



## Intelligent Nano-Protective Production In Industrial Paints

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Industrial paints with nanotechnology are the highest technology in the paint industry. Nanotechnological paints, also known as "smart paints", are protective and decorative, they can have properties such as antimicrobial, water repellent and fire retardant, which help to clean the ambient air and self-clean with light thanks to their photocatalytic cleaning feature. However, considering the industrial nature of production, the infrastructure and production technology are insufficient when considering the efficiency, cost and time criteria. These negative conditions can be overcome by using electrohydrodynamic atomization (EHDA), ie electrospinning and electrospray methods. In recent studies; It has been stated that the EHDA technique, which enables the production of capsules (electrospray) or fibers (electrospinning) under high voltage, can be an alternative for industrial paint applications. In this study, it is aimed to give information about the basics of EHDA technique and the production and usage possibilities of electrospray method as a smart nanoprotector in industrial paint applications.

**Keywords:** *Electrohydrodynamic atomization, nanoparticle, smart nanoprotector*

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### 1. Introduction

The word "nano", derived from the Greek word "nanos", means little old man or dwarf. Today, the word nano is used as a technical unit of measurement. Mathematically, a nanometer is equivalent to one billionth of a meter [1]. There are other things that change as we go down to nano levels. Different powers can have unexpected effects in the nano size. Nanotechnology is used as a scale, and nanotechnology is used as a technology tool developed at

this scale. For this reason, working in nanotechnology and nanoscience is considered a more disciplined situation; It constitutes a wide-ranging region that does not target a specific issue and requires cooperation. Nano 1 / 1000.000.000 means 1 / 1000.000.000 scale in studies. With a glance at the atoms and their alignment; It is aimed to innovate in materials and production techniques and to develop new products with superior properties according to needs. Since nanotechnology is only a measure of nanotechnology, nanotechnology has a wide range of applications from material production to magnetic, electronic, mechanical, optical and biomedical applications. Many of the properties of today's engineering materials are

calculated on microstructures of large sizes (numbers, crystals). However, nanomaterials owe their superior properties to structures that are several hundred times smaller than micrometers. Recently, work in this area has focused on the manufacture, characterization, and application of nanoscale materials, systems and devices. Thanks to nanotechnology, supercomputers can be viewed under a microscope, thousands of movies can be made on DVDs, nano robots can be used to find and repair diseased tissue in the human body, the human brain can be powered with additional nano memory, 50 times lighter and very durable materials will be produced than the current weight. It is possible to change textile products used in daily life, to conduct aviation and space research, and even to emerge new rocket and aircraft designs. We can say that these developments are a scientific and technological revolution that can reshape the world. In short, the new era started as nanotechnology and nanoscience. This discipline, nanotechnology, aims to design and manufacture nanoscale materials and manufacture new devices from these materials. Since nanotechnology is a discipline in this context, the methods used in note technology may differ from known methods [2].

Paints with nanotechnology are the top technology in the paint industry. Nano technological paints, also known as "smart paints", are protective and decorative, they have properties such as antimicrobial and fire retardant, which help to clean the ambient air and self-clean with light thanks to their photocatalytic cleaning feature.

Nano paint applied walls; surfaces are scratch-proof, anti-fingerprint, dust-proof, resistant to water and moisture, preventing bacteria and mold growth, resistant to heat, cleans the air (eliminates the smell of food, cigarette) and cleans itself with light.

In addition, UV cured, high scratch-resistant varnishes designed using nanotechnology, double-component varnishes that can be applied with brush and roller, fire retardant varnishes are also products with nano technology. In traditional, known paints, both interior and exterior paints, the contamination on the surface can be removed from the surface at a certain rate with some physical effects (such as wiping the surfaces with a soapy cloth, washing). However, nanotechnological dyes contain smart molecules in their formulation structures. Thanks to the nano particles it contains and the porous structure of the resin, organic pollutants that are carried on the surface by rain water and air over time break down with the effect of sunlight or light and turn into harmless compounds of CO<sub>2</sub>, water, nitrate and sulphate salts (Self-cleaning with light).

