WASTE POTASSIUM BASED RECYCLE AGENT PREPARATION AND NANOFIBER PRODUCTION

Original scientific paper
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ABSTRACT: *The low potassium content in the foods consumed daily and the absence of potassium in most foods direct people to potassium intake directly through supplementary foods. It is known that large amounts of potassium are present in banana fruit and peel. This study is aimed at utilizing banana peel waste to produce an easy-to-use, thin, lightweight, biocompatible, and innovative nanofibrous material. First of all, waste banana peels were lyophilized with a freeze-dryer device and pulverized with a mixer blender. Next, EDX conducted an elemental analysis of the potassium-containing banana peel powder. Then, PVP-based nanofibers with recycled potassium-containing banana peel powder were produced. PVP solutions containing different concentrations of banana peel powder were prepared under equal conditions, and the solution properties such as conductivity, viscosity, pH, and surface tension were determined. Finally, Scanning Electron Microscopy (SEM) was used to analyze the structural properties of PVP-banana peel powder nanofibers, such as fiber diameter, fiber diameter uniformity coefficient, and elemental analysis with EDX to confirm the presence of potassium in the nanofibrous material. It is thought that these nanofiber surfaces, which can be transformed into a high-value-added product by evaluating the waste food material, will be especially useful for a treatment for supralingual application of potassium.*

Keywords: *Waste, recycle, potassium, PVP, nanofiber, electrospinning.*

PRIPREMA RECIKLAŽNIH SREDSTAVA NA BAZI OTPADNOG KALIJUMA I PROIZVODNJA NANOVLAKNA

APSTRAKT: *Nizak sadržaj kalijuma u namirnicama koje se svakodnevno konzumiraju i odsustvo kalijuma u većini namirnica usmeravaju ljude na unos kalijuma direktno putem dopunske hrane. Poznato je da su velike količine kalijuma prisutne u plodovima i kori banane. Ova studija ima za cilj korišćenje otpada od kore od banane za proizvodnju tankog, laganog, biokompatibilnog i inovativnog nanofibroznog materijala koji je jednostavan za upotrebu. Pre svega, otpadne kore od banane su liofilizovane pomoću uređaja za sušenje zamrzavanjem i usitnjene mikserom. Zatim je EDKS sproveo*

elementarnu analizu praha kore banane koji sadrži kalijum. Zatim su proizvedena nanovlakna na bazi PVP-a sa recikliranim prahom od kore banane koji sadrži kalijum. PVP rastvori koji sadrže različite koncentracije praha kore banane pripremljeni su pod jednakim uslovima i određena svojstva rastvora kao što su provodljivost, viskozitet, pH i površinski napon. Konačno, skenirajuća elektronska mikroskopija (SEM) je korišćena za analizu strukturnih osobina nanovlakna u prahu od kore banane PVP, kao što su prečnik vlakana, koeficijent uniformnosti prečnika vlakana i elementarna analiza sa EDKS-om da bi se potvrdilo prisustvo kalijuma u nanovlaknastom materijalu. Smatra se da će ove površine od nanovlakna, koje se mogu transformisati u proizvod sa visokom dodatom vrednošću procenom otpadnog materijala hrane, biti posebno korisne za tretman supralingvalne primene kalijuma.

Ključne reči: *otpad, reciklaža, kalijum, PVP, nanovlakna, elektropredenje.*

1. INTRODUCTION

Sustainability of waste materials is of great importance in the world, and in this study, it is planned to evaluate banana peel waste and transform it into a value-added product. Banana is the second most consumed tropical fruit worldwide. However, this consumption generates a lot of waste. Banana peels are a carbon-rich waste that can take up to two years to decompose and biodegrade, creating odors and producing excessive greenhouse gas emissions that contribute to climate change. Banana peels, which make up about 35% of the banana by weight, generate 3.5 million tons of waste annually [1]. Today, the value of sustainability and an environmentally friendly approach is increasing day by day, and recycling and using banana peel waste instead of harming the environment maintains its importance in terms of both human and natural health. When the textile-related studies on the utilization of banana peel wastes in the literature are analyzed, the adsorption properties of banana peels in the removal of dyes from textile wastewater were examined [2]. In another study, heavy metal adsorption with banana peel wastes and the efficiency of textile dyes were analyzed [3]. Another study on banana peel in the textile sector examined the effect of banana peel extract on the flame retardancy of cotton and cotton-polyester blended fabrics. The study determined that banana peel, after finishing processes using banana peel wastes, positively contributed to flame retardancy [4].

