ABSTRAK

Pemanfaatan biomassa lignoselulosa, seperti Tandan Kosong Kelapa Sawit (TKKS), kerap dikembangkan sebagai sumber energi terbarukan yang ekonomis dan ramah lingkungan. TKKS memiliki potensi besar untuk dikonversi menjadi berbagai produk bernilai tambah, seperti bioetanol melalui hidrolisis enzimatik. Hidrolisis enzimatik dilakukan dengan beberap enzim, salah satunya adalah enzim selulase. Namun, enzim selulase memiliki kelarutan yang tinggi dalam air, sehingga akan sulit untuk dipisahkan dari produk dan tidak dapat digunakan kembali. Hal tersebut menyebabkan kerugian di beberapa aspek, baik secara biaya maupun efektivitas. Salah satu cara yang dapat menanggulangi permasalahan tersebut yaitu melalui imobilisasi enzim. Penelitian ini bertujuan untuk menentukan kondisi optimum dalam mengimobilisasi enzim selulase pada matriks biochar/kitosan/glutaraldehid, serta menentukan kondisi optimum enzim selulase dalam menghidrolisis CMC. Selain itu, menentukan kemampuan reusabilitas enzim terimobilisasi dalam menghidrolisis CMC dan Tandan Kosong Kelapa Sawit (TKKS). Pada penelitian ini dilakukan imobilisasi enzim selulase pada matriks biochar/kitosan/glutaraldehid. Hasil penelitian menunjukkan enzim selulase terimobilisasi optimal pada konsentrasi kitosan 1,5%; konsentrasi glutaraldehid 3%; konsentrasi biochar 1,5%; perbandingan volume *beads* : enzim 1:2; dan waktu perendaman enzim selama 24 jam. Selain itu, enzim terimobilisasi dapat menghidrolisis CMC secara optimum pada pH 3,5, suhu inkubasi 50 ^{o}C, dan waktu inkubasi 10 menit. Perhitungan kinetika enzim terimobilisasi, yaitu K_M sebesar 9,678 mg/mL dan V_{max} sebesar 73,899 mmol/min. Enzim selulase terimobilisasi dapat digunakan sebanyak 6 kali siklus hidrolisis CMC dengan aktivitas enzim terakhir 7,245 U/mL dan *residual activity* 14,285%. Pada hidrolisis TKKS, enzim terimobilisasi dapat digunakan sebanyak 3 siklus hidrolisis dengan aktivitas enzim pada siklus ketiga di jam ke-72 sebesar 198,264 U/mL.

Kata kunci: Enzim selulase, Imobilisasi enzim, Biochar, Kitosan, Glutaraldehid

ABSTRACT

The utilization of lignocellulosic biomass, such as Oil Palm Empty Fruit Bunches (OPEFB), is frequently explored as an economical and environmentally friendly renewable energy source. OPEFB holds significant potential for conversion into various value-added products, such as bioethanol, via enzymatic hydrolysis. Enzymatic hydrolysis employs various enzymes, including cellulase. However, cellulase is highly water-soluble, making it difficult to separate from the product and preventing its reuse; this results in disadvantages regarding both cost and efficiency. Enzyme immobilization offers a solution to this issue. This study aimed to determine the optimal conditions for immobilizing cellulase on a biochar/chitosan/glutaraldehyde matrix and to identify the optimal conditions for the immobilized cellulase to hydrolyze CMC. Additionally, the study evaluated the reusability of the immobilized enzyme in hydrolyzing both CMC and OPEFB. Cellulase was immobilized on the biochar/chitosan/glutaraldehyde matrix. The results indicated that optimal immobilization occurred at a chitosan concentration of 1.5%, glutaraldehyde concentration of 3%, biochar concentration of 1.5%, a bead-to-enzyme volume ratio of 1:2, and an enzyme immersion time of 24 hours. Furthermore, the immobilized enzyme achieved optimal CMC hydrolysis at pH 3.5, an incubation temperature of 50°C, and an incubation time of 10 minutes. Kinetic parameters for the immobilized enzyme were calculated as follows K_M 9.678 mg/mL and V_{max} 73.899 mmol/min. The immobilized cellulase could be used for six CMC hydrolysis cycles, retaining a final activity of 7.245 U/mL and a residual activity of 14.285%. In the hydrolysis of EFB, the immobilized enzyme can be used for three hydrolysis cycles, with the enzyme activity in the third cycle at the 72nd hour reaching 198.264 U/mL.

Keywords: Cellulose enzyme, Enzyme immobilization, Biochar, Chitosan, Glutaraldehyde