

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 Masmullyadi 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

Perustakaan Negara Malaysia

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

ISBN 978-967-2792-72-7

PERPUSTAKAAN Universiti Teknikal Malaysia Melaka	
No. Aksesan 87516806	No. Panggilan TP 962-4 U7 N67 2023 9 n2/158124
Tarikh 12 JAN 2024	

TABLE OF CONTENTS



Preface.....	ix
Acknowledgements	xi
List of Abbreviations	xiii
Chapter 1: What is Fertilizer?.....	1
1.1 Fertilizer	1
1.2 Role of Fertilizer in Plant Growth	3
Chapter 2: Type of Commercialized Fertilizers and Safety Concerns in the Fertilizer Industry.....	9
2.1 Organic and Inorganic Fertilizers.....	9
2.2 Organic Fertilizer	11
2.3 Inorganic Fertilizer	12
2.4 Urea Fertilizers	14
2.5 Urea Formaldehyde Fertilizer.....	19
2.6 Issues and Concerns in the Fertilizer Industry.....	20

Chapter 3: Engineered Urea Fertilizers	27
3.1 Needs for Greener Fertilizer	27
3.2 Slow-or Controlled-Release Fertilizer.....	30
3.3 Controlled Release Fertilizer.....	31
Chapter 4: Potential of Chitosan, Natural Rubber and Lignin in Fertilizers	45
4.1 Fertilizer Processing	45
4.2 Chitosan in Fertilizers	46
4.3 Natural Rubbers (NR) in Fertilizers.....	53
4.4 Lignin as a Biodegradable Binder	59
4.5 Calcium Lignosulfonate (CaLS).....	64
Chapter 5: Development of Chitosan and Natural Rubber-based Fertilizers Binder	69
5.1 Steps in Preparation of Urea Fertilizer	69
5.2 Making of Chitosan-Based Urea Fertilizer (CBUF) Binder	71
5.3 Making of Natural Rubber/Chitosan-based Urea Fertilizer (NR/CBUF) Binder.....	78
5.4 Properties and Biodegradability of Natural Rubber and Chitosan-based Fertilizers	86

Chapter 6: Granulation and Preparation of Urea-Calcium Lignosulfonate Fertilizer.....	127
6.1 Fertilizer Granulation.....	127
6.2 Granulation Process	128
6.3 Rheological Analysis	130
6.4 Granulation of Urea-Calcium Lignosulfonate Fertilizer	140
6.5 Rheological Properties of Urea-CaLS Fertilizers.....	153
6.6 Spray Behaviour Analysis of Urea-CaLS Fertilizers.....	161
Chapter 7: Materials Characterization, Testing and Analysis for Fertilizers' Production	167
7.1 Raw Materials Characterization	167
7.2 Testing and Analyses of Solid Fertilizers	180
Conclusions.....	189
References	191
Index	207

GREEN FERTILIZER

BINDER FROM CHITOSAN, NATURAL RUBBER & LIGNIN

"Green Fertilizer-Potential of Chitosan, 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. Chitosan, 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 urea 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 Faculty 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

ISBN 978-967-2792-72-7



05900

9 789672 792727

Website : <https://penerbit.utm.edu.my>
Books Online : <https://utembooks.utm.edu.my>
Email : penerbit@utm.edu.my