

HYDROGEL BIO-COMPOSITE BASED ON  
GELLAN GUM WITH MODIFIED  
MONTMORILLONITE FOR TISSUE  
ENGINEERING APPLICATIONS

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MASTER OF SCIENCE  
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Perpustakaan Sultanah Nur Zahirah  
Universiti Malaysia Terengganu.



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Lihat Sebelah

HAK MILIK  
PERPUSTAKAAN SULTANAH NUR ZAHIRAH UMT

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MODIFIED MONTMORILLONITE FOR TISSUE ENGINEERING  
APPLICATIONS**

**SAFFAWATI SYAZWANI BINTI MOHD**

**Thesis Submitted in Fulfillment of the Requirement for the Degree of Master of  
Science in the School of Fundamental Science  
Universiti Malaysia Terengganu  
March 2016**

*Dedicated to*

*My beloved parents (Ayoh and Mek) and siblings*

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfillment of the requirements for the degree of Master of Science

**HYDROGEL BIO-COMPOSITE BASED ON GELLAN GUM WITH  
MODIFIED MONTMORILLONITE FOR TISSUE ENGINEERING  
APPLICATIONS**

**SAFFAWATI SYAZWANI BINTI MOHD**

**(APRIL) 2016**

Main Supervisor : Khairul Anuar Mat Amin, Ph.D

School : School of Fundamental Science

This research focused on the study of physical, chemical and mechanical characteristics, cell studies and antibacterial properties of gellan gum (GG) hydrogel incorporated montmorillonite (MMT) fillers. In this study, organo-montmorillonite (CTA-MMT) was successfully synthesized using Na-MMT and hexadecyltrimethylammonium bromide (CTAB) surfactant via cationic exchange reaction. X-ray diffraction (XRD) test showed the increasing in basal spacing from 12.7 Å (Na-MMT) to 19.2 Å (CTA-MMT) while two new peaks appeared for CTA-MMT on the FTIR spectra analysis which corresponded to the presence of CH<sub>2</sub> bonding, 1469 cm<sup>-1</sup> and C-H (2918, 2850 cm<sup>-1</sup>) symmetrical and asymmetrical vibrations of CTAB surfactant. Then the uniformly cross-linked GG/ Na-MMT, GG/CTA-MMT, and GG/Cloisite15A at wide range of MMT concentrations (2-20% w/w) were characterized to find the optimum values of stress-at-break, strain-at-break and Young's modulus through compression profile. GG/Na-MMT10, GGCTA-MMT10 and GG/Cloisite15A5 produced optimum value of E, which were 222 kPa, 236 kPa, and 295 kPa, respectively. Swelling properties of GG hydrogels

were increased upon the addition of clay and optimum at 5% (w/w) for Cloisite15A and 10% (w/w) for both Na-MMT and CTA-MMT. GG/CTA-MMT10 and GG/Na-MMT10 showed better thermal stability due to their high temperature onset and low temperature completion. Cell studies exhibit that the GG incorporated with Na-MMT was noncytotoxic to human skin fibroblast cells (CRL2522) with increase cell growth after incubated for 72 h. In contrast, the GG hydrogels incorporated CTA-MMT and Cloisite15A revealed that the cells were dying and the cell growth were depleting after cultured for 72 h. For qualitative antibacterial study, GG hydrogel containing CTA-MMT is the only sample which exhibited inhibition against the gram-positive bacteria, *i.e.* *Staphylococcus aureus* and *Bacillus cereus* but limited inhibition was quantified against gram-negative bacteria (*Escherichia coli* and *Klebsiella pneumonia*), due to the presence of CTAB molecules. The explorations of hydrogel based gellan gum incorporated montmorillonite exhibits good physical and mechanical properties and biocompatibility effects to meet the application of tissue engineering.

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu  
sebagai memenuhi keperluan untuk Ijazah Sarjana Sains

**BIO-KOMPOSIT HIDROGEL BERASASKAN GAM GELAN DAN  
MONMORILONIT TERUBAHSUAI UNTUK KEGUNAAN  
KEJURUTERAAN TISU**

**SAFFAWATI SYAZWANI BINTI MOHD**

**(APRIL) 2016**

Penyelia Utama : Khairul Anuar Mat Amin, Ph.D

Pusat Pengajian : Pusat Pengajian Sains Asas

Penyelidikan ini menfokuskan kepada kajian tentang ciri-ciri fizikal, kimia dan mekanikal, kajian sel serta keupayaan sifat antibakteria ke atas penambahan monmorilonit (MMT) pada hidrogel gam gelan (GG). Dalam kajian ini, organik-monmorilonit (CTA-MMT) telah berjaya disintesis menggunakan Na-MMT dan surfaktan n-hexadecyltrimethylammonium bromide (CTAB) secara tindakbalas penukaran kation. X-ray difraksi (XRD) menunjukkan kenaikan pada ruang basal dari 12.7 Å (Na-MMT) kepada 19.2 Å (CTA-MMT) manakala kehadiran dua puncak untuk CTA-MMT pada analisis spektra FTIR menunjukkan kehadiran ikatan CH<sub>2</sub>, 1469 cm<sup>-1</sup> dan C-H (2918, 2850 cm<sup>-1</sup>) secara ikatan simetri dan tidak simetri dari surfaktan CTAB. Kemudian hidrogel gam gelan yang mengandungi GG/Na-MMT, GG/CTA-MMT dan GG/Cloisite15A pada kepekatan MMT yang berbeza (2-20% w/w) dicirikan untuk mendapat nilai tekanan, kadar regangan dan modulus elastik optima melalui ujian mampatan. GG/Na-MMT10, GG/CTA-MMT10 and GG/Cloisite15A5 menghasilkan nilai E yang optima iaitu 222 kPa, 236 kPa, dan 295 kPa. Sifat pengembangan cecair GG semakin meningkat selepas penambahan tanah

dan mencapai nilai optima pada 5% (w/w) untuk Cloisite15A dan 10% (w/w) untuk Na-MMT dan CTA-MMT. GG/CTA-MMT10 dan GG/Na-MMT10 menunjukkan kestabilan haba yang lebih baik merujuk kepada suhu permulaan yang tinggi dan suhu pengakhirannya yang rendah. Kajian sel mendapati GG yang ditambah Na-MMT bersifat tidak toksik ke atas sel kulit fibroblas manusia (CRL2522) dengan berlakunya peningkatan pada jumlah sel selepas diinkubasi selama 72 hari. Berbeza dengan GG hidrogel yang ditambah dengan CTA-MMT dan Cloisite15A menunjukkan pertumbuhan sel semakin berkurang dan akhirnya mati selepas pengkulturan selama 72 hari. Untuk kajian kualitatif antibakteria, GG yang mengandungi CTA-MMT sahaja yang menunjukkan berlakunya perencatan iaitu pada bakteria Gram-positif, *Staphylococcus aureus* dan *Bacillus cereus* manakala perencatan yang terhad berlaku pada bakteria Gram-negatif (*Escherichia coli* dan *Klebsiella pneumonia*) disebabkan kehadiran molekul CTAB. Justeru, sifat hidrogel berasaskan gam gelan dan monmorilonit yang dikaji dalam penyelidikan ini memenuhi kriteria fizikal dan mekanikal serta kesesuaian sifat bio untuk aplikasi kejuruteraan tisu.