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Preparation, characterization and ion-exchange properties of an organic-inorganic composite cation exchanger: Polyaniline-Bi(III) iodovanadate

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ABSTRACT

Polyaniline based composite cation exchange materials have been used in industrial application for more than hundred years. The organic-inorganic composite cation exchanger was prepared by using sol-gel process. The organic polymer part furnishes the good chemical and mechanical properties, whereas the inorganic part improve the ion-exchange behavior and thermal stability. A new and novel polyaniline-Bi(III) iodovanadate composite cation exchanger prepared by using sol-gel process and was characterized by FT-IR, XRD, SEM-EDS studies. The ion exchange capacity, effect of size and charge of metal ion, eluent concentration, effect of time on IEC and elution behavior was also studied by column method. Polyaniline-Bi(III) iodovanadate composite exhibit ion exchange capacity for Na^+ ion is 1.48 meq/g.

Keywords: Ion exchange capacity, sol-gel process, elution behavior, Thermal stability.

1. INTRODUCTION

Polyaniline has become one of the most interesting organic conducting polymer due to its high chemical and environmental stability, easy to synthesis in laboratory, feasibility of electrical conductivity and low cost of aniline monomer[1-3]. Literature survey reported that many ion exchange composite cation exchanger used for the separation of some toxic metal ions and dyes from the environment. New organic-inorganic conducting polymer composite cation exchanger developed by incorporation of organic polymer into the inorganic hetero polyacid moiety[4]. The obtained material is especially used in electrical, optical and magnectic properties of organic-inorganic polymer composite material. Polymer based composite cation exchanger have enormous applications such as ion selective electrode, photocatalyst, antimicrobial, sensors, enivironmental remediation etc. This paper deals with preparation, characterization, ion exchange studies and chemical stability of newly fabricated polyaniline-Bi(III) iodovanadate composite cation exchanger. The structural analysis of polyaniline-Bi(III) iodovanadate composite was done by FT-IR, XRD and SEM-EDS studies.

2. Experiment

2.1. Reagents and Instrument

The reagents used for the preparation were analytical grade and used without any further purification. FT-IR spectra was recorded on a JACSO-4100 FT-IR Spctrometer. X-ray diffraction pattern was also recorded by using analytical system Shimadzu XRD-6000 model and the spectrum was recorded $10^0 - 90^0$ using Cu-Kα radiation. The surface morphology and elemental composition was determined by using scanning electron microscope JSM-6390Lv energy dispersive X-ray detector

2.2. Preparation of polyaniline-Bi(III) iodovanadate cation exchanger

Polyaniline gel was prepared by 0.2M solution of aniline and potassium persulphate in 1M hydrochloric acid[5] with constant stirring. Bi(III) iodovanadate inorganic ion exchanger was prepared by mixing 1:2:3 volume ratio of 0.2M solution of bismuth nitrate, potassium iodate and sodium meta vanadate. The mixture of solution was adjusted to pH=1 by using 1M HNO_3 and the precipitate was sitirred for 1 hour[6]. The gel of polyaniline was mixed with inorganic precipitate of Bi(III) iodovanadate and the mixture was stirred thoroughly using magnetic stirrer. The green coloured gel was kept for one day. The gel was filtered and dried it in oven at 50^0C. The dried product of composite cation exchanger crushed and the product is converted into H^+ form by using 1M HNO_3 with occasional shaking for one day. The product is filtered and dried at 50^0C. The H^+ form of polyaniline-Bi(III) iodovanadate is used for ion exchange and chemical stability studies.

2.3. Ion exchange capacity

The ion exchange capacity of dry H^+ form of polyaniline-Bi(III) iodovanadate was determined by column process using 0.1M NaCl as eluent. The liberated H^+ ion was determined titrimetrically against NaOH solution by using phenolphthalein indicator and IEC was calculated by using formula,

$$IEC = (N * V) / W meq/g$$

Where, N and V is the normality and volume of NaOH respectively and W is the weight in gram.

2.4. Chemical stability

To find out extent of dissolution of composite cation exchange material, chemical stability wasstudied in different organic and inorganic solvents. 250mg of H^+ form of polyaniline-Bi(III) iodovanadate mixed with 25mL of different solvents and kept for 24 hours. After 24 hours the composite material was filtered and dried. The stability of composite cation exchanger was determined by change in colour and weight of composite cation exchanger.

3. RESULTS AND DISCUSSION

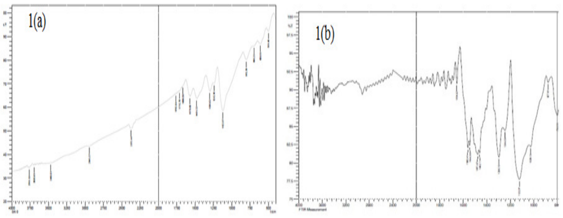

Figure – 1(a): FT-IR spectrum of Polyaniline; (b). FT-IR spectrum of Polyaniline-Bi(III) iodovanadate.

The incorporation of organic polymer polyaniline into the inorganic marix of Bi(III) iodovanadate confirmed by carrying out FT-IR spectral studies. The characteristic peaks of polyaniline and Bi(III) iodovanadate were observed in the FT-IR spectrum of polyaniline-Bi(III) iodovanadate composite shown in figure1b. The FT-IR peak observed at 3400 cm^{-1} is due to the –OH stretching vibrations. The benzenoid and quinoid stretching frequency obtained at 1477 cm^{-1} and 1560 cm^{-1}[7]. Peaks at 1270 cm^{-1} and 1654cm^{-1} assigned to –CN- stretching and –NH bending vibration in neihbouring quinoid ring[8]. The characteristic bands at 878, 784 and 671 cm^{-1} may be assigned to M-O stretching[9].

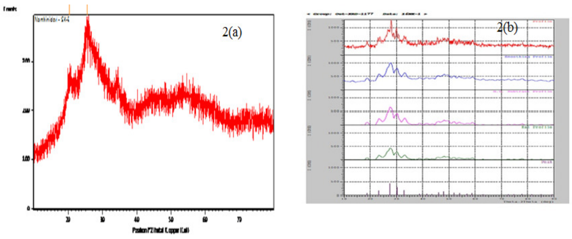

Figure - 2(a): XRD pattern for polyaniline; (b) XRD pattern for polyaniline-Bi(III) iodovanadate.

The XRD partten of polyaniline shows broad peak at 2 theta value of 25.43^0which indicate low crystallinity of the conducting polymer XRD pattern of polyaniline-Bi(III) iodovandate composite (Figure 2b) exhibit high intensity peaks at 2 theta values 26.09^o, 33.6^0 and 32.8^o. The observation in the XRD pattern of polyaniline composite shows that the composite is crystalline nature and calculated particle size is 14.96 nm.

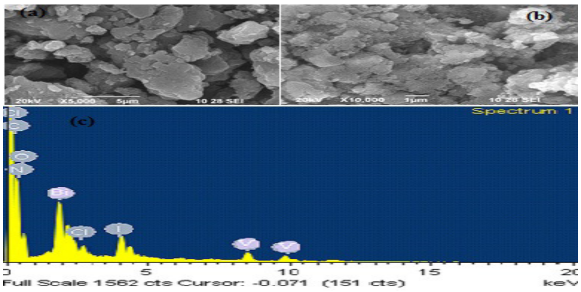

Figure - 3(a): SEM photograph for polyaniline: (b) SEM photograph for polyaniline-Bi(III) iodovandate;(c) EDS analysis for polyaniline-Bi(III) iodovanadate.

Figure 3(a) and Figure 3(b) represent SEM photographs of polyaniline and polyaniline-Bi(III) iodovanadatecomposite respectively. SEM photorgraph of polyaniline salt suggest that agglomerates randomly distributed on its surface where as polyaniline-Bi(III) iodovanadate composite have porous morphology with granular structure[10]. It is clearly evident from SEM study, inorganic ion exchanger homogeneously distributed on the surface of polyaniline. Figure 3(c) shows that presence of all the elements present in the material which shows purity of composite.

The ion exchange capacity affected by the size and charge of metal ions. Ion exchange capacity of polyaniline-Bi(III) iodovanate composite for various alkali and alkaline earth metal cations follows the order $K^+ > Na^+ > Li^+$ and

Ba^{2+}> Sr^{2+}> Mg^{2+} respectively. The ions with smaller hydrated ionic radii easily enter the pores of cation exchanger resulting in higher adsorption. Similar observation was observed by M. A. Mesalem et al., and F. C. Nachood et al., [11,12]. Elution behavior was carried out to find out the volume of eluent (NaCl) required for complete elution inH^+ion from 1g composite cation exchanger on H^+ form and represented in figure 4(b). It is clear from figure 4(b) 120 ml of Nacl is enough for complete elution of H^+ ions.

