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# Impact of Polymeric Solutions Parameters on Morphological Properties of Composite Nanofibers.

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## Abstract

The aim of this mini review article, discussed the recent research in the field of polymer nanocomposite deals with properties of polymer solution parameters such as viscosity, molecular weight, concentration of polymeric substance in solution and surface tension of solution on morphological properties of nanofibers produced by electrospinning technology such as nanofiber diameters and the number and size of beads formed on the surface of the nanofiber web. All researches have proven that the viscosity or concentration of the polymer solution, lead to increase the diameters of the nanofibers and reduces the size and number of beads, as well as converting the fiber path jet from unstable and unmonotonous to more stable. This behavior positively affects the formation and orientation of the fibers, but did not lead to the enhancement of the crystalline and thermal properties of the nanofibers. Therefore, other researchers studied adding nanoparticles such as salts to polymeric solutions to get rid of the number and size of beads in the nanofiber web as a result of using low concentrations. These nanoparticles improve the morphological properties as well as enhance the crystalline and thermal properties of the nanofiber network, leading to increased engineering and medical applications such as wastewater treatment and drug delivery.

**Key Words:** Solution Parameters, Composites nanofibers, Nanoparticles, Nanofiber Diameters, Beads Formation.

## Introduction

The parameters of the polymeric solution are one of the important characteristics that must be controlled in the electrospinning technique in order to obtain composite nanofibers with high physical specifications [1and 2]. These parameters are viscosity, surface tension, conductivity, and molecular weight, dipole moment, and dielectric constant [1and 3]. Controlling any of these parameters increases the applications of composite nanofibers in fields such as tissue engineering scaffold [4], protective clothing, electronics, catalysis, ceramic fibers, wound dressing [3], drug delivery materials [5 and 6]. One of the most important parameters of polymeric liquids is the concentration of the polymeric solution and its direct relationship to the viscosity of the liquid. Low viscosity liquids produce polymeric fibers with low diameters [7], but they suffer from morphological problems such as the number and sizes of beads formed in the fibrous tissue are many, and this phenomenon leads to weakness in the performance of the fibers and limits its applications in engineering and medical fields [8]. While solutions with high concentrations are free from the phenomenon of beads and there is stability in the process of deposition of fibers on the collector, in addition to an improvement in the orientation of the fibers [9]. However, the composite





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nanofibers suffer at the same time from a weakness in the crystalline and thermal properties as a result of having high diameters that cause a decrease in their porosity and surface area [10 and 11]. In order to overcome the problem of beads formation, many researchers studied adding nanoparticles that increase the electrical and thermal conductivity of the polymeric solution beside reducing the diameter of the composite nanofibers, improve their physical properties and eliminate the formation of beads in the web of nanofibers deposited on the collector. These particles are the salt [12 and 13], which having a good physical specifications as surface area, particle size distribution and surface chemistry [14]. Where bonhomie was added to polyacrylonitrile [2], also fibers spun from PEO [15], collagen type I-PEO [12], and PDLA [13]. For example, these particles have a small size with low loading levels [16] and a high ability to dispersion in the polymer matrix with an absence of the aggregates at low particle size [17] and lead to strong interference with the polymer chains and enhance the thermal and electrical conductivity, these materials lead to a new technologies because of its strong and flexible structure [18 and 19]. Therefore, the nanoparticles are essential with a view to expanding the industrial applications of nanocomposites [20 and 21]. On the other hand, the relationship between the viscosity, concentration and surface tension of polymeric solutions is linked to each other in a direct relationship, Kuchi et al studied the preparation and characterization of composite nanofibers from (TiO2-PVP) and the researchers found that increasing the concentration (PVP) means increasing the surface tension, in addition of the adding of the TiO2 nanoparticles lead to produce a uniform and smooth nanofibers without any bead formation [22]. The bonds in the polymer chains have a relationship with the viscosity of the solution and lead to an increase in the electrostatic force of the solution, which would enhance (instability of the nanofiber jet) and also promote an increase in the time period to be longer [23 and 24]. The surface tension property of the solution is very important in starting the nanofiber electrospinning process when the applied potential forces overcome the surface tension force of the polymeric solution [25].

