Investigation of the oligodynamic effect in slime mold

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Abstract

This project investigates the oligodynamic effect on a slime mold. The oligodynamic effect explains the toxicity of certain metals against bacteria and has long been utilized in anti-microbial applications. This research aims to determine whether *Physarum polycephalum* will distinguish and navigate around potentially toxic metals (gold, silver, copper, rhodium, nickel, iron, tantalum, silicon, tungsten, iridium, platinum, tin, and indium) when moving towards a food source, the impact said metals may have on its physiology, and the induced chemical changes to the metals both on their surfaces and in the bulk. Surface and bulk elemental analysis (by Auger electron spectroscopy and energy dispersive spectroscopy), as well as high-resolution imaging by scanning electron microscopy, will be used to analyze the metals before and after exposure. Findings from this project could be applied to fields such as engineering or medicine, including its use as an advanced biological sensor.

Methods

Instrumentation

- **Field Emission Scanning Electron Microscopes (FE-SEM):** Zeiss SUPRA 55VP and Zeiss Ultra 55 were used for high-resolution surface imaging
- **Energy Dispersive Spectrometry (EDS):** An Oxford Ultim detector was used for bulk elemental composition & mapping
- **Auger Electron Spectroscopy (AES):** Physical Electronics 710 Nanoprobe was used at a ~5 nm depth sensitivity

Step 1: Pre-Exposure Analysis: FE-SEM images, AES spectra, and EDS spectra were collected from 13 metal samples.

- Gold, silver, copper, rhodium, nickel, iron, tantalum, silicon, tungsten, iridium, platinum, tin, and indium.

Step 2: Biological Exposure: Metal samples were placed in the growth environment of *P. polycephalum* alongside a nutrient food source (oats). Time-lapse photography over 4 days documented the paths taken by the organism.

Step 3: Post-Exposure Analysis: FE-SEM images, AES spectra, and EDS spectra were re-collected from all exposed metal samples. Surface morphology and elemental composition were compared to pre-exposure data to identify any slime mold-induced chemical or physical changes to the metal surfaces.

Results

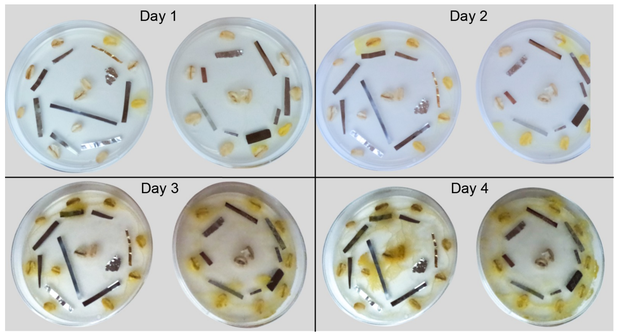


Figure 1: Time-lapse pictures of the slime molds growth through four days.

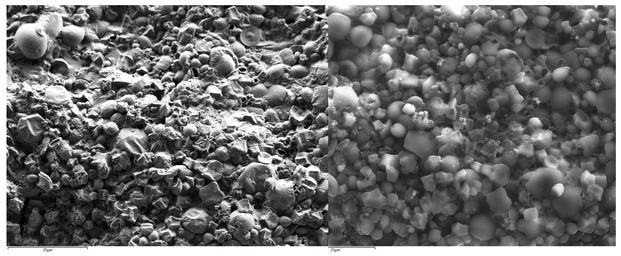


Figure 2: FE-SEM imaging (75 µm) of *P. polycephalum*

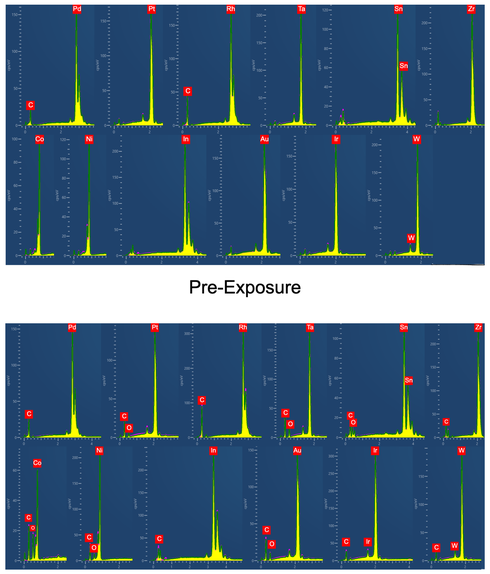


Figure 3: EDS spectra of all metals before exposure vs spectra of metals after exposure.