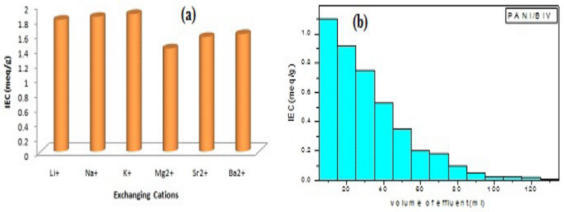

Figure - 4(a): IEC of polyaniline-Bi(III) iodovanadate composite for various metal ions; (b) Elution behavior of polyaniline-Bi(III) iodovanadate composite.

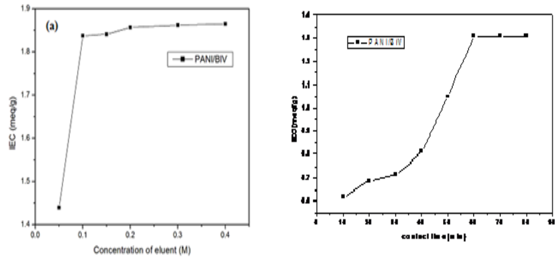

Figure – 5: Na^+IEC for polyaniline-Bi(III) iodovanadate as a function of (a) Eluent concentration; (b) Contact time.

Eluent concentration is main factor which affect the Na^+ ion exchange capacity. The minimum molar concentration of eluent was found to be 0.1 M. The effect of time on ion exchange capacity shows constant. Ion exchange capacity after 60 min.

Chemical stability study was carried out to find the stability of prepared composite cation exchanger in different solvents of intrest such as DMW, 2M HCl, H_2SO_4, NaOH, ether, 1,2-dichloroethane, cyclohexane and benzene. The polyaniline-Bi(III) iodovanadate composite was more stable in DMW, Partially stable in mineral acid and organic solvents and unstable in 2M NaOH because of dedoped form of ion exchanger.

4. CONCLUSION

In this present paper, polyaniline-Bi(III) iodovanadate composite cation exchanger have enhanced Na^+ ion exchange capacity compared to polyaniline and Bi(III) iodovanadate. The composite cation exchanger was prepared successfully by using sol-gel method. FT-IR and SEM-EDS studies confirmed that the inorganic ion exchanger incorporated into polyaniline matrix. XRD spectral studies proved that the composite cation exchanger is in nano size range and crystalline nature. Ion exchange capacity and chemical stability studies proved that the composite material act as good ion exchanger and stable in mineral acid and organic solvents. It was concluded that polyaniline-Bi(III) iodovanadate composite act as good potential for environmental remediation.

5. REFERENCES

1. X. Ding, D. Han, Z. Wang, X. Xu, L. Niu and Q. Zhang, Micelle assisted synthesis of polyaniline magnetic nanorods by in-situ self-assembly process, J.Coll.Interf.Sci., 320 (2008) 341-345.
2. B. J. Kim, S. G. Oh, M.. G. Han and S. S. Im, preparation of polyanilinenanoparticle in miceller solution as polymerization medium, Langmuir, 16 (2000) 5841-5845.
3. Y. Gao and Y. Zhou, Polyanilinenanofibers fabricated by electrochemical polymerization: a mechanistic study, Eur. Poly. J., 43 (2007) 2292-2297.
4. A. A. Khan, M. M. Alam, Inamuddin and F. Mohammed, J. Electroanal. Chem., 572 (2004)67-78.
5. X. R. Zeng and J. Man Ko, Polymer, 39 (1998) 1187-1195.
6. R. Buhra, M. Naushad, R. Adnan, Z. A. Alothman ad M. Rafathullah, Polyanilineupportednanocompositecation exchanger: synthesis, characterization and application for efficient removal of Pb^{2+} ion from aqueous medium, J. Ind. Eng. Chem, 21 (2015) 1112-1118.
7. Y. Furukawa, F. Ueda, Y. Hyodo, T. Nakajima and T. Kawagoe, Macromolecules, 21 (1988) 1297.
8. E. T. King, K. G. Neoh and K. L. Tan, Prog. Polym. Sci., 23 (1998) 277.
9. G. Socrstes, Infrared characteristics group frequencies, Wiley, NJ, (1980) 145.
10. Deepti, B. PatleWasudeo, B. Gurnule and A. B. Zade, Synthesis, characterization and ion exchange properties of a terpolymer derived from 4-hydroxybenzophenone, biuret and formaldehyde, Der. Pharma. Chemica., 3 (2011) 341-353.
11. M. A. Mesalem, Sorption Kinetics of cooper, zinc, cadmium and nickel ions in synthesized

silico-antimonate ion exchanger, Colloid surf A: Phy. Eng. Aspects, 225 (2003) 1380-1384.

12. F. C. Nachood and W. Wood, The reaction velocity of ion exchanger, J. Am. Chem. Soc., 66 (1944) 1380-1384.