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Preparation of electroless silver plating on aramid fiber with good conductivity and adhesion strength

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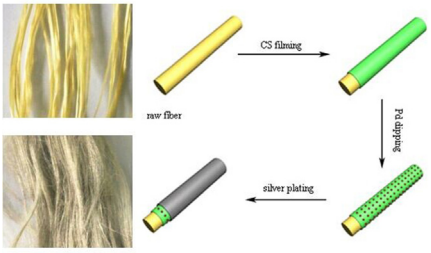
HIGHLIGHTS

- We propose a facile method to produce conductive aramid fiber.
- Cross linked chitosan combined with Pd (II) ions to form catalytic film.
- The silver-plated fiber has good conductivity.

GRAPHICAL ABSTRACT



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ABSTRACT

A novel method was developed to prepare silver-plated aramid fiber. Crosslinked chitosan (CS) with —NH_2 and —OH functionalities was used as chelator to absorb palladium ions and formed a catalytical film on the fiber surface, which can successfully initiate silver deposition in the following electroless plating stage. Compared to conventional methods, sensitization process was eliminated and good conductivity as well as strong adhesion to metal layer was obtained, thanks to the chelating effect between chitosan and silver layer. SEM images indicate a dense and uniform silver coating was fabricated on the fiber surface. The electrical resistance of prepared fiber was as low as 0.38 Ω/cm, showing good conductivity. The durability of this aramid fiber is outstanding under harsh condition. These attractive features exhibited by this aramid fiber make it a potentially promising candidate for biomedical electronic field.

1. Introduction

In recent years, functionalized high performance fibers, especially conductive fiber has attracted a great deal of attention, due to the rapid development of electronic devices. Aramid fiber was well-known for its excellent properties, such as strength, tenacity, outstanding chemical resistance, impact resistance, light weight, heat resistance and low elongation. These excellent characteristics lead to broad applications of aramid fiber in fields of military, protective equipment and high-end industrial materials. There is no doubt if conductivity can be imparted into aramid fiber, the application fields and markets of aramid fiber would be significantly expanded. In other words, several interesting functions such as static electricity prevention, electromagnetic shielding, etc. can be achieved by aramid fiber with a certain degree of conductivity. It is known that conductive aramid fiber can be widely applied in smart textile, electromagnetic shielding materials, and flexible circuit boards (FCBs) materials [1–3].

A variety of methods have been developed to prepare conductive materials, such as electron beam evaporation [4], sputtering deposition [5], chemical vapor deposition (CVD) [6], and electroless plating [7]. For example, Ma et al. [8] prepared CS-Pd membrane by

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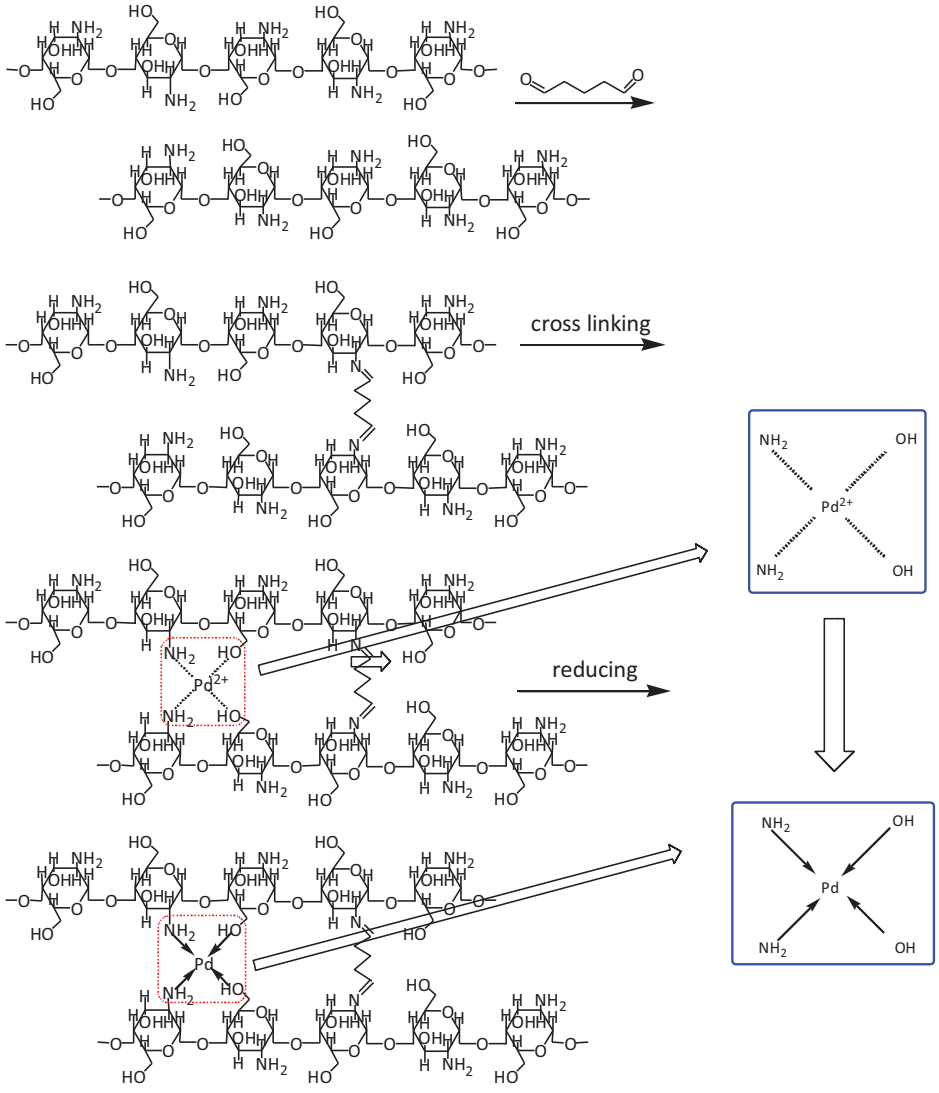

