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Editorial

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Smart theranostic nano materials: recent progress from bench to bedside translation

Abstract

The use of nanoparticles for diagnosis and therapy of cancer which is also called theranostic nanoparticle could be a highly demanded medicine in the future to improve personalized cancer disease management. Among all pre-clinical materials, gold based nanocrystals could be ideal inorganic base materials for designing of theranostic platform and has revolutionized translational potential from bench to bedside.

Keywords: Nanomaterials, Clinical trials, Indicators, Diagnosis, Theranostic nanoparticle, Porous silica, Carbon nanotubes, Graphene oxide, Biocompability, Positron emission tomography

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Editorial

One of the key revolutionized technologies of 21st century in disease management especially in cancer treatments is the application of nanotechnology using smart nanomaterials.[1] Evolution of several recent clinical trials is one of the indicators that predict how fast the nanotechnology is progressing from bench to bedside direction. The use of nanoparticles for diagnosis and therapy of cancer which is also called theranostic nanoparticle could be a highly demanded medicine in the future to improve personalized cancer disease management.[2] Several organic and inorganic nanoparticles have been in the race to design the best theranostic nanoparticle that can efficiently target the tumor site without damaging the healthy tissue. Smart nanoparticle platforms of carbon nanotubes, graphene oxide, quantum dots, ironoxide, gold, polymeric (e.g mostly ester based biodegradable polymers), ferritin, porous silica, and liposome etc have been engineered in such as way that the functionalized nanoparticles have potential translational ability in the clinic. There are several challenges in the development of roboust theranostic nano platform appropriate for disease detection and therapy.[3]

a. Smart formulation chemistry is needed while selecting appropriate therapeutic agents such as anticancer drugs, metallic nanocrystals, imaging contrast agents such as radioisotopes/ fluorescent dyes, and incorporation of all of them in a single theranostic nanoparticle.

b. The designed theranostic nanoparticle should have a selective targeting ability based on the characteristic feature of the disease.

c. Third, the selectively targeted theranostic nanoparticle should have high payload delivery efficiency for therapy and high sensitivity and accuracy for imaging.

d. The formulated materials should not affect the healthy organs and easily eliminate from the body or degradable in such a way the byproducts of the formulated material should be safe for the body.

e. The overall theranostic nanoformulation as a cancer nanomedicine should be cost effective and human friendly to handle.

However pre-clinical theranostic nano-formulations, those that are multifunctional and combine imaging and therapy capabilities in one shot, are still in their infancy and so far none have been approved in this capacity. Although, Food and Drug Administration (FDA) has approved so far 35 therapeutic nanoparticles in clinical trials are not from above concerns.

To the date, the materials for theranostic formulation that enter in clinical trial will further need translational stages of the formulation. The choice of basic materials and their toxicity are still considered key primary stage of the translation. However sufficient progress that has been made during the last decade in certain materials such as biodegradable polymeric nanoparticles, iron oxide and gold nanoparticulates, (NCT00356980, NCT00848042), silica nanoparticles (NCT02106598), and silica gold nanoparticles (NCT01270139).[4] Doxil, a pegylated liposomal doxorubicin is the first FDA approved nanodrug used to treat some types of cancers, including metastatic ovarian cancer and AIDS-related Kaposi's sarcoma.

Among all pre-clinical materials, gold based nanocrystals could be ideal inorganic base materials for designing of theranostic platform.[5,6] Excellent biocompability, tailorable geometry and surface charges, Fasile and versatile bioconjugation capability with targeting molecules (i.e antibodies, peptide/protein fragments), higher reproducibility, and lower cost are the potential characteristic feature of the gold nanoparticle by itself.[7] Gold nanoparticle based platforms have been used for number of therapeutic strategies (e.g. chemo, genetic, immune and photothermal) and imaging strategies (e.g. MRI, CT and photo acoustic).[8] The unique optical properties of gold nanoparticles are due to the presence of localized Surface Plasmon Resonance that varies (absorption/scattering) based on size, shape and the dielectric surroundings. These are the additional features that resulted the gold nanoparticles a unique theranostic nanoparticles by themselves without conjugation of additional therapeutic and imaging molecules.[9] In addition, gold with other materials such as iron oxide, silica etc. forms hybrid constructs that can be used as by bride imaging modality with the fusion of positron emission tomography (PET)/CT or PET/MRI, or Ultrasound/CT which dramatically complement to overcome the limitations of either one's modality.[10] Another beauty of gold nanoparticle is the versatile synergy between diagnostics and therapeutic characteristics that can be achieved by engineering the gold nanomaterials.[11] Apart from the improved efficacy, safety and

pharmacokinetics, recent ongoing studies are focusing to obtain precise physiochemical properties, toxicity, immunogenicity, absorption, distribution, metabolism and excretion of the nanoparticles in various animal models. Some other challenges are scalability, preciseness of reproducibility, bioavailability, therapeutic indexes, marketability and regulation/safety. Once the gold based theranostic formulation crosses the regularity barrier such as standardization, safety and risk guidelines.[12] and the day to see a successful translation from bench to bedside is very close.

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Conflicts of interest

None.

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