PEMBUATAN BIOPLASTIK KITOSAN-TiO_2-CNT-NPK SEBAGAI MODEL PUPUK LEPAS-LAMBAT NPK YANG BERSIFAT ANTIBAKTERI

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INTISARI

Pada penelitian ini telah dilakukan pembuatan bioplastik kitosan-TiO_2-CNT-NPK sebagai model pupuk lepas-lambat NPK yang bersifat antibakteri terhadap patogen tanaman. Bioplastik ini dibuat untuk mengatasi rendahnya penyerapan nutrisi mayor nitrogen, fosfor, dan kalium tanaman melalui pemupukan konvensional, serta kerugian produksi akibat patogen tanaman yang menjadi masalah utama penghambat produksi tanaman.

Bioplastik dibuat dengan mencampurkan kitosan, TiO_2, CNT (*Carbon Nanotube*), dan pupuk NPK. Kitosan berperan sebagai matriks dan senyawa antibakteri, TiO_2 sebagai *filler* anorganik dan material antibakteri, serta CNT sebagai *filler* anorganik serta adsorben pupuk. Dua variasi bioplastik yang dibuat adalah kitosan (Cts)-TiO_2 dan Cts-TiO_2-CNT. Penambahan TiO_2 dilakukan dengan variasi 1, 2, 3, 4, dan 5% (b/b) terhadap kitosan. Penambahan CNT dilakukan mulai dengan variasi 0,1, 0,2, 0,3, 0,5, dan 1% (b/b) terhadap kitosan dan diberikan pada bioplastik paling optimum variasi penambahan TiO_2. Pupuk NPK dibuat dengan urea, $(NH_4)H_2PO_4$, dan KCl yang menghasilkan perbandingan N, P, dan K 15:15:15 (b/b). Kitosan yang digunakan konstan pada 2 g. Bioplastik dikarakterisasi dengan FTIR dan XRD serta diuji kekuatan mekanik, dan derajat *swelling*-nya. Penyerapan dan pelepasan nitrogen dan fosfor diuji dengan spektrofotometer UV-Vis sedangkan untuk kalium dengan AAS. Aktivitas antibakteri diuji dengan metode difusi-*disk* terhadap isolat bakteri patogen tanaman yaitu *Ralstonia* sp.

Hasil eksperimen menunjukkan bahwa penambahan TiO_2 meningkatkan kuat tarik hingga konsentrasi 4% (b/b) terhadap kitosan dan memunculkan aktivitas antibakteri terhadap *Ralstonia* sp. Penambahan CNT meningkatkan sifat mekanik hingga penambahan 0,1% (w/w) terhadap kitosan serta meningkatkan kemampuan penyerapan NPK pada bioplastik. Bioplastik Cts-$TiO_{2\text{-}80}$-CNT_{10}-NPK dipilih sebagai bioplastik paling optimum berdasarkan sifat mekanik dan uji penyerapan NPK yang diuji kinetika pelepasannya terhadap NPK. Bioplastik ini memiliki kuat tarik dan kemuluran berturut-turut sebesar 6,15 MPa dan 41,38% serta aktivitas antibakteri yang tergolong "sedang". Efisiensi absorpsi yang dimiliki terhadap nitrogen, fosfor, dan kalium berturut-turut adalah 95,44, 76,11, dan 97,52%. Konstanta laju pelepasan nitrogen, fosfor dan kalium pada bioplastik Cts-$TiO_{2\text{-}80}$-CNT_{10}-NPK berturut-turut sebesar 0,00158, 0,076, dan 0,008 mg g^{-1} jam $^{-1}$. Bioplastik ini juga memiliki kinetika pelepasan N, P, dan K secara berurutan memenuhi kinetika reaksi orde semu kedua, orde Higuchi, dan orde reaksi kedua.

Kata kunci: Kitosan, TiO_2, CNT, pupuk NPK, dan *Bioplastic Fertilizer* (BPF).

PREPARATION OF CHITOSAN-TiO_2-CNT-NPK BIOPLASTIC AS A MODEL OF NPK SLOW-RELEASE FERTILIZER WITH ANTIBACTERIAL ACTIVITY

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ABSTRACT

In this research, chitosan-TiO_2-CNT-NPK bioplastic was made as a model of NPK slow-release fertilizer which is antibacterial against plant pathogens. This NPK bioplastic fertilizer is made to overcome the low absorption of major nutrients of nitrogen, phosphorus and potassium in plants through conventional fertilization, as well as production losses due to pathogens.

Bioplastics were made by mixing chitosan, TiO_2, CNT, and NPK fertilizers. Chitosan was supposed as a matrix, TiO_2 as an inorganic filler and antibacterial agent, and CNT as an inorganic filler and fertilizer adsorbent. Two variations of the bioplastics made were Cts-TiO_2 and Cts-TiO_2-CNT. The addition of TiO_2 was carried out with variations of 1, 2, 3, 4, and 5% (b/b) of chitosan, while CNT was added starting from 0,1, 0,2, 0,3, 0,5, and 1% (b/b) of chitosan to the most optimum bioplastics in the addition of TiO_2. One gram of NPK fertilizer was made with urea, $(NH_4)H_2PO_4$, and KCl which produces a ratio of N, P, and K 15:15:15 (b/b). Chitosan was used constant at 2 g. Bioplastics were characterized by FTIR and XRD and tested for their mechanical strength and degree of swelling. The absorption and release of nitrogen and phosphorus were tested by UV-Vis spectrophotometer while for potassium by AAS. Antibacterial activity was tested by the disk-diffusion method against bacterial isolates that were pathogenic to plants, namely *Ralstonia sp*.

The experimental results show that the addition of TiO_2 increases tensile strength up to 4% (w/w) of chitosan and raises antibacterial activity against *Ralstonia sp*. The addition of CNT increases the mechanical properties of up to 0,5% (w/w) addition and increases the absorption ability of NPK in bioplastics. Bioplastic Cts-$TiO_{2\text{-}80}$-CNT_{10}-NPK was chosen as the optimum bioplastic based on mechanic and absorption properties so its release properties against NPK then was tested. This bioplastic has tensile strength and elongation properties of 6.15 MPa and 41.38%, respectively and antibacterial activity which was classified as "moderate". The absorption efficiency of nitrogen, phosphorus, and potassium were 95.44, 76.11 and 97.52%, respectively. The release rate constants of nitrogen, phosphorus and potassium in the bioplastic Cts-$TiO_{2\text{-}80}$-CNT_{10}-NPK were 0.00158, 0.076, and 0.008 mg g^{-1} $hour^{-1}$, respectively. This bioplastic also had the reaction kinetics of releasing N, P, and K fitting the pseudo-second, Higuchi, and second-order reaction kinetics, respectively.

Keywords: Chitosan, TiO_2, CNT, NPK fertilizer, and Bioplastic Fertilizer (BpF).