Review Article **ISSN: 2349 – 7114**

Asian Journal of Research in Pharmaceutical Sciences and Biotechnology

Journal home page: www.ajrpsb.com

NANO MEDICINE: A NOVEL CLASS OF DRUG DELIVERY SYSTEM

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ABSTRACT
Nanomedicine has emerged as one of the very promising fields of pharmaceutical research in the last few decades. Drug delivery is one of the areas where this technology has made remarkable progress. The present article is an attempt to present the brief history of Nanomedicine and market forecasts about Nanomedicine. The article presents the composition, classification, advantages and examples of Nanomedicine assisted drug delivery. Developments in Nanomedicine assisted therapeutic applications and the future prospects have also been discussed. The drug can be released at the specific target site instead of circulating throughout the body it will be more effective for a particular given dosage.

KEYWORDS
Nanotechnology, Novel Drug Delivery and Nanomedicine.

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INTRODUCTION[1]

Nanotechnology

Nanotechnology and nanoscience are widely seen as having a great potential to bring benefits to many areas of research and applications. The term “nanotechnology” was first used in 1974, when Norio Taniguchi, a scientist at the University of Tokyo, Japan, referred to materials in nano meters[1].

Define[2, 3]

Nanotechnology is embraces applications of nanoscience to pharmacy as nanomaterials, devices

like drug delivery, diagnostic, imaging and biosensor.

One nanometer (nm) is one billionth, or 10^{-9} of a meter. For comparison, typical carbon-carbon bond lengths, or the spacing between these atoms in a molecule, are in the range 0.12 - 0.15 nm.

Many of the cells are of the dimensions of micro meter. These provide the possibility of nanoparticles entering the cells and detect/treat the molecular changes that occur due to cancerous causes, in small percentage of cells and other problems. Therefore, the necessary tools must be extremely sensitive.

Scientists and researchers hope that nanotechnology can be used to create therapeutic agents that target specific cells and deliver the toxin in a controlled, time-release manner.

Classification of Nano dosage forms

The following nano dosage forms are available in recent nanotechnology (Figure No.1).

Advantages

- It helps in improving solubility and bioavailability.
- It helps in reducing toxicity.
- It helps in enhancing release and providing better formulation opportunities for drugs.
- More rapid onset of therapeutic action.
- Less amount of dose required.
- Improve the patient compliance.

Polymer based nanoparticulate drug delivery systems

1. Hydrogel based nanoparticulate drug delivery systems.
2. Dendrimer based drug delivery systems.
3. Calcium carbonate nanoparticles.
4. Chitosan based nanoparticulate drug delivery system.
5. Silicone nanopore membrane based drug delivery system.
6. Albumin and gelatin nanospheres.
7. Polymeric nanocapsules as drug carriers.
8. Polystyrene nanospheres.

Preparation of Nanoparticles

Dispersion of preformed polymers by:

- Solvent evaporation method.
- Spontaneous emulsification/solvent diffusion method.
- Salting-out/ emulsification diffusion method.
- Production of nanoparticles using supercritical technology.
- Polymerization methods.
- NPs prepared from hydrophilic polymers.

Evaluation of Nanoparticles[4-6]

FTIR analysis

Infrared spectra were recorded on Shimadzu 8400S FT-IR spectrophotometer using KBr pellet method.

Particle Size Analysis

Size of the formed drug particles was measured by dynamic laser light scattering diffractometer (Nanotrac, Ultra).

X-Ray Diffraction Study

X-ray diffraction analysis was employed to detect the crystallinity of the pure drug and the formulations, which was conducted using a XRD-6000 diffractometer (Shimadzu, Japan).

Differential Scanning Colorimetry

Differential scanning colorimetry (DSC) was conducted on Diamond DSC Calorimeter.

Scanning Electron Microscopy

Particle morphology was observed using scanning electron microscopy (SEM), JSM-6390 (JEOL, Japan).