Nanotechnology is a multi-disciplinary field that includes both textiles and many other disciplines (medical, electronics, chemistry, biology, etc.). Nanofibers are one of the subunits of nanotechnology, and nanofiber production, especially by the electrospinning method, has gained great importance in recent years, both in R&D and industrial applications. Fiber spinning from many natural and synthetic polymers can be realized in nanofiber production by the electrospinning technique. Nanofibers have recently become an increasingly important research topic due to their microstructural properties, such as small pore sizes, high porosity, high specific surface area (m^2/g), and very fine fiber diameter.

It is thought that the nanofiber material containing potassium produced in this study will be useful in sublingual applications. In the literature, there are studies on the production of

nanofibers using different active ingredients and supralingual applications. In a study conducted by [5] in 2022, supralingual application of PVA-based and paracetamol-loaded nanofibers was performed in rabbits, and paracetamol concentration values in the blood were determined. It was stated that nanofibrous materials have an important potential for such supralingual applications.

2. MATERIALS AND METHODS

2.1. Materials

In this study, PVP (Mw 360.000 g/mol) was used as a polymer, distilled water and ethanol (absolute ≥99.8%) were used as solvents, banana peel powder was used as a potassium agent, and Cremophor RH40 was used as a surfactant.

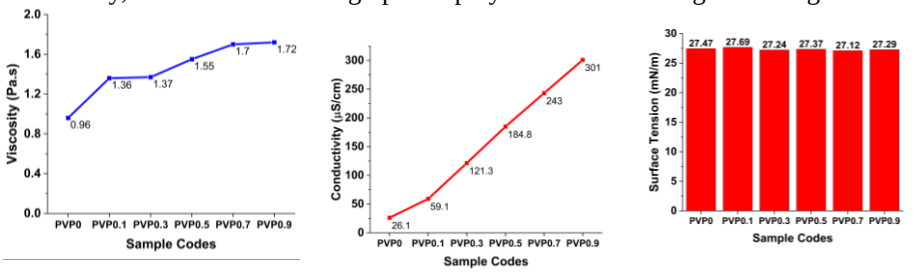
2.1. Methods

In general, the study was carried out in five stages. Firstly, waste banana peels were lyophilized using a freeze dryer. After the lyophilization process, potassium was concentrated in the dried peel, and then the dry peels were powdered by passing through a mixer. EDX elementally analyzed the potassium-containing powder material. Preparation of polymer solutions with optimum properties (polymer and agent concentration, appropriate solvent selection, solution preparation techniques, etc.) is very important in terms of fiber spinning performance and fiber morphology in the production of nanofibers. In the study, PVP polymer concentration was kept constant at 12 wt %, and ethanol and distilled water were used as solvents in a 50:50 ratio. When a homogeneous solution was obtained, banana peel powder was added to the PVP solution at different concentrations, such as 0.1, 0.3, 0.5, 0.7 and 0.9 wt %. In nanofiber production by electrospinning, determination of the solution properties used as raw material is very important in terms of fiber spinning performance and morphological properties of fibers (fiber diameter, uniformity, etc.) [6]. The solution properties, such as surface tension, conductivity, viscosity, and density, of PVP-based solutions with different concentrations of potassium agents were determined. Nanofibers were produced from the prepared polymer solutions under equal conditions by the electrospinning method by applying optimum process parameters voltage (22.3 kV), distance between electrodes (22 cm), and feed rate (0.4 mL/h). For the structural and morphological characterizations of PVP-based nanofiber, images were taken at different magnifications (x1.000 and x20.000) with SEM. Average fiber diameter and fiber diameter uniformity coefficients were calculated from SEM images with Image J software. At least 100 different measurements were carried out on each sample. Thus, as the potassium concentration increased, changes in fiber diameter and morphology were analyzed. EDX analysis was also performed on the nanofibers to demonstrate the presence of potassium in the structure of the fibrous material. Finally, fiber diameter uniformity coefficients were calculated [7].

