Whole-Cell Microbial Biosensors

Development of whole-cell microbial biosensors can allow rapid, on-site detection of heavy metals in contaminated environments. Cadmium (Cd\(^{2+}\)) is a heavy metal deemed toxic to humans and the environment by the World Health Organisation (WHO). Released predominantly through industrial processes, cadmium cannot be degraded and accumulates in soils and waterways. The focus of this study is the characterisation of a cadmium responsive construct, consisting of a bi-directional promoter, cadR gene and gfp reporter gene on a broad host range plasmid (Figure 1A). The CadR regulatory protein is constitutively expressed, inhibiting transcription of gfp under the control of the promoter. The presence of cadmium in the cell results in its binding by CadR and subsequent production of GFP, allowing both qualitative (Figure 1B) and quantitative analyses (Figures 2-4).

This study aims to determine the lowest concentration of cadmium detectable, time until detection and the response of the cadmium biosensor to other heavy metal ions. As the majority of whole-cell microbial biosensors are based in Escherichia coli, comparisons will be made to the environmentally relevant Pseudomonas aeruginosa PA01 and Shewanella oneidensis MR-1.

Results

Low concentrations (0.1-1 µg ml\(^{-1}\)) of Cd\(^{2+}\) were detected by the cadmium biosensors

![Figure 2](image_url)

Cadmium biosensors were induced between 5-80 minutes by 2 µg ml\(^{-1}\) Cd\(^{2+}\)

![Figure 3](image_url)

Cadmium biosensors are highly specific to Cd\(^{2+}\) at higher concentrations

![Figure 4](image_url)

Conclusions and Future Directions

- The cadmium biosensors detected low concentrations (0.1-5 µg ml\(^{-1}\)) of Cd\(^{2+}\) 3 hours after induction.
- Fluorescence in response to induction by 2 µg ml\(^{-1}\) Cd\(^{2+}\) was found to occur within 5-80 minutes, dependent on the bacterial species.
- Although the microbial biosensors respond to Cd\(^{2+}\), non-specificity of the the CadR protein may result from non-specific ion binding at lower concentrations.
- When exposed to higher levels of Cd\(^{2+}\) (20 µg ml\(^{-1}\)) the cadmium biosensors showed increased specificity.
- These cadmium biosensors will be tested against samples from known contaminated environmental sites to determine the effect of complex environments.

Referecnes: