Adsorption of Benzene and Borderline / Group B Heavy Metals by Poly (butadiene-co-acrylic acid) Gel

Kyushu Univ.: Brian Adala Omondi, Hirotaka Okabe, Yoshiki Hidaka, Kazuhiro Hara

E-mail: brio254@athena.ap.kyushu-u.ac.jp

Introduction

Heavy metals of toxicological and deleterious effects to human body system refers to the borderline and the class B elements with a density greater than 5 g cm^{-3} of water[1]. The main sources that contribute more to the diffuse contamination of heavy metals into water bodies are the natural, industrial and agricultural activities. To remediate against these pollutants, various functional materials have been proposed. Gels are versatile in applicability, they can swell and increase their surface area of adsorption, are responsive to various stimuli such as pH and temperature and are easy to synthesize. Present study explores the synthesis, application and re-usability of poly (butadiene-co-acrylic acid) gel as a potential adsorbent for both heavy metals and mono-aromatic compounds from aqueous solution.

Experimental

Into 60% aqueous solution of acetone in glass beaker, butadiene (0.571 ml) and acrylic acid (0.294 ml) monomers were added in a 4:3 w/w ratio, respectively to make 10 ml solution. Then *N,N'* –methylene-bisacrylamide (0.06g) and *N,N,N'N'* – tetramethylenediamine (30 µl for 10ml) were added followed by 0.02g of ammonium persulfate to initiate gelation. The solution mixture was thereafter stirred and incubated at 40℃ for 24 hours. After completion of the gelation reaction, the resultant gel was washed-out to remove any unreacted ingredients. The gel was then characterized by FT/IR and NMR spectroscopy, treated in acidic solution and applied against aqueous benzene and the multi-element ion solution (Fluka, Sigma-Aldrich) diluted 100 times; for the removal of heavy metals.

Results and Discussion

Poly (butadiene-co-acrylic acid) gel was successfully synthesized using solution radical polymerization. NMR and FT/IR characterization led to the identification of the COOH and the -C=C- active groups responsible for the adsorption of both organic and inorganic toxic adsorbates simultaneously. Following treatment of the gel surface with mild protic acid, the gel successfully adsorbed benzene's aromatic ring onto its surface, with an adsorption capacity of 2.81 mg/g within 360 minutes. As seen in Table I, this was the fastest equilibrium time and with a favourable degree of sorption among the common adsorbents used for aromatic compounds adsorption.

Table I Equilibrium time and adsorption capacities *q* of benzene by various adsorbents.

Material	*q* (mg/g)	t (min)
Poly (butadiene-co-acrylic acid) gel	2.81	360
Surfactant-modified montmorillonite	3.47	1440
Surfactant-modified zeolite (NSMZ #2)	1.19	1000
Activated carbon	4.76	4320

Metal adsorption was a function of relative abundance, ion charge and pH of the solution. Iron, which had the highest relative abundance in the initial stock solution, was the most heavily extracted metal by the gel leading to more than 50% extraction with an adsorption capacity, q = 13.6 µg/g as seen in Fig. 1. Where initial concentration was the same, competitive adsorption was influenced by the charge of the ion. Considering B^{3+}, Zn^{2+} and $Cu^{1+/2+}$ ions, copper was the most extracted ion, followed by zinc and boron, with q = 4.79 µg/g, 2.62 µg/g and 1.99 µg/g respectively. This is because one B^{3+} consumes three COO^- active sites of the gel whereas Zn^{2+} and $Cu^{1+/2+}$ required only two and/or one, respectively.

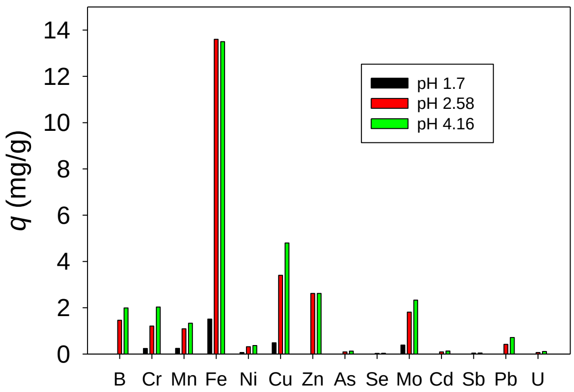

Fig. 1 Adsorption capacities of various metals as a function of pH.

Adsorption capacity also increased with increasing pH of the metal ion solution, with optimum sorption occurring at pH 4.1 and least at original pH 1.7.

Acknowledgment

JSPS KAKENHI Grant Number 21656239, 24360398, supported this work.

Reference

1. M. H. Martin, Biological Monitoring of Heavy Metal *Pollution: Land and Air*. Springer Science & Business Media, 2012