

Anticancer activities of organogermanium compounds

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ABSTRACT: Among the diversified applications of germanium in biological, chemical, industrial, medical and pharmaceutical fields, this overview focuses on anticancer actions of organogermanium. Organogermanium compounds (OGCs) with their low toxic profiles are applied in different biological, medical and pharmaceutical fields than the inorganic germanium compounds. For anticancer studies, OGCs in previous studies were synthesized using both liquid and gaseous phases, but recently the use of wet chemical reduction method to synthesize capped water-dispersible (GeNPs) to help promote green chemistry is the encouraged practice.

KEYWORDS: Organogermanium compounds, anticancer activities, wet chemical reduction method, nanoparticles of germanium, green chemistry.

1. INTRODUCTION

In 1886, Clemens Winkler discovered Germanium in Germany, whose name originated from Latin name, “Germania” meaning “Germany” [1]. As Dmitri Mendeleev predicted the existence of gallium in 1871, so did he predict the existence of germanium in the same year [1]. Germanium is a silvery semi-metal solid. The compounds have chemical, industrial, biological and medical applications. Germanium can be used as an alloy, solar panels, thermal imaging applications, a catalyst and a semiconductor. Germanium and its oxide are used as infrared spectroscopies. Germanium oxide can be further used in microscope objectives and wide-angle camera.

2. CHEMISTRY, ANTICANCER STUDIES AND DRAWBACK OF GERMANIUM

Oxidation states of germanium occur as +2 and +4. Compounds with oxidation states in +4 are more numerous and stable than those in oxidation states in +2 [1]. The two forms in which germanium exists are the inorganic germanium, with common examples of germanium dioxide (GeO_2) and germanium tetrachloride (GeCl_4), and organic germanium, known as organogermanium compounds (OGCs). Organogermanium compounds have wide range of biological activities with low toxic levels [2, 3]. An example of OGC is organic germanium-132, which is a supplementation for cancer symptoms [4]. It also has anticancer activities and the presence of an active compound, carboxylethyl germanium sesquioxide ($\text{GeCH}_2\text{CH}_2\text{COOH}$) $_2\text{O}_3$, aids the immune system [5, 6]. Another organogermanium compound of bis (2-carboxylethylgermanium) sesquioxide (CEGS) has very strong anticancer activities [3, 7]. Figure 1 shows the chemical structure of carboxylethyl germanium sesquioxide.

Other medical treatments are in the treatment of AIDS, arthritis and heart diseases. Other organogermanium compounds such as germanium(IV)-polyphenol complexes and decaphenylgermanocene complexes are potential anticancer agents [8]. Organogermanium compounds such as Ge-132 (bis-betacarboxy-ethylgermanium sesquioxide [9], acetates of trialkyl- and triphenyl-substituted germanium [10] are successful potentials for antimicrobial activities [11]. Organogermanium compounds are in different preclinical and clinical stages for anticancer studies. The toxicity of germanium and its related compounds have no sufficient evidence to support the drawbacks, but nephrotoxicity or renal failure and neurotoxicity had been reported to be encountered in the use of germanium related compounds [1, 12, 13, 16, 17, 18, 19, 20].

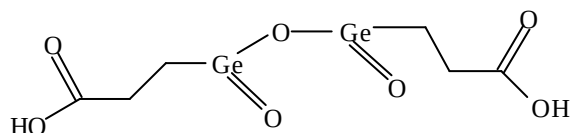
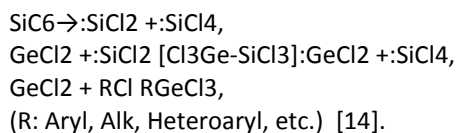


Fig. 1. Carboxylethyl germanium sesquioxide.

3. RECENT STUDIES

Previous synthesis used to produce OGCs were both in liquid and gaseous phases. The first was liquid phase catalytic disproportionation, which seemed rather problematic, though cheap [14]. The second involved the production of organochlorogermanes with introduction of GeCl_2 into germanium-halogen bond. The gaseous phase takes place in three stages. Hexachlorodisilane was decomposed to form dichlorosilylene during the first stage. Dichlorosilylene was inserted into tetrachlorogermane to form dichlorogermylene was formed in the second stage. In the third stage, dichlorogermylene reacted with chlorosubstituted, as well as, unsaturated compounds to form OGCs [14].

The equations of reaction for the synthesis in gaseous phase synthesis in three stages are as follows:



Recent research involves the promotion of green chemistry. A simple, environmental friendly and cost effective wet chemical reduction method was used to synthesize capped water-dispersible nanoparticles of germanium (GeNPs). The GeNPs capped with chitosan is good model to load antitumor drugs and useful for biological applications [15].

4. CONCLUSION

Germanium is a non toxic element. Its organogermanium compounds have low toxicities. The biological applications as anticancer agent are common among organogermanium. Recent studies involve germanium nanoparticles to aid delivery of anticancer and antitumour drugs.

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