Plasma treatment to enhance germination of Australian Plants Seeds

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**Project outline:**
This project aims to investigate how low temperature gas plasma (also known as glow discharge) techniques can be applied to seeds of Australian plants that are difficult and tedious to germinate, and/or suffer from high mortality at the seedling stage due to fungal infections. One aim is to achieve enhanced germination yields and shorter germination times by controlled erosion of seed coats. Another aim is to develop methods for the controlled removal of fungal spores that sit on seeds and cause diseases such as “damping off”. By improving the rates and yields of seedlings, the outcomes of this study will contribute to the conservation of plants whose seeds are rare and valuable and to the horticultural development of plant species that currently are not economical to produce by the nursery trade.

Seeds of many Australian plant species (e.g., Fabaceae and Mimosaceae families) possess a hard coat that presents essentially an impermeable wall and protects the seed from damage and environmental influences. It causes delayed germination; such seeds will usually only germinate after long periods of time under "normal" conditions. Germination can, however, occur rapidly after a bushfire or some other environmental cause that affects the hard seed coat. With the widespread control of bushfires and agricultural clearing, many such plants, such as the WA “poison peas”, are becoming rare and endangered. Other Australian plants produce seeds with less hard and thick coats but the seeds contain germination inhibitors (e.g., genus Eremophila) that delay germination and frustrate propagators. The inhibitors often appear to be located in the seed coat. While such mechanisms for delayed germination are an effective strategy for survival of seeds until optimal survival conditions for young seedlings have arisen, they present a serious challenge for the efficient propagation of such plant species and also reduce natural regeneration when humans alter ecosystems. A third problem is that some rare and endangered species (e.g., some Banksia species and other Proteaceae) are very susceptible to fungal root attack particularly at the seedling stage, leading to the rapid death of young plants. One possible solution is to disinfect seeds by the removal of fungal spores, thus increasing the yields from the small number of available seeds. Reasons for wanting to propagate such species include conservation; survival depends on effective propagation and re-vegetation in the wild. Secondly, such species often are pioneer species that are well adapted to harsh conditions and thus are an essential part of re-vegetation efforts where environmental damage has occurred. Thirdly, many "difficult to germinate" species have attractive flowers and foliage and would provide commercial opportunities in the nursery trade if the propagation problems can be solved. The sale of rare plants by nurseries for planting in home gardens would also contribute to conservation.

In this study, gas plasma techniques will be investigated for their potential to etch hard seed coats, seed coats containing germination inhibitors, and fungal spores, and thus achieve effective germination. If successful, this will allow the controlled, reproducible treatment of large numbers of seeds with short treatment times. Gas plasma techniques are well established in a number of industries; most prominent are applications in industries that require conversion of hydrophobic polymers to hydrophilic surfaces, and in the semiconductor industry for plasma etching and plasma modification of materials. It is known that certain plasmas can etch synthetic polyamide materials and similar polymers. Such etching in plasmas is highly homogeneous and reproducible, and the thickness of removed material is controllable at the nanometer scale. This project will establish the scientific basis for such an approach.

**Aims and Significance of Project:**
The principal aim of this project is to acquire a fundamental understanding of the physico-chemical factors that achieve effective plasma etching of seed coats and therefore provide the scientific basis for...
designed treatment of seeds of various “difficult” species. It is necessary to study how different plasmas erode seed coats and assess the mechanisms not only with seed coats but also by comparison with etching effects on synthetic polymers. Analytical techniques such as cross-section electron microscopy and XPS will provide the means of studying the effects of plasmas on seed coats and fungal spores. Such research is necessarily inter-disciplinary, and the student will acquire skills and understanding of materials science, plasma science, surface science and analysis, and the effects of plasmas on biological systems. While studying a specific problem, the knowledge and skills will be applicable to other areas as plasma techniques are of interest for interface control with a number of biological systems. This will equip him/her well for future employment in areas where physico-chemical surface science and techniques are applied to practical problems including biological and biotechnology applications.

**Methodology:**
Seeds of selected species will be treated with plasmas (gas discharges) struck in various gas atmospheres (oxygen, hydrogen peroxide, etc.) and the erosion of seed coats assessed by cross-section electron microscopy. The etch rates will also be measured on synthetic polyamide polymers which will allow easier control studies than seeds. The chemical effects of plasma treatments will be assessed by XPS. It will then be studied how the etching, to various depths (and thus residual coat thickness) affects water uptake / swelling of seeds. This will be complemented by germination studies in which the yields of germination and the times of germination will be recorded. For seeds that contain germination inhibitors, it will also be attempted to measure the content, removal, and release of the inhibitors, and to correlate this with germination yields and speed.

**References**

**About Adelaide:**
Adelaide is the capital of South Australia and offers a very high standard of living (top 6 in the world according to “The Economist”), with great climate, food, wine, beautiful unspoiled nature and beach environments, in an inexpensive setting. The Mawson Institute (MI) has recently been established at the University of South Australia, with strong support from the South Australian Government to research new manufacturing technologies. Manufacturing is an important and substantial part of South Australia’s economic base. The MI promotes a strategy based upon strong basic and applied research that encourages scientific and technological innovation within the manufacturing sector. Fundamental to this is the Institute’s multidisciplinary approach, building research teams in concentrations that encompass a diverse range of disciplines, and collaboration with partners from both academia and industry. The institute is based in two new state-of-the-art buildings with outstanding research facilities (see photo of the MM building).