IN VITRO BIOCOMPATIBILITY OF MULTIWALLED CARBON NANOTUBES WITH SENSORY NEURONS

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Abstract

Multiwalled carbon nanotubes (MWCNTs) possess unique properties rendering them a potentially useful biomaterial for neurobiological applications such as providing nanoscale contact-guidance cues for directing axon growth within peripheral nerve repair scaffolds. The in vitro biocompatibility of MWCNTs with postnatal mouse spinal sensory neurons was assessed for this application. Cell culture medium conditioned with MWCNTs was not signifi cantly toxic to dissociated cultures of postnatal mouse dorsal root ganglia (DRG) neurons. However, exposure of DRG neurons to MWCNTs dispersed in culture medium resulted in a time- and dose-dependent reduction in neuronal viability. At 250 μgmL−1, dispersed MWCNTs caused signifi cant euronal death and unusual neurite morphologies illustrated by immunofluorescent labelling of the cytoskeletal protein beta (III) tubulin, however, at a dose of 5 μgmL−1 MWCNTs were nontoxic over a 14-day period. DRG neurons grown on fabricated MWCNT substrates produced neurite outgrowths with abnormal morphologies that were significantly inferior in length to neurons grown on the control substrate laminin. This evidence demonstrates that to be utilized as a biomaterial in tissue scaffolds for nerve repair, MWCNTs will require robust surface modification to enhance biocompatibility and growth promoting properties.

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SYNTHESIS AND CHARACTERIZATION OF NOVEL CHITOSAN NANOCOMPOSITE HYDROGELS FOR DRUG DELIVERY AND BONE TISSUE ENGINEERING

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Abstract

Biodegradable materials for drug delivery and bone tissue engineering are currently intensively developing and improving, but there are still a lot of problems to solve related with bioactivity, biocompatibility, release profile etc.

Osteosarcoma is an aggressive malignant neoplasm arising from primitive transformed cells of mesenchymal origin that exhibit osteoblastic differentiation and produce malignant osteoid. It is the most common histological form of primary bone cancer [1,2]. Treatment is most destinations and made up for: intensive multidrug short induction chemotherapy, amputation or tumor resection within the limits of normal tissue and in the last phase again chemotherapy. This kind of neoplasm is most recently detected in young male till 25 age, therefore improving methods of treatment is so important.

Chitosan is a natural-based polymer obtained by alkaline deacetylation of chitin received from powdered shrimp shells was purchased from Acros Organics.

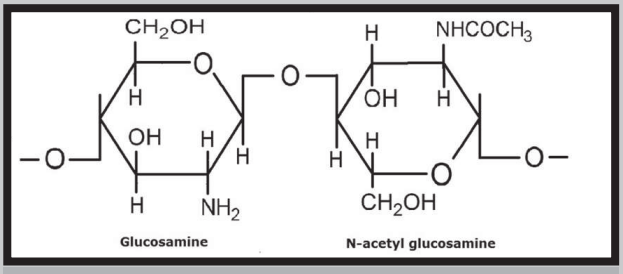

FIG.1. Chemical structure of chitosan

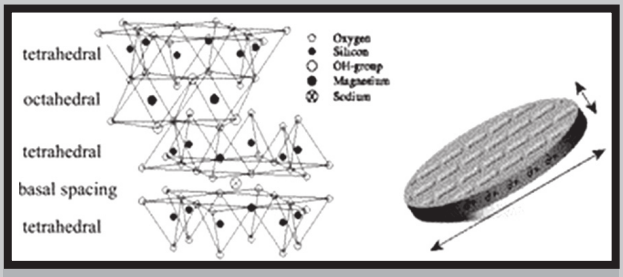

FIG.2. Structure of Laponite plate.
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Its main advantages are non-toxic, non-immunogenic, non-carcinogenic degradation products, biocompatible, bioactive and biodegradable. These properties cause chitosan a very good candidate for novel hydrogel drug delivery systems. Chitosan easily forms hydrogel particles and entraps biomolecules through a number of mechanisms, including chemical crosslinking, ionic crosslinking, and ionic complexation [3,4]. A possible alternative of chitosan by the chemical modification also has been useful for the association of bioactive molecules to polymer and controlling the drug release profile. There are few methods of modification, or example.: copolimerization, grafting, chemical and ionic crosslinking, polyelectrolyte complexes, etc [5]. Previous studies demonstrated that chitosan could promote the proliferation and osteogenesis but only with moderate swelling ratio of composite, too high ability of entrapment water solutions are not recommended. There are a lot of advantages in chitosan properties that can be used in research work to obtain the material of the best expected properties.

Laponite® (LA) is a plate-like synthetic clay hectorite-type belongs to a family of phyllosolicates type 2:1 [6]. Its structure represent empirical formula: $Na^{0.7+}[Si_8Mg_{5.5}Li_{0.3}O_{20}(OH)_4]^{0.7-}$*. The plates size is about 25 nm x 0,92 nm.*

LA has a large surface area, anionic surface charges and exchangeable Na^+ *cations in hydrated interlayers. Presence of sodium cations causes better adsorption properties for cationic drug molecules. Moreover, the exfoliated LA particles may act as multifunctional crosslinkers in forming the nanocomposite hydrogels, and the polymer chains were anchored to the particles and entangled to form a network [7]. Used synthetic clay has got the same type structure and but better sorption properties to montmorillonite but it has got serious advantage - as a synthetic compound shows low heavy metal content.*

The initial results indicate that the incorporation of clay improved the swelling behavior in contrast to the pure chitosan beads. There also had been revealed significant disproportion of viscosity received hydrogels according to different type of LA or different concentration. Increasing content causes telling rise of viscosity, especially reported in higher content of used crosslinker.

