rehman et al. 2008).

**Distribution of size particles**

It is a directory, indicating the particles sizes. The distribution of a residue, or granulated material, or scattered particles in fluid, a mathematical purpose that defines the comparative amount, usually by mass of particles that is present according to their size. This method is a guide, Demonstrating in which proportions, what sizes of particles are present,(relative particle total as a percentage where the aggregate number of particles is 100 %) in the trial particle group to be measured (Chandramohan, Srinivasan et al. 2011). It operates on the principle that, as a beam of laser is dispersed by a cluster of particles, The size of particles is inversely proportional to the angle of light scattering, for example: the greater the angle, the lesser the particle size (Hawker, Hüthwohl et al. 1998).

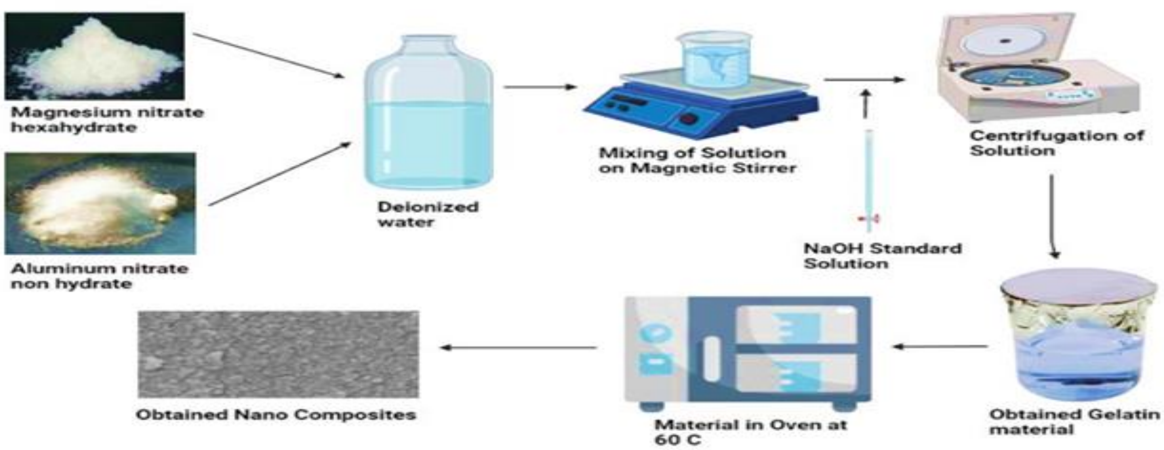


**Figure 1: Experimental workflow**

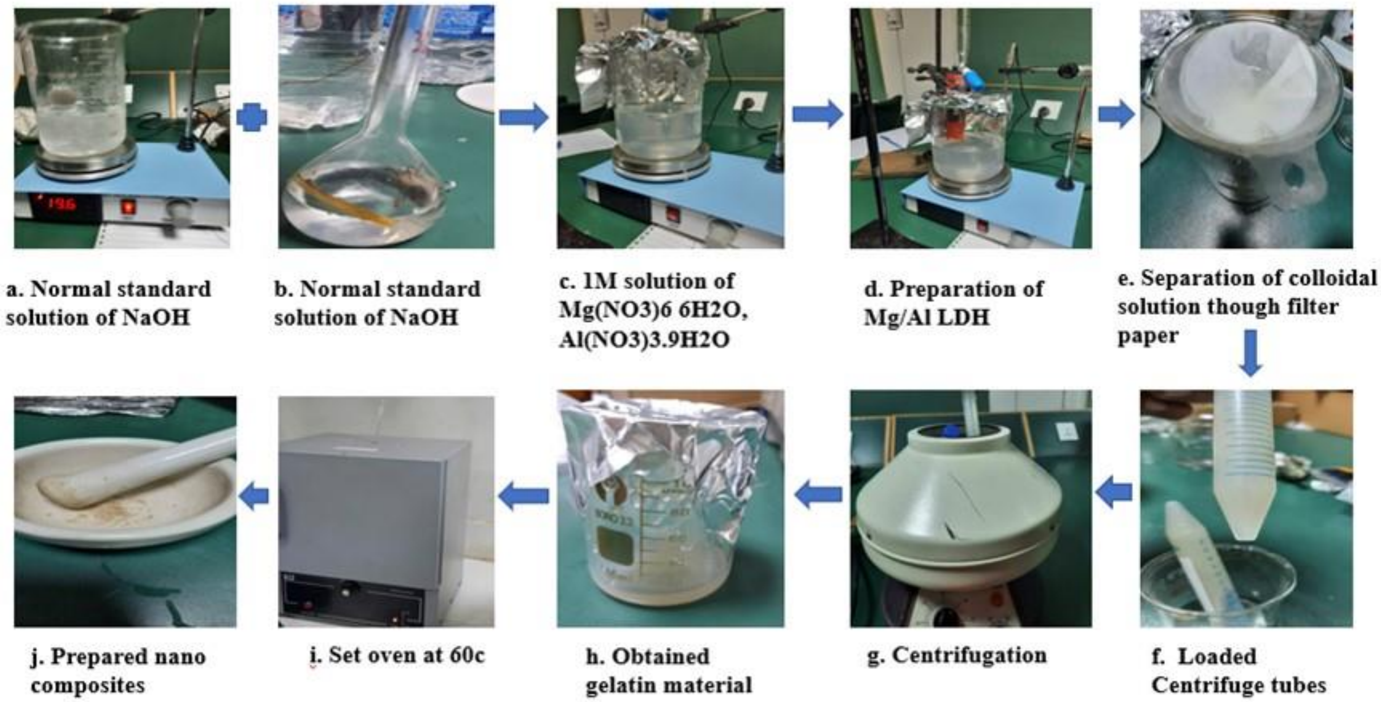


