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Editorial

New Trends on Vanadium Chemistry, Biochemistry, and Medicinal Chemistry

Dinorah Gambino

Área Química Inorgánica, Facultad de Química, Universidad de la República, Montevideo 11800, Uruguay; dgambino@fq.edu.uy

Vanadium was discovered twice. Andrés Manuel del Rio, a Professor of Mineralogy in Mexico, discovered it for the first time in a vanadinite ore. Nevertheless, at that time, French chemists dismissed the discovery, concluding that this ore was a chromium mineral. Vanadium was rediscovered in 1830 by Nils Gabriel Sefstrôm, a Swedish chemist, while analyzing samples of iron from a mine in Sweden. He named the new element after Vanadis, the Swedish goddess of beauty and fertility, because of the brilliant and attractive colors of the chemical compounds in which it was first found. Currently, the originally suggested name of the element could equally be associated with the fertile work of scientists over the last 190 years developing new compounds and materials based on vanadium.

In particular, the recognition of the exceptional chemical and biological properties of vanadium compounds has led, in recent decades, to vast research in order to explore their chemistry, biochemistry, and medicinal chemistry. Although the benefits of using vanadium compounds in medicine are still inconclusive, their prospective application as therapeutic agents against diseases, such as diabetes, cancer and those provoked by parasites and bacteria, has led to extensive research. Researchers from all over the world are dedicating their efforts to vanadium research that is related to the potential therapeutic applications of vanadium compounds and to obtain an insight into their modes of action and beneficial effects on health. This Special Issue collects research contributions focused on recent advances in vanadium chemistry, biochemistry, medicinal chemistry, and toxicology. In the following introduction, the contributions covered in this themed issue are summarized in alphabetical order of the family name of corresponding author.

Debbie Crans and colleagues studied the acute toxicity in mice of a previously developed heteroleptic oxidovanadium (V) schiff base complex that had demonstrated anticancer properties against human ovarian, prostate and brain cells as well as enhancing effects of oncolytic viruses. The compound showed low oral toxicity which encourages the design of oxidovanadium (V) complexes with low toxicity for potential applications in cancer therapy [1].

Joao Costa Pessoa and Isabel Correia presented a review work on how the interactions of vanadium complexes with proteins and other biological targets can be misinterpreted. The review emphasizes the fact that in the case of studying biochemical interactions or effects in order to determine binding constants or active species, or propose mechanisms of action, it is essential to evaluate the speciation of the vanadium compound in the media where it is acting. When vanadium (IV) and vanadium (V) compounds are dissolved in biological media, they undergo chemical transformations, particularly at the low concentrations used in biological experiments [2].

Rupam Dinda and colleagues synthesized and characterized two new oxidovanadium (V) complexes that manifested in vitro cytotoxic potential comparable with that of clinically used drugs, which caused cell death by apoptosis [3].

Teresa Fortoult and colleagues explored the use of inhaled vanadium (V) as an option for lung cancer treatment. Aerosol delivery increased apoptosis and growth arrest of the tumors with no respiratory clinical changes in mice [4].

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Citation: Gambino, D. New Trends on Vanadium Chemistry, Biochemistry, and Medicinal Chemistry. *Inorganics* **2022**, *10*, 68. https://doi.org/10.3390/inorganics10050068

Received: 5 May 2022
Accepted: 18 May 2022
Published: 22 May 2022

Enrique Gónzalez-Vergara, Antonio Rodríguez-Diéguez and colleagues described the synthesis and characterization of a new member of a family of compounds based on decavanadate and a 2-aminopyrimidine ligand, together with its interaction with RNA as potential target for cancer treatment [5].

Anastasios Keramidas, Yannis Simos and colleagues reported novel vanadium (V) complexes with the siderophore vitamin E-hydroxylamino-triazine ligands and their chemical and biological properties. Instead of exhibiting antioxidant activity, the compounds were radical initiators and did not exert significant cytotoxic activity against tumor cell lines [6].

Ignacio León and colleagues performed a review of the activity of vanadium compounds over cell signaling pathways on cancer cells and of the underlying mechanisms, thereby providing insight into the role of these proteins as potential new molecular targets of vanadium complexes [7].

Irma Sánchez-Lombardo and colleagues performed kinetic studies of sodium and metforminium decavanadates and unraveled the nature of their decomposition products. Cytotoxic activity studies using non-tumorigenic HEK293 cell line and human liver cancer HEPG2 cells showed that decavanadate compounds exhibited selective action toward HEPG2 cells after 24 h. In addition, an insulin release assay in βTC-6 cells showed that metforminium decavanadate enhanced insulin release [8].

Patricia Williams and colleagues reported the antioxidant and anticancer activities and the bovine serum albumin interaction of the oxidovanadium (IV) complex with the flavonoid naringin. The complex generated typical effects shown by apoptotic pathways, such as the generation of intracellular reactive oxygen species (ROS), depletion of reduced glutathione and depolarization of mitochondrial membrane potential, producing cell death by an oxidative stress mechanism. Although the oxidovanadium (IV) naringin complex showed a greater affinity to serum albumin than free naringin, it could still be transported and delivered by it [9].

In a second contribution to the issue, Williams and colleagues reported the synthesis and characterization of an oxidovanadium (IV) heteroleptic complex with the polyphenol chrysin and 1,10-phenanthroline as ligands. The cytotoxic effect of this complex proved to be higher in the human lung cancer A549 cell line than that of the oxidovanadium (IV) chrysin homoleptic complex. The probable mechanism of action proved to involve the production of ROS, the decrease in the natural antioxidant compound glutathione (GSH) and the ratio GSH/GSSG (GSSG, oxidized GSH), and mitochondrial membrane damage. Cytotoxicity studies using the non-tumorigenic HEK293 cell line showed that the new heteroleptic compound exhibited selectivity towards tumor cells [10].

As a concluding remark, I thank all the contributors to this Special Issue which covers recent progress in vanadium science across a range of subject areas.

Funding: This research received no external funding.

Conflicts of Interest: The author declares no conflict of interest.

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