The aim of research is to develop a bioactive system biopolymer/layered silicate intelligent nanocomposite based on chitosan and synthetic clay by a cross-linking reaction using sodium tripolyphosphate as the gel factor. The resultant composite were characterized by Fourier transform infrared spectroscopy, scanning electronic microscope and X-ray diffraction analysis. The bioactivity in physiological pH solution (SBF pH=7.40) [8], drug encapsulation efficiency and controlled release behaviour were also investigated by using the model drug to reveal the effects of introduced LA.

[Engineering of Biomaterials, 122-123, (2013), 1-2]

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References

[1] Zheng M., Han B., Yang Y., Liu W.: Synthesis, characterization and biological safety of O-carboxymethyl chitosan used to treat Sarcoma 180 tumor. Carbohydrate Polymers 86 (2011) 231-238
[2] Lewandowska-Szumieł M., Komender, J., Chłopek, J.: Interaction between carbon composites and bone after intrabone implantation. Journal of Biomedical Materials Research 48/3 (1999) 289-296
[3] Pielichowska K., Błażewicz S., Bioactive polymer/hydroxyapatite (nano)composites for bone tissue regeneration. Advances in Polymer Science 2010, 232, 97–207.
[4] Ta H.T., Dass C.R., Dunstan D.E.: Injectable chitosan hydrogels for localised cancer therapy. Journal of Controlled Release 126 (2008) 205-216
[5] TGiri T.K., Thakur A., Alexander A., Ajazuddin, Badwaik H., Tripathi D.K.: Modified chitosan hydrogels as drug delivery and tissue engineering systems: present status and applications. Acta Pharmaceutica Sinica B 2/5 (2012) 439-449
[6] http://www.laponite.com (10.07.2013)
[7] Yang H., Hua S., Wenbo Wang W., Wang A.: Composite Hydrogel Beads Based on Chitosan and Laponite: Preparation, Swelling, and Drug Release Behaviour. Iranian Polymer Journal 20/6 (2011) 479-490
[8] Kokubo T., Takadama H.: How useful is SBF in predicting in vivo bone bioactivity. Biomaterials 27 (2006) 2907–2915Manufacturing Engineering 17 (2006) 423-426.

MECHANICAL AND TRIBOLOGICAL PROPERTIES OF A-C:H/Ti COATINGS DOPED BY SILVER USING ION IMPLANTATION AND MAGNETRON SPUTTERING METHODS

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Abstract

Due to favorable mechanical, tribological and biomedical properties the carbon coatingsare of interest of many branches of the industry [1]. Growing interest in Ag doped DLC coatings is observed within the space of the last several years. Both, well known antibacterial properties [2] of silver as well as a good biocompatibility [3] of carbon coatings constitute the outstanding solution for a variety of applications, especially for medical implants.

The aim of this study was the evaluation of influence of silver onto the mechanical and tribological properties of nanocompositeDLC coatings. Carbon coatingswere producedusinga hybridRFPACVD/MSmethod and silver ions wereincorporated into carbon matrix.The processes consistof followed stages: synthesis of nanocompositecarbon (CVD) doped titanium coatings (PVD)[4] and nextstage carbon (CVD) and silver deposition (PVD)or Ag ion implantation into carbon coating. Carbon layers synthesis was performed with use of the classic RF PACVD process in methane atmosphere whereas as the titanium ions source the pulsed magnetron sputtering (MS) process was applied. Second stage was performed in the same reaction chamber but the PVD process was carried out using the silver cathode. The ion implantation process was carried out with the use of silver ions with energy of 15 keV. In order to determine the influence of silver ion implantation process onto overall physiochemical properties of carbon coatings four ion doses of 2,4,7 and $10\times10^{16}Ag^{+}/cm^{2}$ were applied.

Due to application of the gradient of chemical composition of Ti–C it is possible to manufacture thick and well adherent carbon layers with a very good mechanical, tribologicalparametersand corrosion resistive. Application of silver as a doping material allowedmodification of the mechanical and biological properties of manufactured layers depending on the silveramount (C:Ag ratio).

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References

[1].C. Donnet, Recent progress on the tribology of doped diamond-like and carbon alloy coatings: a review, Surface and Coatings Technology, 100-101 (1998) 180 – 186
[2].J. S. Kim, E. Kuk, K. N. Yu, J. Kim, S. J. Park, H. J. Lee, S. H. Kim, Y. K. Park, Y. H. Park, C. Hwang, Y. Kim, Y. Lee, D. H. Jeong, M. Cho, Antimicrobial effects of silver nanoparticles, Nanomedicine: Nanotechnology, Biology and Medicine 3(2007)95–101
[3].S. E. Rodil ,R. Olivares, H. Arzate, S. Muhla, Properties of carbon films and their biocompatibility using in-vitro tests, Diamond and Related Materials12 (2003) 931–937
[4]. M. Cłapa, D. Batory, Improving adhesion and wear resistance of carbon coatings using Ti:C gradient layers, Journal of Achievements in Materials and Manufacturing Engineering, 1 – 2 (2007) 415–418