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Facile synthesis of VF_2 nanobelts and its application as a new floating-type absorbent for wastewater treatment

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ABSTRACT

The VF_2 nanobelts are successfully prepared by a facile post-synthesis treatment method. We have mainly investigated the effects of fluorine sources, the molar ratio of NH_4F to V_2O_5, reaction temperature and time on the structures and properties of the samples. It is found that NH_4F can not only provide F^-, but also regulate the growth of VF_2 nanobelts. Moreover, the adsorption performance of VF_2 nanobelts has also been investigated. The results demonstrate that the as-synthesized VF_2 nanobelts exhibit a fast adsorption rate for methylene blue (MB), in which the adsorption equilibrium can be reached at 5–10 min. In addition, the adsorption process well fits with the pseudo-second-order model. Due to the ultra-light weight, VF_2 nanobelts can naturally float on the upper surface of aqueous system after stopping stirring. Hence, it can easily be recycled from wastewater. We expect that the VF_2 nanobelts, as a new floating-type absorbent, could be used for wastewater treatment.

1. Introduction

In the recent years, considerable attentions have been paid to one-dimensional nanostructures, *e.g.*, nanowires, nanobelts, nanotubes, etc. [1–3] Due to their unique physical and chemical properties, one-dimensional nanostructures have been widely applied as photo catalysts [4], adsorbents [5], supercapacitors [6] and battery electrodes [7]. Many methods have been used to synthesize one-dimensional nanostructures, including electrospinning, chemical vapor deposition, vapor-liquid-solid method, and so on [8–10]. Recently, inorganic ion mediation method has aroused an extensive interest owing to its simplicity and low cost. For example, Zhu and coworkers [11] have synthesized single crystalline WO_3 nanobelts through an NH_4^+-mediated method, which exhibit extremely high adsorption capacity for organic dye. To the best of our knowledge, nevertheless, the morphology-controllable synthesis of vanadium difluoride (VF_2) has not been available in the existing references. On the other hand, adsorption is a simple and low-cost technology in wastewater treatments. However, the adsorbents are usually difficult to be separated from the aqueous system, especially when the powder-type adsorbents are used. Thus, it is still a big challenge to separate and recycle the adsorbents in wastewater treatment. It is desirable to develop the easy-recycled adsorbents.

Herein, we have prepared VF_2 nanobelts by a simple post-synthesis method, in which NH_4F was employed as the controlling chemical. To understand the effects of NH_4F on the samples, a series of comparative experiments were carried out. Moreover, the VF_2 nanobelts exhibit an excellent adsorption performance for methylene blue (MB) dye. It is important that due to the ultra-light weight, VF_2 nanobelts can naturally float on the upper surface of aqueous system after stopping stirring. As a result, it can easily be recycled from wastewater system.

2. Experimental

All reagents were of analytical grade, purchased from Beijing Chemical Reagents Industrial Company of China, and were used without further purification.

2.1. Preparation of VF_2 sample

Typically, 0.91 g (5 mmol) V_2O_5 was dispersed into 30 mL of deionized water containing 0.0555 g (1.5 mmol) NH_4F. After being stirring for 0.5 h, the dispersions were transferred to a 40-mL Teflon autoclave and heated at 180 °C for 24 h. After the reaction

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was completed, the upper floating solids in the autoclave were collected; then the sample was washed with distilled water and absolute ethanol for several times, and dried at 60 °C for 5 h in air. Herein, the yield of VF_2 sample was 0.1-0.2 g, because an amount of ammonium vanadate formed and deposited in the bottom of autoclave. It is worth noting that the V_2O_5 powders used in the experiment were obtained by calcining commercial NH_4VO_3 at 400 °C for 2 h. Herein, the possible reaction between V_2O_5 and NH_4F is proposed as follows:

$$7\,V_2O_5 + 2\,NH_4F \rightarrow 2\,VF_2 + 2\,(NH_4)_2V_6O_{16} + 3\,[O]$$

Because of the reaction complexity, the detailed reaction process needs further study in future.

