

**STUDY OF DEGRADATION OF CELLULOSE-
ACETATE MEMBRANE IN OSMOTIC
TECHNIQUE FOR BENTONITE SOIL
CHARACTERISATION**

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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

Tanah liat bentonit adalah sesuatu bahan yang penting yang digunakan sebagai penampungan dalam pelupusan sisa radioaktif tahap tinggi (HLW). Bentonit di Malaysia yang ditemui baru-baru ini mempunyai potensi untuk pengurusan HLW kebangsaan sekiranya Malaysia membuat keputusan untuk membangunkan program tenaga nuklear. Laporan ini membentangkan maklumat baru mengenai sifat fizikal, kimia dan kandungan mineral dalam bentonit tempatan. Kajian pengekalan lengkungan tindakbalas air-tanah (SWRC) telah dijalankan untuk memahami ciri-ciri interaksi air dan tanah, dan juga untuk mendapatkan ilmu lanjut mengenai kejuruteraan tanah dan pemahaman tingkah laku bentonit tersebut. Kajian pelbagai tekanan sedutan keatas sampel tanah dijalankan dengan teknik keseimbangan wap (VET) dan teknik osmosis. Namun, membran separa telap selulosa asetat yang digunakan sering merosot semasa menjalani kajian, ini berlakunya intrusi oleh polietilena glikol (PEG) ke dalam sampel tanah. Ini menyebabkan kejejasan ketepatan bacaan SWRC. Kehadiran enzim selulase diatas membran yang telah hancur adalah disyaki disebabkan oleh kulat-kulat *Trichoderma atroviridae* dan *Paecilomyces lilacinus*, yang terdapat di dalam tanah. Untuk mengesahkan perkara tersebut, dua agen antikulat telah digunakan, iaitu chloroxilenol dan iodine untuk menghapuskan kulat-kulat tersebut. Untuk mengkaji keberkesanan antikulat ini, 1 % hingga 20 % kepekatan di dalam 100 μ l larutan PEG untuk mengkaji tumbesaran kulat dan menentukan perencatan kepekatan minimal (MIC). Laporan MIC menunjukkan 8 % kepekatan iodine berkemampuan untuk menghapuskan segala mikroba dan bagi chloroxilenol pula 10 % kepekatan diperlukan. Teknik osmotik dijalankan dengan penambahan iodine tidak memberikan tanda-tanda intrusi, berbanding dengan chloroxilenol dimana intrusi masih berlaku. Mikroskop pengimbasan elektron (FESEM) telah mengesahkan kehadiran kulat diatas membran dan juga menunjukkan kesan degradasi dan kerosakan. Pemeriksaan dengan mikroskop kuasa atomik (AFM) juga menunjukkan kesan kerosakan membran dan pembesaran pori membran juga didapati dengan sampel yang telah ditambah chloroxilenol. Ini dipercayai disebabkan oleh klorin di dalam chloroxilenol yang menyebabkan intrusi berlaku. Membran yang ditambah dengan iodine menunjukkan sedikit pembesaran pori, namun saiz pori tidak cukup besar untuk membenarkan instrusi berlaku

