SINTESIS NANOMATERIAL MCM–41 SEBAGAI SISTEM PENGHANTAR OBAT (*DRUG DELIVERY SYSTEM*) SENYAWA ANTIKANKER SOLASODIN

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INTISARI

Silika mesopori *Mobil Composition of Matter No. 41* (MCM–41) merupakan material yang menjanjikan sebagai sistem penghantaran obat karena memiliki luas permukaan tinggi, struktur pori heksagonal teratur, dan biokompatibilitas yang baik. Penelitian ini bertujuan mengembangkan sistem penghantaran obat berbasis MCM–41 hasil sintesis sonokimia sebagai pembawa solasodin dengan meningkatkan efektivitas aktivitas antikanker terhadap sel kanker payudara T47D. Evaluasi dilakukan melalui kajian karakteristik struktural dan kimia permukaan material, analisis interaksi fungsional solasodin–MCM–41, penentuan kapasitas adsorpsi, studi profil pelepasan berbasis pH fisiologis, serta pengujian aktivitas sitotoksik secara *in vitro* menggunakan sel T47D.

Proses sintesis MCM–41 dilakukan dengan variasi waktu sonikasi dan dikarakterisasi menggunakan *X-ray diffraction* (XRD), *Fourier transform infrared spectroscopy* (FTIR), *transmission electron microscopy* (TEM), *scanning electron microscopy–energy dispersive X-ray* (SEM–EDX), *Brunauer–Emmett–Teller* (BET), *particle size analysis* (PSA), serta analisis zeta potensial. Studi adsorpsi dilakukan pada berbagai variasi pH dan konsentrasi awal, kemudian dianalisis menggunakan model isoterm dan kinetika adsorpsi. Uji pelepasan obat dilakukan pada media dengan pH fisiologis (1,2; 5,5; 6,1; dan 7,4), sedangkan aktivitas sitotoksik solasodin dan SSD/MCM–41 dianalisis menggunakan metode MTT (3-(4,5-dimetiltiazol-2-il)-2,5-difeniltetrazolium bromida).

Hasil penelitian menunjukkan bahwa MCM–41 memiliki struktur mesopori heksagonal teratur dengan kapasitas adsorpsi optimum pada pH 4. Pengembanan solasodin menyebabkan penurunan luas permukaan dari 1129,39 menjadi 849,31 m^2/g dan penyempitan diameter pori dari 3,41 menjadi 2,17 nm, mengindikasikan interkalasi yang efektif. Adsorpsi mengikuti isoterm Langmuir (q_{max} = 1,69 × 10^{-2} mmol/g) dan kinetika kesetimbangan orde kedua, sedangkan analisis FTIR mengonfirmasi terbentuknya ikatan hidrogen antara solasodin dan gugus silanol. Studi pelepasan menunjukkan profil pH-*dependent* dengan pelepasan minimal pada pH 1,2 dan tertinggi pada pH 7,4. Model Higuchi memberikan kecocokan terbaik ($R^2 > 0,98$), menandakan mekanisme difusi Fickian. Uji sitotoksisitas menunjukkan aktivitas antikanker sangat tinggi pada solasodin (IC_{50} = 0,456 µg/mL) dan SSD/MCM–41 (IC_{50} = 0,757 µg/mL). Secara keseluruhan, MCM–41 hasil sintesis sonokimia terbukti efektif sebagai pembawa solasodin melalui mekanisme adsorpsi kuat, pemuatan stabil, pelepasan terkontrol berbasis pH, serta aktivitas sitotoksik yang tetap tinggi, sehingga berpotensi dikembangkan sebagai sistem penghantaran obat antikanker berbasis nanoteknologi.

Kata kunci: MCM–41, solasodin, adsorpsi, pelepasan obat, T47D.

SYNTHESIS OF MCM–41 NANOMATERIALS AS DRUG DELIVERY SYSTEM FOR ANTICANCER COMPOUND SOLASODINE

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ABSTRACT

Mesoporous silica Mobil Composition of Matter No. 41 (MCM–41) is a promising material for drug delivery systems due to its high surface area, regular hexagonal pore structure, and good biocompatibility. This study aims to develop a drug delivery system based on sonochemically synthesized MCM–41 as a carrier for solasodin by increasing the effectiveness and selectivity of anticancer activity against T47D breast cancer cells. The evaluation was conducted through a study of the structural and surface chemical characteristics of the material, analysis of the functional interaction between solasodin and MCM–41, determination of adsorption and loading capacity, a study of the release profile based on physiological pH, and in vitro cytotoxic activity testing using T47D cells.

The synthesis of MCM–41 was carried out with variations in sonication time and subsequently characterized using X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), transmission electron microscopy (TEM), scanning electron microscopy–energy dispersive X-ray (SEM–EDX), Brunauer–Emmett–Teller (BET) analysis, particle size analysis (PSA), and zeta potential analysis. Adsorption studies were conducted at various pH values and initial concentrations and were analyzed using adsorption isotherm and kinetic models. Drug release studies were performed in physiological pH media (1.2, 5.5, 6.1, and 7.4), while the cytotoxic activity of solasodine and SSD/MCM–41 was evaluated using the MTT assay (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide).

The results demonstrate that MCM–41 possesses an ordered hexagonal mesoporous structure with optimum adsorption capacity at pH 4. Solasodine loading reduced the surface area from 1129.39 to 849.31 m^2/g and decreased the pore diameter from 3.41 to 2.17 nm, indicating effective intercalation. Adsorption followed the Langmuir isotherm (q_{max} = 1.69 × 10^{-2} mmol/g) and second-order equilibrium kinetics, while FTIR confirmed hydrogen bonding between solasodine and silanol groups. Release studies revealed a pH-dependent profile, with minimal release at pH 1.2 and the highest release at pH 7.4. The Higuchi model showed the best fit ($R^2 > 0.98$), indicating a Fickian diffusion mechanism. Cytotoxicity assays showed strong anticancer activity for solasodine (IC_{50} = 0.456 µg/mL) and SSD/MCM–41 (IC_{50} = 0.757 µg/mL). Overall, sonochemically synthesized MCM–41 proved to be an effective solasodine carrier through strong adsorption interactions, stable loading, pH-responsive controlled release, and preserved cytotoxic activity. These findings highlight its potential for development as a nanotechnology-based anticancer drug delivery system.

Keywords: MCM–41, solasodine, adsorption, drug release, T47D.