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Combination of struvite pyrolysate recycling with mixed-base technology for removing ammonium from fertilizer wastewater

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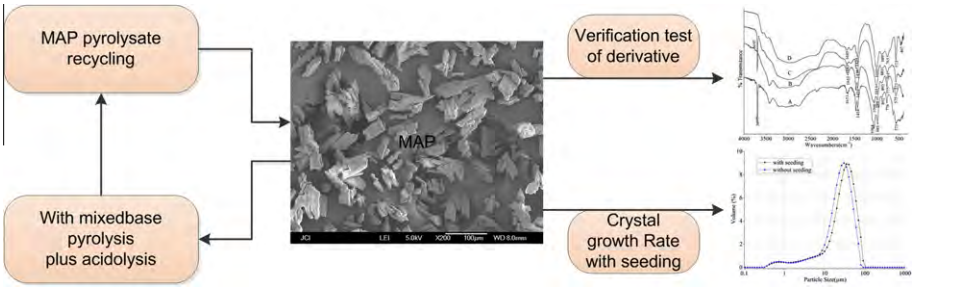
HIGHLIGHTS

- MAP pyrolysis was studied with mixed-base addition.
- An acidolysis step to release magnesium and phosphate ions was studied.
- The MAP pyrolysate and its derivatives were experimentally verified.
- The crystal growth rate of MAP, with seeding, was calculated to be 17.6%.

GRAPHICAL ABSTRACT



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ABSTRACT

Removal of ammonium from wastewater via struvite (MAP) pyrolysate recycling combined with a mixed-base $NaOH/Mg(OH)_2$ technology was investigated, and the phosphate and magnesium concentration in the supernatant were measured. The optimal parameters for acidolysis were a pH of 1; temperature of 120 °C and time of 2 h. The presence of derivatives of amorphous magnesium hydrogen phosphate ($MgHPO_4$), namely magnesium phosphate ($Mg_3(PO_4)_2$) and magnesium pyrophosphate ($Mg_2P_2O_7$) were verified by experiment. The ammonium removal ratio in this combined mixed-base technology was 96.8% in the first cycle, 80.6% in the second, and 81.0% after acidolysis. The phosphate and magnesium ions concentration in the supernatant were about 1 mg/L and 40 mg/L, respectively. The grain size of MAP was 1.52 nm without seeding and 1.79 nm with seeding, and the growth rate of MAP was 17.6%.

1. Introduction

Ammonium is a toxic chemical that has become a major environmental pollutant (Değermenci et al., 2012; Hung et al., 2003). The recovery and removal of ammonia nitrogen from wastewater can be accomplished by, either alone or in combination, biological, physical, or chemical methods (Xiaoyao Tan et al., 2006; Calli et al., 2005; Bonmati and Floatats, 2003; Jeong and Hwang, 2005). As one of the resource recycling method for the removal of high concentrations of ammonia nitrogen and phosphorus from wastewater, struvite precipitation has been extensively studied (Zhang et al., 2009; Stefanowicz et al., 1992; Türker and Celen, 2007).

Zhang et al. (2009) reported that the ammonia nitrogen release ratio was more than 90% with a NaOH solution during MAP pyrolysis at an OH^- to ammonium molar ratio of 2:1, heating temperature of 110 °C, and heating time of 3 h. He et al. (2007) found that magnesium sodium phosphate ($MgNaPO_4$) was formed during MAP decomposition with NaOH, and ammonium removal was initially 84%. However, the ammonia nitrogen recovery ratio in wastewater declined steadily with increasing numbers of cycles, from 92% in the first cycle to 77% in the fifth (Türker and Celen, 2007). Zhang et al. (2009) reported that the supplementation of $MgCl_2{\cdot}6H_2O$ plus $Na_2HPO_4{\cdot}12H_2O$ in each cycle made up for the losses of magnesium and phosphate in successive cycles.

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