

UREA ENCAPSULATION IN THE CYLINDER OF ZEOLITE-CLAY COMPOSITE MODIFIED WITH WHITE CEMENT AND CARBOXYMETHYL CELLULOSE AS A MODEL OF SLOW-RELEASE UREA FERTILIZER

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ABSTRACT

A study on the synthesis of zeolite-clay composites modified with white cement and carboxymethyl cellulose to encapsulate urea as a model of slow-release fertilizer has been performed. The cylindrical composite was prepared by mixing natural zeolite, natural clay, white cement, and carboxymethyl cellulose at a specific ratio using a home-made mold. Infrared spectrophotometer and X-ray diffractometer were used to characterize the composites. Its physical strength was analyzed through compressive strength and water absorption capacity test. The concentration of urea released from the composite was determined using an Ehrlich reagent and analyzed with a UV-Vis spectrophotometer.

Infrared spectra of the composites showed functional groups of calcium silicate hydrate at 3448 dan 1635 cm^{-1} as the main product of the hydration and pozzolan reaction in the composite. The corresponding diffraction pattern confirmed the presence of minerals tobermorite ($2\theta = 26.62^\circ; 27.62^\circ; 32.45^\circ; 39.39^\circ$ and jennite ($2\theta = 19.69^\circ$). Increasing the amount of white cement and carboxymethyl cellulose increased the compressive strength but decreased the capacity of water absorption of the composite. Contrarily, enhancing the natural zeolite ratio in the composite decreased the compressive strength but increased water absorption capacity. The urea released from zeolite-clay-white cement composite and zeolite-clay-white cement-carboxymethyl cellulose kinetically followed Korsmeyer-Peppas model with rate constants (k) of 11.81 hour^{-n} ($n=0.29$) and 19.39 hour^{-n} ($n = 0.49$), respectively. The n values indicate Fickian diffusion. Both composites can be classified as a slow-release fertilizer based on the European Committee for Standardization (CEN).

Keywords: zeolite-clay composites, calcium silicate hydrate, slow-release urea fertilizer

ENKAPSULASI UREA DALAM SILINDER KOMPOSIT ZEOLIT-LEMPUNG TERMODIFIKASI SEMEN PUTIH DAN KARBOKSIMETIL SELULOSA SEBAGAI MODEL PUPUK UREA LEPAS-LAMBAT

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INTISARI

Studi pembuatan komposit zeolit-lempung termodifikasi semen putih dan karboksimetil selulosa untuk mengenkapsulasi urea sebagai model pupuk lepas lambat telah dilakukan. Preparasi komposit berbentuk silinder dilakukan melalui pencampuran zeolit alam, lempung alam, semen putih, dan larutan karboksimetil selulosa menggunakan perbandingan tertentu dalam cetakan khusus. Komposit dikarakterisasi menggunakan spektrofotometer inframerah dan difraktometer sinar-X. Analisis kekuatan fisik komposit dilakukan melalui uji kuat tekan maupun kapasitas serapan air. Penentuan konsentrasi urea dalam uji pelepasan urea dari komposit optimum dilakukan menggunakan reagen Ehrlich dan analisis dilakukan dengan spektrofotometer UV-Vis.

Spektra inframerah komposit menunjukkan gugus fungsi yang mengindikasikan keberadaan mineral kalsium silikat hidrat pada bilangan gelombang 3448 dan 1635 cm^{-1} sebagai produk utama reaksi hidrasi dan pozzolan pada komposit. Difraktogram sinar-X menguatkan keberadaannya dalam bentuk mineral *tobermorite* ($2\theta = 26,62^\circ; 27,62^\circ; 32,45^\circ; 39,39^\circ$) dan *jennite* ($2\theta = 19,69^\circ$). Peningkatan massa semen putih maupun konsentrasi larutan karboksimetil selulosa meningkatkan nilai kuat tekan dan menurunkan kapasitas serapan air dari komposit. Sebaliknya, peningkatan rasio zeolit alam dalam komposit menurunkan nilai kuat tekan serta meningkatkan kapasitas serapan air. Secara kinetika, karakter melepas-lambat urea komposit silinder zeolit-lempung termodifikasi semen putih dan karboksimetil selulosa, mengikuti model kinetika Korsmeyer-Peppas dengan laju pelepasan (k), secara berurutan = 11,81 jam^{-n} dan 19,39 jam^{-n} serta eksponen pelepasan (n) = 0,29 (*Fickian diffusion*) dan 0,49 (*Fickian diffusion*). Kedua komposit dapat digolongkan sebagai pupuk lepas-lambat berdasarkan *European Committee for Standardization (CEN)*.

Kata kunci: komposit zeolit-lempung, kalsium silikat hidrat, pupuk urea lepas-lambat