

INTISARI

Modifikasi Permukaan Silika dengan Asam Fosfonoasetat dan Aminoetildihidrogenfosfat untuk Adsorpsi Co(II), Ni(II), Cu(II), dan Zn(II)

Oleh

Dian Maruto Widjonarko

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Telah dilakukan modifikasi permukaan silika gel dengan asam fosfonoasetat (*phosphonoacetic acid/PA*) dan aminoetildihidrogenfosfat (*aminoethylidihydrogenphosphate/AEPH₂*) dengan gugus jembatan dari glisidoksi propiltrimetoksisilan (*γ-glycydoxypropyltrimethoxysilane/GPTMS*) dan 1,4-dibromobutana serta karakterisasi adsorpsinya terhadap Co(II), Ni(II), Cu(II), dan Zn(II). Pengaruh NaOH dan HNO₃ pada aktivasi silika; pengaruh etanol, toluena, dan air pada penyambungan GPTMS pada silika; serta pengaruh air, tetrahidrofuran (THF), dan dioksana pada penyambungan AEPH₂ pada GPTMS tersambung silika dikaji. Pengaruh GPTMS dan 1,4-dibromobutana serta PA dan AEPH₂ beserta laju, kapasitas, dan selektivitas adsorpsinya juga dikaji.

Modifikasi permukaan silika dilakukan secara bertahap. Silika mula-mula diaktivasi dengan NaOH dan HNO₃. Selanjutnya, silika disambung dengan GPTMS dan 1,4-dibromobutana dilanjutkan dengan PA dan AEPH₂. Material hasil dianalisis situs aktifnya dengan spektroskopi infra-merah dan porositasnya dengan metode adsorpsi-desorpsi gas N₂. Adsorpsi Co(II), Ni(II), Cu(II), dan Zn(II) oleh material hasil dilakukan dengan teknik batch dengan menganalisis kandungan logam terlarut sisa adsorpsi dengan spektroskopi serapan atom. Laju, kapasitas, dan selektivitas adsorpsi material dianalisis dengan menggunakan sejumlah model kinetika dan isoterm adsorpsi.

Hasil penelitian menunjukkan bahwa modifikasi permukaan silika berhasil dilakukan. Material hasil terdiri dari fosfonat yang terikat pada silika melalui gugus jembatan organosilan. Material hasil termasuk material mesopori. NaOH lebih mampu daripada HNO₃ untuk meningkatkan aktivitas silika. Toluena lebih mampu dibandingkan dengan etanol dan air untuk menyambung GPTMS pada silika. Air adalah pelarut yang lebih mampu dibandingkan THF dan dioksana untuk menyambung AEPH₂ pada GPTMS tersambung silika. GPTMS dan 1,4-dibromobutana yang tersambung menghasilkan gugus jembatan organosilan sedangkan GPTMS menghasilkan situs aktif tambahan berupa COC. PA dan AEPH₂ yang tersambung menghasilkan situs aktif berupa POH dan PO yang masing-masing mampu menukar kation dan membentuk ikatan kompleks dan kelat. PA yang tersambung menghasilkan situs aktif tambahan COO yang mampu membentuk ikatan kompleks dan kelat sedangkan AEPH menghasilkan NH. Situs aktif dan ion logam sangat dipengaruhi pH. Adsorpsi Cu(II) cenderung mengikuti orde-2 sedangkan Co(II), Ni(II), dan Zn(II) cenderung mengikuti pseudo orde-2. Model isoterm adsorpsi Freundlich sesuai untuk Cu(II) sedangkan model isoterm adsorpsi Langmuir sesuai untuk Co(II), Ni(II), dan Zn(II). Kapasitas adsorpsi material hasil dari sumber PA lebih besar daripada AEPH₂ sedangkan kapasitas adsorpsi material hasil dari sumber GPTMS lebih besar daripada 1,4-dibromobutana. Pengaruh potensial ionik lebih dominan daripada pengaruh situs aktif dan porositas. Material hasil memiliki pola selektivitas adsorpsi Cu(II)>Co(II)>Ni(II)>Zn(II).

Kata kunci: silika gel, modifikasi, fosfonat, organosilan, adsorben

ABSTRACT

Modification of Silica Surface with Phosphonoacetic Acid and Aminoethyldihydrogenphosphate for Adsorption of Co(II), Ni(II), Cu(II) and Zn(II)

Dian Maruto Widjonarko
06/240868/SPA/00120

Modification of silica gel surface with phosphonoacetic acid (PA) and aminoethyldihydrogenphosphate (AEPH₂) through bridging group of γ -glycydxypropyltrimethoxysilane (GPTMS) and 1,4-dibromobutane and its adsorption characteristic toward Cu(II), Ni(II), Cu(II), and Zn(II) have been performed. The effect of NaOH and HNO₃ in activation; effect of ethanol, toluene, and water in grafting of GPTMS on silica; and effect of water, tetrahydrofuran (THF), and dioxane in grafting of 2-aminoethyldihydrogenphosphate (AEPH₂) on GPTMS grafted onto silica have been studied. The effect of GPTMS and 1,4-dibromobutane; PA and AEPH₂; and rate, capacity, and selectivity of adsorption of resulted materials were evaluated also.

The modification of silica was carried out in multisteps. Firstly, silica was activated with NaOH and HNO₃ in various contact time. Then, GPTMS and 1,4-dibromobutane were grafted, followed with grafting of PA and AEPH₂ on material previously resulted. The resulted materials were characterized its active sites and porosity with infra-red spectroscopy and adsorption-desorption of N₂, respectively. While, the adsorption characteristic was studied by applying the materials produced in batch technique toward Co(II), Ni(II), Cu(II), and Zn(II) in aqueous solution. The unadsorbed metal ions were analyzed with flame-atomic absorption spectroscopy. In order to analysis the rate, capacity, and selectivity of adsorption, some isotherm and kinetics models were evaluated.

The result of the study show that modification of silica surface has been succesfully performed. The resulted materials consist of silica centered with phosphonate and bridging with organosilane group. The resulted materials are mesoporous. The activator prefer NaOH to HNO₃ in silica activation. The solvent prefer toluene to water and ethanol in grafting of GPTMS on silica. The solvent prefer water to THF and dioxane in grafting of AEPH₂ on GPTMS grafted onto silica. The grafting of GPTMS and 1,4-dibromobutane result organosilane group while GPTMS result added active site of COC which able to form complex and chelate bonding with cations. The grafting of PA and AEPH₂ result active site of POH and PO which able to exchange cations and able to form complex and chelate bonding, respectively. The grafting of PA result added active site of COO which able to form complex and chelate bonding while AEPH result NH which able to form complex and chelate bonding. This active sites and metal ion depend on pH. Cu(II) adsorption by resulted materials follow second order, whilst for Co(II), Ni(II), and Zn(II) follow to pseudo-2 order. Adsorption of Cu(II) on modified silica follow isotherm adsorption Freundlich model, whilst adsorption of Co(II), Ni(II) and Zn(II) follow isotherm adsorption Langmuir model. The capacity of resulted materials of PA are bigger than of AEPH₂ while capacity of resulted materials of GPTMS are bigger than of 1,4-dibromobutane. Ionic potential effect is more dominant than active sites and porosity effect. The selectivity of resulted materials follow the order of Cu(II)>Co(II)>Ni(II)>Zn(II).

Keyword: silica gel, modification, phosphonate, organosilane, selective adsorbent