Title: Atmosphere-Controlled Thermal Decomposition of Magnesium Ammonium Phosphate Hexahydrate Without Ammonia Loss for Fertilizer Recovery and Transport

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The thermal decomposition of magnesium ammonium phosphate hexahydrate (MAP), a fertilizer recovered from wastewater, was investigated to identify reaction conditions that prevent ammonia loss. Crystalline water accounts for over 40% of the total mass of MAP, increasing transportation costs without contributing to its fertilizing value. Although heating effectively removes this crystalline water, it leads to the simultaneous loss of ammonia, an essential fertilizer component. To address this limitation, novel heating conditions were explored to dehydrate MAP while retaining ammonia by controlling the reaction atmosphere. Samples were heated using a self-designed apparatus under controlled partial pressures of water vapor and ammonia, and the products were characterized by powder X-ray diffraction and quantitative ammonia analysis. In dry air, thermal decomposition proceeded through the inward movement of the reaction interface from the particle surface, producing amorphous magnesium hydrogen phosphate and resulting in the loss of more than 75% of the ammonia content. In contrast, under sufficiently high partial pressures of water vapor, ammonia, or a mixture of both, thermal dehydration occurred with the removal of five water molecules from MAP, forming crystalline magnesium ammonium phosphate monohydrate (dittmarite) while retaining more than 95% of the ammonia content. These findings demonstrate that atmosphere-controlled heating enables effective dehydration of MAP, achieving a mass reduction of up to 36.7% without ammonia loss. These findings highlight the potential of the proposed approach in substantially reducing transportation costs and promoting the widespread utilization of recovered MAP as a fertilizer.