Scheme 1. Reaction pathways of CS pretreatment.

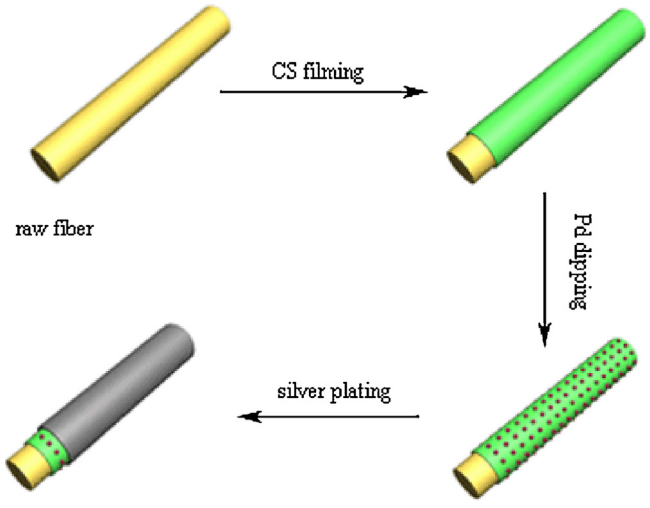

Fig. 1. The process of preparing silver plated aramid fiber.

self-assembly technique in the activation step before electroless plating, and subsequently fabricated the nylon fabric with electromagnetic shielding effect. In the early 1980s, Andretti [9] mixed the polyaniline and aramid and spun a family of conductive fiber

Table 1
Composition of electroless silver plating bath and reducing solution.

Silver plating solution		Reducing solution	
$AgNO_3$ (g)	0.75	glucose (g)	4
ammonia (mL)	1	tartaric acid (g)	0.1
deionized water (mL)	30	Ethanol (mL)	10
		deionized water (mL)	100

called PAN–PPTA. Wang et al. [10] used a method of fixing the silver nanoparticles on the surface of polymetaphenylene isophthamide (PMIA) by poly (dopamine) to fabricate conductive aramid fibers. Among these techniques, electroless metal plating is the most facile way [11–13] and shows greater potential in industrial application. To the best of our knowledge, studies of metalization of aramid fiber by electroless plating still remain insufficient. Moreover, the nature of aramid fiber, including low chemical reactivity, and low surface energy along with high degree of crystallinity leads to inherently poor adhesion strength between fiber and metal layer. Aiming to solve these challenges, many studies were focused on the pretreatment of aramid fiber before electroless plating. Liang et al. [14] used DMSO-NaH to modify the surface of aramid fiber. In Zhao's work [15], supercritical carbon dioxide was used as solvent to accelerate Pd(II) ions' impregnating into aramid fibers. These two approaches achieved decent results on fabricating conductive aramid fiber, but