Preparation of nano-microfibers with a different polymers

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Abstract

In this research, nanofibers have been prepared by using an electrospinning method. Three types of polymer (PVA, VC, PMMA) have been used with different concentration. The applied voltage and the gap length were changed. It was observed that VC is the best polymer than the other types of polymers.

Key words

nano-microfibers, electrospinning method

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تحضير الياف نانوية بأستخدام عدة بوليمرات

نذيرة عباس التميمي

قسم الفيزياء – كلية العلوم – جامعة بغداد

الخلاصة:

تم في هذا البحث تحضير الألياف النانوية بطريقة البرم الالكتروني باستخدام البوليمرات(بولي فنايل الكحول،فنايل كلورا يد كوبوليمر،بولي مثيل مثياكرليت)،

تم ملاحظة مدى تأثير التركيزللمادة البوليميرية ،الفولتية المسلطة ،ونوع البوليمر على قطر الليف المحضر حيث وجد إن زيادة التركيز تؤدي إلى زيادة قطر الليف ،إن زيادة الفولتية تقلل من قطر الليف أو إمكانية حصولنا على ليف نانوي، إما نوع البوليمر فقد لوحظ بان أحسن ليف حصلنا عليه عند استخدم فنايل كلورا يد و بوليمر ،بولي مثيل ميثا اكرليت ويليه بولي فنايل الكحول.

Introduction

Nanofibers prepared by electrospinning have several advantages, such as large surface area to volume ratio, high specific surface area and small pore size, superior mechanical properties and flexibility in surface functionalities[1,2]. Electrospinning is a term used to describe a class of nanofibers forming processes by which electrostatic forces are employed to control the production of nanofibers [3,4].Electrospinning is a novel and efficient method by which fibers with diameters in nanometer scale, termed nanofibers, can be achieved. In electrospinning, a strong electric field is applied on a droplet of polymer solution (or melt) held by its surface tension at the tip of a syringe's needle (or a capillary tube). As a result, the pendent drop becomes highly electrified and the induced charges are distributed over its surface. Increasing the intensity of electric field, the surface of the liquid drop will be distorted to a conical shape known as the Taylor cone [5,6].The basic set-up to run the system consists of a charged polymer solution (or melt) that is contain in needle . Because of its charge, the solution is drawn toward a grounded collecting plate as a jet. During the jet's travel, the solvent gradually evaporates, and a charged, solid polymer fiber is left to accumulate on the grounded target this illustrated in figure(1). The charges on the fibers eventually dissipate, as they are neutralized by the surrounding environment [7].The final product of the process is a nonwoven fiber mat that is composed of tiny fibers with diameters on the order of nanometers to microns.

The principle of electrospinning is to apply high voltage on needle which contains polymer solution container. When polymer solution flows out from needle, the polymer is pulled onto collector by strong electric field and forms nanofibrous structure, based on our pending patent[8].

The diameter of electrospinning nanofibers are dependent on a number of processing parameters that include:-

a. The intrinsic properties of the solution such as the type of polymer and solvent, polymer molecular weight, viscosity (or concentration), elasticity, conductivity, and, surface tension [9-14].
b. The operational conditions such as the applied voltage, the distance between the needle and collector (tip – target distance), and the feeding rate of the polymer solution [12, 15,16].
c. In addition to these variables, the humidity and temperature of the surrounding may also play an important role in determining the diameter of electrospinning nanofibers [16]. For instance, the polymer solution must have a concentration high enough to cause polymer entanglements yet not so high that the viscosity prevents polymer motion induced by the electric field. The solution must be also have a surface tension low enough, a charge density high enough, and viscosity high enough to prevent the jet from collapsing into droplets before the solvent has evaporated[11,12,13,15,].

