Mesoporous Materials in Drug Delivery

Mini Review

Volume 4 Issue 3 - 2016

Negar Abbasi Aval*

Department of Materials Engineering, Isfahan University of Technology, Iran

***Corresponding author:** Negar Abbasi Aval, PhD candidate of biomedical engineering-biomaterial, Biomaterials research group, Department of Materials Engineering, Isfahan University of Technology, Iran,
Email: negar.abbasi@ma.iut.ac.ir

Received: May 20, 2016 | **Published:** November 28, 2016

Introduction

Nanosciences has a very broad application in medicine such as nanomaterials applied in drug delivery. The nanomaterials concluded broad range of materials which can be organic or inorganic. The inorganic materials especially porous ones are the most attractive in drug delivery field. Porous nanomaterials are divided in to three categories according to IUPAC definition [1]. The materials with pores in the range of 2-50 nm are named mesoporous materials, the materials with pores<2 nm are named micro porous and >50 nm are macro porous. The mesoporous materials have some attractive characteristics included an ordered pore network, large surface area and large pore volume due to their size of pores which make them as a potent candidate in catalysis, sensors, separation and nanomedicine particularly drug delivery [2,3]. The first synthesized mesostructured materials was from Mobil industry in 1992 [4] with the name MCM-41 in the silica mesoporous subset. Many other attempts were carried out after MCM-41 in synthesis mesoporous inorganic structures most of them were with the aid of templates such as SBA-15 [5]. Tinplating is a very important factor in preparing the porous structure which can be performed by surfactants appropriately by block copolymers [5,6].

As discussed formerly, pore size is very determinative in adsorption of drug molecules inside the mesoporous structure. The size of porosity can be changed in a broad range (2-50 nm) with altering the chain length of polymeric micelles which make the mesostructured appropriate for delivery of different size of bioactive molecules concluding small drug molecules and large proteins [7]. The size of pores is determinant not only on adsorption of diverse drug molecules but also on the rate of release [8]. Vallet-Regi and co-workers [9] synthesized two silica mesoporous structure (MCM-41 and SBA-15) with different surface area in application as a vehicle for alendronate as drug model in which the one with higher surface yielded to more loading efficacy. Some efforts have been done to have a controlled release of drug such as surface functionalization with chemical groups resulted in strong bindings with drug molecules and a controlled rate in release [10]. As illustrated by Song and co-workers [11], functionalization of MCM-41 and SBA-15 with amino groups was a very operative method in controlling the release rate of ibuprofen. In this research, the ionic binding between carboxyl groups of ibuprofen and amino groups of functionalized surface of mesopores has a very effective impact on controlled release. Another method in controlling the rate of release is functionalization of surface with hydrophobic groups. Some researchers [12] functionalized the surface of SBA-15 with hydrophobic groups like octyl and octadecyl resulted in declining the pore size and hydrophilicity of the surface, the parameters which are so effective in controlling the release rate of erythromycin as a drug model.

The very new method in modifying the mesoporous materials is multi functionalization of them with several groups. For instance, functionalization of silica mesoporous nanoparticles with florescence or magnetic groups (make them applicable in imaging) and light activated artificial machines (controlled delivery) has been reported by Liong and co-workers [13]. Biodistribution is defined as tracking of the intended nanoparticles in the organs and tissues to distinguish the accumulation of the tissues. For testing the bio distribution of the mesoporous silica in cancer therapy, the surface of material was functionalized with folate. The results were about excreting the positively charged nanoparticles from the liver into gastrointestinal tract and finally in the faces of the animal while for the negatively charged nanoparticles, the excretion was within the liver. So, the surface charge of nanomaterials has important effect in biodistribution of them. As well, the shape of mesoporous nanomaterials is another important factor in biodistribution, where; the short rod-shaped mesoporous silica accumulates in liver and the long rod-shaped in the spleen [14]. For targeting the mesoporous silica to breast cancer cells, the surface of the nanoparticles were bio conjugated with DNA aptamers with specific binding potent to nucleolin, a protein which is over expressed on the membrane of the breast cancer cells [15]. Applying superparamagnetic nanoparticles as the core of mesostructured silica can be used in controlled release of drug [16] and as biomarkers in vitro and in vivo [17]. Addition of florescent groups to the surface of superparamagnetic/ mesoporous silica core/shell structure make the platform applicable in three fields such as drug delivery, MR imaging and cell labelling [18]. Another application of mesoporous materials is in cancer treatment with the help of function groups and magnetic cores. The materials which can be used as coating of mesoporous silica are polymers. For example polyethylene glycole (PEG) is applied as a coating on mesoporous silica to make it a potent platform in cancer treatment as PEG can decreases the reticuloendothelial system uptake and enhances the stability of nanoparticles in the path of tumor cells [19]. Multifunctionalization of mesoporous materials let the platform to be multi stimuli responsive yielded to smart drug delivery systems. These smart platforms can release their drug in response to different stimuli such as pH, glucose, enzyme, temperature, light and magnetic field [20].

