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Antibacterial properties of lanthanide metal-organic compounds and variably-structured flavonoids

Nadim Al Lati, Sevasti Matsia, Athanasios Salifoglou

Laboratory of Inorganic Chemistry and Advanced Materials, School of Chemical Engineering, Aristotle University of Thessaloniki, Thessaloniki 54124, Greece
E-mail: nalla@ece.auth.gr

Abstract : The need for novel antimicrobial agents is urgent due to the rise of antibiotic resistance in higher organism pathophysiological processes. In addition to naturally-occurring flavonoid-based compounds, such as naringin and naringenin, this research explores the antibacterial potencies of newly synthesized metal-organic complex materials that contain lanthanide ions chelated by chrysin and 1,10-phenanthroline. The aim of this study is to evaluate their effectiveness against *Xanthomonas campestris*, *Escherichia coli*, and *Staphylococcus aureus* using the agar disc diffusion method.

Introduction

New antimicrobial medicines with unique modes of action are desperately needed as antibiotic-resistant microorganisms are becoming more prevalent. Because of their special coordination chemistry, redox characteristics and possible interactions with bacterial membranes, metal-based compounds containing lanthanides have become attractive options. Their potential to interfere with enzyme activity, impair bacterial cell activities, and produce reactive oxygen species (ROS), which can result in bacterial cell death, has been investigated over the past decades.[1]

However, compounds containing flavonoids, such as naringin and naringenin, are also being studied for their antibacterial properties. Plant-derived polyphenolic chemicals, called flavonoids, are well-known for their bioactivity, which includes antibacterial, anti-inflammatory, and antioxidant properties.[2] Their capacity to interact with bacterial cell membranes, block essential enzymes, and interfere with metabolic pathways, is frequently cited as the reason for their antibacterial activity.[3] The herein reported research describes new flavonoid and hybrid lanthanide-flavonoid materials (**Fig. 1-2**) with distinctly differentiated antimicrobial properties, meriting consideration as future natural product drugs.[4]

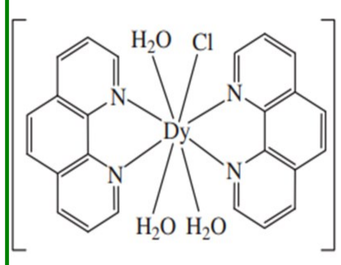


Fig. 1: Lanthanide-phenanthroline complex[4]

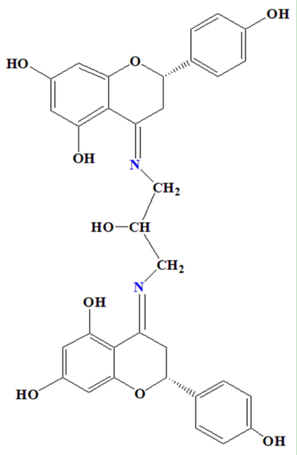
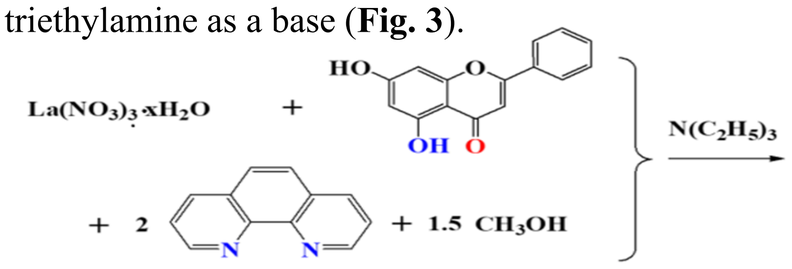


Fig. 2: Double flavonoid compound

Materials and methods

1. Materials: Lanthanides (La, Nd, and Eu), chrysin, 1,10-phenanthroline
Reaction technique: Ternary compounds containing lanthanides were synthesized by reacting $Ln(NO_3)_3 \cdot xH_2O$, chrysin, and phenanthroline in a 1:1:1 molar ratio, under solvothermal conditions at 100 °C for 2 h, using triethylamine as a base (**Fig. 3**).



$[La(C_{15}H_9O_4)(C_{12}H_8N_2)_2(NO_3)_2] \cdot 1.5\ CH_3OH + [(C_2H_5)_3NH]NO_3 + x\ H_2O$

Fig. 3: Synthesis reaction of lanthanum-containing compound[5]

2. Materials: Naringin, naringenin, diamines
Reaction technique: The flavonoid was allowed to react with the desired diamine in an ethanol-based solvent and then the obtained solution was left overnight for reflux. On the next morning, the product was isolated and stored (**Fig. 4**).

