

Nanoscale Ruthenium(III) Complexes with Bioactive Ligands: Structural, Colloidal, and Dual Antimicrobial–Cytotoxic Investigations

Autorzy

Olga Impert
Natalia Czerniecka
Natalia Balińska
Barbara Kubiak
Anna Kozakiewicz-Piekarz
Oleksandra Pryshchepa
Paweł Pomastowski
Michalina Ehlert
Maciej Witwicki
Yogeswara Rao Pateda
Erik Rakovský
Anna Katafias
Rudi van Eldik

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Streszczenie

This study comprehensively analyses two new ruthenium(III) complexes, $[\text{Ru}^{\text{III}}\text{Cl}_4(\text{Nic})_2]^-[(\text{CH}_3)_2\text{NH}_2]^+\text{DMF}$, **1**, and $[\text{Ru}^{\text{III}}\text{Cl}_2(3\text{-HPA})_2]^-[\text{3-HH}_2\text{PA}]^+(\text{EtOH})_2$, **2**, (where Nic = nicotinic acid (vitamin B3), 3-HPA = anion of a 3-hydroxypicolinic acid), as potential antimicrobial agents, highlighting their physicochemical properties, nanoparticle formation, and cytotoxic activity. The complexes were fully characterised by a single crystal X-ray diffraction technique, Fourier-transform infrared, energy-dispersive X-ray, and electron paramagnetic resonance spectroscopies. The synthesis of micro- and nanoparticles (NPs) of these complexes was performed using the liquid anti-solvent crystallisation method. The formation of NPs was confirmed, and their sizes were determined using scanning electron microscopy and dynamic light scattering techniques. The Debye-Scherrer technique, based on powder diffraction X-ray data, indicated the high crystallinity of the nanomaterials. Toxicity and morphological effects on L929 fibroblasts, hepatocellular carcinoma (Hep-G2) and human epithelial colorectal adenocarcinoma (Caco-2) cell lines of the complexes were assessed using the MTT assay and an inverted phase-contrast microscope, respectively. Complex **1** is a promising anti-cancer drug candidate targeting intestinal cancers, showing cytotoxicity against Caco-2 cancer cells and no cytotoxicity against L929 fibroblast cells, while complex **2** is markedly cytotoxic. The antibacterial activity of the complexes was assessed against methicillin-resistant *Staphylococcus aureus* (MRSA) and *Klebsiella pneumoniae* strains using the minimum inhibitory concentration (MIC) method. Complex **2** demonstrates superior bactericidal properties, achieving MIC values as low as $125 \mu\text{g ml}^{-1}$ for *S. aureus*, while complex **1** exhibits lower antimicrobial efficacy. The role of ligand composition in modulating bioactivity was examined.

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