International Journal of Pharmaceutical Science Invention
ISSN (Online): 2319-6718, ISSN (Print): 2319- 670X
www.ijpsi.org Volume 11 Issue 1 ǁ January 2022 ǁ PP. 45-52

Cancer Therapy with Bioinspired Quantam Dots

Anwesha Biswas*[a], Subarna Mukherjee[b], Eqbal Ahmed Ansari[c] and Ankush Biswas[d]

[a*]*Undergraduate student of B. Pharm, Global College of Pharmaceutical Technology, Palpara, Krishnagar, Nadia,741101, West Bengal, India. Email ID: anwesha12344@gamil.com*
[b]*Undergraduate student of B. Pharm, Global College of Pharmaceutical Technology, Palpara, Krishnagar, Nadia,741101, West Bengal, India. Email ID: Subarnamukherjee2016@gmail.com*
[c]*Undergraduate student of B. Pharm, Global College of Pharmaceutical Technology, Palpara, Krishnagar, Nadia,741101, West Bengal, India. Email ID: eqbalansari623@gmail.com*
[d]*Assistant Professor, Department of Pharmacology, Global College of Pharmaceutical Technology, Palpara, Krishnagar, Nadia,741101, West Bengal, India. Email ID: abiswas8420@gmail.com*

ABSTRACT: *Cancer's global impact has grown over time; it is now the top cause of death globally. To deal with this mounting load, newer technology with effective drug delivery via greater tumour targeting ability is being considered. Chemotherapy, a sort of drug treatment, is essential in cancer treatment. It does, however, have negative repercussions. Bioavailability appears to be a problem, despite the fact that some natural compounds have less side effects. For example, bioinspired quantum dots have been offered as a promising new type of treatment (QDs). It comes from a plant and has anticancer properties while being low in toxicity. QDs are a potential nanometric material with excellent optical characteristics. These are also used in a range of applications, such as bioimaging and cancer therapy medication administration. QD technology can be used to detect metastatic cancer cells, quantify the quantity of a specific molecular target, and guide targeted cancer therapy by giving biophysical signals that block the target. Current biosensor research and development has piqued interest, problems like sensitivity, efficacy, biofouling, and biocompatibility among others, for point-of-care diagnostic testing and/or in vivo and in vitro diagnostics. As a result of acquiring a deeper understanding of this bioinspired QD method, advancements in cancer therapy drug delivery systems are expected.*

Keywords: *Bioinspired, Quantum dots, Bio-imaging Anticancer Drug delivery, Natural products Application*

Date of Submission: 28-03-2022 Date of acceptance: 19-04-2022

I. INTRODUCTION

Cancer is the leading cause of death worldwide, with over 19.3 million cancer cases and 10.0 million deaths expected in 2020, with lung cancer become the leading cause of death [1]. Despite tremendous efforts to create effective cancer medicines such as chemotherapy, immunotherapy, and innovative targeted methods, the survival rate in many instances remains low. One of the most important steps in improving cancer survival rates is early tumour detection and diagnosis, followed by successful targeted therapy [2]. Plant-based substances, on the other hand, are thought to be safer, less poisonous, and more environmentally friendly than conventional treatments. Many Phyto constituents, such as artemisinin, vincristine, paclitaxel and docetaxel, are known to have anticancer effects. Fe3o4-ag2o decorated cellulose nanofibers (CNFs). Methotrexate and etoposide are linked to quantum dots, which show in vitro drug release and anti-cancer efficacy [3-4]. Furthermore, dendrimers, liposomes, nanopores, nanoemulsions, and other nanoparticles are used in nanotechno logy for medication delivery. Nanoparticles are a potential medication delivery technology; however, it is impossible to predict the drug's fate in vivo. Quantum dots (QDs) are semiconducting clusters of atoms that are purposefully created and have exceptional optical capabilities. They typically have a size range of 2–20 nm [6-7]. Texas Instruments Incorporated invented QDs in the 1980s, since then, they've been used in a wide range of applications, involving cancer diagnosis and treatment (8). Because studies have demonstrated that folate-decorated nano-formulations target specific folate receptor positive malignancies, and QDs aid in drug release and targeting in vivo, they can be utilised to target and track certain cancers [9-12]. There is also a lot of literature covering many applications of nano structured materials and QDs in the biomedical field; however, this article focused on recent discovery in the use of plant compounds and QD in cancer therapy. It will help to pique the interest of a wide range of researches and healthcare experts.