Zeta Potential Analysis

The zeta potential was measured on dispersions of nanoparticles batch, diluted with an aqueous solution NaCl (0.9% W/V) using zetasizer.

Swelling index

200 mg of nanoparticles were dispersed in phosphate buffer pH 7.4 for a period of 6 h. The swollen nanoparticles were collected by centrifugation and the wet weight of the swollen nanoparticles was determined by first blotting with filter paper to remove excess water on the surface and then weighing immediately on electronic balance. The weight of swollen nanoparticles was recorded at a predetermined time period (0.5, 1, 2, 3, 4, 5 and 6 h). The percentage swelling was calculated by using equation:

$$\mathbf{Ssw = Wt\text{-}Wo/Wo\ X\ 100}$$

Where,
Ssw is the percentage swelling,
Wt is weight of the nanoparticles at time t,
Wo is the initial weight of nanoparticles.

Encapsulation efficiency

Appropriate amount of nanoparticles were digested with minimum amount of 95 % v/v ethanol until no further material was dissolved. The digested homogenates were centrifuged at 15000 rpm for 30 min and the supernatant was analyzed for drug entrapment. The drug entrapment was measured at 230nm using Elico SL164 UV/vis spectrophotometer. The encapsulation efficiency was calculated using equation:

$$\% \text{ encapsulation efficiency} = \frac{\text{Total mass of drug in nanoparticles}}{\text{Mass of drug used in the formulation}}$$

***In vitro* release studies**[7, 8]

The in vitro release of nanoparticles was studied by using simple diffusion cell apparatus which is opened at both ends, One end tied with sigma dialysis membrane which serves as a donor compartment. The dissolution medium used was freshly prepared phosphate buffer saline pH 7.4. Sigma membrane was soaked overnight in the dissolution medium. The medium was stirred by using the magnetic stirrer and the temperature was maintained at 37^0C ± 0.5^0C. Periodically 5 ml of sample was withdrawn and analysed spectrophotometrically at specified nm.

Mathematical modeling for nonlinear curve

To analyze the mechanism for the release and release rate kinetics of the dosage form, the data obtained was fitted in to Zero order, First order, Higuchi matrix and Krosmeyer and Peppa's model. Using Microsoft excel software. Comparing the r^2-values obtained, the best-fit model was selected.

Zero order kinetics

To study the Zero order release rate kinetics the release rate data were fitted to the following equation.

$$\mathbf{Q_t = Q_o + K_o t}$$

Where,
Q_t = amount of drug dissolved in time t,
Q_o = initial amount of drug in the solution and
K_o = zero order release constant.

First order kinetics

To study the first order release rate kinetics the release rate data were fitted to the following equation.

$$\mathbf{Log\ Q_t = log\ Q_o + K_1 t / 2.303}$$

Where,
Q_t is the amount of drug released in time t,
Q_o is the initial amount of drug in the solution and
K_1 is the first order release constant.

Higuchi model

To study this model the release rate data are fitted to the following equation

$$\mathbf{Q_t = K_H . t^{1/2}}$$

Where,
Q_t = Amount of drug released in time t,
K_H = Higuchi dissolution constant.

Krosmeyer and Peppa's release model

To study this model the release rate data are fitted to the following equation

$$\mathbf{M_t / M_\infty = K.t^n}$$

Where,
M_t / M_∞ = fraction of drug release,
K = release constant, t = release time and
n = Diffusion exponent for the drug release that is dependent on the shape of the matrix dosage form.

Hixson-Crowell model

To study the Hixson – Crowell model the release rate data are fitted to the following equation

$$\mathbf{W_o^{1/3} - W_t^{1/3} = Kst}$$

Where,
W_o = amount of drug in the dosage form,
W_t = remaining amount of drug in the pharmaceutical dosage form,
Ks = constant incorporating the surface-volume relationship.

