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## CAPTER 1

### INTRODUCTION

The aim of this work was to produce biodegradable film based on polyvinyl alcohol/vanadium pentoxide (V2O5)/grapefruit peel powder (GF) (PVA/GF/V2O5). Grapefruit peel powder and V2O5 effects on the physicochemical/structural properties of the films was evaluated. The properties like, solubility, thickness, antioxidant activity, humidity, water vapor permeability (WVP), color indices, FTIR, TGA, SEM and XRD tests were investigated. According to the results, increasing of grapefruit peel powder led to an increase in the color indices (a and b) and thickness of the films, and on the other hand, a decrease in the solubility and L index was observed with the addition of V2O5 nanoparticles in the samples. Addition of V2O5 to the film increased the index a and b of the samples. The antioxidant properties of the samples increased with the addition of grapefruit peel powder and V2O5. The electrostatic interaction between polyvinyl alcohol, grapefruit peel powder, and V2O5 nanoparticles was confirmed by FTIR. According to the SEM images, films containing grapefruit peel powder and nanoparticles have a granular heterogeneous film. The TGA results showed that the thermal stability of films containing grapefruit peel powder and nanoparticles was better than the control sample, and the results obtained from XRD showed that with the addition of grapefruit peel powder, there were slight changes in the intensity of the peaks, and addition of V2O5 led to the increasing of peak intensity, which has the highest percentage of impact on the film’s crystallite structu

## CAPTER 2

### INTRODUCTION

In this study, we examined the effect of vanadium pentoxide (V2O5) on the mechanical, thermal, and morphological properties of poly(vinyl alcohol) (PVA)/V2O5 nanocomposites. The PVA/V2O5 nanocomposites were prepared by solution mixing, followed by film casting. The results show that the Young's moduli of the resulting nanocomposites films were higher than the pure PVA modulus with increasing V2O5 content, and it reached a maximum point at about 0.4 wt % V2O5 content at 8.55 GPa. The tensile strength and stress at break increased with increasing V2O5 content. The addition of V2O5 did not affect the melting temperature. The crystallization temperatures of PVA were significantly changed with increasing V2O5 content. The 5% weight loss degradation temperature of the nanocomposites was measured by thermogravimetric analysis. The degradation temperatures of the V2O5 nanocomposites increased with increasing filler content and were higher than the degradation temperature of pure PVA; this showed a lower thermal stability compared to those of the nanocomposites. The results show that the thermal stability increased with the incorporation of V2O5 nanoparticles. The dielectric constant of PVA had a tendency to improve when the dispersion of particles was effective. The morphology of the surfaces the nanocomposites was examined by scanning electron microscopy. We observed that the dispersion of the V2O5 nanoparticles was relatively good; only few aggregations existed after the addition of the V2O5 nanoparticles at greater than 0.4 wt %. In perspective, the addition of 0.4 wt % V2O5 nanoparticles into PVA maximized the mechanical, thermal, and electrical properties. © 2011 Wiley Periodicals, Inc. J Appl Polym Sci, 2011

## CAPTER 3

### INTRODUCTION

For the first time, using an extrusion process, macroscopic composite poly-vinyl alcohol(PVA)/poly-aniline (PANI)-V2O5 fibers have been generated. Besides the extrusion process itself, this is certainly the first redox reaction addressed while performing an extrusion shaping process. The as-synthesized fibers have been characterized at different length scales, revealing at the mesoscale a 30° preferential orientation of the nanoribbons subunits toward the macroscopic fiber main axis. At the microscopic length scale, despite a semiamorphous nature, electron spin resonance (ESR) spectroscopy has been employed to reveal partial reduction of V5+ species to V4+ ones, where the paramagnetic species local environment has been found to be close to hydrated vanadium oxide xerogels. Concerning the organic counterpart, the aniline is oxidized into poly aniline when considering both the fibers characterization through ESR and Fourier transformed infrared (FTIR) spectroscopy and the well-known strongly oxidizing character of V5+ species toward aniline. These new PVA/PANI-V2O5 fibers are cycling when sensing alcoholic vapors while offering a good selectivity. The addressed sensitivity allows sensing 5 ppm of ethanol within 3−5 s at 42 °C. Beyond, the as-synthesized PVA/PANI-V2O5 macroscopic fibers possess a toughness of 12 J g−1, a value that has been increased by more than 120 times when compared with nanoporous inorganic fibers.