On the other hand, the relationship between surface tension and solution viscosity plays a key role in determining a suitable ranges of solution concentrations as well as obtaining continuous nanofibers. Surface tension is cautious and uncontrollable the flow of the polymer solution to the tip of the needle and by the cohesive nature of high viscosity solutions, in addition of, an increase in viscosity leads to an increase in the electrical conductivity of the polymeric solution [26] . In order to produce stable and continuous composite nanofibers with good morphological appearance and low diameter of nanofibers, solvent having high dielectric constant was used, low surface tension and low viscosity, for example, use ethanol as a solvent to produce poly (vinylpyrrolidone)-TiO2 nanofiber.

Low molecular weight of polymers require higher concentrations than the same polymers that having a high molecular weight in order to produce stable, continuous with no beads formation [27]. Also, the molecular weight of polymeric solutions plays an important role in the performance of humidity sensing, as the high molecular weight gives a faster sensing of humidity with a short time ,recovery time, and least hysteresis, because the composite nanofibers produced by polymers with high molecular weights have a high surface area [28].

## Conclusion

Parameters of polymeric solution as viscosity, surface tension, conductivity, and molecular weight, dipole moment, and dielectric constant had been discussed in previous studies in this review. The controlling of any of these parameters lead to increase the applications of composite nanofibers in fields such as tissue engineering scaffold and medical applications. One of the most important parameters of polymeric liquids is the concentration of the polymeric solution and its direct relationship to the viscosity of the liquid. Low viscosity liquids produce polymeric fibers with low diameters, but they suffer from morphological problems such as the number and sizes of beads formed in the fibrous tissue are many, and this phenomenon leads to weakness in the performance of the fibers and limits its applications in

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engineering and medical fields. Therefore, the adding nanoparticles that increase the electrical and thermal conductivity of the polymeric solution besides reducing the diameter of the composite nanofibers, improve their physical properties and eliminate the formation of beads in the web of nanofibers deposited on the collector.

## Conflicts of Interest

The author declares that they have no conflicts of interest.

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# تأثير معلمات المحاليل البوليمرية على الخصائص المورفولوجية للألياف النانوية المركبة

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**الخلاصة:**

في مقالة المراجعة المصغرة هذه، تتعامل الأبحاث الحديثة في مجال مركبات البوليمر النانوية مع خصائص محلول البوليمر مثل اللزوجة والوزن الجزيئي وتركيز المادة البوليمرية في المحلول والتوتر السطحي للمحلول على الخصائص المورفولوجية للألياف النانوية التي تنتجها تقنية الغزل الكهربائي مثل أقطار الألياف النانوية وعدد وحجم الخرز المتكونة على سطح شبكة ألياف النانو. أثبتت جميع الأبحاث أن لزوجة أو تركيز البوليمر يزيد من أقطار الألياف النانوية ويقلل من عدد وحجم الخرز المتكونة، بالإضافة إلى تحويل مسار الألياف النفاثة من غير مستقر وغير رتيب إلى أكثر استقرارًا. يؤثر هذا السلوك بشكل إيجابي على تكوين وتوجيه الألياف، لكنه لم يؤد إلى تعزيز الخصائص البلورية والحرارية للألياف النانوية. لذلك، درس باحثون آخرون إضافة الجسيمات النانوية مثل الأملاح إلى المحاليل البوليمرية للتخلص من عدد وحجم الخرز في شبكة الألياف النانوية نتيجة استخدام تركيزات منخفضة. تعمل هذه الجسيمات النانوية على تحسين الخصائص المورفولوجية بالإضافة إلى تعزيز الخصائص البلورية والحرارية لشبكة الألياف النانوية، مما يؤدي إلى زيادة التطبيقات الهندسية والطبية مثل معالجة المياه الصناعية ونقل الدواء.

**الكلمات الدالة**: معلمات الحل، الألياف النانوية المركبة، الجسيمات النانوية، أقطار الألياف النانوية، تكوين الخرز.