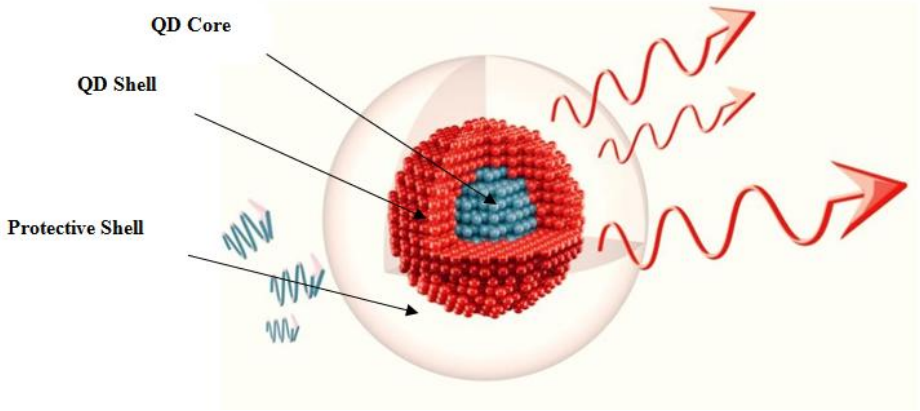


Fig.1 Quantum Dots

Bioinspired QDs in drug delivery

Plant derived bioinspired quantum dots (QDs) exhibit remarkable medication deliver and anticancer potential while being low in toxicity. Quantum dots are well known for their optical activity and find applications in a variety of fields, including bioimaging and medication administration in cancer therapy. Beneficiaries benefit from QDs in medicine delivery natural goods. Curcumin loaded PLGA nano particles with QDs were tested for Cytotoxin action on BCBL1 and HBL 6 cell lines by Bellettied et al. in 2017. Curcumin's bioavailability and hence its activity were improved as a result of the loading process [13-14]. Paclitaxel and (CdTe/Cds/Zns) QDs co-loaded NLCs (nano Structure lipid carriers) were studied in vitro and vivo using emulsion, evaporation and low temperature solidification procedures. Most quantum dots are cytotoxic because they include heavy metals like cadmium; however, carbon-based QDs have been shown to be less toxic, make them more biocompatible. Carbon dots, often known as C-dots are tiny nanoparticles with a nearly spherical form and also have a crystalline or amorphous core with sp2 hybridised carbon sheets united by oxygen containing sp3 hybridised carbon. Furthermore, since the development of green chemistry, the production of green based C-dots has increased consciously, as it enhances biocompatibility, lower harmful chemical side effects, and is more cost effective and suitable (15, 16).

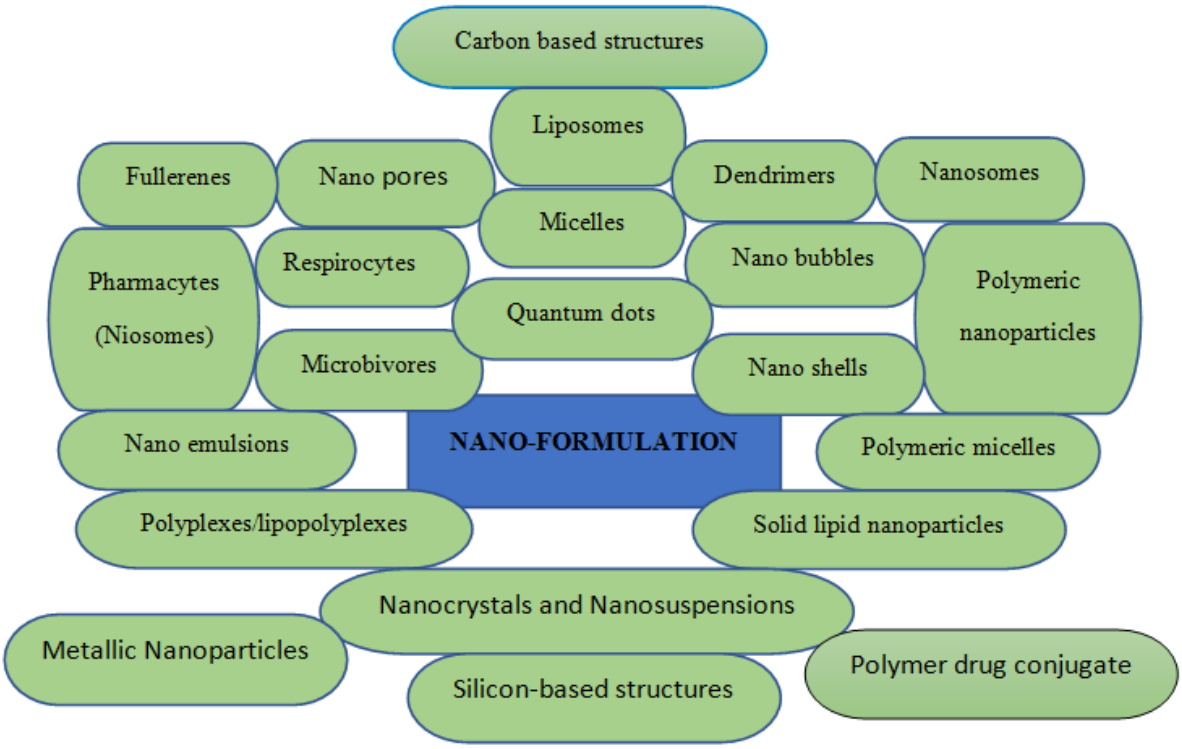


Fig.2 Nano-formulations of various sorts are employed in medication delivery system

