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Bottom-Up Preparation of Ultrathin 2D Aluminum Oxide Nanosheets by Duplicating Graphene Oxide

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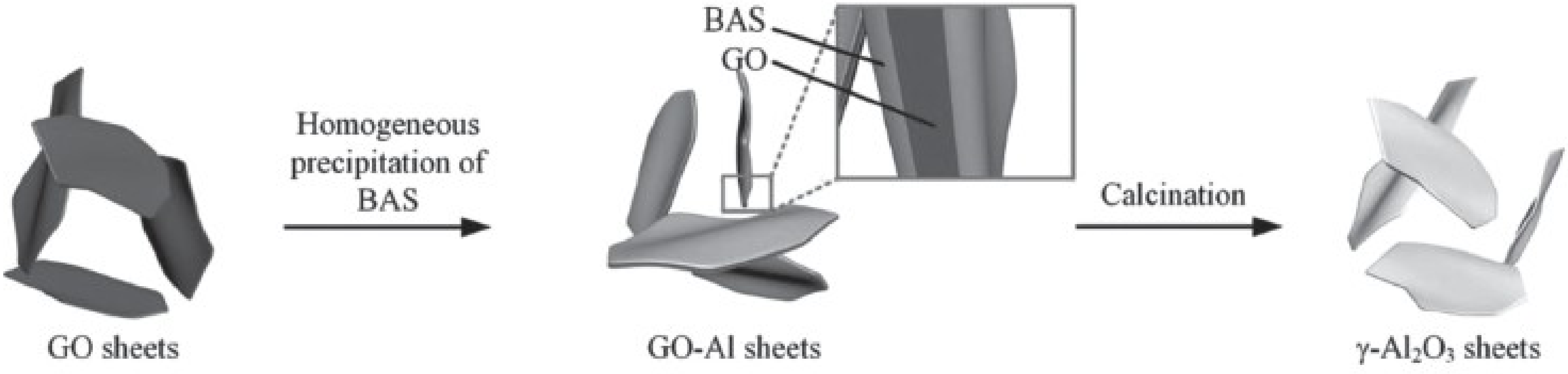

By
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Introduction

- 2D nanosheets exhibit unique physical and chemical properties different from the bulk materials, due to the very large surface-to-volume ratio and the quantum-confinement effect.

- 2D nanosheets have demonstrated their broad applications in solar cells, energy-storing devices, photocatalytic system, and so on.

- There are two strategies for synthesizing 2D nanosheets: top-down and bottom-up methods. In the top-down strategy, nanosheets are exfoliated from the bulk crystal, either by chemical reactions or mechanical effect. Evidently, the crystal used as the raw material should have a 2D layered structure. The bottom-up strategy involves directly growing the nanosheets starting from atoms, ions, or molecules.

- It is still challenging to fabricate 2D graphene-like nanosheets from materials that do not have a 2D layered structure.

- For this purpose, the bottom-up strategy is the best choice, but the difficulty in this strategy is how to find a compatible template and synthesis reaction to achieve the 2D growth of the materials.

In this paper

- In this paper, they have synthesized Al_2O_3 nanosheets using bottom-up preparation method taking GO as a template and $Al_2(SO_4)_3$ as a precursor.

- They have shown that 2D Al_2O_3 nanosheets are more efficient to remove fluoride from water compared to Al_2O_3 particles. Adsorption isotherm is matching with Langmuir isotherm.

