Nitrilotris(methyleneephosphonic) acid as a complexing agent in sorption of heavy metal ions on ion exchangers

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HIGHLIGHTS

- Different ion exchangers were used in removal of heavy metals from solutions.
- The different factors affecting the metal ions loading in the presence of NTMP.
- The pH, contact time and system composition were studied.

ARTICLE INFO

Article history:
Received 3 August 2012
Received in revised form 28 October 2012
Accepted 29 October 2012
Available online 7 November 2012

Keywords:
Adsorption
Chemical processes
NTMP
Heavy metal
Ion exchangers

ABSTRACT

In this work the strongly basic anion exchanger Amberlite IRA 402, the weakly basic anion exchangers Purolite A 100 and Purolite A 103 as well as the chelating ion exchangers Purolite S 920 and Purolite S 930 were used to investigate the influence of phase contact time, pH and metal(II) concentration on the sorption of the heavy metal complexes of Cd(II), Pb(II), Cu(II) and Zn(II) with nitrilotris(methyleneephosphonic acid), NTMP. These types of complexes are often found in industry where NTMP is used. The studies were carried out in the M(II):NTMP = 1:2 system. The sorption capacity of the studied ion exchangers increases with the increase of the initial M(II) ions concentration and the sorbate/ion exchanger ratio. It was found that sorption capacity increases with the increasing temperature and initial pH of metal solution. Equilibrium sorption tests show that chelating ion exchangers as well as the strongly basic anion exchanger have a larger capacity and affinity for sorption of Cd(II), Pb(II), Cu(II) and Zn(II) complexes with NTMP than weakly basic anion exchangers. It was found that the Langmuir and Hill models were more representative to describe complexes sorption than the Freundlich, and Dubinin–Radushkevich ones whereas the kinetic process followed the pseudo second-order pattern.

1. Introduction

In recent years the organic chemicals possessing phosphonates functional groups, among them, phosphonates-based chelating agents are of great interest. They are often structure analogues of aminopolycarboxylates for example: NTA (nitrilotriacetic acids) and NTMP (nitrilotris(methyleneephosphonic) acid, EDTA (ethylenediaminetetraacetic acid) and EDTMP (1,2-diaminoethanetetras(methyleneephosphonic acid), or DTPA (diethylenetriaminepentaacetic acid) and DTPMP (diethylenetriaminepentakis(methyleneephosphonic acid). They are used in a growing number of applications to prevent formation of precipitates, to depress metal ions activity and to increase the total dissolved metal ion concentrations. In many of these applications their molecular charge, protonation level, ability to bind metal ions are significantly important [1,2]. Moreover, they can form stable and water soluble complexes with metal ions as.

hybrid inorganic–organic materials useful for intercalation, catalysis, sorption and ion exchange. Therefore phosphonates can be also applied for chemical water treatment, oil drilling, formulation of detergents and corrosion control [3–7]. For example, many water treatment chemical formulations contain NTMP as an important ingredient owing to the following advantages:

- Multifunctional performance from a single raw material.
- Superior cost/performance in scale inhibition.
- Synergistic performance from formulated mixtures.

Phosphonates are used in both consumer and institutional laundry detergents applications. In consumer laundry products they perform special functions such as stain removal, bleaching stabilization and anti-encrustation. They find use as co-builders, synergistic boosters for stain removal in combination with phosphonates and anti-encrustation additives. During their use in the above-mentioned fields of industry, the synthetic phosphonate chelating agents are brought into contact with toxic metal ions. Therefore