**Recent findings in the development of super-nano-antimicrobials: synergistic antimicrobial nanomaterials with enhanced functionality**

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The development of innovative nanosized materials capable to prevent the growth of undesired or pathogenic biological species is nowadays a consolidated nanotechnological field. Nanophases of transition metals (e.g. Cu, Ag, Zn, etc) and their compounds are being frequently employed as novel and efficient bioactive agents that are claimed to be safe and well tolerated by human beings. Several applications have been demonstrated for nanoantimicrobials (NAMs), including: food packaging and improvement of feedstock shelf-life, anti-fouling coatings and paints, textiles, biomedical and disposable devices, etc. [1]. Antibacterial ionic species released by NAMs provide an ideal alternative route to fight bacterial resistance towards conventional disinfecting agents. Since 2004, we have been developing and characterizing a number of different antimicrobial systems capable to exert a controlled release of metallic ions into aqueous solutions without generating a significant leaching of whole nanoparticles into the same contact media, as demonstrated by microscopy and spectroscopy validations [2-4]. With the rapid spreading of resistance among common bacterial pathogens, bacterial infections, especially antibiotic-resistant bacterial infections, have drawn much attention worldwide. In light of this, our most recent efforts are being oriented towards the synthesis of innovative NAMs nanoparticles, including metal and metal oxide nanoparticles, with synergistic antimicrobial activity. In the present work, superparamagnetic iron oxide nanoparticles Fe₃O₄ (MNPs) have been electrodecorated by copper nanoparticles (CuNPs) to exploit in a synergistic way MNPs antibacterial and biocompatible properties and the antimicrobial action provided.by CuNPs. The magnetic nanoparticles were synthetized via co-precipitation of Fe2+ and Fe3+ salts in aqueous media, either naked or capped in-situ by polyacrylic acid (PAA) or polyethylenimine (PEI) [5, 6]. The Sacrificial Anode Electrolysis (SAE) method [7, 8] has been used to electrodecorate these MNPs in an electrochemical cell, using tetrabutyl ammonium chloride (TBAC) or benzyl dimethyl hexadecyl ammonium chloride (BDHAC) as electrolytes. All the nanomaterials were characterized by UV-visible Spectrophotometry, Transmission Electron Microscopy (TEM) and X-ray Photoelectron Spectroscopy (XPS). A detailed surface chemical investigation was performed to identify the Fe2+ and Fe3+ features present in the XPS peaks. Since the main XP photoelectron Fe2p peak is well known to be a very complex system, a combined study of both secondary peaks (Fe3p) and valence band region (VB) was performed [9, 10]. Surface spectroscopy and morphological analyses demonstrated that interactions between the different nanophases occurred in composite materials, since the resulting nanomaterials both retain the MNPs magnetic properties and reveal new spectroscopic features in the valence band region of modified magnetite compared to the bare sample. Magnetic measurements are in progress, as well as the assessment of the antibacterial effects of the nanocomposite materials.

**References:**

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