Opinion

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Management of agroindustrial waste for the development of polymeric micro and nanomaterials

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Opinion

Currently, worldwide, different environmental problems are occurring such as: high rates of air pollution, melting of glaciers, decreased flora and fauna in ecosystems, high pollution of water resources, among others. This has generated problems of access to drinking water, a latent threat of destruction of the environment and even put human survival at risk. This critical situation has caused researchers to ponder and ask themselves how the excessive use and consumption of materials is affecting the environment. The way in which materials produce harmful effects on the environment can be analyzed from several points of view, on the one hand, the transformation of materials from their initial state in nature until they become a finished product leads to the implementation of different transformation processes that require the use of great amounts of energy; the problem is that the majority of this energy comes from non-renewable natural resources such as coal, oil, gas, and water resources, among others. On the other hand, each day the products are being designed for a shorter shelf life compared to the degradation time of the materials, generating millions of tons of garbage per day, which, due to its inconvenient final disposition, produce great pollution problems in rivers, land and air. The inadequate selection of materials in the design process in regard to the final disposition of the products has been the cause of unimaginable environmental impacts. There are many examples of this situation. For example: the inexpensive polyethylene plastic bags are used only while transporting purchased products, then, they end up in the garbage or on the street and take between 150 and 300 years to degrade, generating contamination of water beds, rivers, oceans and soil. Another example is found in children's toys made of polyethylene, polypropylene, among others, which are usually used for a few months and then, when they break, fail or stop being used, they also end up in the trash, requiring around 200 years or more to degrade (Figure1), causing the same polluting effect of the previous case. The situation stated above, should be scaled globally, given that these phenomena of polluting materials in nature are closely related to the rate of population growth, thereby increasing the consumption of products that have been called "single-use".

Figure 1 Home appliances and tires that pollute the environment.

Therefore, the first strategies have been to raise awareness so that consumers do not purchase these single-use products; to stimulate the re-use of products when they have finished their primary life cycle; to generate recycling processes in different fields and to search for materials with short degradation times. This last angle is the one that has received the most attention from researchers and investigation groups, laboring to propose new synthesis, transformation and degradation processes of new materials. Currently, there is also research and development of polymeric materials (synthetic and natural) on a micro and nanometric scale with excellent properties for applications in medicine, smart textiles, filtration systems, among others (Figure 2). In this sense, it is a great opportunity to develop more efficient biodegradable materials (micro and nanomaterials) that can be used in the manufacture of different mass consumption products, and that impact the environment as little as possible. In many countries, the technique of electrospinning is currently being investigated and developed to transform polymers into fibers or particles of different sizes, which offer properties not found in conventional solid materials. Electrospinning is a process where a liquid material (usually polymeric) mixed with a solvent receives a high voltage, and leaves the needle capillary to go to a collector, which is located at the negative pole of the voltage source, forming very thin fibers.[1] This process has been used due to its versatility in the constant shaping of membranes and fibers of different types: flat with random fibers, oriented and crossed fibers, as well as random and oriented tubular fibers, among others. In the Figure 3 & Figure 4 is showing the different equipment designed and used for preparation of membranes constituided by micro-nanofibers. Therefore, research projects have been carried out with researchers from the Research Group in Design, Innovation and Technical Assistance of Advanced Materials - DITMAV and the Group of Development and Application of New Materials – DANUM, both from the Universidad Pedagógica y Tecnológica de Colombia – UPTC, and through international cooperation agreements, researchers from the Materials Research Institute - IIM of the Universidad Nacional Autónoma de México - UNAM and the Faculty of Physics of the Universidad Autónoma Metropolitana de México– UAM, whose research projects have revolved around the preparation, characterization and evaluation of polymeric nanofiber membranes from natural-type materials and supplies such as potato starch, cellulose from sugarcane stalks of Boyacá, as well as polymers such as lactic polyacid, polycaprolactone, among others.