Result and discussion

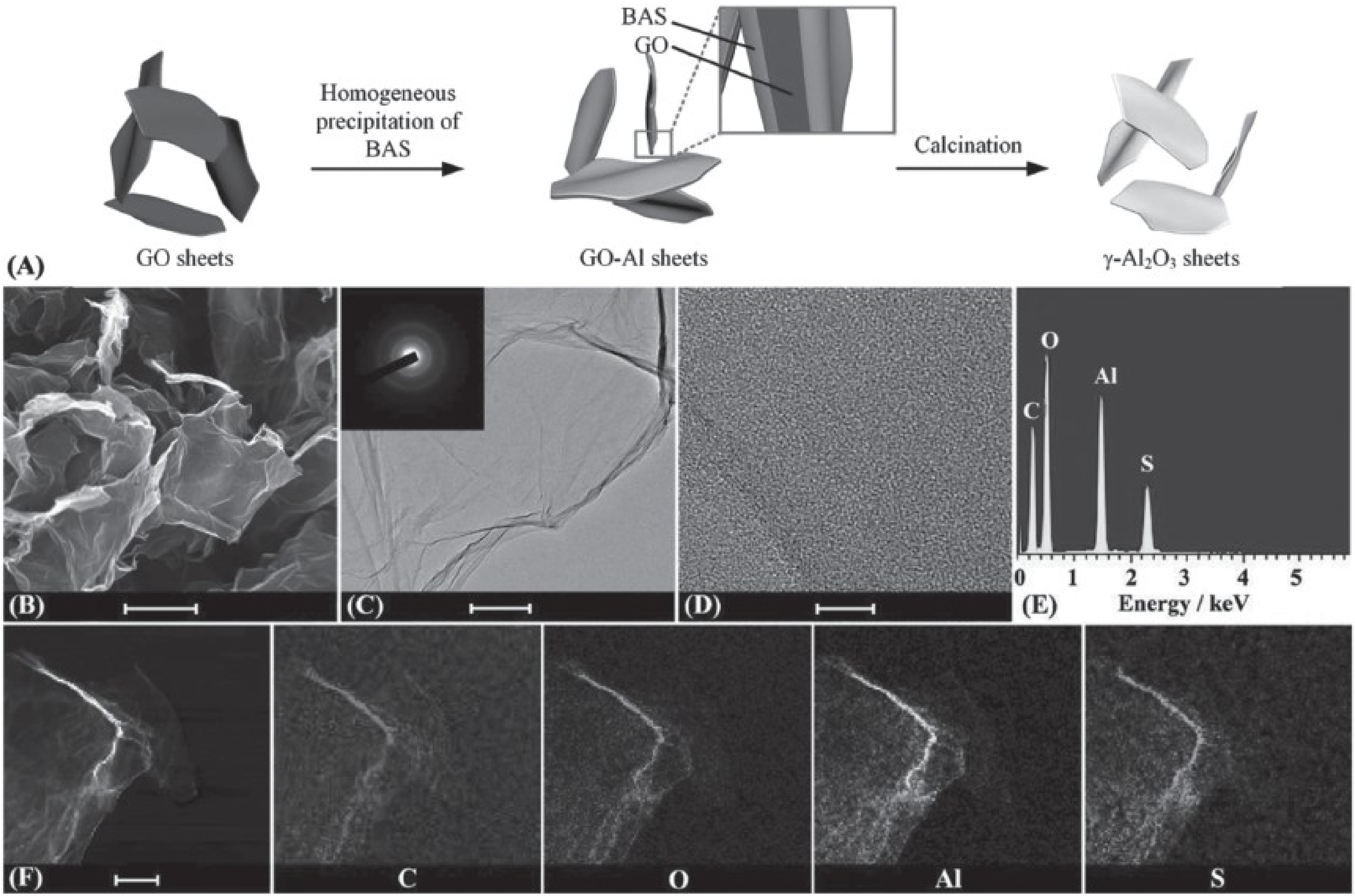

Figure 1. A) Schematic illustration of the preparation of 2D-Al_2O_3 nanosheets. B) SEM image of GO-Al composite sheets. C,D) TEM images of GO-Al composite, the inset of (C) is the selected area electron diffraction pattern of a GO-Al sheet. E) EDX spectrum of the GO-Al composite sheets. F) EDX elemental mapping images of a GO-Al sheet. Scale bars: B) 5 μm, C) 200 nm, D) 10 nm, and F) 1 μm.

