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Synthesis of bismuth-based nanoparticles into an imidazolium ionic liquid by reactive magnetron sputtering

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Abstract content

Sputtering deposition over liquid substrates is considered as one of the most promising methods for synthesizing and stabilizing original nanostructured materials. Recently, room temperature ionic liquids, referred to as 'designer green solvents,' have attracted exceptional attention in obtaining nanoparticles of high purity and controlled size. However, to our knowledge and up to now, only metallic nanoparticles have been synthesized by sputtering. Therefore, the scope of our study is to synthesize semiconductor nanoparticles by injecting different reactive gases. By sputtering a bismuth target onto 1-butyl-3-methylimidazolium bis(trifluoromethanesulfonyl)imide [BMIM][TFSI] ionic liquid in an Ar, Ar/O_2, and $Ar/O_2/CF_4$ plasmas, we succeeded in obtaining metallic bismuth, bismuth oxide, and bismuth oxyfluoride nanoparticles respectively. Directly after synthesis, transmission electron microscopy showed the formation of non-agglomerated spherical nanoparticles with a size smaller than 20 nm. Various analytical techniques as XRD, Raman, UV-Vis, and IR spectroscopy were employed to characterize the nanoparticles. First, sputtering bismuth in an Ar plasma allowed obtaining a dark color solution containing metallic bismuth nanoparticles. Thereafter, the influence of target power, sputtering time, and aging on the nanoparticles' concentration and suspension was explored. Secondly, by injecting O_2 and CF_4 reactive gases, the solution stays transparent. The different techniques confirmed the formation of bismuth oxide and oxyfluoride nanoparticles. Moreover, the variation of the O_2 and CF_4 flow rates enabled tuning the composition depending of reactive gas ratio. The following nanoparticles are favorable for photocatalytic applications. Finally, the interaction of the ionic liquid with the different plasmas, without target sputtering, was investigated by optical emission spectroscopy to verify if the created radicals modify chemically the ionic liquid.