Pengembangan Perancah Karbon Berbasis Kolagen King Kobia/HPMC/PVA untuk Aplikasi Rekayasa Jaringan Tulang = Development of King Kobia Collagen/HPMC/PVA-Based Carbon Scaffolds for Bone Tissue Engineering Applications

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Abstrak

Kerusakan tulang adalah salah satu penyebab utama kecacatan manusia yang secara keseluruhan menyebabkan penurunan kualitas hidup. Teknologi rekayasa jaringan telah dikembangkan untuk solusi kerusakan tulang dengan menerapkan perancah berbasis biomaterial. Berbagai material polimer alami dan sintesis dapat digunakan sebagai material perancah tulang untuk membantu adhesi dan proliferasi sel. Material konduktif berbasis karbon juga dapat dikombinasikan dalam perancah tulang dan telah diteliti dapat meningkatkan kekuatan mekanis perancah serta membantu proses pertumbuhan sel. Pada penelitian ini, dilakukan pengembangan perancah tulang menggunakan material kolagen, hydroxypropyl methylcellulose (HPMC), dan poly(vinyl alcohol) (PVA), dengan penambahan material multiwalled carbon nanotube (MWCNT) dan reduced graphene oxide (rGO). Material kolagen diekstraksi secara mandiri menggunakan metode deep eutectic solvent dari sumber ikan king kobia. Kolagen hasil ekstraksi dikarakterisasi secara fisika kimia dengan SEM, FTIR, XRD, dan DSC, dengan hasil karakterisasi menunjukkan kolagen mengandung gugus amida dan memiliki struktur triple helix khas kolagen. Dengan demikian kolagen king kobia hasil ekstraksi cocok untuk dilanjutkan sebagai material perancah. Fabrikasi perancah dilakukan menggunakan freeze-drying, kemudian dikarakterisasi secara fisika kimia dengan mengamati morfologi melalui SEM, identifikasi gugus fungsi melalui FTIR, sifat mekanik tekan, porositas, wettability, swelling, dan laju degradasi. Hasilnya menunjukkan perancah berpori dan struktur saling terhubung dengan kekuatan mekanik sekitar 9 MPa yang telah sesuai dengan tulang trabekular, porositas tinggi mencapai 90%, swelling tinggi mencapai 300% tetapi dapat tetap mempertahankan integritas perancah, laju degradasi yang sesuai dengan kehilangan massa perancah yang kurang dari 20% dalam 28 hari, serta sifat hidrofilik dengan sudut kontak air kurang dari 90o. Hasil ini menunjukkan perancah yang difabrikasi dapat menjadi kandidat yang potensial dalam aplikasi rekayasa jaringan tulang. Selain itu, karakteristik konduktivitas perancah dievaluasi melalui pengukuran elektrokimia menggunakan cyclic voltammetry (CV), menghasilkan perancah konduktif yang ditandai dengan pembentukan puncak redoks.

......Bone damage is one of the leading causes of human disability which leads to an overall decrease in quality of life. Tissue engineering technology has been developed for bone damage solutions by applying biomaterial-based scaffolds. Various natural and synthetic polymeric materials can be used as bone scaffold materials to facilitate cell adhesion and proliferation. Carbon-based conductive materials can also be combined in bone scaffolds and have been investigated to increase the mechanical strength of the scaffold and assist the cell growth process. In this research, bone scaffolds were developed using collagen, hydroxypropyl methylcellulose (HPMC), and poly(vinyl alcohol) (PVA), with the addition of multiwalled carbon nanotube (MWCNT) and reduced graphene oxide (rGO) materials. Collagen material was extracted independently using deep eutectic solvent method from king cobia fish source. The extracted collagen was characterized physically and chemically by SEM, FTIR, XRD, and DSC, with the characterization results showing that collagen contains amide groups and has a typical triple helix structure of collagen. Thus, the extracted king cobia collagen is suitable to be continued as a scaffold material. The scaffolds were fabricated using freeze-drying and characterized physically and chemically by observing morphology through SEM, functional group identification through FTIR, compressive mechanical properties, porosity, wettability, swelling, and degradation rate. The results showed porous scaffolds and interconnected structures with mechanical strength of about 9 MPa which is compatible with trabecular bone, high porosity of up to 90%, high swelling of up to 300% but still maintaining the integrity of the scaffold, suitable degradation rate with mass loss of less than 20% in 28 days, and hydrophilic properties with water contact angle of less than 90o. These results suggest the fabricated scaffold could be a potential candidate in bone tissue engineering applications. In addition, the conductivity characteristics of the scaffolds were evaluated through electrochemical measurements using cyclic voltammetry (CV), resulting in conductive scaffolds characterized by the formation of redox peaks.