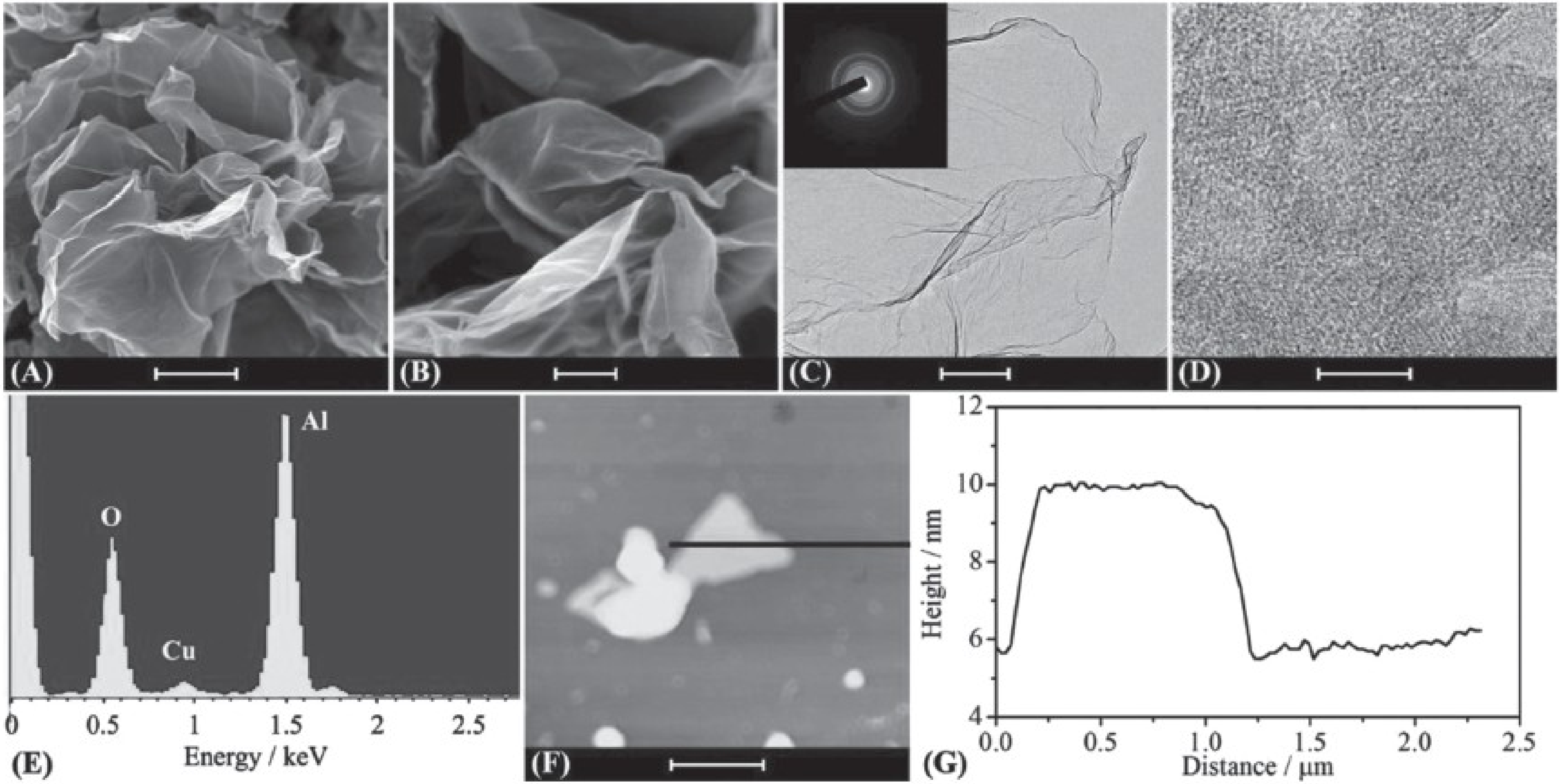

Figure 2. Morphological and structural analysis of the 2D-Al_2O_3 nanosheets. A,B) Typical SEM images of the 2D-Al_2O_3 nanosheets. C,D) Typical TEM images of the 2D-Al_2O_3 nanosheets, and inset of (C) is the selected area electron diffraction pattern of a 2D-Al_2O_3 nanosheet. E) EDX spectrum of the 2D-Al_2O_3 nanosheets. F,G) AFM image and height profile of the 2D-Al_2O_3 nanosheets. Scale bars: A) 2 µm, B) 500 nm, C) 100 nm, D) 5 nm, and F) 1 µm.