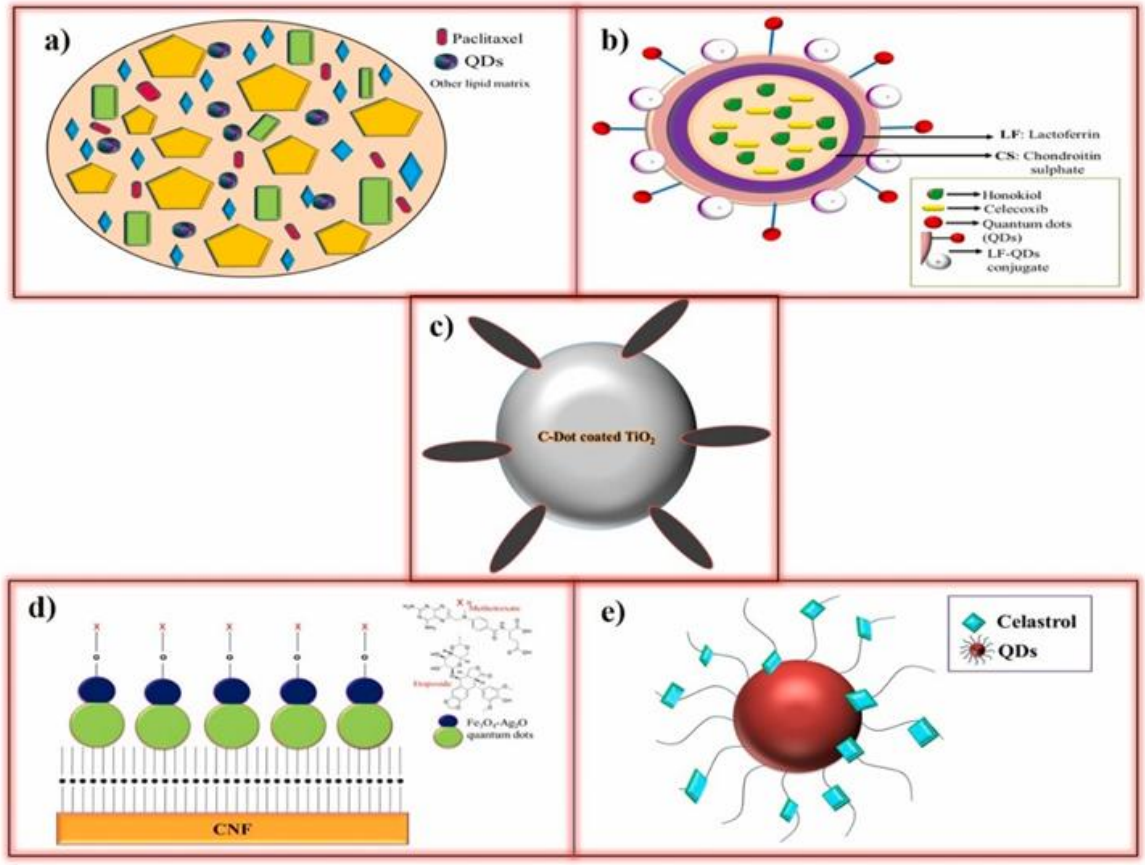


Fig.3Structure of several QD formulations based on natural products

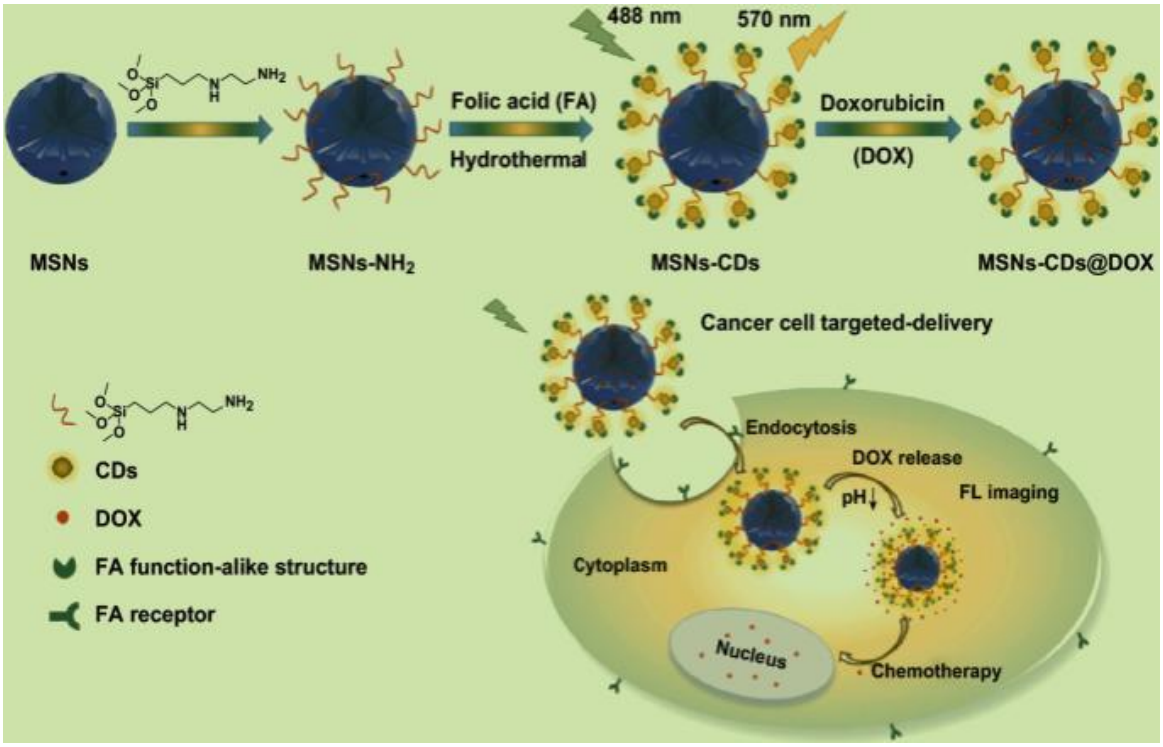


Fig.4 Releasing of DOX into the cancer cells by folic acid produced MSN-CDS

The fluorescent mesoporous silica C-dots nanohybrid (MSN-CDsNH) was discovered to have a high capacity for suppressing cancer cells because they can easily target folate receptor over expressing carcinoma

such as Henrietta Lacks Because The MSN-CDSNH were made in the lab from folic acid and afterwards, using a microwave aided solvothermal technique, they were attached to the façade of amino-modified MSNNH., they were exceedingly biocompatible, as shown in **Fig.3.** Furthermore, the superior fluorescence qualities of MSN-CDS allowed them to keep their unique traits, such as good biocompatibility,
mesoporous structure, and high surface to volume ratio, among others. It also showed stable and bright yellow emission, which led to the creation of value in the diagnosis of fluorescence imaging-guided drug delivery by real-time fluorescence tracking and shows that the MSN-CD-NH may be utilized effectively for both diagnostic and therapeutic applications reducing toxic chemotherapeutic drug side effects while increasing drug delivery to the targeted sites [17].

