Enhanced Antimicrobial Efficacy of Sulfones and Sulfonamides via Cage-Like Silsesquioxane Incorporation

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This work introduces a novel class of hybrid antimicrobial agents by integrating sulfone and sulfonamide functionalities with polyhedral oligomeric silsesquioxanes (POSSs). By employing efficient synthetic protocols, we have successfully prepared both sulfone (ethylvinylsulfone-POSS and phenylethylsulfone-POSS) and sulfonamide (benzenesulfonamide-POSS, *p*-toluenesulfonamide-POSS, 3-fluorobenzenesulfonamide-POSS, and 2-naphthalenesulfonamide-POSS) derivatives with high yields (73–90%). All derivatives were examined using Fourier transform infrared spectroscopy, multinuclear (^{1}H , ^{13}C , ^{19}F, and ^{29}Si) NMR spectroscopy, MALDI-ToF MS spectrometry, and elemental analysis. Additionally, the crystal structure of the *p*-toluenesulfonamide-POSS hybrid was revealed. The unique cage-like POSS structure not only imparts enhanced thermal and chemical stability, a common feature of silsesquioxane-based hybrids, but also boosts the lipophilic character of these compounds, thereby facilitating their interaction with microbial membranes. This interaction, likely resulting in membrane disruption and cell lysis, translates into potent antimicrobial activity (against *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterococcus hirae*, *Staphylococcus aureus*, and *Candida albicans*)—especially against Gram-positive bacteria—at remarkably low minimum inhibitory concentrations in the range from 125 to 3000 μM. In turn, *E. hirae* and *S. aureus* were more susceptible compared to Gram-negative bacteria and *C. albicans*. The strategic incorporation of POSSs into these sulfur-based moieties represents a significant breakthrough, opening new avenues for the development of advanced antimicrobial coatings and therapeutic agents in the fight against antibiotic resistance.

Słowa kluczowe

Anions, Antimicrobial agents, Bacteria, Reaction products, Sulfones

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