## GREEN FERTILIZER

BINDER FROM CHITOSAN, NATURAL RUBBER & LIGNIN

NORAIHAM MOHAMAD JARIAH MOHAMAD JUOI JEEFFERIE ABD RAZAK

# GREEN FERTILIZER

BINDER FROM CHITOSAN, NATURAL RUBBER & LIGNIN

NORAIHAM MOHAMAD JARIAH MOHAMAD JUOI JEEFFERIE ABD RAZAK

Penerbit UTeM Press Universiti Teknikal Malaysia Melaka 2023

#### © Universiti Teknikal Malaysia Melaka ISBN: 978-967-2792-72-7

#### FIRST PUBLISHED 2023

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, electronic, mechanical photocopying, recording or otherwise, without the prior permission of the Penerbit UTeM Press, Universiti Teknikal Malaysia Melaka.

Member of the Malaysian Scholarly Publishing Council (MAPIM) Member of the Malaysian Book Publishers Association (MABOPA) Member of Clarivate Analytics

> Editor and Proof Reader Ahmad Yusairi Bani Hashim

Manuscript Editor Mohd Hafizuddin Yusof

Book Cover Designer and Typesetter Ahmad Masmuliyadi Mohd Yusof

Published and Printed in Malaysia by Penerbit UTeM Press

Universiti Teknikal Malaysia Melaka Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

Tel: +606 270 1241 Faks: +606 270 1038

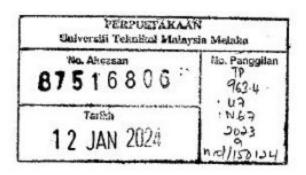


Cataloguing-in-Publication Data

Perpustakaan Negara Malaysia

A catalogue record for this book is available from the National Library of Malaysia

ISBN 978-967-2792-72-7



### TABLE OF CONTENTS



Pre	faceix
	nowledgementsxi
List	of Abbreviationsxiii
Cha	pter 1: What is Fertilizer?1
1.1	Fertilizer1
1.2	Role of Fertilizer in Plant Growth3
Cha	pter 2: Type of Commercialized Fertilizers and
Saf	ety Concerns in the Fertilizer Industry9
2.1	Organic and Inorganic Fertilizers9
2.2	Organic Fertilizer11
2.3	Inorganic Fertilizer
2.4	Urea Fertilizers14
2.5	Urea Formaldehyde Fertilizer19
2.6	Issues and Concerns in the Fertilizer Industry

Cha	pter 3: Engineered Urea Fertilizers27
3.1	Needs for Greener Fertilizer27
3.2	Slow-or Controlled-Release Fertilizer30
3.3	Controlled Release Fertilizer31
Cha	apter 4: Potential of Chitosan, Natural Rubber and
Lig	nin in Fertilizers45
4.1	Fertilizer Processing45
4.2	Chitosan in Fertilizers46
4.3	Natural Rubbers (NR) in Fertilizers53
4.4	Lignin as a Biodegradable Binder59
	Calcium Lignosulfonate (CaLS)64
Cha	apter 5: Development of Chitosan and Natural
	bber-based Fertilizers Binder69
5.1	Steps in Preparation of Urea Fertilizer69
	Making of Chitosan-Based Urea Fertilizer (CBUF)
	Binder71
5.3	Making of Natural Rubber/Chitosan-based Urea
	Fertilizer (NR/CBUF) Binder78
5.4	Properties and Biodegradability of Natural Rubber
	and Chitacan based Fortilizers 86

. . .

Cha	apter 6: Granulation and Preparation of Urea-
Cal	cium Lignosulfonate Fertilizer127
6.1	Fertilizer Granulation127
6.2	Granulation Process
6.3	Rheological Analysis130
6.4	Granulation of Urea-Calcium Lignosulfonate
	Fertilizer
6.5	Rheological Properties of Urea-CaLS Fertilizers 153
6.6	Spray Behaviour Analysis of Urea-CaLS Fertilizers 161
Cha	opter 7: Materials Characterization, Testing and
Ana	alysis for Fertilizers' Production167
7.1	Raw Materials Characterization167
7.2	Testing and Analyses of Solid Fertilizers180
Cor	nclusions
Ref	erences191
Ind	ev 207

### GREEN FERTILIZER

BINDER FROM CHITOSAN, NATURAL RUBBER & LIGNIN

"Green Fertilizer-Potential of Chitasan, Natural Rubber & Lignin" offers a valuable resource for those interested in sustainable agriculture and green alternatives to traditional fertilizers. With its detailed research findings, innovative methods, and practical examples, the book highlights the potential of utilizing natural materials as binders in fertilizer formulations to promote sustainable and environmentally friendly practices in the fertilizer industry. Chitasan, natural rubber, and calcium lignosulfonate materials are renewable, sustainable, and environmentally friendly, making them an ideal substitute for traditional binders like formaldehyde.

The toxicity of formaldehyde as a binder in fertilizers is a global issue that requires serious attention. Although the research findings are primarily on a laboratory scale, this book offers potential solutions to reduce the impact of formaldehyde by substituting it with green binders made from natural resources, such as chitosan, natural rubber, and calcium lignosulfonate. This book sheds light on the toxicity of formaldehyde in fertilizers and the importance of adopting sustainable and environmentally friendly practices in the fertilizer industry.

This book is a pioneering work in the niche of green fertilizers that specifically combines area with chitosan, natural rubber, and calcium lignosulfonate. It highlights three types of natural materials that are widely available in Malaysia and other parts of Asia. While other books with the keyword "Green Fertilizer" typically address topics such as green manure, organic fertilizer, or organic farming, this book focuses on the innovative potential of these green materials for fertilizer formulations using simple methods, testing, and measurement for usability.



NORAIHAM MOHAMAD is currently an Associate Professor at the Foculty of Industrial and Manufacturing Technology and Engineering, Universiti Teknikal Malaysia Melaka (UTeM). She earned her Ph.D. in 2011 from Universiti Kebangsaan Malaysia (UKM) in the field of Mechanical and Materials Engineering. Her research interest is mainly in polymer/rubber composites & nanocomposites properties & characterization, including green materials, body armor materials, and process optimization.



JARIAH MOHAMAD JUOI is currently an Associate Professor at the Faculty of Industrial and Manufacturing Technology and Engineering, Universiti Teknikal Malaysia Melaka, Malaysia. She earned her Ph.D. in 2008 from the University of Sheffield, United Kingdom. Her research interest is mainly in ceramic & glass composites, properties & characterization, including coating, green materials, waste recycling, and immobilization.



JEEFFERIE ABD RAZAK is currently an Associate Professor at the Faculty of Industrial and Manufacturing Technology and Engineering, Universiti Teknikal Malaysia Melaka, Malaysia, He received his Ph.D. in Materials Science from the Universiti Kebangsaan Malaysia, Malaysia, His research interests are polymer & rubber blends, dielectric & conductive polymeric composites, and polymer-based nanocomposites. He is a chartered engineer with Engineering Council, UK, and a Professional Technologist by the Malaysia Board of Technologists under the nanotechnology area.



PENERBIT UTeM Press

Website: https://penerbit.utem.edu.my Books Online: https://utembooks.utem.edu.my Email: penerbit@utem.edu.my