3. RESULTS AND DISCUSSION

3.1. Polymer Solution Characterization

Polymer solution properties were measured in terms of understanding the effect of banana peel powders on solution properties and fiber spinning performance. Viscosity, conductivity, and surface tension graphs of polymer solutions are given in Figur



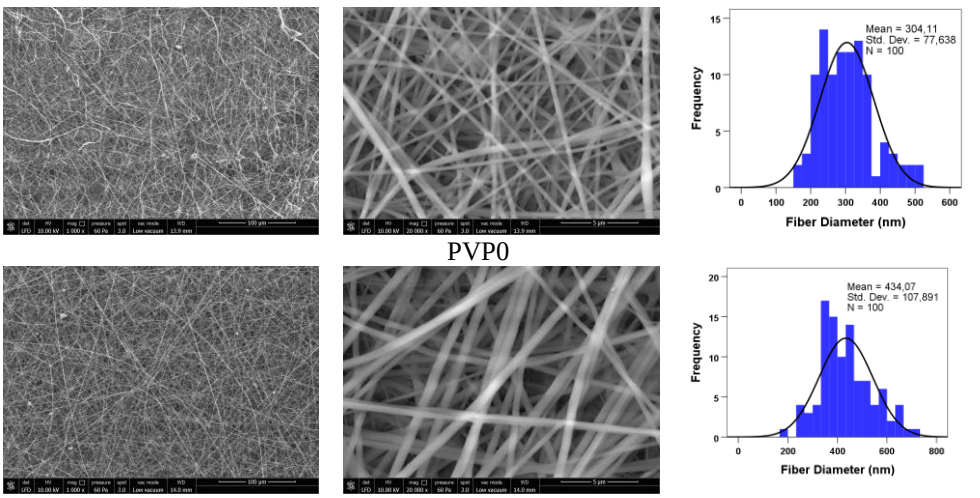
(a) (b) (c)

Figure 1: Solutions properties of PVP based polymer solutions with different concentrations of banana peel powder a) Viscosity b) Conductivity c) Surface tension

According to the polymer solution results; viscosity and conductivity increases and surface tension does not change with banana peel powder concentration increasement.

3.2. Fiber Morphology Results

SEM images of PVP nanofibers with various concentrations of banana peel powder are given in Figure 2.