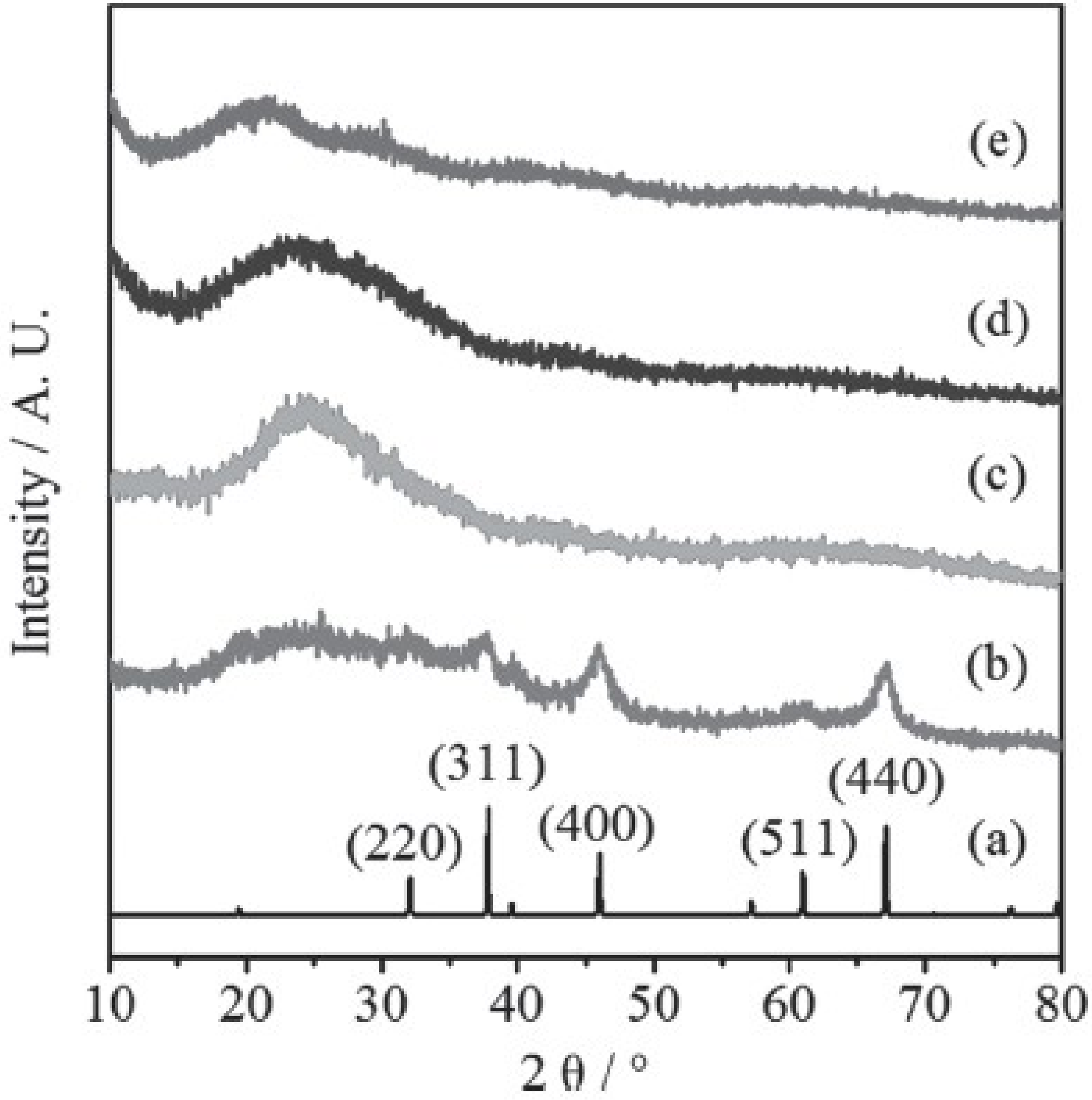

Figure 3. XRD patterns of: a) a simulated pattern of γ-Al_2O_3, b) 2D-Al_2O_3 nanosheets, c) Al_2O_3 particles, d) GO-Al, and e) BAS.

