SYNTHESIS AND CHARACTERIZATION OF SUPERABSORBENT CARBONACEOUS COATED NITROGEN PHOSPHORUS POTASSIUM (NPK) FERTILIZER

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Kajian ini bertujuan untuk menghasilkan baja kawalan perlepasan dan pengekalan air CRWR yang disalut dengan penyerab karbon polimer (SAC). Dalam usaha untuk mencapai objektif utama, kajian ini telah diklasifikasikan kepada tiga peringkat; mensintesis karbon polimer daripada gentian Kenaf semula jadi, menghasilkan SAC polimer dan kompoun NPK melalui proses salutan dan mengkaji sifat-sifat kompoun NPK yang disalut dengan SAC polimer melalui pengawalan pengeluaran kadar baja dan pengekalan air di dalam tanah. Pada mulanya, kajian tentang penukaran serat kenaf semulajadi kepada serat karbon melalui proses hidrotermal telah dijalankan pada masa operasi yang berlainan (2 jam-14 jam). Tujuan kajian ini untuk mengenal pasti kandungan karbon tertinggi dan serat karbon pada waktu operasi 6 jam dipilih untuk digunakan sebagai pengisi dalam pembuatan SAC polimer. Kemudian, kajian ini diteruskan pada pempolimeran graf asid akrilik untuk menghasilkan penyerab polimer (SAP) dengan mengubah jumlah paut-silang. Kesan jumlah paut-silang terhadap tindak balas kuantiti penyerapan air oleh polimer penyerap air telah dikenal pasti. Sifat-sifat yang optimum bagi polimer penyerap air telah digunakan untuk menghasilkan SAC polimer. SAC polimer dihasilkan dengan mempelbagaikan jumlah karbon sebagai bahan pengisi di dalam SAC polimer. Selepas itu, ujikaji penyerapan air yang paling tinggi oleh polimer penyerap air dan SAC polimer telah ditakrifkan dengan menggunakan kaedah uncang teh dalam air tulen. Struktur kedua-dua jenis polimer telah dianalisa menggunakan Transformasi Inframerah Spektroskopi (FTIR) dan morfologi telah disintesis menggunakan Pengimbas Mikroskop Elektron (SEM). Hasil optimum penyerapan air oleh penyerab polimer (170.11 g air / g sampel) adalah MBA0.01. Kemudian, penyerapan air yang tinggi bagi SAC polimer dicatatkan (293 g air / g sampel) pada MBA0.01-C2.0. Penghasilan baja kawalan perlepasan dan pengekalan air (CRWR) telah dikaji dengan ujikaji pengawalan pengeluaran kadar baja dan pengekalan air di dalam tanah selama 30 hari. Unsur-unsur seperti nitrogen (N), fosforus (P) dan kalium (K) telah diuji oleh Induksi Pengabungan Plasma-Jisim Spektroskopi (ICP-MS). Ujikaji pengawalan pengeluaran kadar baja dan pengekalan air dalam tanah membuktikan baja yang disalut polimer penyerap air boleh meningkatkan keupayaan penyerapan tanah dan pegangan air dan melepaskan nutrisi secara perlahan selama lebih dari 30 hari. Kemudian, kajian kinetik dilaksanakan dalam analisis baja CRWR untuk mengenal pasti mekanisma pelepasan nutrisi di dalam tanah menggunakan model Korsmeyer-Peppas. Mekanisma pelepasan nutrisi bagi semua sampel mematuhi ciri-ciri penyebaran Fickian kerana nilai n di antara 0.5 hingga 1.0. NPK baja bersalut SAC polimer menunjukkan model kinetik yang terbaik kerana nilai r^2 adalah dalam julat 0.95-0.99. Pekali penyebaran bagi NPK baja bersalut SAC polimer adalah lebih tinggi berbanding NPK baja bersalut SAP.