Experimental

1- Material:

a- Poly (vinyl alcohol) PVA (CH3CHOH(CH2 –CHOH)n) with Mw= 14.000; viscosity of 4% aqueous sol. At 20 C; iwere made in USA with degree of hayrolysis (98.5-100) % and residual polyvinylacetute 0 to 3%

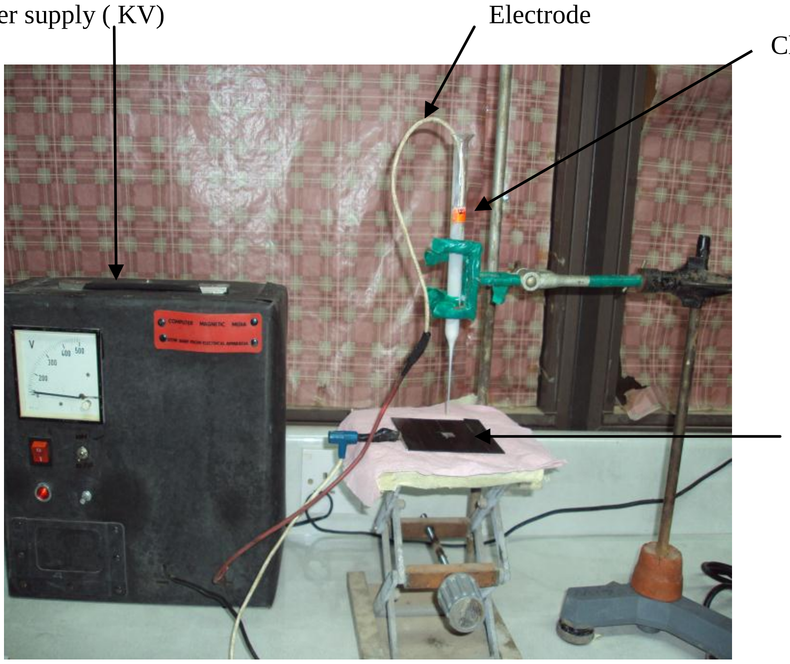


Fig. (1) –Electrospinning apparatus

b-vinyl chloride copolymer VC ("corvic R 46188).
A vinyl chloride /vinyl acetate copolymer for use in electrophoresis
Brook field viscosity of 20%
Acetone at 25^0 c Approx 40 cp
Passes through 52 mesh
BDLT chemicals Ltd Poole England
Important no liability accepted for accident in handing or use.

C- poly (methyl methacrylate) (PMMA). (from ICI, England).
Chemical formula of repetitive unit $CH_2=C(CH_3)COOH3$
Molecular Weight M_w (gm/mol)= 84000
Melting Temperature (^{0}C)= 213
Density (gm /cm^3)= 1.2
Refractive index=1.49

Procedure

PVA solutions were prepared by dissolving PVA into distilled water at (40-60)^{o}C, when the solution of PVA was completed, it have been used to product fibers with and without TiO_2 nanoparticles solution into 25 ml of PVA solution respectively. The mixing processes were done at room temperature. The same process repeat for VC which dissolving in acetone at (20-25^{0}C) and PMMA which dissolving in chloroform at (30-50^{0}C).

In this research, the contrition of polymer, gap distance, applied voltage and the type of polymer have been changed distance, voltage, type of polymer.

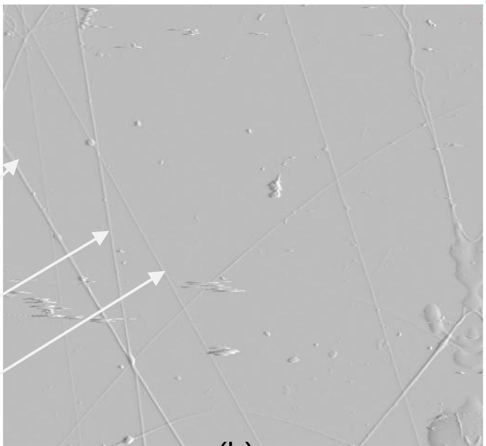
Results and Discussion

<u>1-The concentration of the polymer:</u>

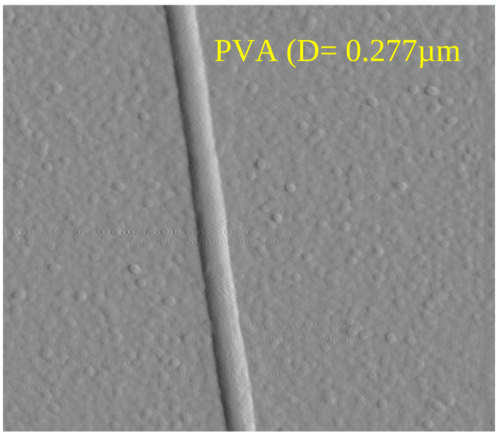
It was observed that the increasing of polymer concentration with affixed voltage and the distance between the needle and collector constant derive to increase the diameter of nanofibers.