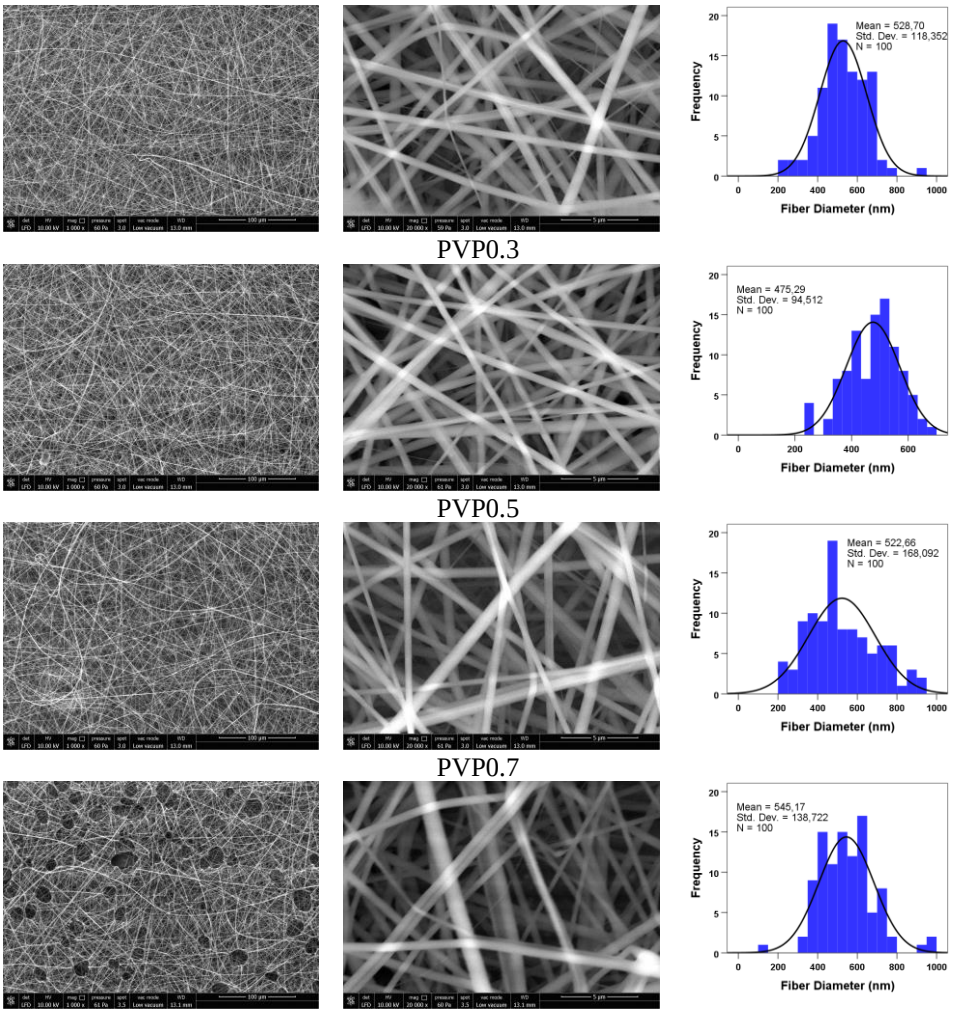


Figure 2: SEM images (1.000x-20.000x) and histograms of PVP nanofibers produced with various concentrations of banana peel powder

When SEM images were analyzed, as the concentration of banana peel powder increased, nanofiber morphology was negatively affected, and stickiness were formed in the nanoweb structure. In general, nanofibers were smooth, fine, uniform and without beads. It is possible to say that average fiber diameter and viscosity increased with banana peel powder concentrations. Average fiber diameter values were between 304-545 nm. Figure 3 illustrates the variation of average fiber diameter and fiber diameter uniformity coefficient with banana peel powder concentration.

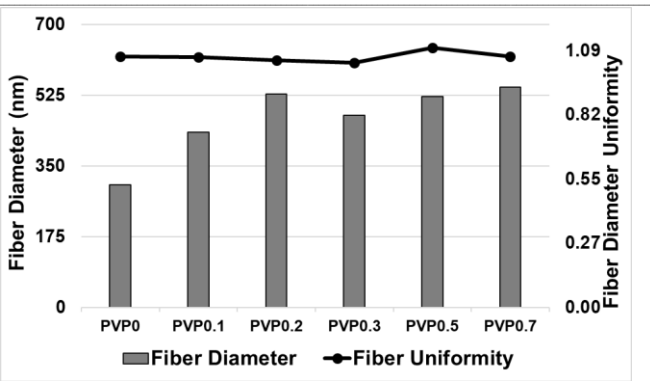
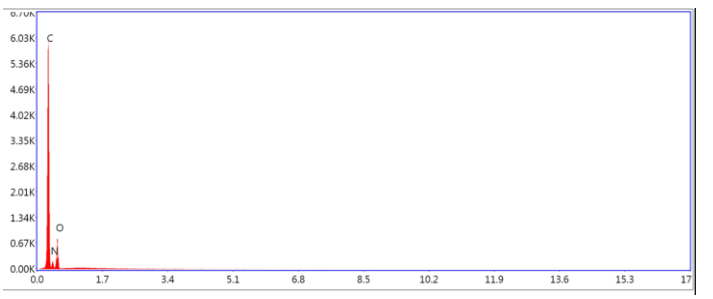
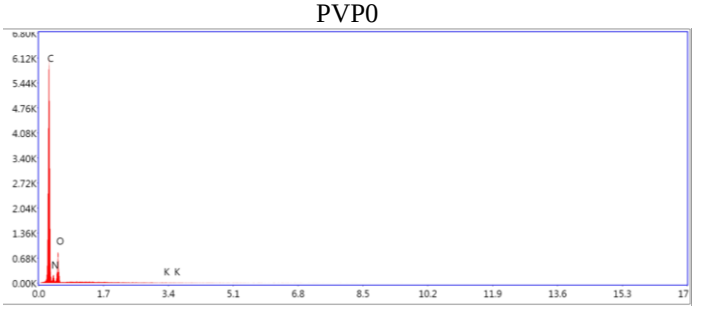


Figure 3: Average fiber diameter and diameter uniformity results of PVP nanofibers with various concentrations of banana peel powder

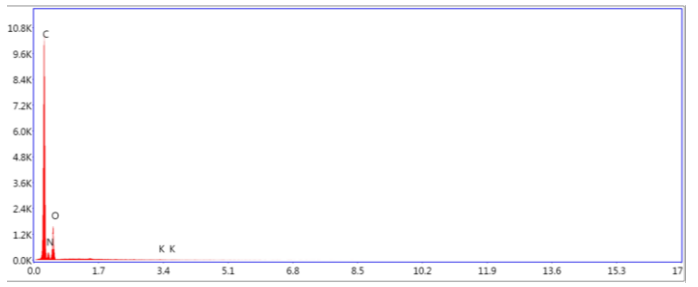
The existence of potassium (K) entrapped within the PVP nanofibrous webs was confirmed by the EDX spectrums (Figure 4).



