Adsorbent Materials for the Effective Removal of Cadmium-II from Aqueous Solutions

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Introduction

The variety and quantity of wastes that are released into the environment are the primary drawbacks of industrialization. Heavy metals are one of the most dangerous types of inorganic pollutants because they cannot be broken down by living things. For the removal of heavy metals, porous activated carbons, zeolites, bio-adsorbent materials and carbon nanotubes are frequently utilized as adsorbents. These materials, on the other hand, have limited practical applications due to their low adsorption capacities, low efficiency, or high cost. Metal-organic frameworks (MOFs) and coordination networks (CNs) have received more attention in recent years due to the rapid development of new materials. Most MOFs are made from metal organic carboxylic derivatives from metal ion nodes that are linked by organic linkers to form 1D chains, 2D layers and micro pore filled 3D crystal structures. Among the CNs material families, phosphate coordination networks are rapidly gaining importance. It is recommended to select CNs that is stable in water media to increase their adsorption capacity across a wide pH range. The main advantages of MOFs and CNs in adsorption processes over other adsorbent materials are their large specific surface area, well-organized unique structures and stable, uniformly sized pores. Sure, MOFs have high absorbance capacities for a wide range of species, including dyes, drugs and heavy metals from wastewater.

Description

Metal plating, the production of iron and steel, mining and the production and use of phosphate fertilizer are just a few of the many sources of cadmium contamination. It can be harmful to human health and the environment even at low doses. For the purpose of treating wastewaters that contain heavy metals, numerous treatment techniques, such as ion exchange, precipitation, filtration, oxidation-reduction, membrane separation and adsorption, have been developed. The most prudent, plausible and specific strategy for weighty metal expulsion from fluid arrangements is the adsorption method. In order to use hazardous metal adsorbents, researchers are concentrating on the creation of new, more effective adsorbent materials made of natural materials or highly selective synthetic systems. Because they are non-biodegradable and tend to accumulate in the environment, heavy metal ions are extremely toxic to living organisms even in low concentrations. The removal of cadmium ions from aqueous solutions through adsorption onto MOF materials has only been reported in a small number of studies to the best of our knowledge. These studies used composites like cyclodextrin metal-organic framework-based nonporous carbon and MOF loaded onto iron oxide nanoparticles. The arrangement of these materials includes the utilization of more noteworthy

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amounts of reagents and numerous readiness steps, which lead to an increment of the creation costs [1-3].

In order to remove cadmium ions from aqueous solutions, two nickel-cobalt coordination networks were utilized as adsorbent materials in this study. The techniques of thermal gravimetric analysis (TGA), Fourier-transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and FTIR were used to investigate the structure, morphology and properties of the materials. In order to better predict and comprehend some of these compounds' unique properties, we conducted PM3 semi empirical structural property analyses in light of these adsorption properties. As a result, octahedral models were developed for networks containing N-bis (phosphonomethyl) glycine in addition to Ni^{2+} and Co^{2+} ions. The central metal ions Ni and Co coordination networks' partial charges, torsion angles and bond lengths/angles are compared. Using the same S, additional experiments were carried out to investigate the effect of contact time on adsorption: L ratio, the same concentration of Cd in solution, an initial pH of 5 but different contact times (15–120 minutes) at 25 °C for the suspension. The suspensions were filtered after the contact time expired and the liquid was collected for cadmium concentration analysis. The adsorbent mechanism and pseudo-first and second order kinetic models were used to estimate the adsorption rate constants. Using the same S, it was determined how the initial concentration of Cd(II) ions affected the adsorption capacities of Co–Gly and Ni–Gly L ratio at various initial concentrations (ranging from: 5–300 mg/L). The experimental adsorption data were correlated using the Langmuir freundlich and redlich-Peterson non-linearized isotherm models. As a function of pH, contact time and the initial concentration of cadmium, their adsorption capacities have been investigated [4].

For the purpose of recovering Cd ions from the surface of the studied CNs, a S: was used in conjunction with HCl solution 0.2 M with an initial pH. The samples were mixed for 15 minutes at a ratio of 1 g/L. The phases were separated following the regeneration process and the extracted Cd ions from the solution were determined using recycled adsorbent in another adsorption process. Five cycles of the adsorption-desorption process were carried out with the materials. For the purpose of removing Cd (II) ions from aqueous solutions, CNs was used as adsorbent materials in this study. Compared to other materials that have been reported in the specialty literature the current investigations demonstrated that the studied CNs have a high affinity for the removal of Cd (II) ions from aqueous solution. It was determined that a pseudo-second-order kinetic model defines the adsorption of Cd (II) ions on the studied material by applying appropriate kinetic models to the experimental data [5].

Conclusion

The equilibrium sorption data were modelled using Langmuir, Freundlich and Redlich-Peterson isotherms. The first one was the best fit to the experimental data, resulting in maximum adsorption capacities of 51.5 mg/g for Co–Gly and 58.1 mg/g for Ni–Gly, respectively. The electrostatic attraction between Ni–Gly and the positively charged heavy metal ions (Cd^{2+}) increases as a result of the higher specific surface area and pore volume of Ni–Gly and the higher negative partial charges of Ni in the network revealed by PM3 semi empirical computations. The primary factor that increases Ni–Gly's adsorption capacity is this discovery. As a result, as demonstrated by both experimental and theoretical approaches, Ni–Gly is the adsorbent material with a greater capacity for adsorption.

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