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多指标综合分析法在保水剂合成与评价中的应用

Application of multi-indicator analysis on synthesis of super absorbent polymers

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中文摘要:

为合成更贴近生产实际的超吸水树脂保水剂, 及提高其使用效果, 该研究以淀粉、丙烯酸、丙烯酰胺为主要原料, 采用过硫酸铵为引发剂, N,N'-亚甲基双丙烯酰胺(MBA)为交联剂在一定温度和中和度下制备了高吸水性复合材料。合成过程中选取五因素四水平正交试验设计, 重复3次。采用Z分综合评价法和综合平衡法对其作为保水剂时的去离子水吸水倍率、土壤中吸水倍率、失水速率及种子发芽率等4个指标进行综合评价。研究得出影响保水剂性能的因素重要程度为温度>中和度>丙烯酰胺>过硫酸铵>MBA。优化筛选出了最佳合成配方及反应条件。即: 1g淀粉加入15mL水熟化后, 加入5mL丙烯酸, 2.0g丙烯酰胺, N,N'-甲基双丙烯酰胺1mg, 采用KOH溶液使体系中和度为90%, 在85℃下反应40min。该研究所采用的试验方法和评价体系简便易行, 可用于超吸水树脂保水剂或其他新型材料的合成与评价。

英文摘要:

Abstract: With the development of economy and society, humans' demand for water is sharply increasing. China's freshwater resource per capita is only about 1/4 of the world's. However, due to irrational exploitation and utilization of water resources, the water scarcity in China is becoming a more and more serious problem. Therefore, the development of water-saving technology is imperative. Super absorbent polymer (SAP) is a chemical water-saving product that has developed very fast in recent years. It is a functional polymer material with high water-absorbent capability. Its internal, cross-linked, hydrophilic polymer network structure is able to adsorb and hold a large amount of water, while its physical structure remains stable. Thus it can absorb water more than hundreds of times of its own weight. What's more, the water held by SAP can be slowly released for plant use in arid lands. In this study, with the help of orthogonal design, a series of super absorbent polymers was prepared with different synthesis conditions and formulas. By using starch, acrylic acid, and acrylamide as main materials and functional monomer, N,N'-Methylenebisacrylamide (MBA) as crosslinker, and ammonium persulphate as initiator, the super absorbent resins were synthesized at certain reaction temperatures and neutralization degrees which refers to the molar ratio of alkali and acrylic acid. After the synthesis, these novel composite super absorbent resins were evaluated by using a composite evaluation system. In this system, four indices of effectiveness were used: absorbency of deionized water, water absorbency in soil, water-holding capacity, and the effect on germination percentage of seeds. These four indices involved in the present composite evaluation system concluded not only the most widely used indexes in the laboratory setting, but also the useful indices in real production systems. Two statistical methods of Z-score comprehensive evaluation and comprehensive balance analyzing were used to build the comprehensive evaluation system. The system could be accepted for optimizing the synthesis conditions and selecting the best and the most effective SAP suitable for practical agricultural production. Compared to some other previous studies that take the absorbency of deionized water as the only evaluation standard, the present study got a more comprehensive view to test the effectiveness of SAP, especially in practical situations. The evaluation system and calculation methods were simple and rapid. Thus they could be easily extended and utilized for the synthesis and evaluation of SAP or other new materials. The statistical data obtained from the results of variance analysis and range analysis indicated that temperature was the most significant factor affecting the character of the polymer. The order of importance of the five factors was temperature > neutralization degree > acrylamide > ammonium persulphate > MBA. As the result of the composite evaluation of two statistical methods, the optimal synthesis condition was chosen as follows: 1g cured starch, 5mL acrylic acid, 1mg MBA, 0.02g ammonium persulphate, and 2.0g acryl amide were incubated together at 85℃ and with 90% neutralization degree adjusted by 1% KOH aqueous solution for 40min to produce the raw resin. After 24h drying, the final product could be obtained. The selected optimal super-absorbent polymers demonstrated good potential for water saving in agriculture. Moreover, it could be applied to water-saving agriculture, seedling transplanting, soil and water conservation, and many other fields.

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