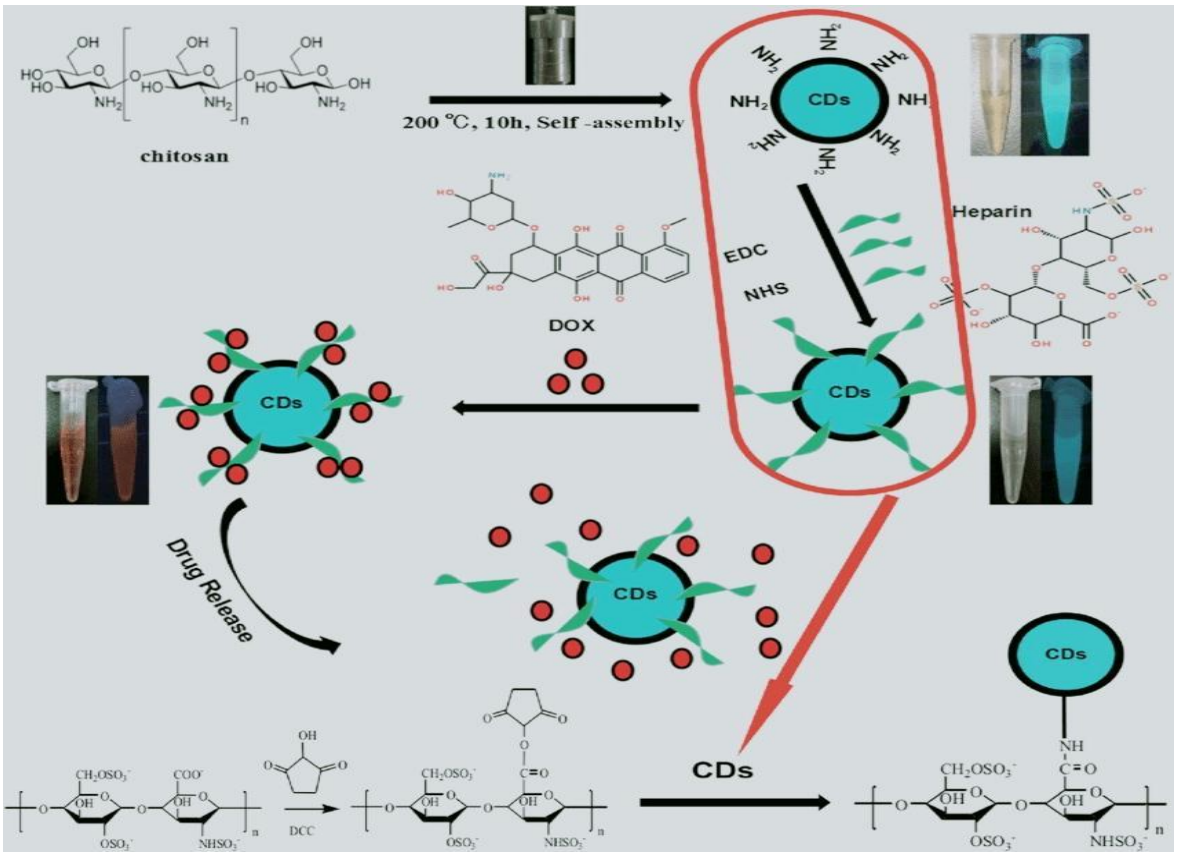


Fig.5 Synthesis of C-dotand DOX-completion CDs-HepCDs-Hep/DOX, as well as drug release as a pH response

Although most quantum dots are cytotoxic due to heavy metals such as cadmium, carbon-based quantum dots have been found to be less toxic, making them more biocompatible. According to a pH-based investigation, water soluble carbon dots combined with the anticoagulant heparin (Hep) and the anticancer drug doxorubicin (DOX) substantially reduced blood clotting. As shown in Fig. 4, the DOX was delivered to the cancer cells that were being targeted. The CD has a high loading capacity of 32.2 percent for DOX and Hep, respectively. 28.45% and 28.45% are the respective percentages. Furthermore, DOX was said to be more successful at turn aside. Carcinoma from spreading when it was given with Hep- CD. Hepatitis helps to improve blood compatibility. Because of the existence of DOX and Hepatitis easy administered in the absence of electrostatic interaction situation that are extremely acidic. Furthermore, the outcomes of the experiment indicate CDs have been shown to effectively lessen the negative effects of DOX and Hep, as well as other drugs be utilised for image-guided drug deliver.

