Journal of Fiber Bioengineering and Informatics 12:1 (2019) 25–33
doi:10.3993/jfbim00312

The Properties of Wool-based Activated Carbon Tubes Prepared by Potassii with no Gas and Its Mechanism Study

Wen-Yang Tang, Chi-Yu Fu, Jia-xin Yu, Wu Chen*

State Key Engineering Laboratory for Advanced Textile Processing and Clean Production, Wuhan Textile University, Wuhan 430200, China

Abstract

In this study, the wool-based activated carbon tubes (ACTs) were successfully prepared by potassii as additive. The ACTs had formed a tubular morphology with numerous pores located in both two sides. The mechanism of the tube formation were mainly investigated by removing overlapping scales on the surface of fibers and comparing the effects of experimental parameters. The removal method were carried out by formic acid and ultrasonic wave oscillation. The influence between scales and tubes was characterized by scanning electron microscopy (SEM), thermogravimetric analysis (TGA), methylene blue (MB) through discussing the morphology study, thermal property and adsorption capacity of ACTs. The surface morphology of the ACTs were affected by carbonization temperature, while the scale layers has no relations with the formation of a tubular morphology. Scale layers had almost no effects on thermal decomposition because close weight loss between ACKC2 and ACKC5. The adsorption capacity of ACTs from raw wool using two-step method is in the range of 18.50-26.75 mg/g, which was obviously higher than using one-step method with 14.40-84.00 mg/g. The adsorption capacity of ACTs decreased because of the removal of scale layers using one-step, which is contrary to ones using two-step.

Keywords: Activated Carbon Tubes; Wool Fibers; Scales Layers; Thermal Decomposition; Adsorption

1 Introduction

Activated carbon (AC), has been highly used because of its large specific surface area (S_{BET}), high adsorption capacity and numerous pore structure, is a kind of non-polar carbon materials obtained through coal, wood and various biomass as precursor by a series of physical and chemical methods such as crushing, sieving, carbonization and activation [1, 2]. The physical activation process is usually carried out by water steam, CO_2 flow or chemical method by acid, alkali and salt [3-4]. And the carbonization process needs to be heat treated under protective gas flow like Ar or N_2 flow. It has been used for catalyst, adsorbent [5], water purification [6], supercapacitors [7]. In addition to environmental protection, chemical medicine preparation and food preservation,

*Corresponding author.
Email address: wuchen@wtu.edu.cn (Wu Chen).

Mar. 2019

it's also widely used in life, military and other fields [8, 9]. Another characteristic of AC is strong vapor adsorption capacity, which can be fully utilized [10]. There are some pores in the internal structure and active functional groups that can react with molecules on the surface.With stable chemical properties, activated carbon is heat resistant and does not react with acid or base. According to lots of researches, AC can be prepared with a wide range of raw materials, but traditional AC preparation mainly relies on wood and coal, which has caused a negative impact on the ecological environment [11]. With enhanced public awareness of environmental protection, researchers begin to study on some eco-friendly materials used for AC to reduce the hazardous effects [12]. Wool, a kind of proteinic fiber mainly constituted with 18α-amino acids, has good features like chemical and mechanical properties, which can be used as textile materials [13]. Like other proteins, wool is a very active material [14]. It contains three main types of reactive groups: peptide bonds, amino acid side chains, and disulfide cross-linkings [15]. Chemicals which can react with wool include water, acid, alkali, reductant, oxidant, alkyl amine, formaldehyde, alcohol, anhydride, acyl chloride, and dye [16, 17]. The study on absorbability of wool with acid dyes demonstrates the possibility to remove the colorant from wastewater using AC [18]. Although traditional granular AC and powdered AC have their own advantages, the ACTs from wool fibers have the characteristics of small diameter and more concentrated pore distribution, which can effectively reduce diffusion limit and is favorable for rapid adsorption and desorption that adsorption capacity is higher at low concentration of adsorbents [19].

In this study, the waste wool from sweater or felt had been used to prepare ACTs showing a special hollow morphology, and the proper process, experimental parameters were also discussed in order to figure out the mechanism of the tubes formation. The removal of the scale layers will inevitably lead to the change of fiber properties. Therefore, the first step to study the mechanism is to remove the scale layer and then discuss its influence. This paper mainly compared the experimental conditions, for instance, the removal of scales, the concentration of activators, the carbonazation temperature and the methods. These parameters would all affect the preparation efficiency of ACTs and then marked the optimum experimental conditions. The morphology study, chemical content, thermal decomposition and adsorption behavior were tested and characterized by SEM, TGA and MB respectively. Also, some properties like yields, pore sizes, wall thicknesses were analyzed with the increasing temperature.

2 Experiment

2.1 Materials

Wool (leftovers from a sweater) with the diameter about 25 um, potassii (anhydrous pellets, AR grade, 99.0% minimum purity), anhydrous formic acid (AR grade, 98.0% minimum purity), distilled water, nitrogen gas, methylene blue (AR grade, 98.0% minimum purity), Hydrogen squaminate disodium trihydrate, potassium dihydrogen squaminate, potassium squaminate, monopotassium phosphate.

2.2 Fabrication of Activated Carbon Tubes

In this study, the process of removing scale layers followed the method available in some researches. The method need to combined the physical and chemical steps together named formic acid and