Adsorption of Mg(II) and Ca(II) on disulfonato-silica hybrid (DSSH) in the aqueous solution has been studied. The hybrid was synthesized by sol-gel process with sodium silicate solution from rice hull ash, chloropropyltrimethoxysilane (CTS) and 4-amino-5-hydroxy-naphthalene-2,7-disulfonic acid monosodium salt (ANSNa) as silica source, cross linker and active group, respectively. Sodium silicate solution was reacted with CTS and ANSNa that were added dropwise. Adsorption of magnesium and calcium ions on DSSH was carried out in a batch system. Solution pH significantly affected magnesium and calcium adsorption and the optimum condition was obtained at pH = 6. The synthesized DSSH showed a high adsorption capacity of 0.0844 mmol/g and 0.1442 mmol/g for Mg(II) and Ca(II), respectively. The adsorption isotherm obtained with Langmuir isotherm model gives the negative values of ΔG°, i.e. -23.334 kJ/mol and -22.757 kJ/mol for Mg(II) and Ca(II), respectively, indicating the spontaneous process of adsorption. Kinetic studies showed that the adsorption of Mg(II) and Ca(II) ions onto DSSH follows the pseudo-second-order kinetics.

**Keywords**: adsorption; silica; magnesium; calcium; sulfonate

### ABSTRAK

Adsorpsi Mg(II) dan Ca(II) pada hibrida disulfonato-silica (DSSH) dalam larutan telah dipelajari. Hibrida disintesis melalui proses sol-gel dengan natrium silikat dari abu sekam padi, kloropropiltrimetoksilane (CTS), dan garam mononatrium asam 4-amino-5-hidroksi,2-7-naftalenadisulfonat (ANSNa) berturut-turut sebagai sumber silika, pengait silang, dan gugus aktif. Larutan natrium silikat yang diperoleh dari abu sekam padi direaksikan dengan natrium hidroksida, kemudian ditambahkan CTS dan ANSNa secara bertetes-tetes. Adsorpsi magnesium dan kalsium pada DSSH diuji menggunakan sistem batch. Nilai pH larutan secara nyata berpengaruh terhadap adsorpsi Mg(II) dan Ca(II) dan kondisi optimum diperoleh pada pH = 6. DSSH hasil sintesis memperlihatkan kapasitas adsorpsi yang tinggi yaitu sebesar 0,0844 mmol/g dan 0,1442 mmol/g berturut-turut untuk Mg(II) dan Ca(II). Isoterm adsorpsi diperoleh dengan model Langmuir memberikan nilai ΔG negatif, yaitu -23,334 kJ/mol untuk Mg(II) dan Ca(II), dan -22,757 kJ/mol untuk Ca(II), yang menunjukkan adsorpsi berlangsung spontan. Dari kajian kinetika ditunjukkan bahwa adsorpsi ion Mg(II) dan Ca(II) mengikuti kinetika pseudo orde-kedua.

**Kata Kunci**: adsorpsi; magnesium; kalsium, silika, sulfonat

### INTRODUCTION

Recent studies of adsorption have demonstrated that solid substrate of silica materials is able to adsorb Mg ion from industrial effluents, natural water, and sea water [1]. Adsorption of magnesium and calcium ions is rarely studied, because these ions are not the common and toxic pollutants released into the natural waters from various industrial activities. Nevertheless, these ions can increase the hardness of water [2].

The investigation of adsorbent has been focused on synthesis and application. Sulfonato silica can be formed by grafting method [3-4]. Researches about sol-gel method besides the grafting one have been reported, i.e. preparing sulphonated-silica (ormosil) hydrogels [5], polyacrylate silica nanocomposite [6], and the hexagonal mesoporous silica modified with 2-mercaptopthiazoline [7]. The sol-gel method has special quality, because the formation of bonding at sol process. Therefore, in this study the formation of sulfonato silica was done using sol-gel method.

Nevertheless, sulfonic functionalized silica was obtained by bonding thiol group and then was oxidation by hydrogen peroxide. The sulfonic acid functionalized silica can be used as an efficient heterogeneous catalyst for a three-component synthesis of...