2.2. Characterization

The samples were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM), high resolution transmission

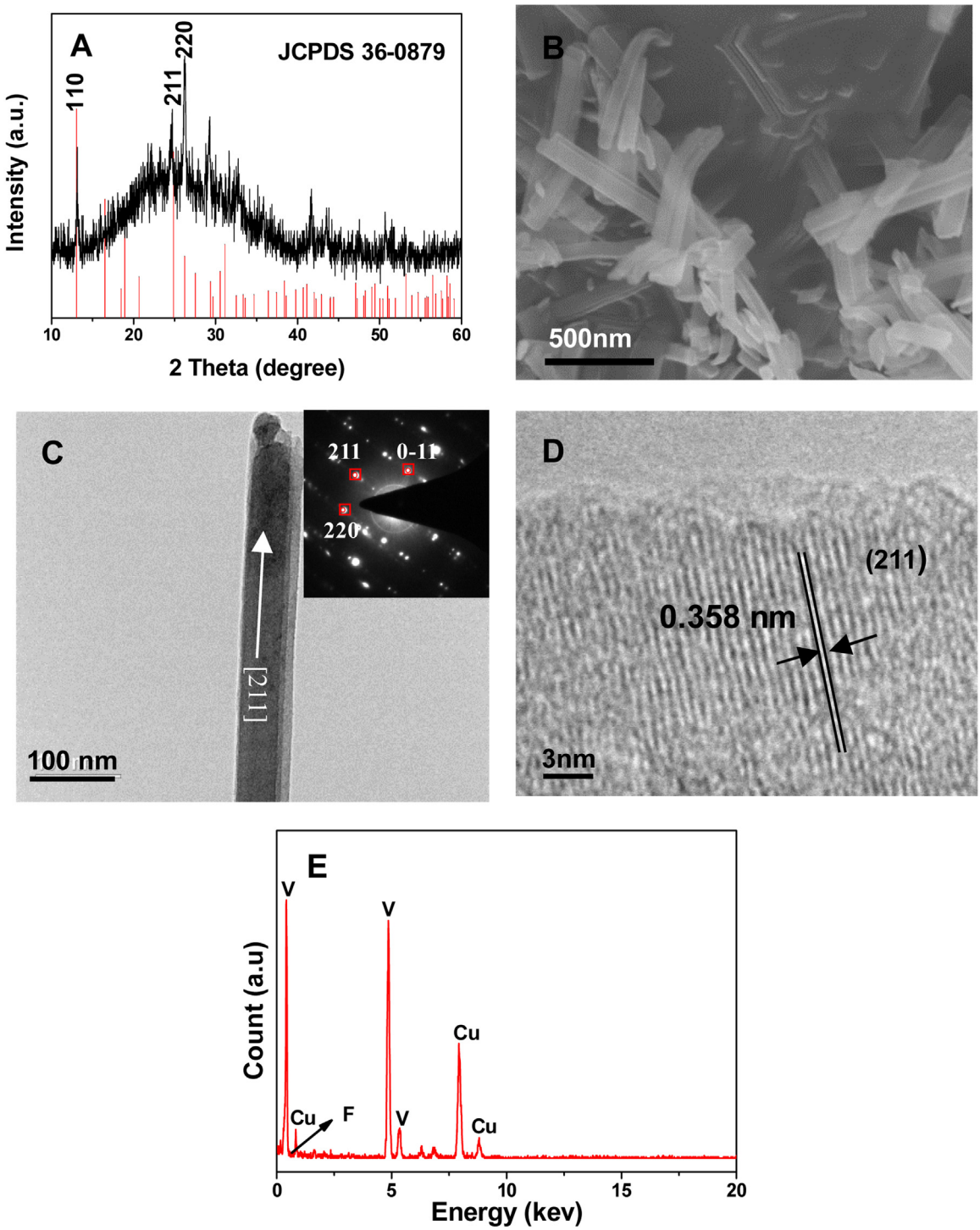

Fig. 1. (A) XRD pattern, (B) SEM image, (C) HRTEM image (the inset of SAED pattern), (D) Lattice fringe image and (E) EDS analysis of the VF_2 nanobelts: V_2O_5:NH_4F = 1:0.3 (molar ratio), 180 °C/24 h.