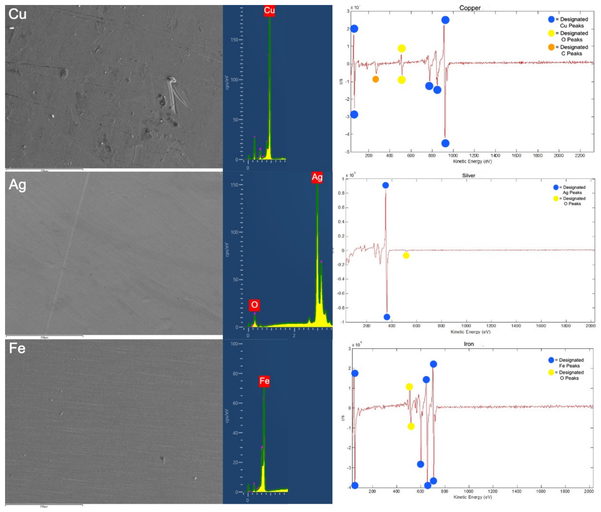


Figure 4: FE-SEM imaging (Left) of copper, silver, and iron, EDS graph (Middle) of concentration of elements, and AES graph (Right) of metals prior of exposure to slime mold.

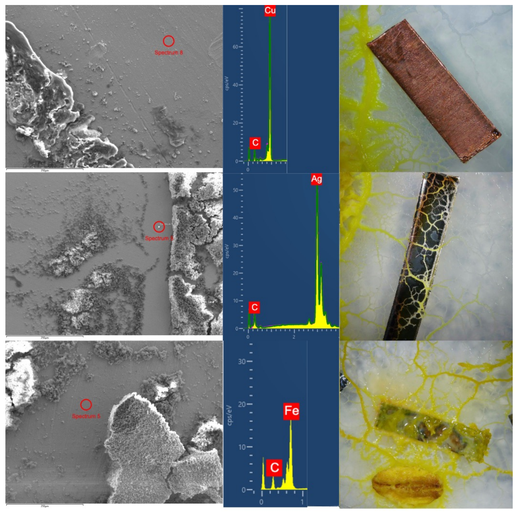


Figure 5: FE-SEM imaging (Left) of copper, silver, and iron, EDS graph (Middle) of concentration of elements, and macro photos (Right) of metals after exposure to slime mold.

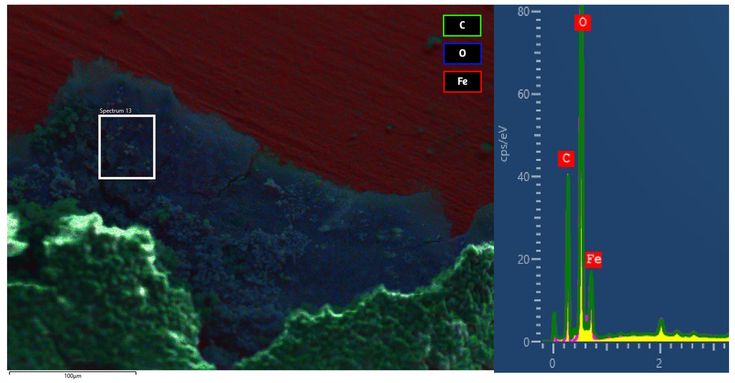


Figure 6: Graph shows the concentration of carbon, oxygen, and iron in the white squared box. Green color represents carbon, blue represents oxygen, red represents iron.

Conclusion

Time-lapse photography revealed that *Physarum polycephalum* exhibited selective navigational behaviors when traveling to food sources. Post-exposure FE-SEM imaging revealed surface morphological changes on multiple samples; this indicates a significant chemical interaction between the organism and metal surfaces. EDS analysis confirmed elemental composition changes due to the slime mold, such as the increase in elemental carbon and oxygen post-exposure (Figure 3). In Figure 5, *P. polycephalum* completely avoided and navigated around copper, a known contributor to the oligodynamic effect. This avoidance of a toxic metal further confirms that *P. polycephalum* demonstrates rudimentary intelligence. The slime mold was also observed to be highly attracted to iron (Figure 5). The high concentration of oxygen in Figure 6 suggests that *P. polycephalum* oxidized iron and induced localized corrosion. Future work will focus on further analysis of the surface modification induced by the plasmodial contact. The unique sensing capabilities of *P. polycephalum* could be used as an advanced biological sensor and could be applied in fields such as engineering and medicine.

Acknowledgements

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