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Designing a drug-delivery vehicle with Au-Fe_3O_4-graphene quantum dots: A tri-pronged mechanism for bioimaging, synaphic delivery and apoptosis induction in cancer cells

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Graphene Quantum Dots (GQDs) are proving to be effective imaging paraphernalia for the comprehension of morphological alterations in the cellular membrane due to high absorption coefficients and quantum efficiency. Such quantum dots can be used in drug/delivery vehicles, biolabelling as well as in PCR. An upsurge of expanded interest in the field of magnetic nanotechnology has led us to allow indepth exploitation of magnetic nanoparticles in nanomedicine. Encapsulating the core made up of magnetic nanoparticles by Gold nanoshell leads to the development of a proficient biocompatible and stabilized drug/delivery system under physiological conditions. Further a nanocomposite was created by allowing conglomeration of Au- Fe_3O_4 core-shell with GQDs. This modular design enables Au-Fe_3O_4-GQDs to perform multiple functions simultaneously, such as in multimodal imaging, drug delivery and real-time monitoring, as well as combined therapeutic approaches. The ability of MNPs to enhance proton relaxation of specific tissues and serve as MR imaging contrast agents is one of the most promising applications of nanomedicine. In the present work, Au-Fe_3O_4 nanoparticles are used as able cargo for the docking of anti-cancer drug such as Doxorubicin (DOX) using cysteamine as a linker for the attachment. The attachment could be monitored using UV-visible spectroscopy. The stability of Au-Fe_3O_4 nanoparticles was scrutinized by measuring the flocculation parameter which was found to be in the range of 0-0.65. Further, zeta potential measurements confirmed the pH of 7.4 at which maximum drug attachment can take place. The amalgamation of the drug along with activated folic acid as a navigational molecule is the critical phase for targeted drug delivery. Attachments were verified using FTIR and NMR which confirmed the formation of non-covalent interactions. The drug loading capacity of the Au-Fe_3O_4 was found to be 76%. Drug-release was studied using the AC magnetic field generator and was found to be temperature dependent phenomena. GQDs were found to be effective players in tracking the drug-delivery vehicle around the miscreant cell and inside them. Au-Fe_3O_4-GQD-FA-DOX complex was found to be comparatively non-toxic for normal cells and considerably toxic for Hep-2 cells due to hyperthermal properties of SPIONS and targeted-mechanism of folic acid.

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