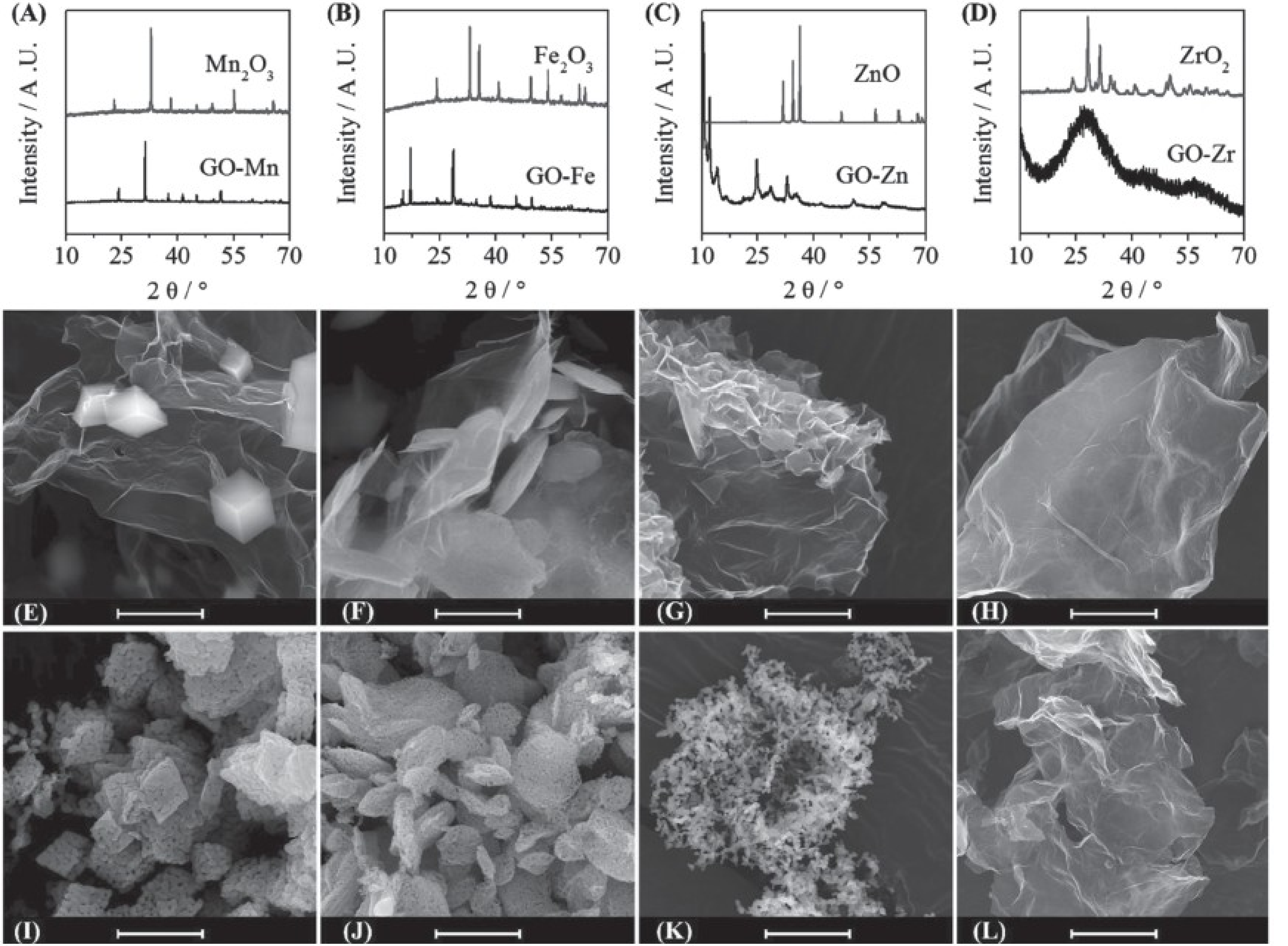

Figure 4. A–D) XRD patterns of GO-M (M = Mn, Fe, Zn, and Zr) and the corresponding metal oxides after calcination. E–L) SEM images of GO-Mn (E), GO-Fe (F), GO-Zn (G), GO-Zr (H), Mn_2O_3 (I), Fe_2O_3 (J), ZnO (K), and ZrO_2 (L). Scale bars: 3 μm.

