Carbon-integrated mesoporous silica nanoparticles for doxorubicin adsorption and release

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The mesostructured silica nanoparticles (MSN) have been extensively studied for the purpose of drug delivery application due to their unique properties such as biocompatibility, high stability, porous structure to withhold the bulky drugs, high and tailorable internal and external surface area, as well as functionalizable surface. However, MSN is hydrophilic while most anti-cancer drugs are hydrophobic. The purpose of this study was to modify the MSN with activated carbon (AC) which is expected to produce more efficient adsorption and release medium for the anticancer drug doxorubicin (DOX) as the drug model. MSN was modified with AC through co-condensation (CMSCN) and post-grafting (PMSCN) method. MSCN has been characterized using X-Ray Diffraction, Nitrogen gas physisorption, Fourier Transform Infrared, Transmission Electron Microscope, and Field Emission Scanning Electron Microscope-Energy Dispersive X-Ray, while adsorption and release of drugs was observed using UV Spectrophotometer. The characterization demonstrated that the MSN produces relatively higher number of pores with larger diameters while addition of AC led to the decrease in the crystallization, surface area and diameter of the pores. The contact angle test shows that MSN modified with AC displayed higher hydrophobicity. PMSCN showed highest adsorption percentage with 95.92%, followed by MSN and CMSCN with 90.88% and 82%, respectively. To investigate the release ability of DOX from DOX-MSN and DOX-MSCN, the release activity was conducted at 37° C, and in acidic pH solution, since the cancer cells were more acidic than normal cells. At pH 3.0, DOX released by MSN, PMSCN and CMSCN were 75.9%, 86.8% and 80.2%, respectively. While at pH 5.5, DOX released by MSN, PMSCN and CMSCN were 48.8%, 65.5% and 56.3% respectively. At pH 7.4, 27.8%, 30.4 and 28.8% of DOX were released by MSN, PMSCN and CMSCN, respectively. This study recommend carbon-functionalized MSN to be further studied for drug delivery application.

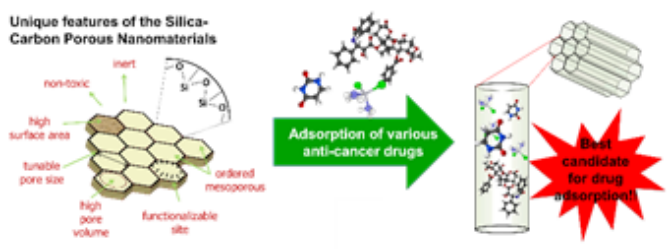

Figure: Silica-carbon porous nanomaterials for drug delivery application

Recent Publications

1. Kamarudin, NHN, Setiabudi, HD, Jalil, AA, Adam, SH, Salleh NFM. (2019). Utilization of lapindo volcanic mud for enhanced sono-sorption removal of acid orange 52. Bulletin of Chemical Reaction Engineering & Catalysis, 14(1):189-195.
2. Mansor M.,Timmiati, SN, Lim KL, Zainoodin, AM, Kamarudin, NHN. (2018). Ni-based Catalyst Supported on Mesostructured Silica Nanoparticles (MSN) for Methanol Oxidation Reaction (MOR).

Jurnal Kejuruteraan SI 1(1): 17-23.

3. Kamarudin, NHN, Jalil, AA, Triwahyono, ST, Timmiati, SN (2016). Microwave-assisted Synthesis of Mesoporous Silica Nanoparticles as A Drug Delivery Vehicle. Malaysian Journal of Analytical Science 20 (6): 1382-1389.
4. Kamarudin, NHN, Jalil, AA, Triwahyono, S, Sazegar, MR, Baba, S, Hamdan, S, Ahmad, A. (2015). Elucidation of acid strength effect on ibuprofen adsorption and release by aluminated mesoporous silica nanoparticles. RSC Advances, 5: 30023-30031.
5. Kamarudin, NHN, Jalil, AA, Triwahyono, S, Artika, V, Salleh, NFM, Karim, AH, Jaafar, NF, Sazegar, MR, Mukti, RR, Hameed, BH, Johari, A.(2014). Variation of the crystal growth of mesoporous silica nanoparticles and the evaluation to ibuprofen loading and release. Journal of Colloid and Interface Science, 421 (2014).
6. Kamarudin, NHN, Jalil, AA, Triwahyono, S, Salleh, NFM, Karim, AH, Mukti, RR, Hameed, BH, Ahmad, A. (2013). Role of 3-aminopropyltriethoxysilane in the preparation of mesoporous silica nanoparticles for ibuprofen delivery: Effect on physicochemical properties, Microporous and Mesoporous Materials. 180: 235-241.

Biography

NH Nazirah Kamarudin has her interest in empowering materials for various applications, especially using porous and nano materials for adsorption and catalysis. During her master study, she introduced acidic metals into zeolites and studied its intrinsic acidity for the catalytic isomerization, which brought her further into insight into modification of mesoporous silica nanoparticles (MSN) during PhD, By using ibuprofen as the model drug, various modification was conducted to tailor the mesoporous silica structures to suit the demand in controlled drug release application. These include the study of physiochemical properties of the material as well as understanding the mechanisms of adsorption and release through the surface. The use of nanoscale technologies to design the drug carrier had been her passion since then. Currently, she works on the modification of MSN using carbon and polymeric materials for the anti-cancer drugs adsorption and release.

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