Morphology of zinc oxide nanoparticles: effect on functional activity and performance for application in bionanocomposites for food packaging.

The consumer's continuous demand for food with natural quality, safe, minimally processed, and with extended shelf-life and the concern with environmental impact are driving the use of bio-based materials in food packaging. The application of nanotechnology in food packaging enhances material properties, such as barrier to gases, thermal and light stability, and mechanical strength, offering active and intelligent functionalities that assure protection and preservation.

Zinc oxide (ZnO) is currently found in mainly daily life applications. It has received a positive safety evaluation from European Food Safety Authority (EFSA) for packaging applications as transparent ultraviolet light (UV) absorbers on the basis of an absence of a significant migration in particulate form. It also is considered GRAS (Generally Recognized as Safe) by the Food and Drug Administration (FDA). Zinc oxide nanoparticles (ZnO NP) are also known to have good antimicrobial properties and therefore are suitable to be applied as active compounds. Despite the abundant literature addressing the use of ZnO NP as antimicrobial component in packaging materials, the effect of particles size and morphology on the activity against different microorganisms is still poorly studied.

This project aimed at developing ZnO NP with different shapes (spherical, rod and flower), and sizes and studying the impact on the antioxidant and antimicrobial activities of the materials where the particles have been incorporated. The ZnO NP were produced by different methods: hydrothermal, solvothermal, microwave radiation, ball milling and sol-gel. A green synthesis approach with pumpkin seed extracted has been tested in order to create a sustainable route. ZnO NPs were characterized by powder X-ray diffractometer (XRD), Fourier transform infrared spectroscopy (FT-IR), UV-visible spectroscopy (UV–vis), Scanning electron microscopy coupled to energy-dispersive X-ray spectroscopy (SEM/EDS), Electron paramagnetic resonance (EPR) and nitrogen adsorption-desorption isotherms. Zinc quantification was performed by atomic absorption spectroscopy (AAS). All the results were compared with commercial ZnO NP.

The sol-gel method was found to be the most suitable to control the shape and sizes of the ZnO NP. The following control parameters were optimised for each shape: solvent, precursor, and physicochemical settings such as temperature and pH. Spherical NP were obtained with 80-95 nm, rod shape with length of 100-130 nm and width of 50-60 nm, and flower shape were obtained with length of 650-800 nm and diameter of 450-550 nm. The antimicrobial activity was

evaluated by the agar diffusion assay and viable cell count (spiral plate), showing that the particles with different morphologic characteristics render different functional performance.

This is to be correlated with particles surface specific area and with the migration behaviour after incorporation in the packaging material.