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Overview of Layered Compounds

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Abstract

Layered compounds are easy to obtain two-dimensional materials by mechanical dissection due to the very weak van der Waals force (vdW force) binding between layers, which has attracted extensive attention in recent years.Its special performance is that its own structure is a nanostructure, and it is also the original material to prepare inorganic - inorganic, inorganic-organic nanocomposite materials. Layered compounds have many different kinds, they are within the layer by covalent bonds between atoms, and according to the different nature of the force between the layers, they can be divided into two categories: the first is layer with strong covalent bonds, between two adjacent thin layer by weak van der Waals force coupling, a typical representative of the material such as graphene and molybdenum trioxide; The second type is the cambium structure attracted by electrostatic forces between the layers. Due to their unique chemical and physical properties, layered compounds are widely used in heterogeneous catalysis, nonlinear optical materials, solid-phase proton or electronic conductors, energy storage materials, superconductivity, flame retardant materials and environmental protection.

Keywords

Layered compound, nanostructure, van der Waals force, catalyst, lithium ion battery.

1. Introduction

Over the past 50 years, the silicon-based semiconductor industry has made great achievements, and information technology has developed rapidly in accordance with Moore's Law.However, as the characteristic scale of the device enters into the nanometer scale, the heat generated by the processor operation is difficult to be eliminated, and the traditional semiconductor technology has approached the physical limit.Therefore, it is urgent to find new materials that can replace semiconductor silicon.With the discovery of graphene, a large number of two-dimensional materials have been successfully prepared in recent years, such as graphite, hexagonal boron nitride, molybdenum trioxide, metal sulfide and so on.Such materials are potential materials for electronic devices because of their rich physical properties.Because lamellar compounds are bonded by extremely weak vdW forces, they are easy to obtain two-dimensional materials by mechanical stripping, which has attracted extensive attention in recent years [1, 2].

Layered compounds are not only the parent materials of two-dimensional materials, but also they have many industrial applications and have been paid much attention for a long time. In layered compounds, the atoms of crystal cells are arranged into layers regularly on the plane, and the bonding cooperation between atoms on the plane is much greater than the interaction between atoms on the plane.

2. Structural Characteristics of Layered Compounds

As a special group, layered compounds are characterized by their own structure, which is a kind of nanostructure. Meanwhile, they are also the original materials for the preparation of inorganic-inorganic and inorganic-organic nanocomposites [3]. Layered compounds, it is a kind

of compound has its own layer, the layer spacing at the molecular level, usually only a few nanometers, lamellar body itself is what we call inherent in the repeat unit or structure unit, it is made of the specific structure unit along a direction by Shared Angle, edge, surface accumulation of space mesh structure, such as in molybdenum oxide, its inherent structural unit for MoO6 octahedron, different phase structure along a direction by MoO6 Angle, altogether or coplanar combine, form the distinctive but relatively stable compounds. In addition, the structure of layered compounds has another characteristic: there are ions or neutral molecules that can move freely between the layers, which makes the layered compounds have two special properties: (1) when the main structure of the layers is not changed, interlayer ions can be exchanged according to actual needs; (2) The substance after exchange has relatively high stability.These two properties make it possible for a series of layered compound derivatives to be synthesized, and provide an effective way for the synthesis and application of layered compounds [3].

3. Classification of Layered Compounds

Layered compounds have many different kinds, they are within the layer by covalent bonds between atoms, and according to the different nature of the force between the layers, they can be divided into two categories: the first is layer with strong covalent bonds, between two adjacent thin layer by weak van der Waals force coupling, a typical representative of the material such as graphene and molybdenum trioxide; The second type is the cambium structure attracted by electrostatic forces between the layers.In nature, there are many natural layered compounds, and there are many kinds. At the same time, many new layered structure substances are also being synthesized constantly, which has become a kind of important compounds. Layered compounds can also be divided into inorganic [4] and organic [5] layered compounds. In general, according to the types of charges in their layers, inorganic layered compounds can be divided into cationic and anionic types [6].

4. Properties and Applications of Layered Compounds

Due to their unique chemical and physical properties, layered compounds are widely used in heterogeneous catalysis, nonlinear optical materials, solid-phase proton or electronic conductors, energy storage materials, superconductivity, flame retardant materials and environmental protection, etc. [7-9].

4.1. Catalyst and Catalyst Carrier

Layered compounds have formed a unique class of catalysts.The conventional heterogeneous catalytic reaction is on the surface of the carrier. In layered compounds, the reactants can diffuse into an intramolecular space different from the bulk environment. It is possible to reduce the activation energy of the reaction and enhance the reaction selectivity [10]. Layered compounds can be used not only as catalysts but also as activators. Because of the unique pore structure in layered compounds, they have many applications in catalysts and catalyst carriers.At the same time, layered compounds can also be applied to the photocatalytic neighborhood.

4.2. Supercapacitors

In recent years, layered structure compounds are popular in the field of supercapacitors because of their large active surface area and stable structure.The current layered structural materials used for supercapacitors mainly include graphene-based materials, transition metal oxides/hydroxides, layered double hydroxides, metal sulfides, new two-dimensional conductive metal carbides, and other layered compounds such as phosphates.The results show that the size and thickness of the layered structure have a significant effect on the

electrochemical properties of the material. Nowadays, the research of layered materials is moving towards larger and thinner, in which the thin layer materials with atomic thickness are getting more and more attention. For example, Yang et al. [11] synthesized a 2nm thick manganese phosphate nanosheet, whose ultra-thin layered properties made its synergistic effect more significant when combined with graphene, further improving its electrochemical performance. Gao et al. [12] synthesized a monolayer -CO(OH)2 with a thickness of 0.48nm by directional growth method, which optimized the performance of supercapacitors at the atomic level.

4.3. Lithium Ion Battery

Layered materials with large specific surface area and stable structure can be used as energy storage materials such as lithium ion batteries [13].In addition, its structure has a large number of tetrahedral and octahedral holes, which are ideal embedding points for lithium ions. In addition, because the layered compounds show weak interlayer van der Waals interaction, lithium ions can interlayer reversibly and form interlayer compounds when the electric potential is low. Among many layered materials, graphite is one of the most studied materials in lithium-ion batteries. It has good layered structure, high specific capacity and low and stable discharge platform potential, so it has become the preferred material for cathode of lithium-ion batteries.

5. Conclusion

Because of the different classification of layered compounds, different types of compounds have different properties, such as cationic layered compounds, which are selective for ion exchange and can be used as specific fixatives, namely adsorbents. Layered compounds can also be used as fillers for polymers to improve some properties of composites.The recent boom in graphene has also inspired further research into the search for other two-dimensional (2D) atomic crystals. At present, a large number of 2D materials, such as MoS2, have been identified, and the block presents the characteristics of an indirect bandgap semiconductor, while 2-D monolayer MoS2 is a direct bandgap semiconductor with a band gap width of 1.9eV [14]. It will have a place in the future nanometer electronic devices and the optoelectronic neighborhood. As a raw material for stripping nanocrystals, layered compounds are attracting more and more attention.

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