Pemodelan dan simulasi adsorpsi etanol-air pada unggun tetap karbon aktif = Modeling and simulation of ethanol-water adsorption in fixed bed column with activated carbon as adsorbent

Pardosi, Natashya Elly Febrina, author

Abstrak

Etanol yang disintesis dari bahan baku terbarukan dapat dimanfaatkan sebagai bahan bakar alternatif pengganti bensin. Umumnya, etanol yang dihasilkan dari proses sintesis masih mengandung air sehingga diperlukan adanya proses pemisahan lanjut. Salah satu metode pemisahan campuran etanol-air dengan tingkat penggunaan energi yang paling efisien adalah adsorpsi. Dalam penelitian ini, kinerja proses adsorpsi kontinyu campuran etanol-air fasa cair diinvestigasi melalui pembuatan model matematis representasi dari proses adsorpsi pada unggun tetap karbon aktif menggunakan perangkat lunak Microsoft Excel. Digunakan model Linear Driving Force (LDF) dengan metode perhitungan Finite Difference Method (FDM) dalam melakukan pemodelan. Proses adsorpsi yang dimodelkan berada dalam kondisi isotermal 30°C, 1 atm. Kesetimbangan adsorpsi campuran etanol-air direpresentasikan dengan isoterm adsorpsi Langmuir. Model disimulasikan untuk mengetahui pengaruh variasi laju alir umpan (5, 10, 15, 20 ml/menit), konsentrasi awal umpan (10%, 25%, 50%, 90% v/v), porositas unggun (0,371; 0,394; 0,411; 0,465) serta tinggi unggun (0,4; 0,8; 1; 1,2 m) terhadap profil kurva breakthrough air.
Hasil simulasi menunjukan keterjalan kurva breakthrough meningkat seiring peningkatan laju alir umpan dan konsentrasi air pada umpan serta pengurangan tinggi unggun, namun tidak tidak berubah pada variasi porositas unggun. Selain itu diketahui bahwa waktu breakpoint terpanjang dari hasil simulasi masing-masing variabel dicapai pada variasi laju alir umpan 5 ml/min, tinggi unggun 1,2 m serta porositas unggun sebesar 0,465. Berdasarkan perhitungan terhadap luas daerah diatas kurva breakthrough, diketahui kapasitas adsorpsi air meningkat dengan signifikan seiring peningkatan konsentrasi air pada umpan. Hal ini ditunjukan dari kenaikan kapasitas adsorpsi dari 0,228 – 1,706 g/gads pada konsentrasi awal air 10 - 90% (v/v).
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Ethanol synthesized from renewable sources is utilized as a substitute for gasoline. Generally, ethanol produced from the synthesis process still contains water, hence, a further separation process is needed. One of the separation methods for the ethanol-water mixture which is considered as most efficient in terms of energy utilization is adsorption. In this study, the performance of the continuous adsorption process of the ethanol-water mixture is investigated by generating a mathematical model that represents the fixed-bed adsorption process of the liquid phase ethanol-water mixture on activated carbon using Microsoft Excel. The model used in this study is the Linear Driving Force Model (LDF) and it’s solved by the numerical Finite Difference Method (FDM). The adsorption process modeled is under isothermal condition of 30°C, 1 atm. The adsorption equilibrium of the water-ethanol mixture is represented by the Langmuir adsorption isotherm. Model simulations are performed to predict the effect of feed flow rate (5, 10, 5, 20 ml/min), feed concentration (10%, 20%, 50%, 90% v/v), bed porosity (0,371; 0,394; 0,411; 0,465) and bed height (0,4; 0,8; 1; 1,2 m) on water breakthrough curves profile.
Based on the simulation results obtained, the steepness of the breakthrough curve increases with the increase

in feed flow rate, water feed concentration, and with the reduction in bed length, however, it doesn’t perform any effect with changes in bed porosity. Besides, it is known that the longest breakpoint time achieved from each variable found at the variation of 5 ml/min feed flow rate; 1,2 m bed height, and bed porosity of 0,465. Based on the calculation of the area above the breakthrough curve, the water adsorption capacity increases significantly with the increase of initial water concentration. This is shown from the increase in adsorption capacity from 0,228 – 1,706 g/gads at the change of initial water concentration from 10 – 90% (v/v).