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Nanocellulose-Based Biomaterial Ink Hydrogel for Uptake/Release of Bovine Serum Albumin

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Abstract: This study explores the potential of using nanocellulose extracted from oil palm empty fruit bunch (OPEFB) as a biomaterial ink for 3D printing. The research focuses on using nanocellulose hydrogels for the controlled uptake and release of proteins, with the specific protein solution being Bovine Serum Albumin (BSA). To provide a suitable material for the bioprinting process, the study examines the characteristics and properties of the printed hydrogels through various analyses, such as morphology, functional group, crystallinity, and compression test. Several parameters, such as initial concentration, temperature, and the presence of calcium chloride as an additional crosslinker, affect the protein uptake and release capabilities of the hydrogel. The study is important for biomedicine as it explores the behavior of protein uptake and release using nanocellulose and 3D printing and can serve as a preliminary study for using hydrogels in biological materials or living cells.

Keywords: 3D printing; bioprinting; cellulose; liquid printing; protein

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1. Introduction

Nanocellulose, a material derived from plant fibers, has gained increasing attention for its advanced properties and potential for commercialization in various industries, particularly in biopolymers and biomedical fields [1,2]. Malaysia, being a major producer of oil palm, has significant potential to transform underutilized biomass into valuable products [3,4]. The extraction and purification of nanocellulose from oil palm empty fruit bunch (OPEFB) using green methods is an efficient way to minimize waste and keep production costs low [5]. The high strength and mechanical properties of nanocellulose make it ideal for use in additive manufacturing (3D printing), and its potential to produce customized and detailed products [1,6].

3D printing categorizes different techniques based on the feed material and application. Most ink materials are in solid, liquid, and powder forms [7]. Previously, many inks were made up of polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), polyurethane (PU), and polyethylene glycol (PEG), which experience resource depletion and are less suitable for sustainability and the environment [8,9]. Nanocellulose from OPEFB as printing ink has a higher biodegradation rate and can benefit underutilized biomass into smart and sustainable material [10–12]. As the demand for biopolymer printing ink increases, it is a great chance to start with nanocellulose. Biopolymer ink derived from natural resources solves some previous ink issues, having high biocompatibility for living thing applications.