BIVMiB040 BB/L013711/1
1 August – 31 October 2017
Funded by Metals in Biology BBSRC NIBB Business Interaction Voucher
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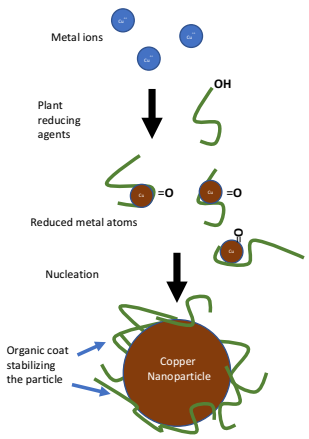
A pilot study to characterize plant-derived compounds that promote the synthesis of copper nanoparticles from contaminating copper ions in waste water

"This study has helped us see the potential future use of plants, plant cell culture or specific plant-produced compounds to remove contaminating copper and other trace metals from, for example, waste water in order to synthesize commercially valuable metal nanoparticles." Andrew Moore, Northumbrian Water Ltd

Ahmed Mohamed, Keith Lindsey and Jennifer Topping, Durham University; Andrew Moore, Northumbrian Water Ltd



Schematic of metal nanoparticle formation in a plant extract (taken from Makarov *et al*., 2014).

RESULTS: Leaf extracts from either coriander or mint were able to facilitate the formation of copper nanoparticles (CuNPs) from copper sulphate solution. Characterization of the CuNPs showed their size ranged from 28-36 nm, they were surrounded by proteins and a proportion of them existed as CuO. The crucial role of plant proteins or protein-containing moieties in CuNP formation was shown by removal of the protein fraction from the plant extracts; CuNPs were not formed in the protein-free fraction. Proteomic analysis revealed that although there was variability between the plant species studied, 105 proteins were associated with the CuNPs formed by both the mint and coriander extracts. Further work, and evidence from the literature, suggested that CuNP formation may be dependent upon protein mixture composition, rather than individual proteins. The second part of our work focused on the potential applications of the CuNPs. The bioactivity of the bio-synthesized CuNPs was compared with commercially available CuNPs in several biological assays. No difference between the two types of CuNPs was observed, confirming that the bio-CuNPs could be used successfully in biotechnological applications.

INITIAL AIMS: Contamination of land and waterways by toxic metals is a serious environmental problem, particularly in areas where mineral mining was once widespread. If the polluting metal can be sequestered into bioactive metal nanoparticles then the nanoparticles could have value in various applications, and the land would be decontaminated using an eco-friendly approach. Plant compounds are thought to be able to precipitate metal ions from dilute solutions to form metal nanoparticles through reduction of the metal ions into metal atoms that coalesce into nanoparticles. There are several possible plant compounds that can act as bio-reductants including flavonoids, terpenoids, sugars and proteins. In this project we studied the formation of copper nanoparticles (CuNPs) from a copper sulphate solution following the addition of plant leaf extract from either mint or coriander, with the aim of gaining a better understanding of how this process occurs, as well as characterising the CuNPs and the bioactive constituents within the plant extracts.

- Plant proteins can be used to reclaim copper in solution in the form of CuNPs
- Bio-CuNPs have the same bioactive properties as commercial (chemically produced) CuNPs
- Further work needed to identify which (if any) of the identified proteins in isolation are sufficient to form CuNPs