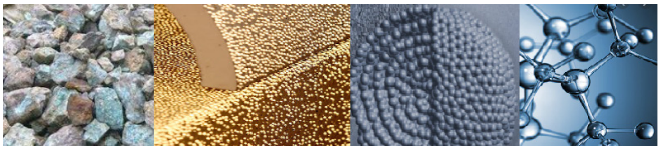

Figure 2 Old and new materials.

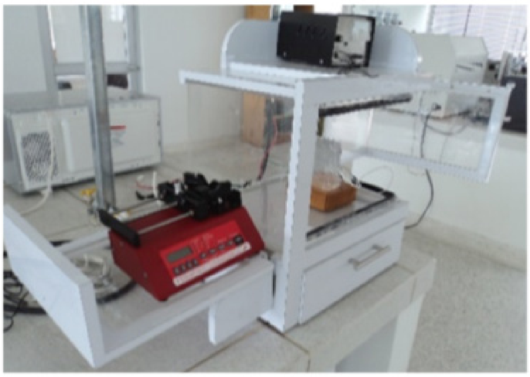

Figure 3 Electrospinning equipment.

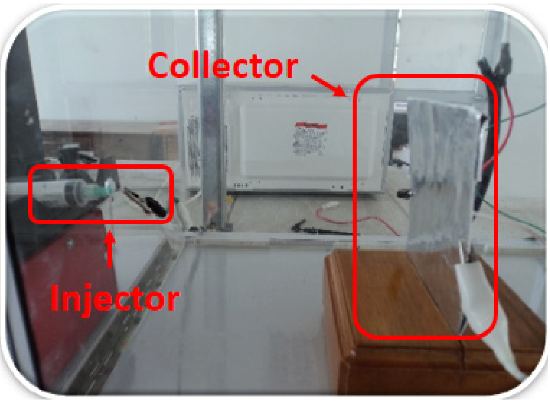

Figure 4 Colector system.

In the department of Boyacá (Colombia) there is diversity of plants and agricultural products, which are usable as fresh food for human consumption. However, organic plant residues such as stems, roots, leaves, fruit peels, are not fully exploited because they are sometimes used as animal feed or composting and, unfortunately, most of these residues are burned in burners or in open pits for the generation of energy (biomass), which produces carbon monoxide and other pollutants into the air. That´s the reason why the aforementioned research groups have generated alternatives to take advantage of these residues in the development of new products from these wastes, generating an important economic impact for the agricultural sector and a decrease in their polluting effect. For the development high technological impact products with these agricultural residues, researches have been carried out to develop degradable polymeric micro and nanofibers applying the electrospinning technique (Figure 5), with which high added value materials were prepared, such as water filters, scaffolding for engineering of fabrics and membranes with special properties for various applications. These materials were physically, chemically and mechanically characterized in order to evaluate the usability viability of these materials. On the other hand, procedures have been established for the extraction of starches and cellulose, in order to generate solutions with different types of solvents, to finally carry out electro-spinning parameterization processes and obtain degradable membranes (Figure 6). The characterization by different analytical techniques such as Scanning Electron Microscopy (SEM), Differential Scanning Calorimetry (DSC), X-ray Diffraction (DRX), Transmission Electron Microscopy (TEM), mechanical tests, among others (Figure 7), have allowed to determine structural, mechanical, and even biological properties, which makes them very suitable for specific applications. The membranes prepared from cellulose acetate were obtained from sugar cane from the Moniquirá region (Boyacá - Colombia) and showed good results for applications in textiles, where fibers of around 258 nm were achieved and showed good temperature resistance and color adhesion,[2] this study shows great potential for replacing polyester clothing that has long degradation times with highly biodegradable textile fibers in the future. Also, it has been possible to utilize the potato (its starch), which is a tuber of high production in various departments of Colombia and the Andean region, with which it was possible to prepare potato starch membranes. The starch is not consumed, because it is small in size and in its natural state it's not suitable for human consumption, which opens up possibilities for other applications such as filters, membranes, textiles, among others.[3,4] Other studies that were carried out with the electro-spinning technique were with industrial polymers from natural sources like lactic polyacid, policaprolactone and chitosan, with which membranes with high potentiality were generated for use in tissue engineering, due to the fact that fibers with diameters less than 1 micron, high mechanical resistance, sufficient porosity and good adhesion and cell proliferation are achieved.[1,5,6]