II. Application of bioinspired QDs.

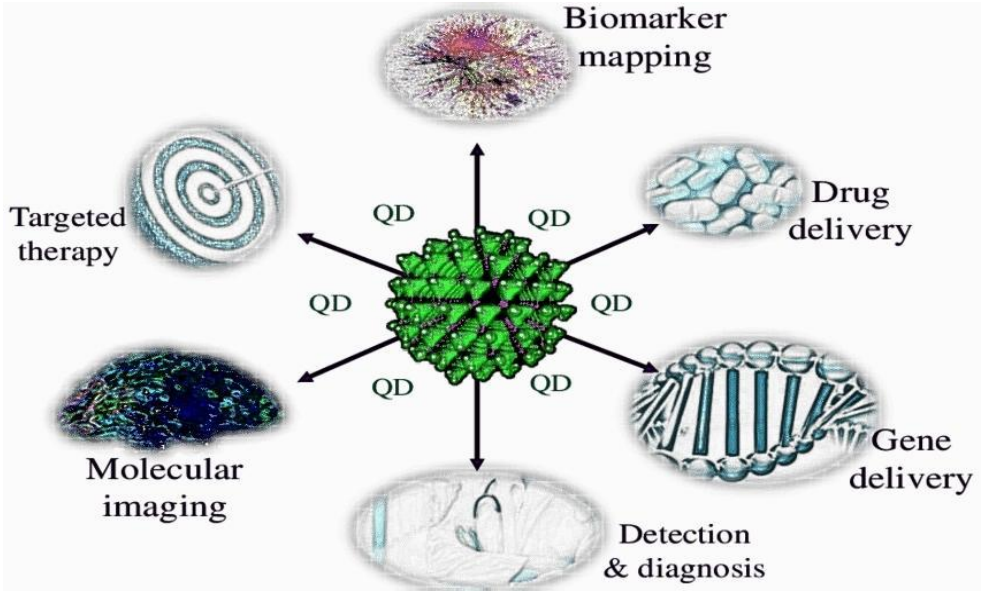
2.1 Bioinspired Quantum Dots as anticancer agents

The use of phytoconstituents in the production of CQDs from plants is a unique approach. Ginsenoside Re (genus panax) based carbon dots were made using

Table I: Natural products that have been utilised in conjunction with QDs are listed below

	Natural product	Formulation	QDs	Cell line
CQDs and QDs as natural product carrier	Celastrol	QDs with drug conjugation	Cys-CdTe	sensitive K562, resistance K562/A02
	Etoposide	Drug linked to QDs coated with cellulose nanofibers	Fe3o4-Ag2o	SKMEL-3
	Paclitaxel	Drug loaded nanostructure lipid carrier with QDs	CdTe/CdS/ZnS	HepG2
	Ginsenoside	Ginsenoside carbon dots	Carbon dots	293T, MCF-7, HepG2, A375
CQD as anticancer agent	Cinnamon, red chili, turmeric, black pepper	C-dots	C-dots made with turmeric, Black pepper, cinnamon, red chili	HK-2, LN-229

technique in 2018. Carbon dot generated was found to be efficient opposed to carcinoma. Healthy cells are unaffected by the A375, MCF-7, and HepG-2 cell lines, however cancerous cells are (293-T). Proliferation of cancer cells and caspase mediation and activation of apoptosis were



found to be linked, also higher level of reactive oxygen species (ROS). A one-pot green synthesis procedure was used to create C-dots (aqueous fluorescent) of turmeric, black pepper, cinnamon and red chilli, which were then examined in vitro. In cytotoxicity tests, human glioblastoma cells (LN-229) and human kidney cells (HK-2) were found to be more cytotoxic. Bioimaging revealed that malignant cells had a higher absorption of c-dots, whereas non-cancerous cells had a lower absorption [18]. Boobalan *et al*. Also studied the anti-cancer effect of fluorescent C-dots (blue/green) produced from oyster mushrooms using hydrothermal synthesis on normal embryonic kidney cells (HEK-293) and a breast cancer cell line (MDA-MB-231). The C-dots inhibited cancerous cell development more effectively than non-cancerous cells, with an IC50 value of 3.34 g/ml for MDA-MB-231 cells and cell viability dropping to 70% for HEK-293 cells at 25 g/ml, making the C-dots more selective. C-dots were also employed as Pb^{+} ion, antimicrobial, and intercalative DNA binding chemical sensors [19]. The mapping of sentinel lymph nodes will help with biopsy and surgery.

The interaction of quantum dots with peptides, antibodies and biomolecules, among other thing, it could be used to target malignancies in vivo. In this review, we'll look at from a clinical stand point, review current.

Development in creating QDs for cancer detection and treatment.

To find metastatic chances of further enhancing QD technology, consider the following points and discuss the m in the future. However, there are two fundamental drawbacks to existing imaging techniques. They don't have enough sensibility, for starters. Malignant cells in small numbers in original or metastatic sites should be found.

Second, there is the imaging. Techniques for detecting specific cancer cell-surface makers have yet to be developed. In many cases, these cell surface indicators could be used as cancer therapy targets and could aid in the detection and treatment of cancer diagnosis and staging. These constraints necessitate advancements in imaging techniques, which are currently l acking. Highly sensitive and bio specific quantum dot imaging probes are being developed. Imaging probes offer the ability to address these in vivo cancer imaging needs, despite the fact that research is st ill in its early phases.

III. Quantum Dots for treatment and detection of cancer

Quantum dots (QDs) are light activated semiconductor nanocrystals that glow. including as high brightness, a tuneable wavelength and photo bleaching resistance. Recent advances in QD surface modification have paved the way for their potential application in cancer imaging. By mapping sentinel lymph nodes, QDs with Near-infrared emission could improve biopsy and surgery. In vivo, QDs could be combined with biomolecules like peptides and antibodies to target cancers. Quantum dots for cancer detection and treatment. Imaging is a crucial therapeutics tool for determining the best cancer treatment. Current imaging approaches for cancer screening include ultrasonography, x-rays computed tomography, radionuclide imaging and magnetic resonance imaging (MRI). On the other hand, have two fundamental drawbacks [21]. For starters, they don't have adequate sensitivity. Malignant cells in small numbers should be found in the main and metastics locations. Second, imaging approaches for detecting specific cancer cell surface makers have yet to be developed markers. These cell surface indicators could be used as cancer therapeutic targets in many cases help in cancer treatment and staging. These constrains necessitate advancements in imaging.

