Meetings International SciTechnol

J Clin Exp Oncol 2018, Volume:7
DOI: 10.4172/2324-9110-C5-021

Potential application of hollow silica nanosphere: Pesticide delivery perspective

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With the beneficial recognition of nanoencapsulation technique, utilization of inorganic porous nanoencapsulation or nanocarrier materials have attracted much attention over biodegradable polymeric or lipid-based nanomaterials because of their mechanical, thermal and chemical stability. However, still controversy remains about the fate of inorganic nanomaterials to the environment. Hence, among the inorganic porous nanoencapsulation or nanocarrier materials porous amorphous silica-based nanomaterials are considered to be most suited materials. So far, US Food and Drug Administration (FDA) have categorized amorphous silica as 'Generally Recognized as Safe (GRAS)' materials that could be used as food additives and vitamin supplements. Application of porous silica nanomaterial as carriers for drug delivery to human where their biocompatibility and non-toxic nature have been well investigated has opened a new dimension to utilize them as potential carriers for pesticide delivery. Amorphous silica nanoparticles have also exhibited their potential to pest control as observed in diatomaceous earth. Thus, it is expected that preparation of controlled release pesticide formulation using silica-based nanomaterial, as a carrier will enable to control of agricultural pests more effectively as well as reduce the pesticide resistant behaviours in insect pest. However, depending on their surface structure, interior design and structural arrangement porous silica nanomaterials are categorized as mesoporous silica nanoparticles (MSNs) and porous hollow silica nanoparticles or nanospheres (PHSNs or HSNs). In terms of pesticide delivery, HSNs have more potential over MSNs because of their large void space that facilitates high pesticide loading capacity. In addition, various synthesis techniques and both pre- and post-synthesis pesticide loading mechanisms allow them to encapsulate a wide range of hydrophilic and hydrophobic pesticide. Moreover, their inability to form covalent bond with pesticide ensures high percentage of pesticide releasing behavior. Ease of surface functionalization as well as to some the extent of hydrogen bonding ability enhances their sustainability for the preparation of controlled release pesticide formulation. The translocation and transportation mechanisms related to nanoparticle uptake by plants are also a promising aspect for the creatiosn of new opportunities for the development of two-way systemic nanoencapsulated pesticide. It is expected that in this phenomenon, HSNs will support plants to combat against physiological stress such as salinity, water lodging or prevent high accumulation of heavy metals as arsenic. Considering the beneficial aspect of porous silica-based nano-carriers especially porous hollow silica nanosphere, this presentation provides an overview of this material, their potential application in pesticide delivery as well as future perspective for further improvement of pesticide formulation used for pest control in agriculture.

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