**Figure 2: Experimental work of Synthesis of Nanocomposite (a-j)**

## RESULTS

### Instrumentation

By using XRD-6000 diffractometer Shimadzu Japan (PXRD) Power X-ray diffraction analysis were performed. By applying the given conditions of Cuα at 30KV and 30mA, XRD results were noted from 2ϴ° -60ϴ° degrees. Perkin Elmer (Waltham, MA, USA) 100 series spectrophotometer is an instrument, which records Fourier-transformed infrared (FTIR) spectrum, by using direct sample technique over the span of 4000-400cm-1. With the help of JEOL (Tokyo, Japan) JSM-6400scanning electron microscope (SEM), the surface morphology of the sample was examined.

### (PXRD) Powder X-ray Diffraction Analysis

The XRD patterns presented the characteristics peaks resembles to the *Mg-Al*- Layered double hydroxides *(Mg-Al*-LDHs) as Shown in Figure 3. The peaks which are shown in results and in graph is reflected from the nanolayers from different angles. the Four peaks at 2ϴ (2-theta) of 10°, 20°, 30° and 35° resembles to the first, second, third and fourth reflections from nanolayers respectively. These 2theta reflections correspond to basal spacing of about 8.9 Å which strongly suggest the intercalation of nitrate anions inside gallery of nanolayers.