The development of novel imaging probes that are both sensitive and bio specific [14]. While still in the early phases ofdevelopment, quantum dot (QD) imaging probes have the potential to transform imaging. These in vivo cancer imaging requirements have the potential to be addressed. We look at how QD technology can be improved in the future to better identify metastatic cancer cells, quantify the number of specific molecular targets, and recommend targeted cancer therapy by providing biophysical signals for target suppression.

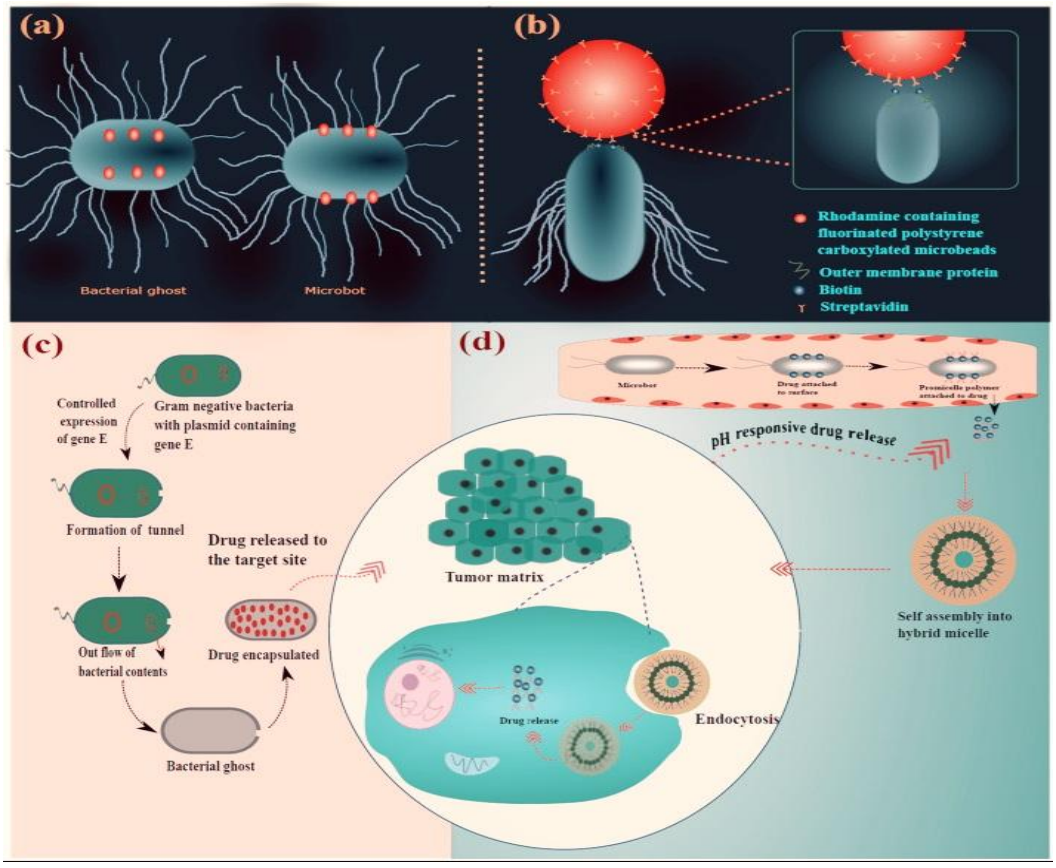


Fig.7 Various bacteria-inspired biomimetic system for tumor therapy are depicted schematically

(a) A bacteria ghost and a microbot equipped with drugs. The medicine is encapsulated by the bacterial ghost, and the drug is carried on the surface of microbot delivery mechanism.

(b) Microbot is bound to the rhodamine containing fluorinated polystyrene carboxylated microbeads through the interaction of biotin and streptavidin on the bacteria surface.

(c) The ejection of cytoplasmic components and their tailored delivery to the tumour matrix are used to pre pare bacterial ghosts.

(d) The microbot with the medicine attached travels through the bloodstream and diffuses to the tumour cel l. The drug is released in reaction to the pH of the tumour cell and self assembles into a hybrid micelle, allowing for tumor-specific drug delivery.