Stability Studies

The Formulated Nanoparticles were kept in small air tight glass containers and stored at different temperature such as 4^0C, room temperature and 45^0C. The Drug content was observed in different time interval.

Applications[9, 10]

1. It is used to improved formulation for poorly soluble drugs.
2. It is used in Controlled release drug delivery.

3. It is used in targeted drug delivery.
4. Nanowire is used to detection of disease protein biomarker, DNA mutation, gene expression.
5. Quantum Dots is used to visualization of tumor and lymph cells.
6. It is used in implantable drug delivery systems.

Commercially available nanoparticles

1. Melamine Nanospheres
2. Magnetic Plain Dextran Nanospheres
3. Gold Nanospheres
4. Silver Nanospheres
5. Silica Nanospheres

Marketed Available Product

1. Endorem® - Superparamagnetic iron oxide nanoparticles - MRI agent.
2. Abraxane® - Albumin nanoparticle containing paclitaxel - Breast cancer.

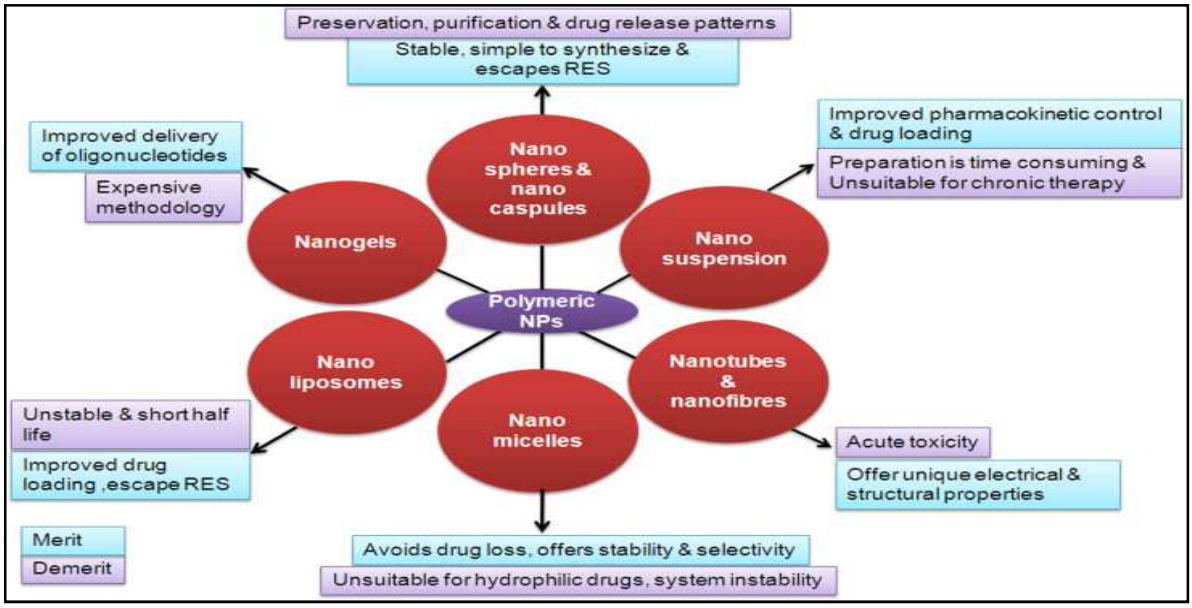

Figure No.1: Classification of Nano dosage forms

CONCLUSION

Nanotechnology is definitely a medical boon for diagnosis, treatment and prevention of cancer and other disease. The integration of nanotechnology into cancer diagnostics and therapeutics is a rapidly advancing field, and there is a need for wide understanding of these emerging concepts. The development of new nanoscale platforms offers great potential for improvements in the care of cancer and other patients in the near future.

ACKNOWLEDGEMENT

The authors would like to acknowledge Asmara College of Health Sciences, School of Pharmacy, Asmara, Eritrea, North East Africa for the preparation of the review work.

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