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响应面法优化MAP沉淀去除回收尿液中磷的研究

Optimization of phosphate recovery by magnesium ammonium phosphate (MAP) precipitation from synthetic urine using response surface methodology

关键词: [磷回收](#) [磷酸铵镁\(MAP\)](#) [尿液](#) [响应面法](#) [钙](#)

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摘要: 基于模拟尿液的组成特点,利用Box-Behnken Design实验及响应面法对磷酸铵镁(MAP)沉淀去除回收尿液磷过程中反应pH值、 Mg^{2+} 与 PO_4^{3-} 物质的量比(Mg/P比)及 Ca^{2+} 与 PO_4^{3-} 物质的量比(Ca/P比)3个重要影响因素(分别表示为 X_1 、 X_2 、 X_3)及各因素之间的交互式影响进行考察,并利用SEM、FTIR、ICP和XRD表征手段分析结晶沉淀组成和晶形特征.实验结果表明,回归方程中 X_1 、 X_2 、 X_3 、 X_1X_3 、 X_2X_3 、 X_1^2 、 X_2^2 、 X_3^2 对磷去除率影响显著;当反应pH值和Mg/P比范围分别在8.5~9.5和1.0~1.2之间时,磷去除率响应值能达到99%.产物表征结果表明,模拟尿液中 K^+ 和 Na^+ 对结晶干扰较小;当 Ca^{2+} 的浓度相对较低(Ca/P比小于0.25)时,沉淀中MAP的纯度高于85%,晶体形状大部分为斜方形;当 Ca^{2+} 的浓度相对较高(Ca/P比大于0.25)时,沉淀中的MAP下降明显,晶体形状开始不规则,杂质增多;当模拟尿液中Ca/P比为0.5时,MAP纯度仅有约70%.

Abstract. Based on the characteristic of urine composition, magnesium ammonium phosphate (MAP) precipitation was utilized to recover phosphate from synthetic urine, and the linear, quadratic and interaction factor effects of reacting pH value, $Mg^{2+}:PO_4^{3-}$ molar ratio and $Ca^{2+}:PO_4^{3-}$ molar ratio (denoted as X_1 , X_2 , X_3 , respectively) in urine were investigated by Box-Behnken Design experiments and response surface methodology. The precipitates were characterized with scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FTIR), Inductive Coupled Plasma Emission Spectrometer (ICP) and X-ray diffraction (XRD). The results showed that X_1 , X_2 , X_3 , X_1X_3 , X_2X_3 , X_1^2 , X_2^2 , X_3^2 had significant effects on phosphate removal efficiency. Phosphate removal efficiency could reach up to 99% at the reacting pH value of 8.5~9.5 and $Mg^{2+}:PO_4^{3-}$ molar ratio of 1.0~1.2. K^+ and Na^+ in urine had a little influence on MAP precipitates. When $Ca^{2+}:PO_4^{3-}$ molar ratio was below 0.25, the purity of MAP exceeded 85% and the MAP crystals had an orthorhombic structure; as $Ca^{2+}:PO_4^{3-}$ molar ratio was above 0.25, the crystals became irregular and the impurity increased. When $Ca^{2+}:PO_4^{3-}$ molar ratio reached 0.5, the purity of MAP was only about 70%.

Key words: [phosphate recovery](#) [magnesium ammonium phosphate \(MAP\)](#) [urine](#) [response surface methodology \(RSM\)](#) [calcium](#)

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