

SINTESIS MEMBRAN BERLAPIS BERBASIS KITOSAN/ASAM SITRAT/KALSIUM FOSFAT SEBAGAI PUPUK FOSFAT LEPAS LAMBAT

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INTISARI

Penggunaan pupuk konvensional yang mudah larut sering menyebabkan rendahnya efisiensi serapan hara oleh tanaman dan pencemaran lingkungan akibat pencucian, terutama fosfat. Untuk mengatasi hal ini, dikembangkan pupuk lepas lambat (*slow release fertilizer*/SRF) berbasis fosfat yang mampu melepaskan nutrisi secara bertahap sesuai kebutuhan tanaman. Penelitian ini bertujuan untuk mengkaji karakteristik membran berlapis berbasis kitosan/asam sitrat/kalsium fosfat (CS/St/CaP) dan mengevaluasi aplikasinya sebagai pupuk lepas lambat fosfat.

Penelitian diawali dengan mereaksikan kitosan yang telah dilarutkan dalam asam asetat dengan asam sitrat sebagai agen penaut silang, membentuk larutan CS/St melalui metode *blending*. Larutan ini kemudian dikombinasikan dengan serbuk kalsium fosfat (CaP) untuk menghasilkan membran CS/St/CaP. Keberhasilan pupuk berbasis membran berlapis dianalisis dengan menggunakan *Fourier Transform Infrared Spectroscopy* (FTIR), *Scanning Electron Microscope-Energy Dispersive X-Ray* (SEM-EDX), dan *Energy Dispersive X-ray Fluorescence* (XRF). Karakterisasi membran seperti uji kuat tarik (*tensile strength*), uji pengembangan (*swelling*), uji hidrofilisitas, dan uji biodegradasi dilakukan untuk mengetahui ketahanan pupuk berbasis membran di dalam tanah. Pengujian lepas lambat pupuk dilakukan dalam media air, yang diamati pada periode waktu 30 hari dengan frekuensi pengamatan setiap hari.

Hasil penelitian menunjukkan bahwa pupuk fosfat berbasis membran berlapis CS/St/CaP telah berhasil dilakukan, dengan karakteristik fisik dan ketahanan tanah yang baik. Hal ini ditunjukkan oleh nilai pengembangan yang memadai, hidrofilisitas tinggi, serta laju biodegradasi yang ramah lingkungan untuk aplikasi pertanian. Uji pelepasan fosfat menunjukkan profil pelepasan lambat, dengan laju pelepasan rata-rata sebesar 6,61 ppm/hari dari 233,6 ppm dalam membran dan total pelepasan fosfat mencapai 84,7% selama 30 hari. Berdasarkan analisis kinetika pelepasan, proses pelepasan pupuk fosfat mengikuti model kinetika Korsmeyer-Peppas ditandai dengan nilai R^2 sebesar 0,9855 dan mengikuti mekanisme *Super Case II Transport* dengan nilai $n > 0,89$ yang mengindikasikan peran dominan erosi matriks dan relaksasi polimer dalam proses pelepasan nutrisi.

Kata kunci: kalsium, kitosan, membran berlapis, pupuk fosfat, pupuk lepas lambat.

SYNTHESIS OF CHITOSAN/CITRIC ACID/CALCIUM PHOSPHATE-BASED MULTILAYER MEMBRANE AS A SLOW-RELEASE PHOSPHATE FERTILIZER

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ABSTRACT

The application of conventional soluble fertilizers often leads to low nutrient uptake efficiency by plants and environmental pollution due to leaching, especially of phosphates. To solve this problem, phosphate-based slow-release fertilizer (SRF) was developed that is able to release nutrients gradually according to plant demand. This study aims to assess the characteristics of chitosan/citric acid/calcium phosphate (CS/St/CaP)-based coated membranes and evaluate their application as phosphate slow-release fertilizer.

The research began by reacting chitosan dissolved in acetic acid with citric acid as a cross-linking agent, forming a CS/St solution through a blending method. This solution was then combined with calcium phosphate (CaP) powder to produce CS/St/CaP membrane. The success of the coated membrane-based fertilizer was analyzed using Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscope-Energy Dispersive X-Ray (SEM-EDX), and Energy Dispersive X-ray Fluorescence (XRF). Membrane characterization such as tensile strength test, swelling test, hydrophilicity test, and biodegradation test were conducted to determine the durability of the membrane-based fertilizer in the soil. Slow-release testing of the fertilizer was carried out in aqueous media, which was observed over a period of 30 days with a frequency of observation every day.

The results showed that CS/St/CaP-coated membrane-based phosphate fertilizer was successfully carried out, with good physical characteristics and soil resistance. This is indicated by adequate development value, high hydrophilicity, and environmentally friendly biodegradation rate for agricultural applications. The phosphate release test showed a slow release profile, with an average release rate of 6.61 ppm/day from 233,6 ppm in membrane and a total phosphate release of 84.7% over 30 days. Based on the release kinetics analysis, the phosphate fertilizer release process follows the Korsmeyer-Peppas kinetics model characterized by an R^2 value of 0.9855 and follows the Super Case II Transport mechanism with a value of $n > 0.89$ which indicates the dominant role of matrix erosion and polymer relaxation in the nutrient release process.

Keywords: calcium, chitosan, multilayer membrane, phosphate fertilizer, slow release fertilizer.