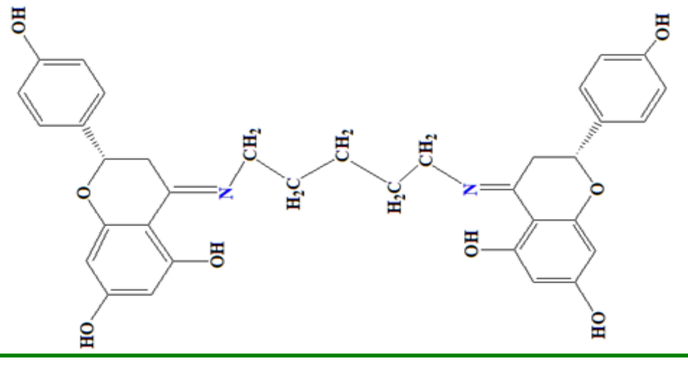


Fig. 4: Structure of double naringenin with 1,5-diaminopentane

Results and Discussion

The antibacterial activity of the newly synthesized compounds was studied using the disc diffusion method. Zones of inhibition (ZOI) were measured on agar plates and values were collected for each compound as shown in **Fig. 5**. The minimum inhibitory concentration (MIC) was consequently determined for each compound.

The results for lanthanide metal-organic compounds showed low minimum inhibitory concentration (MIC) values, which indicated a significant inhibitory action against Gram-negative *Escherichia coli*. These compounds, however, exhibited little to no zone of inhibition against *Staphylococcus aureus*, indicating that their effectiveness against Gram-positive bacteria was low. Flavonoid-containing compounds also showed high inhibitory action against *Escherichia coli*, yet no activity toward Gram-negative *Xanthomonas campestris* and Gram-positive *Staphylococcus aureus*.

The overall antibacterial profile of the compounds tested was selective against Gram-negative *E. coli*, since very high MIC values were recorded against Gram-positive bacteria when tested with lanthanide-containing compounds and no ZOIs were observed with flavonoid compounds against those same Gram-positive bacteria.

The collective results demonstrate the selective antibacterial properties of the investigated compounds and underline the necessity for additional structural adjustments to increase their efficacy against a wider variety of bacterial infections.

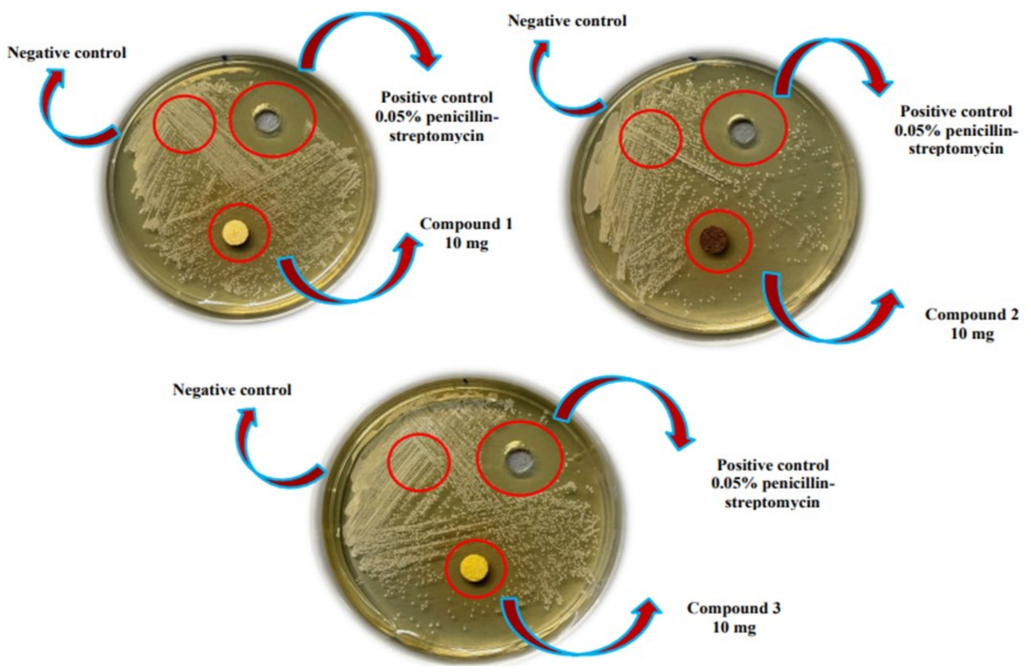


Fig. 5: ZOI values in *S. aureus* strain for lanthanide-containing compounds[5]

Conclusions

- Due to the increasing outbreaks of infectious diseases as well as the rise of antibiotic drug resistance, newly synthesized ternary lanthanide metal-organic compounds and double flavonoids (modified natural products) were tested for their antibacterial properties against Gram-negative and Gram-positive bacterial strains.
- The disc diffusion method, using LB agar powder, was adapted in this research to investigate the antibacterial properties of the newly synthesized compounds.
- Liquid cultures of *E. coli*, *S. aureus*, and *X. campestris* were prepared and applied on petri dishes, containing the agar gel, where pellets containing the compounds were introduced in order to examine their antibacterial properties by measuring their zone of inhibition (ZOI) of and minimal inhibitory concentration (MIC).

Literature

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