Plasma-Laser Assisted Synthesis of Nanoparticles for Antibacterial Coatings

A. Jurov[1,2], N. Krstulović[3], M. Modic[1], N. Hojnik[1,2], A. Nikiforov[4], A. Zille[5], C. Leys[4], U. Cvelbar[1,2]

[1] Jožef Stefan Institute, Jamova cesta 39, SI-1000 Ljubljana, Slovenia
[2] Jožef Stefan International Postgraduate School, Jamova cesta 39, SI-1000 Ljubljana, Slovenia
[3] Institute of Physics, Bijenička c. 46, 10000 Zagreb, Croatia
[4] Department of Applied Physics, Ghent University, Ghent, Belgium
[5] 2C2T-Centro de Ciência e Tecnologia Têxtil, Minho University, Guimarães, Portugal

The “green synthesis” of colloidal nanoparticles and their application for the antibacterial coatings is based on the plasma-laser assisted ablation in liquids. Nanoparticles are synthesized through the process of laser ablation of target in water, which enables additional advantages in comparison with the other standard wet chemical synthesis, such as simplicity and complete utilization of materials. Furthermore, these nanoparticles are used and tested for antibacterial coatings on polymers, where they are grafted or imbedded through atmospheric pressure plasma assisted processes. The advantages of different coatings made from those nanoparticles are presented as well.

1. Motivation

One of the requests in medicine are materials with antibacterial properties, and even though antibacterial coatings are not a novelty, still there is a demand for better effectivity and profitability. The goal of our method is just that, to try the new, simpler, and more affordable approach in the never-ending pursuit for efficiency and inexpensiveness.

2. Experiment

Laser synthesis of nanoparticles in liquids is known as the “green synthesis” technique as it provides not inhalable colloidal nanoparticles of wide variety of metals with no residues or byproducts, and often no further purification is required. Moreover, the laser pulses can additionally generate, de-agglomerate, fragmentate, and re-shape nanoparticles. In addition to those advantages, the laser ablation is a simple and straightforward technique and only a small piece of metal is needed for the process, with no unused remains.

Unlike the methods where nanoparticles are incorporated not only at the surface but in the bulk of polymer material, our method is focused on incorporating nanoparticles only to the surface, keeping the bulk material untouched. This is a cost-efficient route to incorporate nanoparticles into polymers. Within this approach, 3 methods are tested: 1) the polymer surface containing nanoparticles deposited by drop-casting on plasma pre-treated polymer, 2) the polymer surface containing nanoparticles deposited by drop-casting and sequent plasma treatment after water evaporated, and 3) a colloidal Au nanoparticles deposited on polymer surface and plasma treatment with until water evaporates.

Preliminary research was done on various polymers with different colloidal nanoparticles, whereas a special attention was devoted to studies of PVC polymer and Au nanoparticles.

3. Results

The analysis of colloidal nanoparticles exhibits a narrow size distribution which is suitable for antibacterial applications. Moreover, the preliminary results of roughness and contact angle demonstrate appropriate change for nanoparticle impregnation on multiple polymers. Tests done on polymers impregnated with nanoparticles emphasize third method as the best impregnated sample.

4. Conclusion

The presented research shows that chosen methods are a good alternative for the preparation of antibacterial coatings on polymers. Roughness measurements displays interesting results, where a sample made with second method has roughness 20 times higher than untreated polymer, and two times higher than polymer treated only with plasma. Meanwhile, SEM analysis highlights the third method as the best choice for a quick new route to antibacterial coatings.