International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119 Vol. 3 No. 1 June 2016, pp.01-03

http://ijpsat.ijsht-journals.org

Gallium, Biological Relevance and Future Prospects

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ABSTRACT: The versatility of gallium and its compounds is enormous. Apart from its industrial applications due to its cost effectiveness, the diversity of the uses can be seen in biological research. The non toxic nature of gallium is an added advantage to its biological applications. The inorganic compounds are useful to life, though they are with a few drawbacks. The organogallium compounds are more bioavailable than the inorganic compounds. The future prospects of gallium compounds can be managed with the use of microwave synthesis and nanobiotechnology.

KEYWORDS: Gallium, gallium inorganic compounds organogallium compounds, biological applications, microwave synthesis, nanobiotechnology.

1. INTRODUCTION

The endorsement of cisplatin in 1978 led to more researches to be done in chemotherapy [1]. This was to assess the potentials of less toxic properties and improved clinical effectiveness in other metal based chemotherapeutic agents [1]. Among these chemotherapeutic agents is gallium. In 1871, Russian chemist, Dmitri Mendeleyev predicted the existence of gallium and in 1875, a French chemist, named Paul-Emile Lecoq de Boisbaudran discovered gallium spectroscopically [2]. In the same year, Lecoq obtained pure gallium in its free state by electrolysis of gallium hydroxide in potassium hydroxide. Gallium is a Group 13 metal and it is soft and silvery like aluminium. The most important oxidation state is +3 [2]. Gallium is mixed with metals to form low melting point alloys, as well as, microwave equipment [3]. Gallium arsenide is used to make semi-conductors and laser light [4]. In Italy, Gallium Neutrino Observatory was built with large quantities of gallium trichloride (GaCl3) [5]. Trace quantities of gallium can be found in bauxite, diaspore, germanite, sphalerite and by products of blazing coal.

2. BIOLOGICAL RELEVANCE OF GALLIUM AND ITS COMPOUNDS

For the past century ago, the naturally occurring semi-metal of gallium had been reported to be antiresorptive agent, diagnostic agent for cancer, as well as, anticancer and anti-infective agents [1, 6, 7]. Gallium is non-toxic and has no essential biological function, but imitates iron(III) when the ion react and form bonds within the body processes, whereby iron(III) is influenced, such as inflammation [2, 8-10]. Numerous gallium salts are used in the development of gallium based drugs in the fields of pharmaceuticals and radiopharmaceuticals in medicine [6, 10]. The therapeutic effectiveness of gallium is linked with the capability of gallium(III) to interrupt the normal cellular iron homeostasis by vying against Fe3+ from circulation for cellular uptake [1]. In 1971, Hart et al first described the anticancer properties of gallium compounds [2]. Gallium nitrate, with a trade name of Ganite has been administered to treat hypercalcemia linked with tumour metastasis to bones and lymphoma [8]. In 2000, Bernstein et al, proposed gallium maltolate as an organogallium compound [7]. They administered it orally in form of gallium(III) as a potential treatment for various types of cancer, infectious and inflammatory diseases due to its better bioavailability than gallium(III) nitrate. [9, 12]. Gallium thiosemicarbazones and their derivatives, such as 3-aminopyridine-2-carboxyaldehyde thiosemicarbazones (3-AP, Triapine), as well as, other organogallium compounds have potential for anticancer activities and they are in the different preclinical and clinical stages [6, 8, 13]. The ability of bacteria such as Pseudomonas to breathe is hindered and they eventually die when they mistakenly take up gallium ions, due to the fact that iron(III) is redox active and gallium(III) is redox inactive [2]. Gallium nitrate or gallium-transferrin was potent as an antibacterial, as well as, multiple drug-resistant mixtures. A study revealed the efficiency of gallium organometallic compound as antimalarial agent [7]. Amino-phenol Ga(III) was effective to treatment of chloroquine resistant parasites [14]. There are drawbacks, and among the side effects of gallium(III) nitrate are microcytic anaemia, hypocalcaemia (this can be managed with oral supplementation of calcium trioxocarbonate(IV)), visual and auditory toxicities [15].

3. CONCLUSION

Gallium is non-toxic and the biological applications of the compounds had led to different stages of clinical trials.

4. FUTURE PROSPECTS

The syntheses of less toxic gallium complexes can be faster by the increase in the use of microwave synthesis [16]. This will also promote the efficiency of the percentage yield and stable complexes [17] In addition, challenges of toxicity, solubility and drug resistance experienced in the use of conventional drugs and chemotherapeutic agents can be circumvented through the use of nanobiotechnology in order to have safe drug delivery [18].

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