The cleaning cycle will continue as long as the paint is on the surface. As long as the rate of contamination does not exceed the speed of cleaning, the surface will always remain clean. Thus, nanotechnological paints will remain much

cleaner than traditional paints and will not allow the formation of organic dirt on the surface.

Nanomaterials are defined as materials in which a single unit (at least one dimension) is sized between 1 and 1000 nanometers, but is generally between 1 and 100 nm.

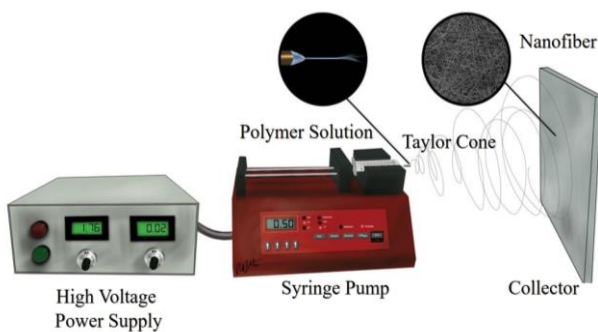
First of all, Zeleny observed in 1914 that when the electrical potential difference between the capillary tube with different liquids and the plate changes, the flow of fluids changes, and the EHDA technique, which was founded, atomization of liquids is achieved by using electrical forces. The EHDA system generally consists of a capillary sprayer needle, high voltage power supply and annular electrode. When high voltage is applied to the capillary sprayer, the polymer solution drop at the tip of the needle is charged with electrostatic force. The deformation and dripping of the solution liquid are caused by the bulk forces on the jet and the normal and tangential stresses (FQ) on the liquid surface. Bulk forces on jet; The electrodynamic force (F<sub>e</sub>) caused by the electric field and proportional to the electric field can be counted as the force of gravity (F<sub>g</sub>), the force of inertia (F<sub>p</sub>) and the drag force (F<sub>μ</sub>) known as the Stokes force for moving droplets. The normal and tangential forces on the jet surface are the electrodynamic stress tensor caused by the surface charge density of the liquid and the local electric field, the stress tensor caused by the pressure difference on both sides of the surfaces between the liquid phases, the dynamic viscosity of the liquid, and the stress tensors caused by the inertia of the liquid. When the electrodynamic force overcomes these other forces, the droplets begin to break off the cone and form a jet. Since this phenomenon was first explained by Sir Ingram Taylor in 1964, this jet cone was named "Taylor cone". The charged droplets move along the electrical field towards the opposite electrode and shrink due to the evaporation of the polymer solvent and break down into nano and micro dimensions. The size and structure of the particles formed are affected by many factors such as the electrical conductivity of the polymer solution, surface tension, rheological and dielectric properties, as well as the high voltage applied during the production phase, plate distance, flow rate of the polymer solution, temperature and humidity of the environment. The structure of the particles formed in the EHDA process changes depending on the voltage applied and the properties of the liquid used. EHDA modes are divided into two as dripping and jet depending on the flow geometry of the fluid. Drip forms, drip, micro drip, stick drip, multiple stick drip and irregular drip; jet mode is classified as conical jet (Taylor cone), flickering jet, multi-jet and branched jet. EHDA method is divided into two as electrospinning and electrospray method depending on the concentration of the polymer solution. Since the concentration of polymer solution is high in electrospinning method, the resulting jet stabilizes and long fibers are formed. In the electrospray method, since the concentration

of the polymer solution is low, capsules are formed as a result of the Taylor cone-shaped jet [3].

Nanofibers is a definition used for fibers with a diameter of 100 nanometers or less. Its properties such as flexibility, high porosity, small pore size, axial strength have caused it to find very different and wide application areas.

