ADSORPSI ZAT WARNA MALASIT HIJAU DAN METIL ORANYE DENGAN SILIKA GEL BERBAHAN DASAR ABU VULKANIK GUNUNG SEMERU

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INTISARI

Penelitian tentang adsorpsi zat warna malasit hijau dan metil oranye pada silika gel yang disintesis dari abu vulkanik Gunung Semeru teraktivasi asam klorida telah dilakukan. Abu vulkanik diaktivasi menggunakan larutan HCl 6 M dengan metode refluks selama 4 jam. Abu vulkanik teraktivasi kemudian dilebur dengan NaOH 4 M untuk menghasilkan natrium silikat. Larutan natrium silikat kemudian ditetesi dengan HCl 3 M sampai terbentuk silika gel. Abu vulkanik teraktivasi dan silika gel hasil sintesis dikarakterisasi dengan spektrometer inframerah (FT-IR), difraktometer sinar-X (XRD), dan fluoresensi sinar X (XRF). Proses adsorpsi zat warna dipelajari dengan melakukan optimasi parameter pH larutan, massa adsorben, waktu interaksi, dan konsentrasi awal adsorbat. Konsentrasi zat warna dalam larutan ditentukan dengan metode spektrofotometer UV-Tampak.

Hasil karakterisasi adsorben menunjukkan bahwa komponen utama abu vulkanik adalah SiO_2 dan Al_2O_3, sedangkan komponen utama silika gel adalah unsur silika. Hasil karakterisasi juga menunjukkan bahwa silika gel hasil sintesis memiliki situs aktif berupa gugus fungsi siloksan (Si-O-Si) dan silanol (Si-OH) serta bersifat amorf. Kondisi optimum adsorpsi zat warna malasit hijau dengan silika gel diperoleh pada pH larutan 7, massa adsorben 0,2 gram, waktu interaksi 15 menit, dengan konsentrasi awal 200 ppm, sedangkan adsorpsi zat warna metil oranye dengan silika gel dicapai pada pH larutan 4, massa adsorben 0,15 gram, waktu interaksi 30 menit, dengan konsentrasi awal 100 ppm. Adsorpsi zat warna malasit hijau dan metil oranye menggunakan silika gel mengikuti kinetika orde kedua semua. Nilai konstanta laju yang dihasilkan secara berurutan sebesar 6,00 dan 0,93 g mg^{-1} $menit^{-1}$. Proses adsorpsi zat warna malasit hijau mengikuti model isoterm Langmuir dengan nilai konstanta Langmuir (K_L) sebesar 228678,89 L mol^{-1} dan energi adsorpsi (E_{ads}) sebesar 30,57 kJ mol^{-1}. Sementara itu, proses adsorpsi zat warna metil oranye juga mengikuti model isoterm Langmuir dengan nilai konstanta Langmuir (K_L) sebesar 605461,04 L mol^{-1} dan energi adsorpsi (E_{ads}) sebesar 32,99 kJ mol^{-1}, yang menunjukkan bahwa adsorpsi terhadap kedua zat warna merupakan kemisorpsi.

Kata kunci: adsorpsi, abu vulkanik, malasit hijau, metil oranye, silika gel

ADSORPTION OF MALACHITE GREEN AND METHYL ORANGE DYES USING SILICA GEL PREPARED FROM MOUNT SEMERU VOLCANIC ASH

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ABSTRACT

Research on the adsorption of malachite green and methyl orange dyes on silica gel synthesized from Mount Semeru volcanic ash activated by hydrochloric acid has been carried out. Volcanic ash was activated using 6 M HCl solution with reflux method for 4 hours. Activated volcanic ash was then melted with 4 M NaOH to produce sodium silicate. The sodium silicate solution was then dripped with 3 M HCl until silica gel was formed. Activated volcanic ash and synthesized silica gel were characterized by infrared spectrometer (FT-IR), X-ray diffractometer (XRD), and X-ray fluorescence (XRF). The dye adsorption process was studied by optimizing various parameters, such as the effects of pH, adsorbent mass, interaction time, and initial concentration of adsorbate. Concentration of the dye in the solution was determined by the UV-Visible spectrophotometer method.

The characterization of materials showed that the main components of volcanic ash were SiO_2 and Al_2O_3 compounds, while the main component of silica gel was Si element. The characterization results also showed that the synthesized silica gel had an active sites of siloxane (Si-O-Si) and silanol (Si-OH) functional groups and it was amorphous. The optimum conditions for the adsorption process of malachite green dye with silica gel were obtained at a solution of pH 7, adsorbent mass of 0.2 g, interaction time of 15 min., and with an initial concentration of 200 ppm, while adsorption of methyl orange dye with silica gel was achieved at a solution pH of 4, adsorbent mass of 0.15 g, interaction time of 30 min., and with an initial concentration of 100 ppm. The adsorptions of malachite green and methyl orange dyes using silica gel were best described by pseudo-second order kinetic model. The adsorption rate constant values for malachite green and methyl orange dyes were 6.00 and 0.93 g mg^{-1} min^{-1}, respectively. The adsorption process of malachite green dye followed the Langmuir isotherm model with a Langmuir constant (K_L) value of 228678.89 L mol^{-1} and an adsorption energy (E_{ads}) of 30.57 kJ mol^{-1}. Meanwhile, the adsorption process for methyl orange dye also followed the Langmuir isotherm model with a Langmuir constant (K_L) of 605461.04 L mol^{-1} and an adsorption energy (E_{ads}) of 32.99 kJ mol^{-1}, suggesting that the adsorption of both dyes was classified as chemisorption

Keywords: adsorption, malachite green, methyl orange, silica gel, volcanic ash