Adsorption and ion exchange studies on synthetic polymeric materials

ABSTRACT

The main objective of our proposed research work is to synthesize advance class organic inorganic composite ion-exchange materials and apply these materials in analytical and electroanalytical applications. Recently, conducting and non-conducting organic inorganic composite materials are relatively new materials, extensively studied during the past two decades. Polymeric organic-inorganic ion-exchange composite materials emerged as a new field of research and development, directed to creation of new smart materials for use in modern and future applications. These applications include chemical/vapour sensor, artificial membranes for ultra- and nano-filtration, pervaporation and gas separation, absorbents for toxic compounds etc. The work is divided in six Chapters.

Chapter 1: It includes the general introduction of adsorption, ion exchange, nanocomposite materials, membrane, ion selective electrode, DC electrical conductivity of polymeric and composite materials, chemical/vapour sensing application and latest literature survey on composite ion exchange materials.

Chapter 2: It this chapter an electrically conductive Polypyrrole-Sn(IV)arsenotungstate (PPy-SnAT) nanocomposite cation exchange have been synthesized by insitu polymerization of polypyrrole with Sn(IV)arsenotungstate (SnAT). The synthesis of PPy-SnAT nanocomposite was characterized by fourier transform infra-red spectroscopy (FTIR), x-ray diffraction (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), energy-dispersive x-ray (EDX) and thermogravimetric analysis (TGA). The ion exchange capacity (IEC) and electrical conductivity of the nanocomposite was found to be 2.50 meq/g and 5.05×10⁻¹ S/cm respectively. The nanocomposite showed appreciable isothermal stability in terms of DC electrical conductivity retention under ambient condition up to 130 °C. The nanocomposite cation exchange based sensor for detection of formaldehyde and ammonia vapors were fabricated at room temperature. It was revealed that the resistivity of the nanocomposite
increases on exposure to higher percent concentration of ammonia and lower concentration of formaldehyde at room temperature (25 °C).

Chapter 3: In this chapter Polypyrrrole-Sn(IV)arsenotungstatecomposite cation exchanger membrane was prepared by solution casting method of polypyrrrole in the presence of Sn(II)arsenotungstate gel and polyvinyl chloride (PVC) as a binder. The formation of Polypyrrrole-Sn(IV)arsenotungstate composite cation exchanger membrane was characterized by Fourier Transform Infra-Red spectroscopy (FTIR), X-ray diffraction (XRD), thermogravimetric analysis (TGA), Scanning electron microscopy (SEM) and Energy dispersive X-ray (EDX). The membrane having a composition of 4.5:1 (composite:PVC) shows best results for water content, porosity, thickness and swelling. Our studies show that the present ion selective membrane electrode is selective for Ba(II) metal, having detection limit (1×10^{-9} M to 1×10^{-1} M), response time (35s) and working pH range (3-5). The selectivity coefficient values for interfering ions indicate good selectivity for Ba(II) over interfering anions. The analytical utility of this electrode was established by employing it as an indicator electrode in potentiometric titration.

Chapter 4: In this chapter a newly synthesized Polycarbazole-Sn(IV)arsenotungstate (Pcz-SnAT) nanocomposite cation exchanger membrane was prepared by solution casting method using Polycarbazole-Sn(IV)arsenotungstate and polyvinyl chloride (PVC) as a binder. The synthesis of Pcz-SnAT membrane was confirmed by characterization using various instrumentation techniques like Fourier Transform Infra-Red spectroscopy (FTIR), X-ray diffraction (XRD), thermogravimetric analysis (TGA), Scanning electron microscopy (SEM) and Energy dispersive X-ray (EDX). The membrane having a composition of 4.5:1 (composite:PVC) showed best results for water content, porosity, thickness and swelling. Our studies show that the present ion selective membrane electrode is selective for Pb(II) metal, having detection limit (1×10^{-7} M to 1×10^{-1} M), response time (20s) and working pH range (3-7). The ion exchange mechanism through Pcz-SnAT membrane was determined by kinetic studies using Nernst-Planck equation at 40 °C, 60 °C and 80 °C. As a result, physical parameters such as self-diffusion coefficient (D_0), energy of activation (E_a) and entropy of activation (ΔS^0) were calculated. The analytical utility of this electrode was established by employing it as an indicator electrode in potentiometric titration.
Chapter 5: The objective of the present study was to assess the suitability and efficiency of synthesized poly(aniline-co-pyrrole)-Sn(IV)tungstoarsenate ((PA-co-Ppy)-STA) nanocomposite for the removal of Ni(II) from aqueous solution. Nanocomposite cation exchanger membrane was prepared by solution casting method using poly(aniline-co-pyrrole)-Sn(IV)tungstoarsenate and polyvinyl chloride (PVC) as a binder. The synthesis of membrane was confirmed by characterization of the nanocomposite membrane by various instrumentation techniques like SEM, EDX, FTIR, XRD, TGA. The experimental equilibrium data were tested by various potentiometric studies like Calibration curve, Transport no., Effect of pH, Response time, Potentiometric titration studies. The experimental data was best followed by selective for Ni(II) metal, having detection limit (1×10^{-9} M to 1×10^{-1} M), response time (35s) and working pH range (5-8). The analytical utility of this electrode was established by employing it as an indicator electrode in potentiometric titration. Various experimental parameter studies proved the absorption of Ni(II) on nanocomposite. Therefore, the present nanocomposite could be applied to purify metal contained wastewater.

Chapter 6: In this chapter the adsorption behavior of polypyrrole-Sn(IV)arsenotungstate (Ppy-SnAT) nanocomposite was explored for the removal of Pb(II) from aqueous solution. The nanocomposite was characterized using SEM, TEM, FTIR, XRD and TGA analysis. The batch experimental method was employed for various parameters such as pH, contact time, initial metal ion concentration, dose and temperature. The maximum adsorption (84%) was observed at pH 6, contact time 240 min and dose 0.01 g, respectively. Adsorption data were evaluated using various isotherm models, and the experimental data were best fitted to the Freundlich isotherm model. The kinetic data were best suited for pseudo-second order kinetic model. The adsorption process was found to be exothermic in nature with decreased randomness at solid/liquid interface. The findings suggest that the present nanocomposite can be use as a potential adsorbent for the removal of heavy metal from aqueous solution.