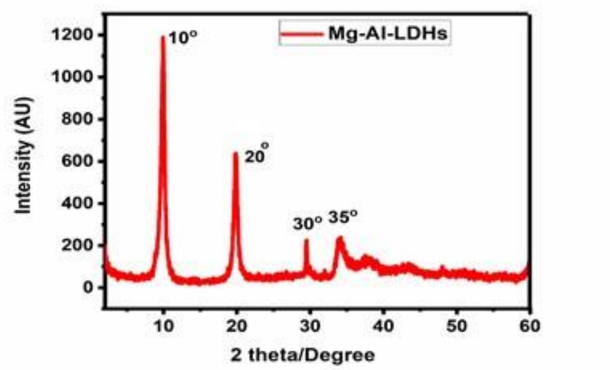


**Figure 3: XRD analysis**

### FTIR (Fourier transformed infrared analysis)

FTIR is performed for further confirmation of XRD. Several infrared bands correspond to the functional groups of the LDHs infrared spectrum of *Mg-Al*-LDHs as shown in Figure 4. Two bands rounded 3000$cm^{-1}$ parallels to the O-H bands of LDHs and bands at 1647 $cm^{-1}$ and 1540$cm^{-1}$ are due to the nitrogen-oxygen double bonds of the nitrate anions, bands at 1324 $cm^{-1}$, 1133$cm^{-1}$ and 845$cm^{-1}$ can be attributed to the *N-O, Mg-O* and *Al-O* single bonds. While the rest of the bands can be attributed to the overtones of bonds, some are different due to inside and out of the LDHs galleries.

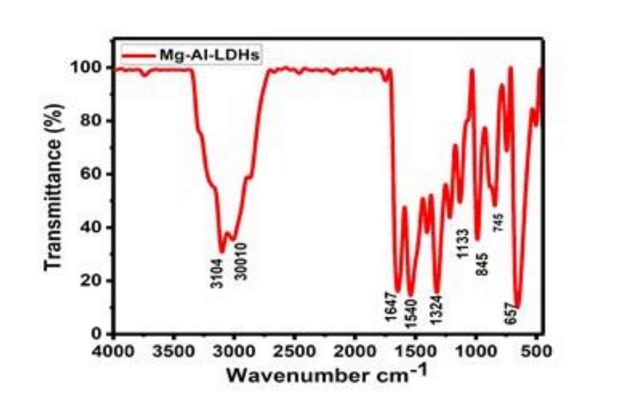


**Figure 4 FTIR spectrum of Mg/Al LDH**

### Scanning electron microscopy and particle size distribution

For the morphology of particles to be shown the sample should be seen in scanning electron microscopy. In Figure 5 the SEM image of the *Mg-Al*-LDHs display particles with rough morphology. By using SPSS software, particle size histogram is generated. By selecting randomly 53 particles (N) using image software, calculation of particle size distribution is done. The average particle size was determined to be 97.80nm ± 27.13nm as shown in Figure 5.

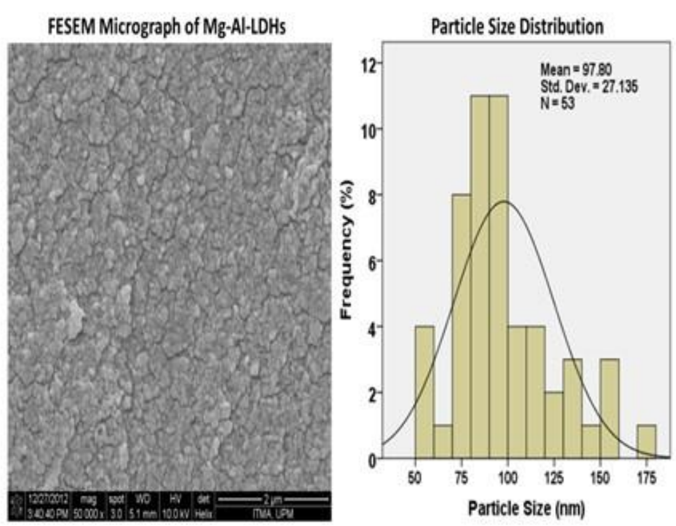


**Figure 5: FESEM micrograph of Mg/Al LDH and particle size distribution histogram**

### CONCLUSION

The purpose of this research was to design magnesium (*Mg*) and Aluminum (*Al*) layered double hydroxide silver Nano particles (*Ag* Nps) based nanocomposite for antibacterial drug delivery. It could help in treating various antibacterial infectious diseases and will improve the drug efficiency and will help to achieve the controlled release property. The production of LDH nanocomposite can be used as an alternative drug delivery system against various diseases. Synthesis of *Mg/Al* LDH-*Ag* Nps based nanocomposite could be an effective tool to be used in antimicrobial applications and treatment. *Ag* Nps coating will confer on the synergistic antimicrobial effects against microbes and thereby would increase the efficacy of the designed nanocomposite formulation.

### CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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### AUTHOR CONTRIBUTIONS

BK, SK and NPC conceived and designed the search experiment. BK and MAR performed the search experiment. BK, JH, SA and AQ performed the contents arrangement. BK, JH and SA wrote the manuscript. All authors read and approved the final version.



### REFERENCES

Alavijeh, M. A., et al. (2019). "Modified montmorillonite nanolayers for nano-encapsulation of biomolecules." Heliyon **5**(3): e01379.

Azároff, L. V. (1974). X-ray Diffraction, McGraw-Hill Companies.

Chandramohan, P., et al. (2011). "Cation distribution and particle size effect on Raman spectrum of CoFe2O4." Journal of Solid State Chemistry 184(1): 89-96.

Correa, S., et al. (2016). "Engineering nanolayered particles for modular drug delivery." Journal of Controlled Release 240: 364-386.

Doyle, W. M. (1992). "Principles and applications of Fourier transform infrared (FTIR) process analysis." Process Control Qual **2**(1): 11-41.

Gisbert-Garzaran, M., et al. (2020). "Engineered pH-responsive mesoporous carbon nanoparticles for drug delivery." ACS applied materials & interfaces **12**(13): 14946-14957.

Gisbert-Garzarán, M., et al. (2020). "Engineered pH-Responsive Mesoporous Carbon Nanoparticles for Drug Delivery." ACS Applied Materials & Interfaces **12**(13): 14946-14957.

Gong, M., et al. (2013). "An advanced Ni–Fe layered double hydroxide electrocatalyst for water oxidation." Journal of the American Chemical Society **135**(23): 8452-8455.

Haase, M. and H. Schäfer (2011). "Upconverting nanoparticles." Angewandte Chemie International Edition **50**(26): 5808-5829.

Hawker, P., et al. (1998). "Effect of a continuously regenerating diesel particulate filter on non-regulated emissions and particle size distribution." SAE transactions: 374-380.

Jackson, M. and H. H. Mantsch (1995). "The use and misuse of FTIR spectroscopy in the determination of protein structure." Critical reviews in biochemistry and molecular biology **30**(2): 95-120.

Kim, J. S., et al. (2007). "Antimicrobial effects of silver nanoparticles." Nanomedicine: Nanotechnology, biology and medicine **3**(1): 95-101.

Kodama, R. (1999). "Magnetic nanoparticles." Journal of magnetism and magnetic materials 200(1-3): 359-372.

Lee, H.-E., et al. (2020). "Cysteine-encoded chirality evolution in plasmonic rhombic dodecahedral gold nanoparticles." Nature communications 11(1): 1-10.

Lewinski, N., et al. (2008). "Cytotoxicity of nanoparticles." small 4(1): 26-49.

Movasaghi, Z., et al. (2008). "Fourier transform infrared (FTIR) spectroscopy of biological tissues." Applied Spectroscopy Reviews 43(2): 134-179.

Natarajan, S., et al. (2020). "Synthesis and characterization of magnetic superadsorbent Fe3O4-PEG-Mg-Al-LDH nanocomposites for ultrahigh removal of organic dyes." ACS omega **5**(7): 3181-3193.

Saifullah, B. and M. Z. B. Hussein (2015). "Inorganic nanolayers: structure, preparation, and biomedical applications." International journal of nanomedicine **10**: 5609.

Sindhwani, S., et al. (2020). "The entry of nanoparticles into solid tumours." Nature materials **19**(5): 566-575

Vermeulen, J. P. (2005). "New developments in FESEM Technology." Advanced materials & processes 163(8): 33-37.

Wang, Q. and D. O'Hare (2012). "Recent advances in the synthesis and application of layered double hydroxide (LDH) nanosheets." Chemical reviews 112(7): 4124-4155.

Yadollahi, M., et al. (2015). "Antibacterial carboxymethyl cellulose/Ag nanocomposite hydrogels cross-linked with layered double hydroxides." International journal of biological macromolecules **79**: 269-277.