This can be explaining in which the higher concentration of polymer solution leads to increasing the viscosity of it. The entanglement of polymer chains is one of the factors, which contributed to viscosity. Therefore, the higher concentration of polymer solution tends to increase the diameter of nanofibers. On the other hand, if the concentration of polymer solution is very low, the polymer chains may not aggregate enough to construct stable nanofibers this result was shown in Fig. (2),(3) and (4) it was found that the varying the applied voltage and distance between the needle ad collector leads to the same behavior.

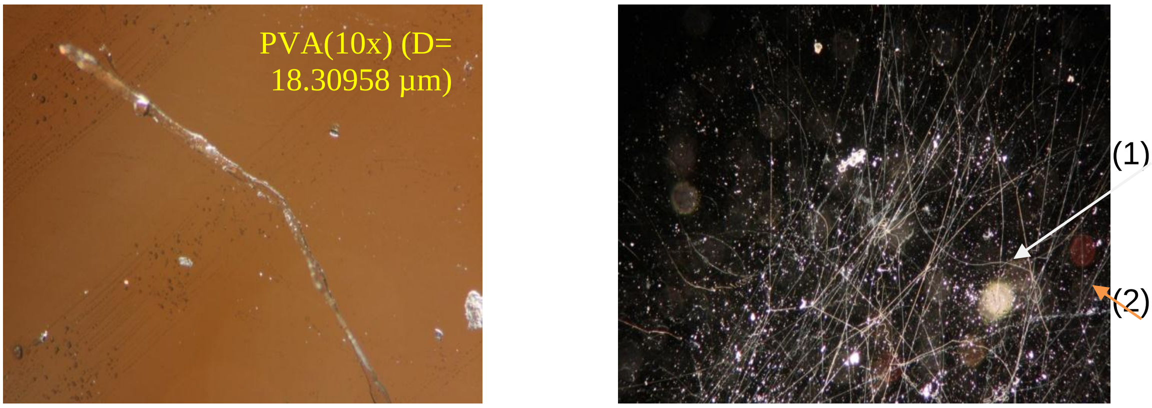
(1)
(2)
(3)



(b)
(512x512 px),(5.0x5.0 μm)



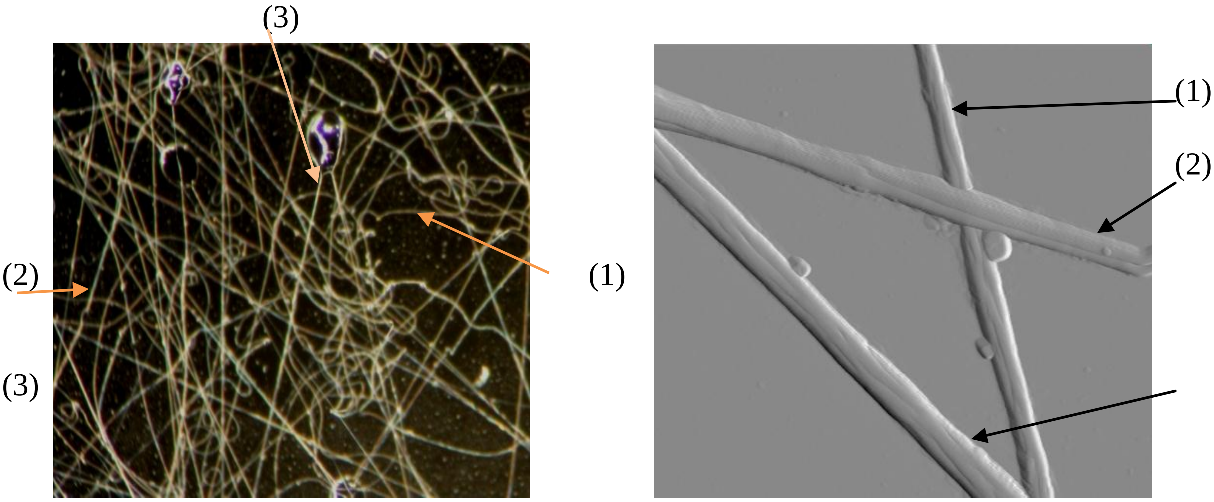
(a)
(512x512 px),(100x100μm)



