以離子交換程序處理含多成分重金屬離子及螯合物混合廢水反應行為之研究

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摘 要

本研究旨在探討以離子交換程序處理含單成分及多成分之螯合重金屬溶液之反應行為，針對不同的反應條件（平衡時間、轉速、樹脂種類、樹脂劑量、水溶液之pH值、重金屬初始濃度、溶液溫度、混合重金屬初始濃度、混合重金屬與螯合劑種類、混合重金屬與螯合劑濃度比、混合螯合劑）進行探討，以了解以瞭解污染物去除效率、分離能力與反應行為之影響，並建立螯合重金屬於水溶液中之成份分佈型態模擬、平衡交換動力模式，作為未來應用研究之參考。 以離子交換程序（IRA910 Cl-樹脂）處理含單一螯合重金屬溶液進行瓶杯平衡實驗時，發現除了pH2時在任何溫度下，無法達到有效吸附，其餘條件皆符合Langmuir equation，大致上隨pH增加其最大飽和吸附量以pH10可達到一定趨勢。發現在不同溫度下隨著重金屬初始濃度增加其平衡交換吸附量也成正比增加。改變操作溫度對樹脂交換的結果以溫度高時平衡交換量最大。經由ΔHapp、ΔGapp、ΔSapp計算得知交換平衡為一吸熱反應且為自發過程。 以離子交換程序（IRA910 Cl-樹脂）處理含單一螯合重金屬溶液進行批次動力實驗時，發現各螯合重金屬系統之成分分佈模擬得知可合理預估不同溶液pH值下之吸附動力行為。模擬結果發現Oxalic Acid在pH中幾乎只有單一物種，無模擬意義外，並須考慮螯合重金屬溶液之沉澱反應，以免模擬誤差增大。模擬結果發現圖形之趨勢會因螯合劑不同而異，與重金屬種類並無直接關係，模擬結果以NTA模擬誤差較大，EDTA及Citric Acid模擬效果良好。利用交換平衡動力模式在各系統中以pH8.0時，大致上正向反應速率大於逆向反應速率，且在各系統中發現以螯合銅其反應速率最快。 以離子交換程序處理含混合螯合重金屬溶液進行瓶杯平衡實驗時，樹脂種類以PA312、IRA910、WA30等三種樹脂其重金屬去除效率及選擇性較佳，樹脂劑量增加對重金屬去除效率則無一定趨勢，大體上隨著混合重金屬初始濃度增加其重金屬去除效率隨之增加。螯合劑種類對重金屬去除率優劣則以Citric Acid最佳、NTA效果最差，大致上螯合劑濃度增加對重金屬去除無明顯助益。隨著混合螯合劑種類不同，還是以單純螯合劑其重金屬去除能力較佳。在各實驗因子中發現選擇性以銅離子較容易達到分離效果，而鎳、鋅金屬分離較差。 以離子交換程序（WA30 Cl-樹脂）處理含混合螯合重金屬溶液進行批次動力實驗，可發現隨轉速增加其反應速率幾乎無任何變化，隨樹脂劑量增加其反應速率亦隨之增加，隨混合重金屬初始濃度增加其反應速率之減少。混合重金屬與螯合劑種類之反應速率以Oxalic Acid最佳、混合重金屬與螯合劑濃度比反應速率以濃度比1：2最佳。混合螯合劑其去除能力普遍較差，因此添加多種螯合劑對整體反應行為並無明顯幫助。WA30Cl-樹脂對於混合螯合重金屬溶液去除效果較差，推測原因可能樹脂受到多種離子之競爭吸附行為，導致整體反應受到影響。

關鍵詞 : 離子交換程序,螯合重金屬廢水,選擇性,成分分佈模擬,平衡交換動力模式

目錄

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