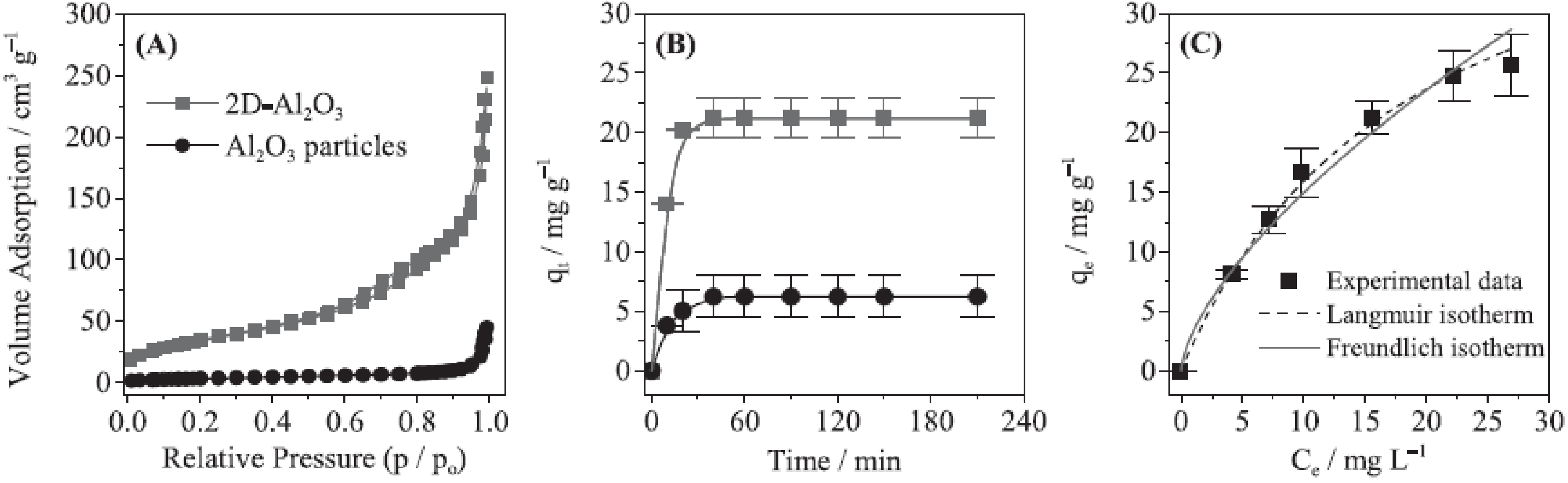

Figure 5. A) N_2 adsorption/desorption isotherms of Al_2O_3 particles and 2D-Al_2O_3 nanosheets. B) Adsorption kinetic curves of fluoride ions on (●) Al_2O_3 particles and (■) 2D-Al_2O_3 nanosheets (volume of fluoride solution: 100 mL, adsorbent mass: 20 mg, initial fluoride concentration: 20 mg mL^{-1}, temperature = 298 K). C) Adsorption isotherm of fluoride ions on 2D-Al_2O_3 (volume of fluoride solution: 100 mL, adsorbent mass: 20 mg, temperature = 298 K).

Conclusion

- They developed a bottom-up method to synthesize graphene-like 2D-Al_2O_3 nanosheets. In this method, GO sheets were employed as the 2D template.

- The amorphous structure of the precursor is crucial for the formation of perfect 2D nanosheets.

- Slow rate of precipitation and slow and steady decomposition of GO-M composition is required to get defect free 2D nanosheets.

- The 2D-Al_2O_3 nanosheets were used as the adsorbent for removing fluoride ions from water, and showed fast adsorption kinetics and large adsorption capacity.

Future direction

- Using this procedure it is possible to synthesis inorganic 2D nanomaterials from the precursor which do not have sheet structure and this materials can be used as catalyst and in environmental science (like purification) due to their large surface to volume ratio.

- MoS_2 can also be used as a template.

Thank you