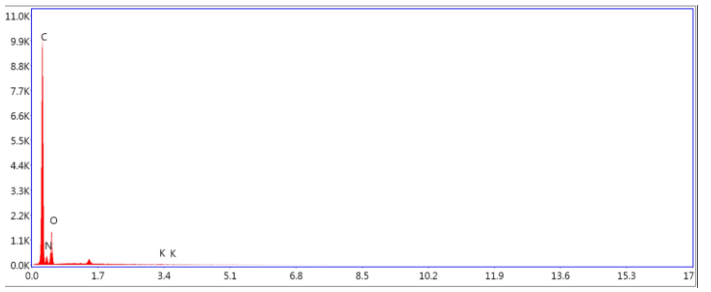
PVP0



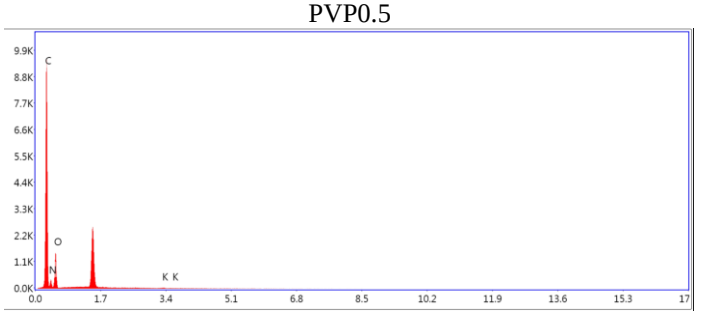
PVP0.1



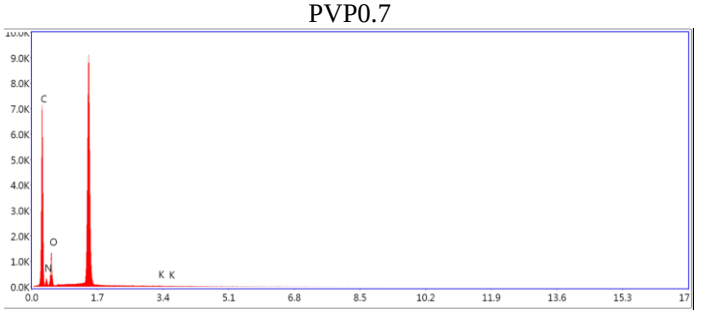
PVP0.3



PVP0.5



PVP0.7



PVP0.9

Figure 4: EDX analyses of PVP nanofibers with various concentrations of banana peel powder

In the EDX spectrum of pure PVP nanofibers, only the peaks assigned to the Kα peaks of carbon (C), nitrogen (N), and oxygen (O) were found, as expected. In other samples, potassium appeared in different concentrations in addition to these elements. Table 1 shows the elemental analysis of elements existence into the PVP nanofibrous structure. It is clearly seen that amounts of K increased with banana peel powder concentration.

Table 1: SEM-EDX results of PVP nanofibers with various concentrations of banana peel powder

Sample Code	C (%)	O (%)	N (%)	K (%)
PVP0	67.08	18.05	14.87	-
PVP0.1	66.67	18.31	14.91	0.10
PVP0.3	65.70	19.38	14.79	0.14
PVP0.5	65.13	19.18	15.33	0.12
PVP0.7	65.03	20.01	14.62	0.34
PVP0.9	62.50	22.25	13.79	0.45

4. CONCLUSION

The potassium-loaded nanofibers produced in the study are thought to be an alternative to potassium capsules taken orally as food supplements on the market. This situation creates significant problems, especially for the elderly, children, and those who have difficulty swallowing medication. Therefore, it is thought that these problems can be eliminated with the sublingual application of a nanofiber preparation with a high potassium content.

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