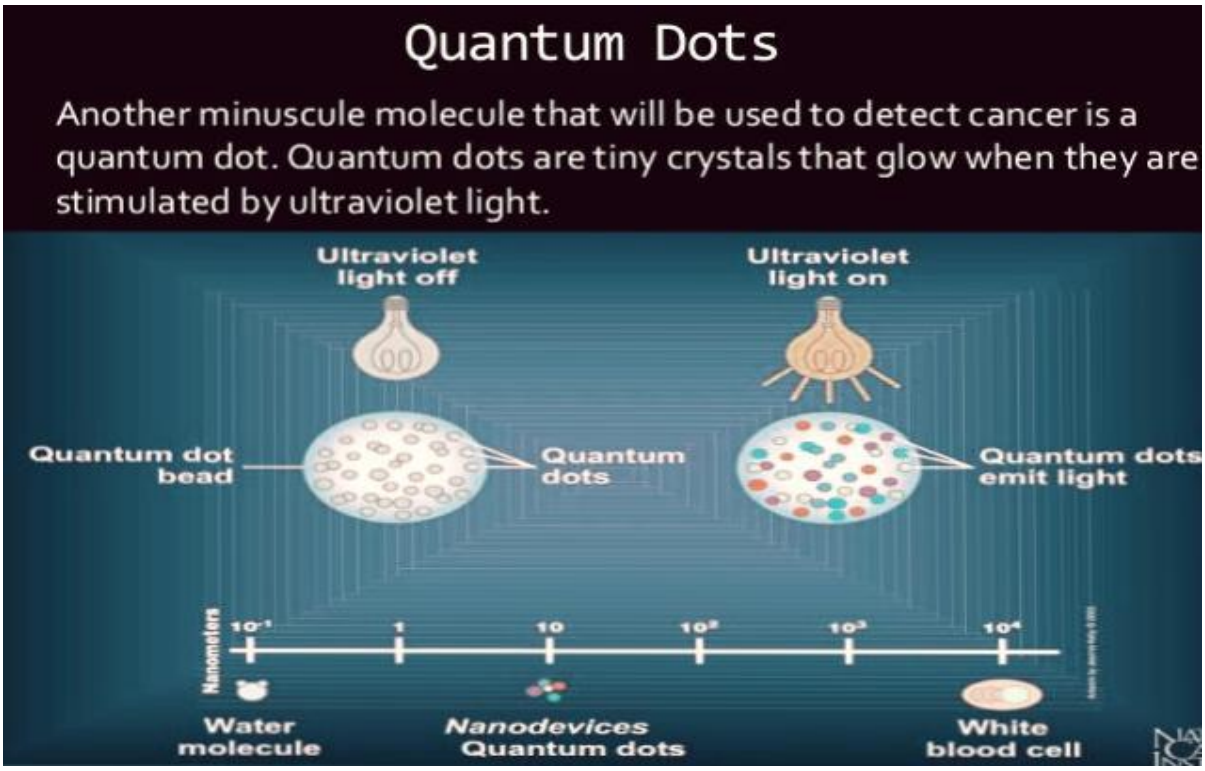


Fig.8 Quantum Dots for cancer detection and treatment

Bioinspired QDs' Drug Delivery Challenges

QDs are an effective drug delivery system with the added benefit of bioimaging due to their fluorescence properties, but they are hard to target and heavy metal toxicity is a worry. By integrating, receptor-ligand on the nanoparticles, specific targeting for some cancers, such as FR positive cancers, can be achieved. Plant-based CQDs provide a means to avoid toxicity, but their destination in the living system is unpredictable.

Furthermore, the dearth of invivo investingations limits our understanding of their impacts in our living system [22].

IV. Conclusion and future prospects

Carbon dots have optical properties and can deliver increased anti-cancer impacts on their own when generated from a natural product with anti-cancer properties activities of cancer. Carbon dots of this type also demonstrated can-specificity. Cells with cer CQDs in drug delivery systems pose a number of issues. Extensive in vivo research and precision targeting can be used to address these challenges.

CQDs have unique receptor ligands attached to them, which allows for this. Chemical procedures are regarded hazardous and toxic since they use a variety of toxic substances that can be harmful to living tissues; thus, green-based alternatives are preferred. They are currently popular because they are safe, biocompatible, and inexpensive. Chemical procedures, on the other hand, are regarded as dangerous and harmful due to the usage of a number of hazardous substances that may harm living cells; hence, green-based alternatives are chosen. They are currently popular because to their safety, biocompatibility, and low cost. The Green-based carbon dots for therapeutic purposes are in the works. a future that is both opportune and hopeful Despite the

fact that several research and examinations have been carried out, Carbon dots have a wide range of therapeutic and non-therapeutic applications, according to research. However, due to drawbacks such as the inability to diagnose, and diagnostic procedures production costs, cytotoxicity, limits on long-term usage, and discharge are all factors to consider. Their applications are limited by the human body, for example. The scientists must continue their work. Invest time in researching these drawbacks in order to improve the long-term utility the product.

Author Contribution

A.B. contributed by Conceptualization, Investigation, Resources, Data curation, Visualization, and Writing an original draft. S.M. and E.A.A. contributed by Validation, Data curation, visualization and other Investigation. A. Biswas contributed by Conceptualization, Validation, Supervision, Reviewing & editing the manuscript draft and Project administration.

ACKNOWLEDGEMENT

A.B., S.M. and E.A.A are thankful to professor A. Biswas for providing constant support &guidance throughout this work and their respective affiliated institution.

