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Preparation of Irradiated Silver Nanoparticles for Polypropylene Nanocomposites with Pineapple Fiber

M.A.Zaine[1],M.E.K.DallaVecchia[1],L.G. H.Komatsu[1],W.L.Oliani[1],andD.F.Parra[1]

[1]dfparra@ipen.br
Instituto de Pesquisas Energéticas e Nucleares – IPEN/CNEN-SP
. Prof. Lineu Prestes, 2242 - Butantã, São Paulo - SP, 05508-000

1. Introduction

Polypropylene (PP) was discovered in 1954 and quickly gained popularity due its excellent chemical resistance and resistance to high temperatures.[1] It is possible to improve and expand the properties and uses of PP and other polymers by adding additives such as fibers and stabilizers.[2] The mixture of polymers with other substances in order to obtain a specific property is called composite. When the material dimensions added are of the order of nanometers, it is called a nanocomposite.[3]

A prominent additive is silver in nanometric dimension that in several studies, concerning the biocidal action of nanosilver incorporated into polymers, showed and promoted a growing interest in the use of these nanocomposites in the medical field.[4] Gamma radiation is ionizing power rays that produce secondary electrons after the absorption of energy in the material, which is called the Compton effect. This is a simple and efficient method for the synthesis of silver nanoparticles by irradiation-induced reduction that offers some advantages over conventional methods. Due to its simplicity, and because it provides metallic nanoparticles in a fully reduced, highly pure and in a stable state eliminating the use of chemical reagents.[5]

Beyond the addition of nanosilver, another additive of great commercial interest is the natural fiber, such as pineapple leaf fiber, which provides to the polymer an improvement in mechanical properties, sustainability and convenient price.[6] Thus, the incorporation of silver nanoparticles from irradiation and pineapple fiber to polypropylene would bring to this material several commercial advantages, such as improvement in physical properties, biocide action, sustainable character and regular cost.

2. Methodology

For the synthesis of silver nanoparticles, AgNPs, from silver nitrate solution with polyvinylpyrrolidone (PVP), the samples were irradiated using a ^{60}Co source at a dose rate of 5 kGy h^{-1}. A 1% $AgNO_3$ solution was used and the gamma radiation doses used for the synthesis of AgNPs were: 5, 10 and 20 kGy, which was also monitoring by a Perspex Red Harwell 4034 dosimeter of gamma radiation.

A total of 5 samples were prepared containing the following materials: PP; IRG (antioxidant); PPgMA (compatibilizer); AgNPs; and Pineapple Leaf Fiber.

Table I: Composition of the samples

SAMPLES	IRG/%	PPgMA/%	Dose/kGy	$AgNO_3$%/PVP K30	Pineapple Leaf Fiber/%
PPP0-REF	1	-	-	-	-
PPP1	1	1	-	-	3
PPP2	1	1	5	1	3
PPP3	1	1	10	1	3
PPP4	1	1	20	1	3

Notes: PP = Polypropylene, PPP = PP-Pineapple. The percentages refer to the total mass of the sample (%m/m), considering 300g of PP for each of the 5 samples.

Sample preparation consisted primarily of sonification of previously irradiated silver samples. The nanosilver solutions obtained from different irradiation doses were added to the PP samples already added of antioxidant Irganox and compatibilizer PPgMA.
The addition of pineapple leaf fiber occurred at the extrusion time, which was carried out with the following conditions: the temperature profile of 185-200 °C, with 100 rpm. The torque used was 50-70 N [1/min].
The specimens were prepared by thermo-pressing and then used to carry out the tests of X-Ray Diffraction Analysis (XRD), Scanning Electron Microscopy (SEM), Energy-Dispersive Spectroscopy (EDS) and Mechanical Tensile Tests.

3. Results and Discussion

The result of EDS spectroscopy of nanocomposite samples PPP2, PPP3 and PPP4 showed clear signals about the incorporation of these nanoparticles in polypropylene, shown in Fig 1. The detection of silicon in the samples was due to the presence of silica from the fiber, which, together with the fiber fragments found (indicated by arrows), proves the hypothesis of fiber incorporation. The same results were found from the SEM micrograph technique.

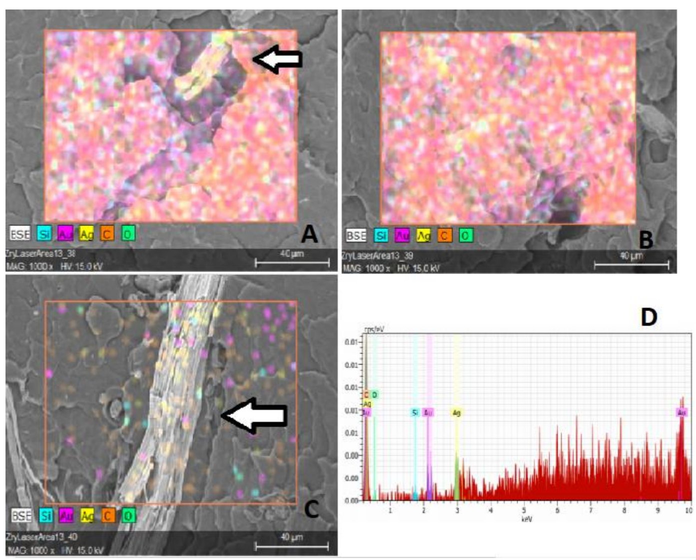

Figure 1: A: EDS spectroscopy of the sample PPP2; B: EDS spectroscopy of the sample PPP3; C: EDS spectroscopy of the sample PPP4; D: Qualitative EDS spectroscopy of the sample PPP4.