Conclusion

In brief, mesostructured structures specifically silica mesoporous are attractive candidates in controlled drug delivery due to their ordered pore structure, high surface area and large pore volume. Functionalization the surface of the mesoporous makes them to be applicable in multi-purpose fields like imaging, cell labelling and cancer treatment.

References

1. N Seaton (1991) Determination of the connectivity of porous solids from nitrogen sorption measurements. Chemical Engineering Science 46: 1895-1909.
2. M Vallet Regí, F Balas, D Arcos (2007) Mesoporous materials for drug delivery. Angewandte Chemie Interl Ed 46(40): 7548-7558.
3. Taguchi, F Schüth (2005) Ordered mesoporous materials in catalysis-review. Micro porous and mesoporous materials 77: 1-45.
4. Kresge, M Leonowicz, W Roth, J Vartuli, J Beck (1992) Ordered mesoporous molecular sieves synthesized by a liquid-crystal template mechanism. Nature 359: 710-712.
5. S Foerster, T Plantenberg (2002) Functional structural hierarchies from self-organising polymers. Angew Chem In Ed 41: 688-714.
6. GJdA Soler Illia, C Sanchez, B Lebeau, J Patarin (2002) Chemical strategies to design textured materials: from micro porous and mesoporous oxides to nanonetworks and hierarchical structures. Chemical reviews 102(11): 4093-4138.
7. M Vallet Regí (2006) Ordered mesoporous materials in the context of drug delivery systems and bone tissue engineering. Chemistry-A European Journal 12(23): 5934-5943.
8. P Horcajada, A Ramila, J Perez Pariente, M Vallet-Regi (2004) Influence of pore size of MCM-41 matrices on drug delivery rate. Microporous and Mesoporous Materials 68(1-3): 105-109.
9. M Vallet Regí, F Balas, M Colilla, M Manzano (2007) Drug confinement and delivery in ceramic implants. Drug metabolism letters 1(1): 37-40.
10. C Tourné Péteilh, D Brunel, S Bégu, B Chiche, F Fajula, et al. (2003) Synthesis and characterisation of ibuprofen-anchored MCM-41 silica and silica gel. New journal of chemistry 27: 1415-1418.
11. SW Song, K Hidajat, S Kawi (2005) Functionalized SBA-15 materials as carriers for controlled drug delivery: influence of surface properties on matrix-drug interactions. Langmuir 21(21): 9568-9575.
12. JC Doadrio, EM Sousa, I Izquierdo Barba, AL Doadrio, J Perez Pariente, et al. (2006) Functionalization of mesoporous materials with long alkyl chains as a strategy for controlling drug delivery pattern. Journal of Materials Chemistry 16: 462-466.
13. M Liong, S Angelos, E Choi, K Patel, JF Stoddart, et al. (2009) Mesostructured multifunctional nanoparticles for imaging and drug delivery. Journal of Materials Chemistry 19: 6251-6257.
14. C Bharti, U Nagaich, AK Pal, N Gulati (2015) Mesoporous silica nanoparticles in target drug delivery system: a review. Int J of pharm investing 5(3): 124-133.
15. LL Li, Q Yin, J Cheng, Y Lu (2012) Polyvalent Mesoporous Silica Nanoparticle-Aptamer Bio conjugates Target Breast Cancer Cells. Adv healthc mater 1(5): 567-572.
16. W Zhao, J Gu, L Zhang, H Chen, J Shi (2005) Fabrication of uniform magnetic nanocomposites spheres with a magnetic core/mesoporous silica shell structure. Journal of the American Chemical Society 127(25): 8916-8917.
17. SH Wu, YS Lin, Y Hung, YH Chou, YH Hsu, et al. (2008) Multifunctional mesoporous silica nanoparticles for intracellular labelling and animal magnetic resonance imaging studies. Chem Bio Chem 9(1): 53-57.
18. YS Lin, SH Wu, Y Hung, YH Chou, C Chang, et al. (2006) Multifunctional composite nanoparticles: magnetic, luminescent, and mesoporous. Chemistry of Materials 18(22): 5170-5172.
19. V Cauda, C Argyo, T Bein (2010) Impact of different PEGylation patterns on the long-term bio-stability of colloidal mesoporous silica nanoparticles. Journal of Materials Chemistry 20: 8693-8699.
20. M Martínez Carmona, M Colilla, M Vallet Regí (2015) Smart mesoporous nanomaterials for antitumor therapy. Nanomaterials 5(4): 1906-1937.

Citation: Aval NA (2016) Mesoporous Materials in Drug Delivery. J Nanomed Res 4(3): 00091. DOI: 10.15406/jnmr.2016.04.00091