It is a method applied by drawing the polymer from a specially prepared solution using an electric field. In addition, nanofibers can be produced from polymers, metal oxides and ceramics with this method. With this method, one-dimensional nanostructures are formed. Since the 1700s, studies have been carried out with this technique, also known as electrostatic spinning. In 1745, Bose described aerosols as the structures obtained by the application of high electric potential to fluid droplets, and then in 1882 Lord Rayleigh answered the question of how many charges overcome the surface tension in the droplet. In 1902 and 1903, the first patents of the devices used to spray liquids with the application of electrical charge were taken by Cooley and Morton.

The electrospinning method enables the production of nanofibres with solid and hollow internal structure, continuous, regular diameter and from various materials such as polymers, metal oxides or ceramics. Unlike other methods, creating one-dimensional nanostructures with this method; It depends on the uniaxial elongation of the viscoelastic jet of polymer solution. Schematic representation of the electrospinning method is shown in Figure 1.1.



**Figure 1.1.** Schematic Representation of Electrospinning Method [4]

Electrospinning system consists of three basic components. These components are high voltage source, metallic needle and collector pad [4].

In this study, it will be provided to obtain nanoprotectors for industrial paint applications with EHDA technique.

## 2. Experimental Studies

### 2.1. Materials

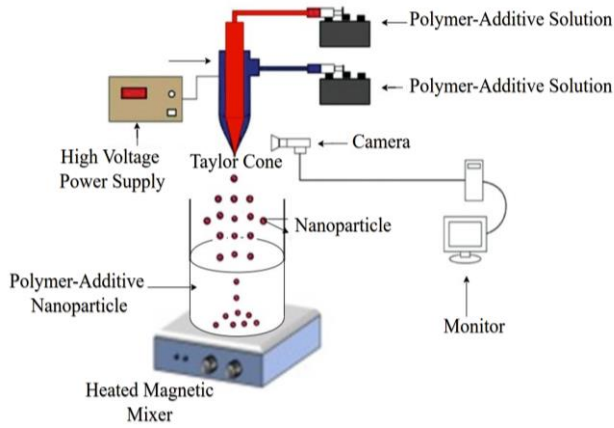
Polymers, synthetic or natural additives and solvents are used in our study.

### 2.2.1. Nano Protection by EHDA Technique

10 ml of the polymer-additive solution was drawn into the plastic syringe and placed in the syringe pump. The connector and a certain length of Teflon hose are attached to the tip of the syringe. Teflon hose is suspended from the support structure to the bottom. 18 gauge stainless steel tip is placed on the tip. A 100 ml beaker is placed on a magnetic stirrer under the tip, with half of the inside of the pure water. The force value to be applied to the polymer-additive solution to be given from the syringe pump was added to the system to obtain a controlled morphology by means of a high voltage power supply. With the EHDA setup, a voltage of 30 kV was applied to flow 2.5 ml per hour from the polymer-additive solution, and the spraying process was carried out into mixed pure water from a working distance of 15 cm. After the polymer-additive solution in the plastic syringe was completely finished, the system was stopped and the sprayed material was taken into the beaker filled with pure water and rested for 1 hour. The material kept for 1 hour was taken into centrifuge tubes. The tubes placed in the centrifuge machine rotate at 3000 rpm and the material inside the tubes is allowed to precipitate. In this way, pure water is removed from polymer nanoparticles. The polymer nanoparticle production parameters with the EHDA system are shown in Table 2.1. EHDA system and polymer nanoparticle production stages are given in Figure 2.1.

**Table 2.1.:** Polymer-Additive Nanoparticle Production Parameters with EHDA System

| Sample name      | Concentration percentage (%) | Syringe pump rate (ml / hour) | High voltage power supply (kV) | Applied distance (cm) |
|------------------|------------------------------|-------------------------------|--------------------------------|-----------------------|
| Polymer-Additive | 10                           | 2.5                           | 30                             | 15                    |