The results obtained by XRD (fig.2) has intensity peaks at : 38.29, 44.5583, 64.82 and 77.443 degrees which correspond to the values (hkl) : (111), (200), (220) and (311) of the crystal planes attributed to silver nanoparticles. These peaks were only observed in samples that were incorporated with AgNPs (PPP2, PPP3, and PPP4), which support the hypothesis of nanosilver incorporation. It is also observed that the characteristic peak of $AgNO_3$ (32.35) appears in PPP2 and PPP3, which indicates that the doses of 5 and 10 kGy were not enough to reduce all silver ions to nanoparticles, made at 20 kGy dose properly.[7]

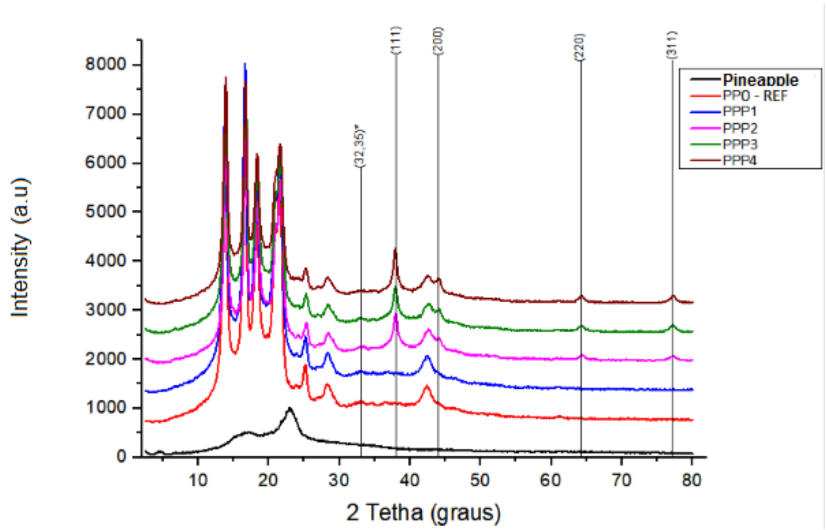

Figure 2: Curves of the XRD analyses.

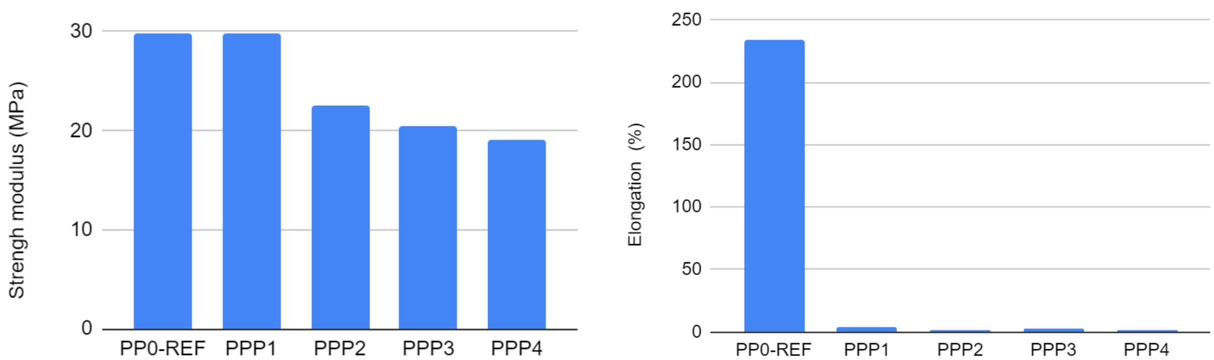

Figure 3: Results of mechanical tensile tests.

The tensile mechanical test indicated that the insertion of fillers in the polymer matrix caused changes in the mechanical properties of the polymer. According to Fig.3, the samples PP0-REF and PPP1 indicated a higher maximum tension modulus, and this value decreases to PPP2 from, PPP3 and PPP4 (notice that the samples with the nanosilver have lower strength modulus). The fiber, in the low concentration, presented a light reinforcement (0.5%), however the presence of silver harmed the property due to the formation of bubbles observed in the transverse section. The observed craters formed are failures that lessen the modulus of the prepared nanocomposites.

4. Conclusions

The results demonstrated a good incorporation of silver nanoparticles and pineapple leaf fibers in the polypropylene matrix. Has been shown that after irradiation with 20 kGy, the silver solution was totally reduced to nanosilver (no $AgNO_3$ observed) and in this form was incorporated in PP.

The results found in this work were preliminar and for future adjustment of the process of nanosilver insertion, in order to eliminate craters, it will expect the improvement of the polypropylene nanocomposite physicochemical characteristics and further expand its relevance in the polymer market.

Acknowledgements

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