ABSTRACT

The aimed of this work is to produce CRWR fertilizer coated by superabsorbent carbonaceous polymer (SAC). In order to achieve to main objective, the work has been classified into three stages; synthesizing of the carbonaceous fibers material from the natural kenaf fibers, producing the superabsorbent carbonaceous fibers materials and NPK compound by coating process and investigating the behavior of the superabsorbent carbonaceous fiber polymer coated NPK compound through the controlled-release and water-retention properties. Initially, a study of the conversion of natural kenaf fiber to carbonaceous fiber through hydrothermal process was conducted at different operating time (2h-14h). The purpose of this study is to identify the highest carbon content and carbonaceous fiber at 6 hours operating time was selected to use as filler in the production of SAC polymer. Then, the study was continued on the graft polymerization of acrylic acid to produce superabsorbent polymer (SAP) by varying the amount of cross-linker was investigated. The effect at different amount of cross-linker in synthesized superabsorbent polymers (SAP) was identified in terms of water absorbency responses. The optimum properties of SAP were used in production of superabsorbent carbonaceous (SAC) polymer at different amount of carbonaceous fiber. Afterward, the optimum water absorbency of synthesize SAP and SAC polymer were characterized using tea-bag method in deionize water. The structures of synthesize SAP and SAC polymer were characterized by Fourier Transform Infrared Spectroscopy (FTIR) and morphologies were examined by Scanning Electron Microscope (SEM) testing. The optimum result of water absorbency of SAP (170.11 g water/g sample) at MBA0.01. Then, the high water absorbency of SAC polymer was recorded (293 g water/g sample) at MBA0.01-C2.0. The CRWR fertilizer that was produced was analyzed for controlled-release and water retention (CRWR) and water retention (WR) in soil analyses for 30 days. The releasing nutrients of nitrogen (N), phosphorus (P) and potassium (K) elements were tested by Induced Coupled Plasma-Mass Spectrometry (ICP-MS) analyzer. Analysis from CRWR and WR in soil proved that NPK fertilizer coating by SAC polymer could enhance the soil absorption and water holding capacity. Meanwhile, the releasing of nutrients from the coated layer was recorded slowly and consistent release compared to NPK fertilizer. Then, kinetic study was calculated from CRWR analysis to identify the release mechanism of nutrients in soil by using Korsmeyer-Peppas model. The nutrients release mechanism for all samples following Fickian diffusion controlled released since the value of n in between 0.5 to 1.0. Other than that, NPK fertilizer coated by SAC polymer fitted well with Korsmeyer-Peppas model since the value of r^2 was in range 0.95 to 0.99. The diffusion coefficient of NPK fertilizer coated by SAC polymer was the highest compared to NPK fertilizer coated by SAP.

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LIST OF SYMBOLS

J	Rate of Mass Transport per Unit Area
D	Diffusion Coefficient
dc/dx	Gradient in Concentration
x	Direction of Mass Transport
C	Amount of System Release
C_0	Initial Amount of System in Solution
K_0	Zero Order Rate Constant
t	Time System Release
K	First Order Rate Constant
qt	Total Amount of System in a Unit Volume of Matrix
C_s	Dimensional Solubility of System in the Polymer Matrix
C_0/C	Fraction of System Release
k	Rate Constant
n	Release Exponent
m_2	Weight of Tea Bag After Reaching Equilibrium
m_1	Initial Weight of Tea Bag Before Immersion in Water
M_t/M	The Released Fraction at Time t
m_i	Weighed Every Day
m_0	Initial Weight
D	Initial Diffusion Coefficient
l	Thickness of Hydrogel Polymer

LIST OF ABBREVIATIONS

MPOB	Malaysia Palm Oil Board
FELDA	Federal Land Development Authority
DOA	Development of Agriculture
LKTN	National Kenaf and Tobacco Board
LTN	National Tobacco Board
HTC	Hydrothermal Carbonization Process
SAP	Superabsorbent Polymer
SAC	Superabsorbent Carbonaceous Polymer
CRWR	Controlled Release and Water Retention
HT	Hydrothermal Process
HTL	Hydrothermal liquefaction
HTG	Hydrothermal gasification
IPN	Interpenetrating Polymeric Hydrogels
AA	Acrylic Acid
Hyd/CL	Hydrogel/Clinoptilolite
FTIR	Fourier Transform Infrared Spectrophotometer
SEM	Scanning Electron Microscopic
WR	Water Retention in Soil
ICP-MS	Induced Coupled Plasma-Mass Spectrometry
NaOH	Sodium Hydroxide
MBA	N’N-methylenebisacrylamide
APS	Ammonium Persulphate
TGA	Thermogravimetric Analysis

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