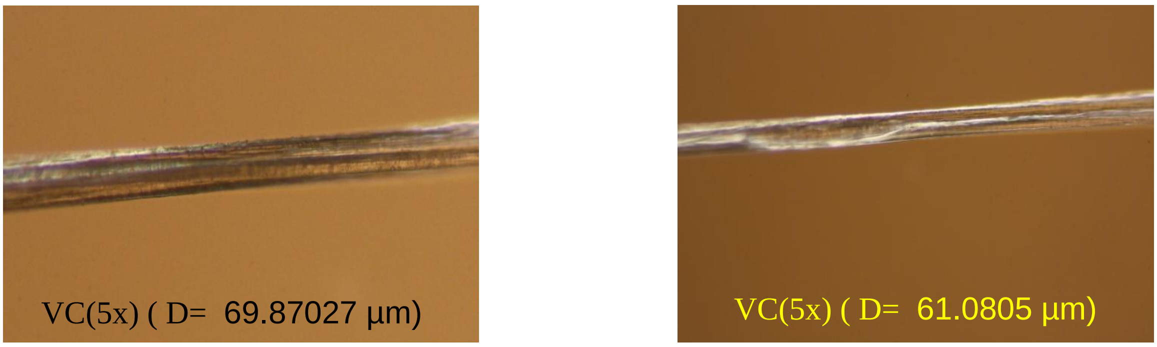
(d) (c)

Fig. (2) Poly(vinyl alcohol)PVA (d= 5cm ,V= 35kv ,N= 0.3mm)

(a)- 3gm PVA (AFM picture) the specification of instrument.
(b)- 3.5gm PVA,(1=.08μm,2=0.6μm,3=0.5μm),(AFM picture)
(c)- 4 gm PVA (5x),(1=1.571μm,2=1.237μm)
(d)- 4.5gm PVA (10x)(d= 0.56)



(b) (10X) (a) (512x512 px),(10.0x10.0μm)



(d) (c)

Fig. (3) Poly(vinyl chloride) VC (d=5cm,V=30kv,N=0.03mm)

a- 4gm VC(AFM picture),(1= 0.46μm,2=0.65μm,3=0.69μm)
b- 4.5gm VC (10x),(1=3.232μm,2= 4.02μm,3= 3.985μm)
c- 4.5gm VC,(d= 3cm,V = 20kv)
d- 5cm VC,(d==3cm,V=20kv)

