論 文 の 要 旨

題目 Application of hydrogel for plant cultivation in contaminated soil

（汚染土壌における植物栽培へのハイドロゲルの応用）

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In the current society, due to the rapid advancement of agriculture and industry, the excessive buildup of heavy metal ions, particularly cadmium, in the soil poses a severe threat to plant growth environments. The highly toxic nature of cadmium heavy metal negatively impacts plant absorption and growth, with potential repercussions on human health through the food chain. Consequently, effectively tackling the issue of cadmium ion pollution in soil has become an urgent concern within the environmental science field.

We successfully synthesized DMAPAA (N-(3- (Dimethyl amino) propyl) acrylamide)/DMAPAAQ (N, N-Dimethyl amino propyl acrylamide, methyl chloride quaternary) hydrogels via free radical polymerization and assessed their capacity to capture cadmium under various cadmium ion concentrations and pH values using inductively coupled plasma emission spectroscopy (ICP). Findings reveal that under pH 7.3 conditions, DMAPAA/DMAPAAQ hydrogels demonstrate optimal cadmium capture performance, fitting well with the Langmuir model. The application of this hydrogel fosters vegetable growth in cadmium stress conditions, particularly at a 4% hydrogel addition, resulting in the highest dry weight of vegetables. Overall, the successfully synthesized hydrogel proves effective in immobilizing cadmium ions in soil, positively influencing vegetable growth and yield, and offering practical significance in mitigating heavy metal ion pollution.

The noteworthy promotional effect exhibited by DMAPAA/DMAPAAQ hydrogels has had an exceedingly positive impact on vegetable growth. Its internal tertiary amine protonation characteristics in aqueous solutions, along with the formation of hydroxyl (OH-) characteristics on the surface, efficiently encapsulate cadmium ions internally, resulting in insoluble cadmium hydroxide precipitates. This mechanism successfully alleviates cadmium pollution in the soil, providing a cleaner and more favorable growth environment for vegetables. In our study, we applied two distinct types of hydrogels,

DMAPAA/DMAPAAQ ion-type hydrogel and DMAA (N, N-Dimethylacrylamide) non-ion-type hydrogel, for vegetable cultivation in uncontaminated soil. DMAPAAQ promotes nitrate ion adsorption through ion exchange mechanisms, releasing nitrate ions for plant absorption. This combined effect not only further enhances the hydrogel's ability to alleviate soil cadmium pollution but also supplies necessary nutrient support for plants. Conversely, the promoting effect of DMAA non-ion-type hydrogel on vegetables is relatively limited, underscoring the critical role of hydrogel composition in its interaction with plants under cadmium stress conditions.

Finally, we successfully synthesized potassium polyacrylate (KMAA) hydrogel through free radical polymerization to address high concentrations of sodium ions in industrial wastewater and saline-alkali soil. Experimental results demonstrate that KMAA hydrogel exhibits outstanding performance in removing sodium ions from aqueous solutions and providing potassium ions. At pH 7, the maximum adsorption capacity of sodium ions reaches 70.7 mg/g, while at pH 4, the maximum exchange capacity for potassium ions is 243.7 mg/g. This successfully synthesized hydrogel provides valuable practical insights for addressing high sodium ion concentrations in water sources and promoting potassium fertilizer supply. In summary, the three hydrogels studied in this research present feasible technical solutions for addressing heavy metal and ion pollution in different environments.