References

[1]. Globocan, The Global Cancer Observatory - All cancers, Int. Agency Res. Cancer- WHO. 419 (2020) 199–200.
[2]. Gao J, Gu H, Xu B. Multifunctional magnetic nanoparticles: design, synthesis and biomedical applications. Accounts of Chemical Research 2009; 42:1097–107.
[3]. J. Iqbal, B.A. Abbasi, T. Mahmood, S. Kanwal, B. Ali, S.A. Shah, A.T. Khalil, Plant derived anticancer agents: A green anticancer approach, Asian Pac, J Trop. Biomed. 7 (12) (2017) 1129–1150, https://doi.org/10.1016/j.apjtb.2017.10.016.
[4]. D. Bisht, D. Kumar, D. Kumar, K. Dua, D.K. Chellappan, Phytochemistry and pharmacological activity of the genus artemisia, Arch. Pharm. Res. 44 (5) (2021) 439–474, https://doi.org/10.1007/s12272-021-01328-4.
[5]. R. Yadav, J. Das, H. Lalhlenmawia, R.K. Tonk, L. Singh, D. Kumar, targeting cancer using phytoconstituents-based drug delivery, Advanced Drug Delivery Systems in the Management of Cancer, Academic Press, 2021, pp. 499–508.
[6]. C.E. Probst, P. Zrazhevskiy, V. Bagalkot, X. Gao, Quantum dots as a platform for nanoparticle drug delivery vehicle design, Adv. Drug Deliv. Rev. 65 (5) (2013) 703–718, https://doi.org/10.1016/j.addr.2012.09.036.
[7]. A.M. Bagher, Sensors & Transducers Quantum Dots Applications, Sensors & Transducers. 198 (2016) 37–43.
[8]. J. Drbohlavova, V. Adam, R. Kizek, J. Hubalek, Quantum dots - characterization, preparation and usage in biological systems, Int. J. Mol. Sci. 10 (2009) 656–673, https://doi.org/10.3390/ijms10020656.
[9]. Y. Yuan, J. Zhang, L. An, Q. Cao, Y. Deng, G. Liang, Oligomeric nanoparticles functionalized with NIR-emitting CdTe/CdS QDs and folate for tumor-targeted imaging, Biomaterials. 35 (27) (2014) 7881–7886, https://doi.org/10.1016/j.biomaterials.2014.05.071.
[10]. Z. Ranjbar-Navazi, M. Eskandani, M. Johari-Ahar, A. Nemati, H. Akbari, S. Davaran, Y. Omidi, Doxorubicin-conjugated D-glucosamine- and folate- bi-functionalised InP/ZnS quantum dots for cancer cells imaging and therapy, J. Drug Target. 26 (3) (2018) 267–277, https://doi.org/10.1080/1061186X.2017.1365876.
[11]. J. Jeevanandam, Y.S. Chan, M.K. Danquah, Nano-formulations of drugs: Recent developments, impact and challenges, Biochimie. 128–129 (2016) 99–112, https://doi.org/10.1016/j.biochi.2016.07.008.
[12]. S. Bhatia, Natural polymer drug delivery systems: Nanoparticles, plants, and algae, 2016. https://doi.org/10.1007/978-3-319-41129-3.
[13]. D. Belletti, G. Riva, M. Luppi, G. Tosi, F. Forni, M.A. Vandelli, B. Ruozi, F. Pederzoli, Anticancer drug-loaded quantum dots engineered polymeric nanoparticles: Diagnosis/therapy combined approach, Eur. J. Pharm. Sci. 107(2017) 230–239, https://doi.org/10.1016/j.ejps.2017.07.020
[14]. Arun kumar.Jay Singh.www.sciencedirect.com for Bioinspired Quantum Dots for cancer Therapy D.Belletti, G. Riva, M. Luppi, G. Tosi, F. Forni, M.A. Vandelli, B. Ruozi, F. Pederzoli, Anticancer drug-loaded quantum dots engineered polymeric Nanoparticles: Diagnosis/therapy combined approach, Eur. J. Pharm. Sci. 107 (2017) 230–239, https://doi.org/10.1016/j.ejps.2017.07.020.
[15]. S.Y. Lim, W. Shen, Z. Gao, Carbon quantum dots and their applications, Chem. Soc. Rev. 44 (1) (2015) 362–381.
[16]. S. Zhu, Y. Song, X. Zhao, J. Shao, J. Zhang, B. Yang, The photoluminescence mechanism in carbon dots (graphene quantum dots, carbon nanodots, and polymer dots): current state and future perspective, Nano Res. 8 (2) (2015) 355–381, https://doi.org/10.1007/s12274-014-0644-3.
[17]. S. Zhao, S. Sun, K. Jiang, Y. Wang, Y. Liu, S. Wu, Z. Li, Q. Shu, H. Lin, In Situ Synthesis of Fluorescent Mesoporous Silica-Carbon Dot Nanohybrids Featuring Folate Receptor-Overexpressing Cancer Cell Targeting and Drug Delivery, Nano-Micro Lett. 11 (2019) 32, https://doi.org/10.1007/s40820-019-0263-3.
[18]. N. Vasimalai, V. Vilas-Boas, J. Gallo, M.d.F. Cerqueira, M. Men´endez-Miranda, J.M. Costa-Fernandez, ´ L. Di´eguez, B. Espina, ˜ M.T. Fernandez-Argüelles, ´ Green synthesis of fluorescent carbon dots from spices for in vitro imaging and tumour cell growth inhibition, Beilstein J. Nanotechnol. 9 (2018) 530–544, https://doi.org/10.3762/bjnano.9.51.
[19]. T. Boobalan, M. Sethupathi, N. Sengottuvelan, P. Kumar, P. Balaji, B. Gulyas, ´P. Padmanabhan, S.T. Selvan, A. Arun, Mushroom-Derived Carbon Dots for Toxic Metal Ion Detection and as Antibacterial and Anticancer Agents, ACS Appl. Nano Mater. 3 (6) (2020) 5910–5919, https://doi.org/10.1021/acsanm.0c0105810.1021/acsanm.0c01058.s001.
[20]. H. Yao, J. Li, Y. Song, H. Zhao, Z. Wei, X. Li, Y. Jin, B. Yang, J. Jiang, Synthesis of ginsenoside Re-based carbon dots applied for bioimaging and effective inhibition of cancer cells, Int. J. Nanomedicine. 13 (2018) 6249–6264, https://doi.org/10.2147/IJN.S176176.
[21]. H. Arya, Z. Kaul, R. Wadhwa, K. Taira, T. Hirano, S.C. Kaul Quantum dots in bio-imaging: revolution by the small Biochem. Biophys. Res. Commun., 329 (2005), pp. 1173-1177
[22]. A.K., K.R.B.S., M.D.G., H.L., J.S., D.K., Bioinspired quantum dots for cancer therapy: A mini-review,
[23]. https://www.researchgate.net/publication/357934388.