**Figure 2.1.** EHDA System and Polymer-Additive Nanoparticle Production Stages

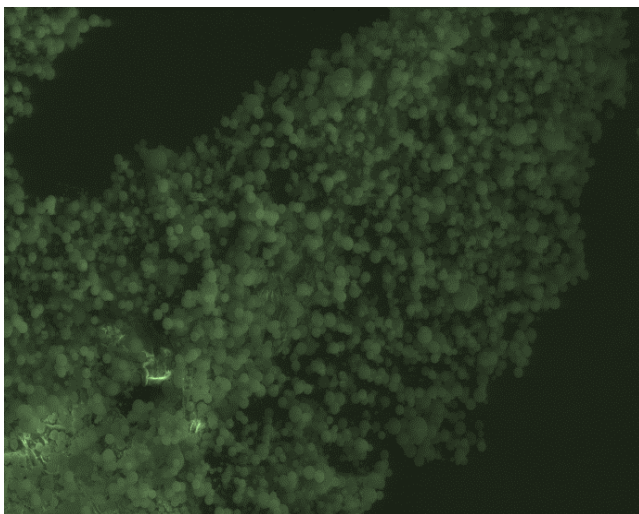
### 2.2.2. Characterization Studies

Surface properties were determined by Morphological (SEM) analysis, Thermoscientific Phenom XL G2 Desktop microscope and the diameters of polymer-additive nanoparticles were calculated on the obtained images.

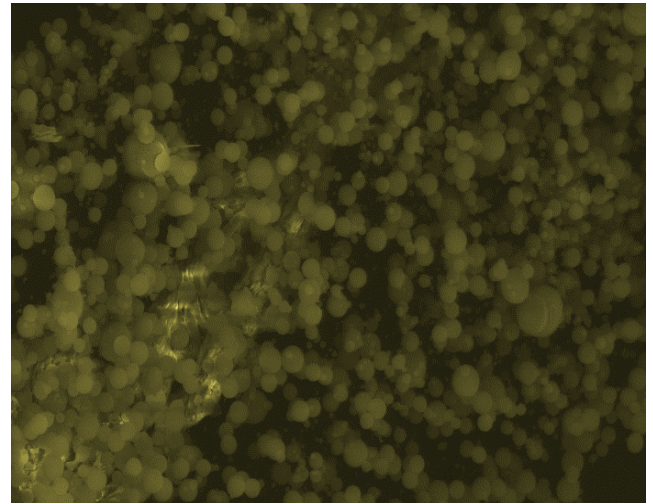
## 3. Result and Discussion

### 3.1. Morphological (SEM) Analysis

Figure 3.1 shows the surface (morphological) images of the polymer-additive nanoparticle. Images of polymer-additive nanoparticles obtained by SEM analysis were taken at x1600 and x3000 magnifications. It has been observed that the nanoparticles obtained by EHDA technique have different diameter distribution in a spherical manner. Diameter distributions were extracted from the average of 60 nanoparticles selected from the image with the help of electron microscopy. Polymer-additive nanoparticles have been detected in the range of 100-500 nm.



1600x



3000x

**Figure 3.1.** Polymer-Additive Nanoparticle Surface (Morphological) Images

## 4. Conclusion

Nanoparticles have been successfully obtained by EHDA technique. It will be able to provide smart nanoprotective effect in many areas as industrial paint with nanoparticles with these identical sizes. In line with the possibilities provided by the EHDA technique, besides the industrial paint application, industrial paints and coatings, pigments and pastes, adhesive raw materials, powder polymers and nanoparticles for binders can be produced.

## Acknowledgements

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## References

- [1] E. Bulus, Fırat Üniversitesi Yüksek Lisans Tezi, (2017)
- [2] E. Bulus, Y. M. Sahin, H. Darici, L. T. Sener, International Journal of Scientific and Technological Research, 5 (2019) 148
- [3] E. Buluş, G. S. Buluş and F. Yakuphanoğlu, Journal of Materials and Electronic Devices, 4(2020) 21
- [4] E. Buluş, G. S. Buluş and F. Yakuphanoğlu, Journal of Materials and Electronic Devices, 4(2020) 32