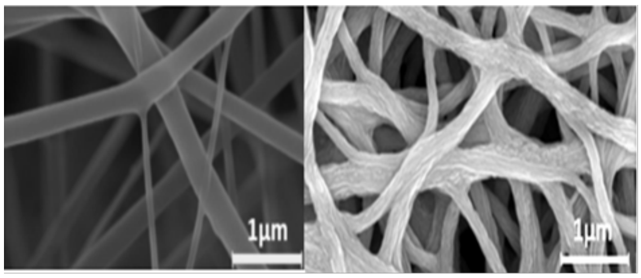

Figure 5 SEM images of PLA nanofibers.

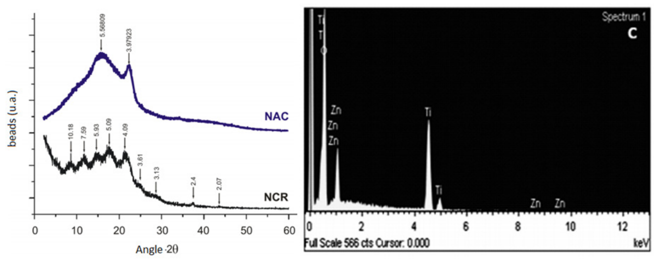

Figure 6 X-Ray Diffraction (DRX) and Energy Dispersive X-rays spectroscopy (EDS) images.

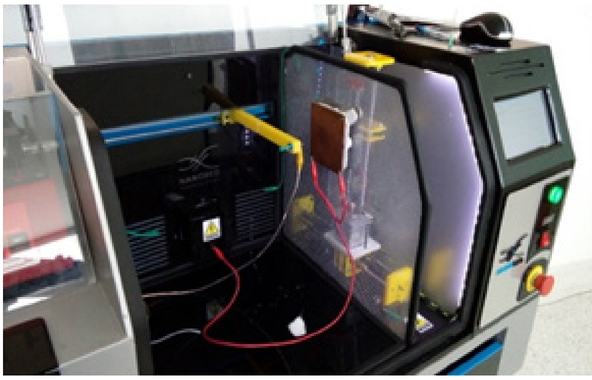

Figure 7 New electrospinning equipment, with collector position system.

For skin regeneration, polycaprolactone membranes with collagen were developed and plasma polymerization was applied, achieving nanofibers between 290 and 530nm, showing improvement in cell adhesion.[7] Other important studies were obtained with the preparation of lactic polyacid membranes with hydroxyapatite and collagen, showing cell growth and reproduction with survival exceeding 72 hours, which is very interesting for the regeneration of bone tissue. Parallel to the previous studies, the aforementioned research groups have made it possible to design and develop their own electrospinning equipment (Figure 7), with which membranes with micro and nanofibers have currently been prepared. In addition to generating advances in the chemical synthesis of different biopolymers, fit for their subsequent transformation by means of said equipment,8–10 It is worth highlighting the patent obtained for the electrospinning equipment by centrifugation (Figure 8).[11]

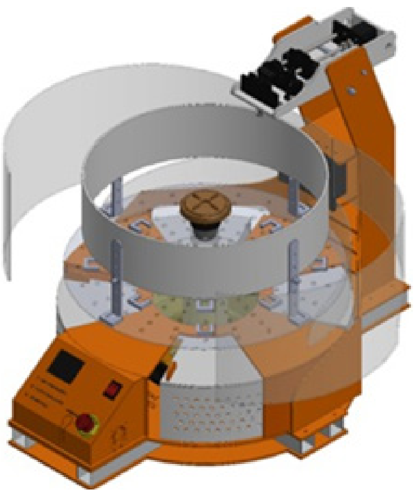

Figure 8 Electrospinning equipment with rotatory collector patented.

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Conflicts of interest

The author declares that there is no conflict of interest.

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