OPTIMIZATION OF WATER ABSORPTION PROPERTIES OF SUPERABSORBENT DOUBLE-NETWORK HYDROGEL BIOCHAR COMPOSITES

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(Nur Ellydia binti Mohamad Gustie Noorambia)

TABLE OF CONTENTS

ABSTRACT

OPTIMIZATION OF WATER ABSORPTION PROPERTIES OF SUPERABSORBENT DOUBLE-NETWORK HYDROGEL BIOCHAR COMPOSITES

Agriculture sector contributes a lot in the economic expansion of the country due to the extensive land and biodiversity. Plant growth is affected by many factors such as the temperature fluctuation due to climatic change, as the heat stress directly affect the agricultural productivity. Frequent irrigation is needed to maintain the soil moisture to support the plant development. Hydrogels are three-dimensional crosslinked polymer networks, which contain a huge amount of water and can be used as carriers for various active ingredients including fertilizers. Hydrogel-based controlled-release fertilizers (CRFs) absorb and retain irrigation water as well as simultaneously supply the nutrients to the plants. Superabsorbent double-network hydrogel-biochar composites (DNHBCs) based on polyacrylate were synthesized in this study via solution polymerization method and cyclic freeze-thaw by using different concentrations of poly(vinyl alcohol) (PVA), *N,N*-methylenebis-acrylamide (MBA) crosslinker and palm kernel shell biochar (BC). The DHNBCs were characterized using Attenuated Total Reflection-Fourier Transform Infra-Red (ATR-FTIR) and Thermogravimetric Analyzer (TGA). Water absorption properties of the superabsorbent DNHBCs were optimized by using Response Surface Methodology-Central Composite Design (RSM-CCD) by varying MBA, PVA and BC concentrations. The PVA and MBA contents of the DNHBC showed significant effects on the water absorption capacity of DNHBC but not the BC concentration. Increasing BC wt% tends to increase the water absorption of the resultant DHNBC, however higher PVA concentration tends to reduce the hydrogel's water absorption. DNHBC-R1 and DNHBC-R7 not only possess high water absorption at 328.28 g/g and 309.08 g/g, respectively, but they also maintain high structural integrity and stability indicating their potentials as multi-functional controlled-release fertilizer (CRF) candidates. The equilibrium water absorption capacities of the DHNBC-R1 and DHNBC-R7 varied in different aqueous media and ionic strength, with decreasing water absorption capacity with increasing ionic strength. The research theme is aligned with Sustainable Development Goal No. 2 (SDG 2) aiming to end hunger, achieve food security, improve nutrition and support sustainable agriculture by 2030.

CHAPTER 1

INTRODUCTION

1.1 Background and problem statement

Agriculture plays a crucial role in ensuring food security in the world, including in Malaysia. The agriculture sector in Malaysia is among the most lucrative sources of income for economic growth, thanks to Malaysia's vast agricultural land and biodiversity (Sani et al., 2022). Recently, the Global Food Crisis Report 2023 reported severe food insecurity and increasing food crisis in 2022 due to climate change, economic shocks, and occurrences of extreme weather conditions. Agricultural output and plant growth are significantly affected by fluctuating annual rainfall and extreme high/low temperatures (Lee et al., 2024), affecting farmers' income. The reduced income among farmers gradually leads to poverty and food insecurity because of global climatic change (Mahmood et al., 2022). Heat stress is another environmental factor that could affect the overall agricultural productivity thus lower the farmer's income (El Khayat et al., 2022; Mansouri et al., 2023).

Water is essential in agricultural irrigation (Chang et al., 2021), industrial and domestic water supply, and to a lesser extent in mining and fisheries (Toriman & Mokhtar, 2012). Irrigation water accounts for about 70% of water consumption in Malaysia (Water in Agriculture, 2023) which contributes significantly to food