#### DESCRIPTION

Nowadays, while human beings enjoy the great convenience brought by the rapid development of science and technology, how to improve the energy storage equipment and raise the efficiency of energy supply to deal with a variety of environmental and safety problems has become an important global issue simultaneously [[1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11]]. Due to the combustible organic electrolyte of lithium-ion batteries (LIBs), some explosion cases often take place in recent years, but this kind of battery with great potential danger is the most commonly used in the past decades [[12], [13], [14]]. Recently, on account of the urgent demand for the market for safety, great efforts have been made in the research of aqueous batteries [[15], [16], [17], [18], [19]]. Among them, aqueous zinc-ion batteries (AZIBs) have become hot alternatives. Not only because AZIBs utilize secure aqueous electrolyte, but zinc anode owns extraordinary theoretical specific capacity (820 mA h g−1) and low budget [[17], [18], [19], [20], [21], [22], [23], [24]]. The potential large capacity of AZIBs attracts people to study cathode materials, but there are still some defects keeping far away with practice [25]. Therefore, this work focuses on the design and synthesis of new cathode materials, trying to improve their electrochemical performance.

At present, the most commonly studied cathode materials for AZIBs are manganese oxides, Prussian blue and its analogues, polyanionic compounds, as well as vanadium based materials [17,[26], [27], [28], [29]]. Among them, vanadium based materials for AZIBs have been widely discussed due to the variable valence states of vanadium, abundant natural reserves and lower prices, not the least of which are (intercalated) vanadium oxide and vanadate [18,[30], [31], [32], [33], [34], [35], [36], [37], [38], [39]]. Because the interlayer water molecules support the layered structure like pillars, V2O5nH2O and its derivatives have a larger interlayer spacing, which indirectly accelerates the diffusion rate of ions and has been extensively studied [[40], [41], [42], [43], [44], [45]]. Linda F. Nazar et al. [40] first developed Zn0.25V2O5nH2O through a hydrothermal method as the cathode for AZIBs and it exhibited high specific capacitance and energy density. The results showed that zinc ions and additional water molecules were intercalated into the interlayer of V2O5∙nH2O and pillared the structure. After receiving the inspiration, many studies are focused on the application of V2O5∙nH2O and its derivatives (mainly including metal ions and conducting polymers intercalated V2O5∙nH2O) as the cathodes for AZIBs [[41], [42], [43], [44], [45], [46], [47]]. For instance, Yanyan Liu et al. [46] synthesized a 3D sponge-like architecture polyaniline-intercalated V2O5∙nH2O by mild molecule-exchange reaction and the interlayer space was enlarged to about 14 Å. Furthermore, the as-assembled AZIBs delivered the high specific capacity of 353.6 mAhg−1 at 0.1 Ag−1. However, all the mentioned above (intercalated) V2O5nH2O as cathode in AZIBs are basically in powder form, which are mixed with the binder and conductive agents. These additives will increase process complexity and the mass of the electrode [12,48]. Therefore, the use of V2O5∙nH2O film as the free-standing electrode is very meaningful and this idea has been rarely reported [49]. Graphene is a 2D sheet with single atom thickness and incredible mechanical properties, but it is easy to accumulate and agglomerate in aqueous solution [50]. The previous report demonstrated that PVA could connect with GO by hydrogen bonding and ameliorating the dispersion of GO to achieve the desired effect, especially can enhance the electrical conductivity [51]. In our previous report, the V2O5∙nH2O/rGO-PVA film was demonstrated that it could be used as the free-standing cathode for solid-state Zn-ion battery using the ZnSO4/CMC gel electrolyte. In this work, we tried to develop this material to be the free-standing electrode for coin-typed AZIBs using Zn(CF3SO3)2) as the electrolyte.

Herein, V2O5∙nH2O/rGO-PVA film was synthesized by one-step hydrothermal process and vacuum filtration. Compared with the traditional method of making electrodes, the film can be directly used as electrode with the supporting of titanium foil, which saves a lot of time and energy and is easier to install the battery. As the free-standing cathode for coin-typed AZIBs, the V2O5∙nH2O/rGO-PVA film exhibits the superb specific capacity of 553 mA h g−1 at the current density of 0.1 A g−1. In the meantime, the capacity is up to 194 mA h g−1 at 0.5 A g−1. It also behaves good cyclic performance with the specific capacity remaining 152 mA h g−1 after 300 cycles. It has been calculated that the high energy density is 354 Wkg−1 and the corresponding power density is 183 W·kg−1. The achieved electrochemical performance proved the V2O5∙nH2O/rGO-PVA film to be a promising cathode material for AZIBs.

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## CAPTER 4

### INTRODUCTION

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