CBMNet
CROSSING BIOLOGICAL MEMBRANES NETWORK, A BBSRC NIBB

The University Of Sheffield.

UNIVERSITY of York

BBSRC

Plants as Nanoparticle Producers

The Challenge

Platinum group metals (PGMs) are used in many industrial applications, often as nanoparticles (NPs). PGMs are rare materials, making them highly valuable, but their increasing dispersal in the environment, often as NPs, is of growing concern due to adverse health impacts.

The metal accumulating ability of plants can be used to capture metals from the environment. Furthermore, previous studies have demonstrated that plants can produce platinum group metal-nanoparticles (PGM-NPs) which can make high-performing plant-based catalysts, either in their native state or after modification. These high value products could help satisfy demand for precious metals in industry and medicine.

However, the full potential of plants as PGM accumulators is yet to be realised and critically depends on the identification and characterisation of membrane transport mechanisms that catalyse PGM uptake and distribution within plant tissues.

The Research

Dr Maathuis is a reader in plant biology at the University of York. The research in his laboratory focusses mainly on plant stress and membrane transport.

Dr Maathuis applied for a CBMNet Proof-of-Concept award with TeeGene Biotech Ltd to develop a collaborative partnership and produce preliminary data that could be built on in future funded projects.

The project aimed to better understand how PGMs and PGM-NPs cross plant membranes, especially with regard to the potential role of membrane transporters and the identification of specific candidate proteins relevant for the transmembrane movement of PGMs and PGM-NPs.

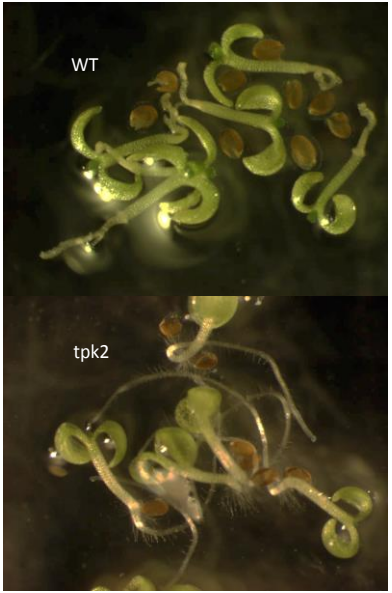

Fig 1: Top and bottom panel show WT and tpk2 mutant growth after 5d on 70 uM Pd^{2+}. Note larger size of WT plants (genotypes showed similar growth in control medium).

CBMNet Proof-of-Concept Award

The Result

Plant membranes were subjected to patch clamp measurements. Background current was recorded in the absence/presence of various concentrations of gold NPs but no effects on current were detected. Similarly, ionic Pd^{2+} was added to the bath in concentrations up to 2 mM and small changes in current were recorded.

In combination, these data suggest that NPs do not cross the membrane and PGMs are taken up in ionic form. After uptake PGMs partially aggregate into NPs in the plant symplast.

All ~1200 Arabidopsis membrane transporter mutants were tested using various plate assays (e.g. Fig 1), at three [Pd^{2+}] and in triplicate. A small number (~30) of promising mutants are now available which includes well known heavy metal transporters from the HMA and COPT families, several of which show different Pd levels in the shoot (Fig 2).

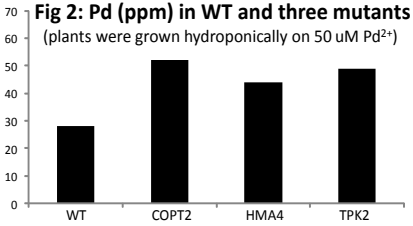

Fig 2: Pd (ppm) in WT and three mutants
(plants were grown hydroponically on 50 uM Pd^{2+})

The Future

Dr Maathuis and Professor Neil Bruce (co-applicant) have secured a BBSRC DTP studentship (2017) to progress this work.

The student will further characterise some of the identified mutants and manipulate gene expression to optimise plant PGM uptake.

If further funding sources become available they intend to (i) study hyperaccumulator plants for PGM uptake capacity (ii) develop extraction/purification processes for PGM recycling, (iii) carry out small-plot field trials and (iv) conduct an economic feasibility study at current and projected PGM prices.

Industry News Coverage:

http://www.chroniclelive.co.uk/business/business-news/teesside-university-spin-out-researches-10336984

https://bdaily.co.uk/articles/2015/10/28/teesside-biotechnology-firm-looks-to-turn-roadside-plants-to-anticancer-drugs

http://www.ukspa.org.uk/blog/15/11/wilton-centre-company-verge-chemical-breakthrough

"The CBMNet PoC award has helped us to make good progress, but how plants interact with PGMs is still largely an unanswered, and very exciting, question"

Dr Frans Maathuis, University of York

"TeeGene Biotech Ltd is undertaking in-depth research into plants from roadside verges that have been subjected to significant levels of air pollution. We are investigating the possibility that they may contain valuable platinum group metals, which can be recycled for use in anticancer drugs and biomedical devices such as pacemakers. There is a growing demand for platinum to be used in medical applications just as there is increasing concern about the environmental impact of platinum deposits due to air pollution so this research is very timely."

Dr Pattanathu Rahman, Director of TeeGene Biotech Ltd

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