Optimasi Proses Hidrolisis Tandan Kosong Sawit Untuk Produksi Furfural Dengan Metode Praperlakuan Alkali Berbantuan Gelombang Mikro = Optimization of Oil Palm Empty Fruit Bunch Hydrolysis Process for Furfural Production with Microwave Assisted Alkaline Pretreatment Method

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Abstrak

Tandan Kosong Sawit (TKS) adalah limbah biomassa industri kelapa sawit, dengan kandungan utamanya meliputi selulosa, hemiselulosa, dan lignin, yang dihasilkan dalam jumlah berlimpah setiap tahunnya di Indonesia. Hemiselulosa pada TKS dapat dikonversi menjadi senyawa furfural dengan terlebih dahulu melakukan praperlakuan untuk merusak struktur lignoselulosa dan menghilangkan lignin. Produksi furfural berbasis biomassa melalui reaksi hidrolisis berkatalis asam menghasilkan produk samping berupa asam levulinat dan asam format yang sangat tergantung pada kondisi reaksi. Pada penelitian ini dilakukan optimasi kondisi reaksi hidrolisis TKS yang meliputi waktu, suhu, dan konsentrasi asam, secara simultan terhadap yield furfural dengan Response Surface Methodology (RSM). TKS dengan ukuran 30 - 40 mesh pertama-tama diberikan praperlakuan alkali berbantuan gelombang mikro dengan menggunakan NaOH dan NH₄OH. Variasi praperlakuan dengan NaOH meliputi konsentrasi basa (1; 2; 3 %), daya microwave (280; 560; 840 W), dan waktu (3; 6; 9 menit). Sedangkan variasi praperlakuan dengan NH₄OH meliputi konsentrasi basa (7,5; 10; 12,5 %), daya microwave (280; 560; 840 W), dan waktu (3; 6; 9 menit). Uji kandungan lignin sesuai SNI 0492:2008, FTIR dan SEM dilakukan untuk mengetahui pengaruh praperlakuan. Efek konsentrasi basa, daya microwave, dan waktu dianalisis menggunakan RSM. Praperlakuan menggunakan NaOH dengan konsentrasi basa 2%, daya microwave 840 W, dan waktu 9 menit menghasilkan TKS dengan kadar lignin terendah sebesar 7,58%. Selanjutnya hidrolisis dilakukan terhadap TKS hasil praperlakuan pada kondisi tersebut dengan variasi waktu reaksi (20; 40; 60 menit), suhu (140; 160; 180 °C), dan konsentrasi H₂SO₄ (0,3; 0,5; 0,7 M). Konsentrasi furfural, asam levulinat, dan asam format dalam fraksi cair hidrolisis kemudian dianalisis menggunakan HPLC. Optimasi respons konsentrasi furfural dilakukan dengan RSM pada software Design Expert menggunakan model Box-Behnken. Hasil optimasi menunjukkan konsentrasi furfural tertinggi sebesar 2481ppm dapat diperoleh pada waktu reaksi 60 menit, suhu 141 °C, dan konsentrasi H₂SO₄ 0,3 M.
Oil Palm Empty Fruit Bunch (OPEFB) is biomass waste from palm oil industry, with the main content including cellulose, hemicellulose, and lignin, which is produced in abundant quantities every year in Indonesia. Hemicellulose in OPEFB can be converted into furfural by first doing pretreatment to damage the lignocellulose structure and to remove lignin. Biomass-based furfural production through acid-catalyzed hydrolysis reaction produces by-products such as levulinic acid and formic acid which is highly dependent on the reaction conditions. In this study, the optimization of the hydrolysis reaction conditions of OPEFB was carried out which included time, temperature, and acid concentration, simultaneously on furfural yield with Response Surface Methodology (RSM). The 30-40 mesh OPEFB was first given microwave assisted alkali pretreatment using NaOH and NH₄OH. Pre-treatment variations with NaOH included

alkaline concentrations (1; 2; 3%), microwave power (280; 560; 840 W), and time (3; 6; 9 minutes). While pre-treatment variations with NH₄OH included alkaline concentrations (7,5; 10; 12,5%), microwave power (280; 560; 840 W), and time (3; 6; 9 minutes). Test on lignin content according to SNI 0492:2008, FTIR and SEM were carried out to determine the effect of pretreatment. The effects of alkaline concentration, microwave power, and time were analyzed using RSM. Pre-treatment using NaOH with alkaline concentration of 2%, microwave power 840 W, and 9 minutes could produce OPEFB with the lowest lignin content of 7,58%. Subsequently hydrolysis was carried out on the pretreated OPEFB in these conditions with variations in reaction time (20; 40; 60 minutes), temperature (140; 160; 180 ° C), and H₂SO₄ concentrations (0,3; 0,5; 0,7 M) The furfural concentration, levulinic acid, and formic acid in the hydrolysis liquid fraction were then analyzed by using HPLC. Optimization of furfural concentration response was done by RSM in Design Expert software using the Box-Behnken model. The optimization results show that the highest furfural concentration of 2481 ppm can be obtained at the reaction time of 60 minutes, temperature of 141 °C, and H₂SO₄of concentration 0,3 M.