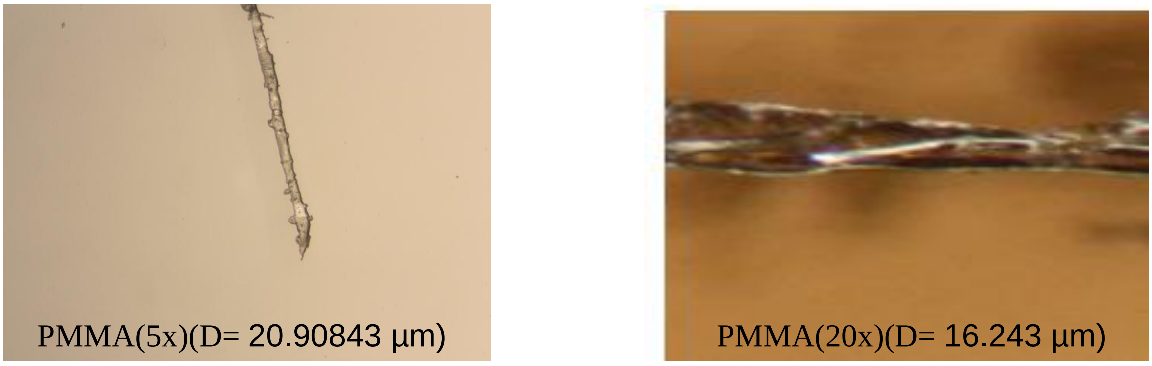


Fig. (4) Poly(methyl methacrylate)PMMA) (d= 5cm,V=30kv ,N= 0.56mm)
a- 7gm PMMA b- 7.5gm PMMA

<u>2-Changing the applied voltage of electrospinning</u>

It has been found that the applied voltage play an important role on the fiber diameter.

The increasing voltage leads to decreasing of fiber diameter and vice versa. The same behavior were obtained when the distance (the gap between the needle and the collector) have been changed, this was clearly observed at fixed distance.

figure (5) & (6), figure (3-2)(a)

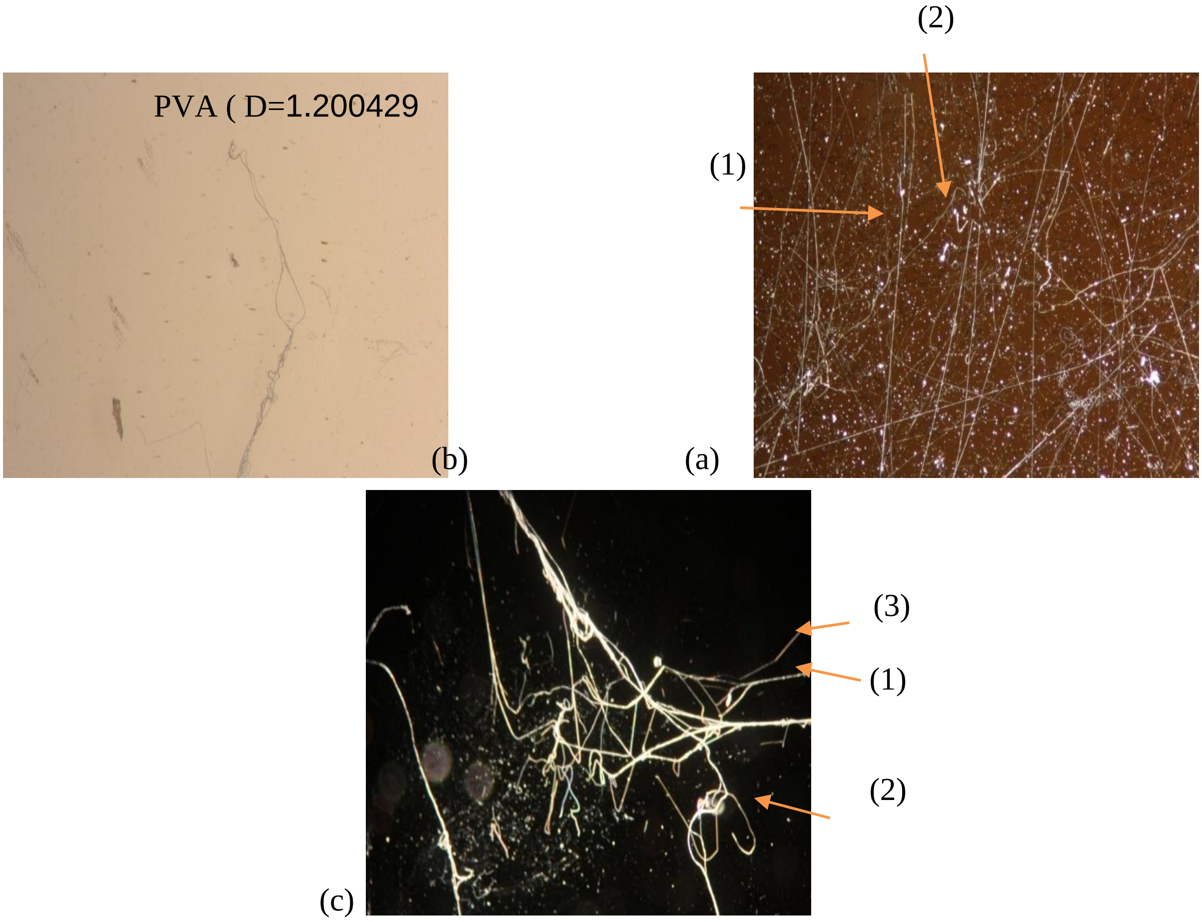
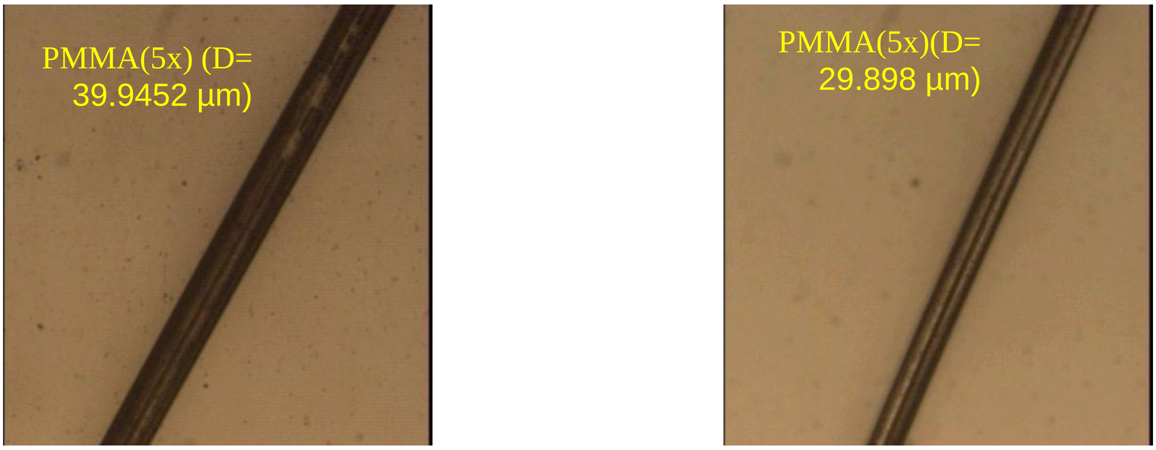