ABSTRACT

Bentonite clays are promising materials for disposal of high-level nuclear waste (HLW). Malaysia has recently discovered bentonite could therefore potentially be useful in managing the nation's HLW should Malaysia decide to embark on a nuclear power programme. This report presents comprehensive data on physical, chemical, mineralogical and microbiological information on the local bentonite. The soil-water retention curve (SWRC) study was conducted to elucidate characteristic soil-water interactions and to obtain further knowledge and understanding of the bentonite engineering properties and behaviour. In order to enable a wide range of suction on the soil sample, the above study was conducted by utilising the vapour equilibrium technique (VET) as well as the osmotic technique. However, since the cellulose acetate semipermeable membrane tends to degrade during testing, resulting in the intrusion of polyethylene glycol (PEG) molecules into the soil sample, there was a concern that the accuracy of the SWRC readings could be jeopardised. The presence of cellulase enzymes on the degraded membranes led to the suspicion that the degradation could have been caused by the fungi *Trichoderma atroviridae* and *Paecilomyces lilacinus*, which are found in soil. To confirm the suspicion, two antifungal agents namely chloroxylonol and iodine, were tested to eliminate the fungi. To test the efficacy of the antifungal agents, concentrations of 1 % to 20 % in 100 μ l of PEG solution were used during fungal plating to determine the Minimum Inhibitory Concentration (MIC). The MIC test results showed that 8 % concentration of iodine was able to eliminate all traces of fungi whilst chloroxylonol was effective at 10 % concentration. The osmotic technique conducted in the presence of iodine showed no signs of intrusion but for chloroxylonol, there was still indication of intrusion. Field Emission Scanning Electron Microscopy (FESEM) confirmed the presence of fungus on untreated membrane samples as well as evidence of defects and tunneling. Screening by atomic-force microscopy (AFM) revealed evidence of degradation or enlarged pore sizes for the chloroxylonol-treated membranes. This was believed to be due to the abrasive chlorine component of chloroxylonol, thus creating possibility of PEG intrusion into the soil sample. As for the iodine-treated membranes, although there was pore size enlargement, it was not sufficient for the intrusion of PEG.

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LIST OF SYMBOLS

%	Percent
MPa	Mega Pascal
U _a	Air Pore Pressures
U _w	Pore Water Pressures
kPa	Kilo Pascal
nm	Nanometre
μm	Micrometre
g	Gram
mm	Millimetre
M	Molar
°C	Degree Celsius
V	Volume
ml	Millilitre
mA	Milliamphere
PEG/g	Polyethylene Glycol per gram
m ² /g	Square metre per gram
m ² /s	Square metre per second
meq/100g	Milliequivalents per 100 grams
CaCl ²	Calcium Chloride
NaCl	Sodium Chloride
Si	Silicon
NaCl	Sodium Chloride
Fe ²	Ferric Ion
Mg	Magnesium

Ca
Na²

Calcium
Sodium Ion

LIST OF ABBREVIATIONS

AFM	Atomic-Force Microscopy
ASTM	Association for Testing Materials
BET	Brunauer-Emmet-Teller
BDGase	β -Glucosidase Assay
BS	British Standard
CEC	Cation Exchange Capacity
CMCase	Carboxymethyl Cellulase
DGR	Deep Geological Repository
DNS	3,5-Dinitrosalicylic Acid
EGME	Ethylene Glycol Monomethyl Ether
ETP	Economic Transformation Programme
FIST	Faculty of Industrial Sciences & Technology
FKASA	Faculty of Civil Engineering & Earth Resources
FESEM	Field Emission Scanning Electron Microscopy
FPase	Filter Paper Assay (Exoglucanases)
GMZ	Gaomaozi (Clay)
GnP	Graphene Nanoplatelets
HLW	High Level Waste
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
LOI	Loss of Ignition
MIC	Minimum Inhibitory Concentration
MNPC	Malaysian Nuclear Power Corporation
MPa	Megapascal
MW	Molecular Weight
MWCO	Molecular Weight Cut-off
NA	Nutrient Agar
PCR	Polymerase Chain Reaction

PEG	Polyethylene Glycol
PDA	Potato Dextrose Agar
pNPG	p-Nitrophenyl β -D-Glucopyranoside
SEM	Scanning Electron Microscope
SR	Shrinkage Rate
SSA	Specific Surface Area
SWRC	Soil-Water Retention Curve
TGA	Thermogravimetric Analysis
THAM	Tromethamine (Tris Buffer)
UVGI	Ultraviolet Germicidal Irradiation
UMP	University Malaysia Pahang
VET	Vapour Equilibrium Technique
XRD	X-ray Diffraction Analysis
XRF	X-ray Fluorescence

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