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Relationships among Graphene, Zinc Oxide and Zinc Oxalate in Nanomedicine

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Abstract

The relationships among graphene (Gr), zinc oxide (ZnO), and zinc oxalate (ZnC_2O_4) are interpreted from the synthesis perspective. ZnC_2O_4 can be prepared using the dual-precursor sol-gel method, and can be regarded as the derivative of reduced Gr oxide (rGO) and ZnO. Owing to the wide use of Gr-based materials and ZnO in nanomedicine, it is anticipated that ZnC_2O_4 can also be used in nanomedicine. The properties of ZnC_2O_4 (e.g., an open and noncytotoxic structure, solubility, adherence, and affinity) are potentially useful in nanomedicine and are explained in this paper.

Keywords: Graphene; Zinc Oxide; Zinc Oxalate; Villous; Nanomedicine

Nanoparticle Carriers for Nanomedicine

Many particles, such as superparamagnetic nanoparticles, Gr, and ZnO have been studied for their applications in medicine. The most exciting and controllable particles are iron oxide nanoparticles, which can be delivered using external magnetic forces. Previous studies have already targeted superparamagnetic iron oxide nanoparticles (SPIONs) by using external magnets. These particles are based on a core of iron oxides and are coated with biocompatible materials, such as drugs, proteins, or plasmids. Therefore, SPIONs have been widely used in biomedicine. However, SPIONs are somewhat limited in biomedical applications. For example, SPIONs functionalized with antibodies against surface receptors bind to cell membranes and induces hyperthermia, damaging the cell membrane locally; by contrast, SPIONs exhibits slower degradation in cells, enhancing its applicability to tumor cells [1].

Purpose of this Work

These new carriers have been the subject of much research. The purpose of this paper is briefly to review relationship among Gr, ZnO, and ZnC_2O_4 and subsequently to mention induced toxicity of SPIONs, Gr oxide, and ZnO. In this paper, essentially intrinsic properties of villous ZnC_2O_4 are explained and interpret as a potential candidate in nanomedicine.

Iron Oxide Nanoparticles

SPIONs are small synthetic Fe_2O_3 or F_3O_4 particles with a core size of <10 nm and an organic or inorganic coating. Their surface modification by organic molecules fulfills different goals. First, this modification stabilizes

nanoparticles with a pH of approximately 7.4 and a high salt concentration. Second, it provides functional groups at the surface for further derivatization. Finally, it avoids immediate uptake by the reticulendothelial system [1].

Researchers have also paid considerable attention to SPIONs for their in vitro applications in medical diagnostics, such as genetics research and technologies based on the immune magnetic separation of cells, proteins, DNA and RNA, bacteria, viruses, and other biomolecules. Additionally, SPIONs are useful in in vivo applications, and can be utilized as delivery systems for drugs, genes, and radionuclides. By applying an external magnetic field, the concentration of SPIONs can be increased at a local site. SPION-containing solutions act as contrast agents in magnetic resonance imaging and are routinely applied in the field of diagnostic imaging.

Relationships among Graphene, Zinc Oxide, and Zinc Oxalate from Synthesis Perspective

Graphene (Gr) derivatives have been widely investigated. Gr-based materials exhibit two-dimensional (2D) plane structures. Gr can be oxidized, reduced, and transformed into Gr oxide (GO) particles. The structure of reduced Gr oxide (rGO) is nearly the same as that of Gr. ZnO particles are synthesized using direct precipitation, sol-gel, adrothermal [2], or bilayer fluxing [3] methods. ZnO can also be prepared from zinc oxalate (ZnC_2O_4) through heating.

ZnC_2O_4 can be synthesized using various methods, such as the simple precipitation sol-gel method [4] or the sol-gel method using rGO and ZnO [5,6]. Research has described the relationships among rGO, ZnO, and ZnC_2O_4, and has found that ZnC_2O_4 can be regarded as the derivative of rGO and ZnO. Moreover, it can be transformed in versus.

Application of Graphene in Nanomedicine

In the domain of nanomedicine, GO is currently applied in delivery systems, tissue engineering, cancer therapy, and imaging; however, GO induces cytotoxicity [7]. The toxicity of Gr and GO is dependent on its physicochemical properties [8], the exposure environment, and the mode of interaction with cells. The cytotoxicity of GO damages the cell plasma membrane, and the interaction of GO with toll-like receptors may induce macrophage necrosis [9].

Application of Zinc Oxide in Nanomedicine

ZnO nanoparticles selectively induce apoptosis in cancer cells, which is likely to be mediated by reactive oxygen species through the p53 pathway. Most anticancer drugs trigger apoptosis through this pathway. ZnO nanoparticles also provide preliminary guidance for the development of liver cancer therapy [10]. The cytotoxicity of ZnO Involves generation of reactive oxygen species (ROS) or induction of apoptosis [11].

Potential Application of Zinc Oxalate in Nanomedicine

ZnC_2O_4 typically exhibits an elongated tetrahedral geometry with two basic structures, α-ZnC_2O_4 and β-ZnC_2O_4 [12]. The crystal form of α-ZnC_2O_4 is triclinic. Adjacent metal ions are linked in a one-dimensional chain structure, but interchain metal ions are linked in a 3D network structure through hydrogen bonding. By contrast, the structure of β-ZnC_2O_4 is determined by its cation and anion chains (i.e., C_2O_4–Zn–C_2O_4–Zn and Zn–O). The octahedral structure formed by zinc cobonding is the optimal location for the insertion of impurities.

ZnC_2O_4 is slightly soluble in water; it is also slightly soluble in a glucose solution in the human body. Even after 3 h, its wt% slightly increases to a 2–3 wt% level. Therefore, it can be slowly degraded in solution.

In ZnC_2O_4, the levels of carbon and zinc determine C–H bonding, and the counter ion effect may play a role in supersaturation. This effect produces the driving force that attracts carbon. In ZnC_2O_4 synthesized from rGO and ZnO, carbon is attracted to the open structure between the cation and anion chains, and in the ZnC_2O_4 crystals, each zinc ion coordinates with six oxygen atoms to form an octahedral structure that readily accommodates and sustains impurities. Consequently, the structure is the optimal location for the insertion of impurities.

Zinc is an integral part of more than 200 enzymes in the human body. Most of these zinc-containing enzymes include zinc ions and a bioligand mixed structure. The zinc activates catalytic functions and acts as a regulator. Therefore, several studies have focused on the design of active centers and the synthesis of complexes.

Nanoparticles precoated with corona proteins have been demonstrated to exhibit reduced cytotoxicity;

albumin is one of the plasma proteins that bind to nanoparticles [11]. Villous ZnC_2O_4 exhibits a less harmful structure, and can be used as a template for nucleation and surface-coated materials.

Conclusions

The relationships among Gr, ZnO, and ZnC_2O_4 can be understood from the synthesis perspective. Phase-refined materials of ZnC_2O_4 have potential applications in nanomedicine, and villous ZnC_2O_4 synthesized using sol-gel and laser methods has a structure different from the elongated tetrahedral α structure of ZnC_2O_4 produced using conventional methods. Phase-refined villous ZnC_2O_4 exhibits excellent properties, including an open and noncytotoxic structure, solubility, adherence, and affinity. These properties demonstrate that villous ZnC_2O_4 has potential uses in nanomedicine.

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