Colloidal synthesis of anisotropic 2D anisotropic bismuth

DESCRIPTION OF THE TECHNOLOGY

Two-dimensional lamellar materials are of great scientific interest due to their physical and chemical properties. These materials could be promising not only for (opto)electronic applications, but also for catalysis, energy storage or biological applications.

Among all ultrathin lamellar materials, those formed by nitrogen group elements or pnictogens occupy a prominent place since their properties can complement or even surpass in some cases those of graphene, the best known 2D material. Among these elements, bismuth (Bi) is particularly noteworthy, since it is a semi-metal with very interesting physicochemical properties, for example: it has a high storage capacity for alkali metals, very low toxicity, high spin-orbit coupling or considerable diamagnetism.

However, the generation of these lamellar materials represents a great challenge since the formation of anisotropic thin films is increasingly complicated as one moves down the elements of the periodic table. The methods that currently exist, such as epitaxial growth or liquid phase exfoliation, lead to the formation of small nanoparticles of different sizes and high polydispersity.

There is, therefore, a need for efficient procedures for the synthesis of high quality 2D pnictogens, and of bismuth in particular given its special properties, that allow to control the growth and morphology of the layers and that are easily scalable.

Research personnel from Universitat de València (ICMOL) have developed a colloidal synthesis method to obtain 2D bismuth crystals, based on a photocatalytic reduction of a Bi(III) organometallic complex.

This synthesis method allows obtaining a 2D bismuth material, also called bismuthene. The lamellar structure of this material is formed by two outer layers of organic molecules containing sulfur atoms and an inner layer formed by a crystal lattice of Bi(0) atoms. These structures present interesting characteristics for energy storage, medical, catalysis or topological properties applications, among others.

MARKET APPLICATION SECTORS

Some examples of applications for 2D bismuth are:

- Energy, as an electrode in sodium ion batteries.
- Medicine, as a contrast agent.
- Electronic applications, as a material with topological properties.
- Chemical catalysis, as part of the structure in porous materials.

TECHNICAL ADVANTAGES AND BUSINESS BENEFITS

The main advantages of this new synthesis method for bismuth 2D lamellar materials are:

- Simplicity and ease of production of ultrathin lamellar materials.
- It allows controlling the size, thickness and plane orientation of the crystals obtained.
- Scalability, it allows obtaining 2D bismuth crystals in large quantities with reproducible characteristics and properties.

In addition, the resulting material, bismuthene, has several advantages over other laminar materials of group 15 elements, such as a high stability against oxidation, and allowance to incorporate functional groups to its structure, allowing the possibility of new properties and functionalities.

CURRENT STATE OF DEVELOPMENT

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The compounds have been synthetized at laboratory level.

INTELLECTUAL PROPERTY RIGHTS

The technology is protected through Spanish patent application P202130722, entitled " Materiales de bismuto 2D anisotrópico y su procedimiento de obtención mediante síntesis coloidal " and priority date 26/07/2021, and by its patent family.

COLABORATION SOUGHT

- User license agreement.
- Subcontracting agreement with companies and/or institutions.

RELATED IMAGES

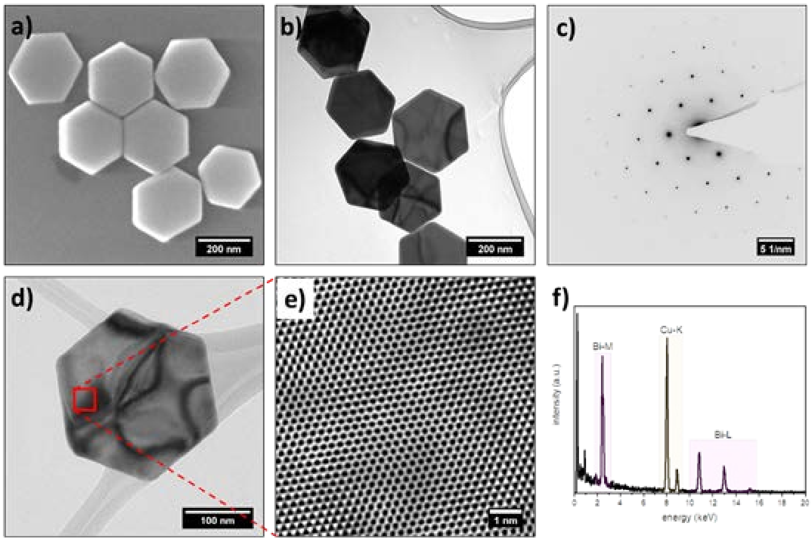

Figure 1: Left, graph of current intensity versus voltage showing hysteretical behavior. Right, top Conductance obtained after applying successive voltage pulses modifying the resistance of the device proportionally and bottom, diagram of the applied voltage sequence to obtain the previous current profile.

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