Currently, there is a growing need to develop a synthetic process for producing environment friendly nanoparticles that do not use toxic chemicals in the synthesis protocol. Researchers in the field of nanoparticle synthesis and assembly have turned to biological systems for inspiration. The synthesis of inorganic materials may occur either intracellularly or extracellularly (Senapati et al., 2005). Numerous recent publications have highlighted the potential of microorganisms, particularly bacteria (including thermophiles) and fungi, to synthesize or sequester metallic and/or oxide nanoparticles (Senapati et al., 2005; Klaus et al., 2001; Gericke and Pinches, 2006; Vigneshwaran et al., 2007; Mohanpuria et al., 2008). The native metabolic process of the microorganisms can lead to the precipitation of nanoparticles in the external environment of a cell or inside the cell. The extracellular presence of lead nanoparticles in the range of 1.77–5.8 µm was characterized by scanning electron microscopy. The presence of particles of lead in the 5–20 nm size range was found on the cell surface, in the periplasmic space and in the cytoplasm and was analyzed by transmission electron microscopy.

K e y w o r d s: Aspergillus species, lead nanoparticles, extracellular synthesis, intracellular synthesis

In the context of the current demand to develop green technologies in material synthesis, a natural process in the synthesis of lead particles by Aspergillus species to suit such technology is reported. The fungal strain was grown in medium containing different concentrations of lead (0.2–1.5 mM) to determine its resistance to heavy metals. The organism was found to utilize some mechanism and accumulate lead particles outside and inside the cell. The extracellular presence of lead particles in the range of 1.77–5.8 µm was characterized by scanning electron microscopy. The presence of particles of lead in the 5–20 nm size range was found on the cell surface, in the periplasmic space and in the cytoplasm and was analyzed by transmission electron microscopy.

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and showed considerable inhibition of growth. Detoxification of metals via reduction of metal is an important defense mechanism in microorganisms as a way to manage metal toxicity (Beveridge et al., 1997), however the enzymatic reduction process in the microorganism resulted in nanoparticle formation. Reduction of metal ions occurs intracellularly (Mukherjee et al., 2001) or extracellularly (Ahmed et al., 2003, Pavani et al., 2011). But when the Aspergillus species was grown in lead acetate, intracellular synthesis of lead nanoparticles was observed. SEM studies (Fig. 2) revealed that extracellular synthesis of lead particles was less and that they were in the 1.77–5.8 µm size range. However, the same strain behaved differently in the extracellular synthesis of zinc nanoparticles. Highly stable zinc nanoparticles were synthesized extracellularly in the size range of 50–120 nm. This indicates that if the metal in the media is in sulphate form the sulphate reductases are released extracellularly and reduce the compounds to sulphides, but if the metal in the media is in an acetate form the enzymes in the cell wall reduce them to metal nanoparticles. TEM studies (Fig. 3) revealed that the lead nanoparticles are present on the surface of fungi, in the periplasmic space and inside the cell in the 5–20 nm size range on a 100 nm scale bar. Nanoparticles are more concentrated on the cell wall than inside the cell. The possible mechanism may be the trapping of the lead ions on the surface of the fungal cells via electrostatic attractions between lead ions and negatively charged carboxylate groups present in the cell wall of mycelia. Then in the next step, lead ions that are entered into the cell may be reduced by the enzymes present in the cell wall and inside the cell. This clearly indicates that reductases or cytochromes that are present inside the cell and cell wall may be responsible for the synthesis of lead nanoparticles inside the cell and cell wall. Intracellular synthesis of nanoscale PbS crystallites by Torulopsis species when exposed to aqueous Pb$^{2+}$ ions was reported by Kowshik et al. (2002) and by Holmes et al. (1995) for Klebsiella aerogenes, when exposed to Cd ions resulted in the intracellular formation of CdS nanoparticles in the 20–200 nm size range. The biogenic process in Aspergillus species open up vistas for better management of bioremediation of contamination once we are able to achieve better understanding and control over size and polydispersity of the nanoparticles and to understand the biochemical and molecular mechanisms in the synthesis of the nanoparticles. To the best of our knowledge, this is the first report on the biogenesis of lead nanoparticles using Aspergillus species.

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Literature

Short communication