Fig. (5) poly (vinyl alcohol)PVA (d=5cm,N=0.3mm)
a- (5x) 3gm PVA,V=26kv,(1=1.554µm,2=1.993µm)
b-(5x) 3.5gm PVA,V=32kv
c- (5x) 3.5gm PVA, V=28kv,(1=1.982µm,2=2.1µm,3=1.843µm)



(b) (a)

Fig. (6) Poly(methyl methacrylate)PMMA),(C=7.5 gm ,N=0.62mm)
a- d=2.2cm,V=20kv
b- d= 2.2cm,V=15kv

the smallest diameter with increasing voltage may be explained by the effect of higher drawing with a stronger applied field.

<u>3-Change the type of polymer</u>

It can be conclude that the PMMA polymer is the best to production the nanofibers.

The PMMA and VC were better than PVA, because the PVA need high voltage compared with the other type of polymer used in this research. In addition length of fiber is not very good.

Also, fiber resulting from the jet of polymer solution the fiber is very intersection with each other. Confusion had cause to determine a single fiber then to identify their diameter. This illustrated in figure (3-2)(c),(3-5)(a ,c),(3-7)(a).

And when use the high diameter of needle or use high concentration the fiber product contain point effect and the fiber irregular.

While when use VC is best to production fiber nano and as tube because this material can production fiber at low and high voltage and can get this (fiber) from the jet of solution to get nanofibers, It can obtained ling fiber with small diameter by using draw process figure (3-3)(a,b).

The same with PMMA but not with jet or to get very small diameter but good length of fiber and regular like in figure (3-6).

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