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Data Descriptor

# Thermodynamic Data of *Fusarium oxysporum* Grown on Different Substrates in Gold Mine Wastewater

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**Abstract:** The necessity for sustainable process development has led to an upsurge in bio-based processes, thereby placing a higher demand on the use of suitable microorganisms. Similarly, thermodynamics is a veritable tool that can predict the behavior of any material under well-defined conditions. Thermodynamic data of *Fusarium oxysporum* used in the bioremediation of gold mine wastewater, for a process supported with different carbon sources, was investigated. The data were obtained using a Discovery DSC® (TA Instruments, Inc. New Castle, DE, USA) equipped with modulated Differential Scanning Calorimeter (MDSC™) software. The data revealed minimal differences in the physical properties of the *F. oxysporum* used, indicating that the utilisation of agro-waste for microbial proliferation in wastewater treatment is as feasible as when refined carbon sources are used. The data will be helpful for the development of environmentally benign process development strategies, especially for environmental engineering applications.

**Data Set:** Available as the supplementary file: http://www.mdpi.com/2306-5729/2/3/24/s1.



**Keywords:** *Beta vulgaris*; cyanide; Differential Scanning Calorimeter (DSC); *Fusarium oxysporum*; thermodynamics; wastewater

## 1. Summary

The application of bio-materials and environmentally benign methods including processes has risen due to the impact of industrial waste on the environment. The danger of such waste to both human and ecological systems is well known. Several reports have been published on microbial remediation of industrial wastewater containing cyanide; however, there is minimal commensurate uptake of such technology by the industry despite the LaRonde and Homestake gold mines in Canada, including Gold Fields Limited, demonstrating the feasibility and robustness of such biological process for cyanide remediation [1–3]. To date, there are no datasets on physical properties of microorganisms that could be deployed for sustainable environmental engineering applications for free cyanide bioremediation, i.e. in wastewater treatment.

Biological remediation of cyanide-containing wastewater has been dominated by the application of microbial species, namely, fungi, bacteria, algae, and protozoa. Bacterial strains such as *Bacillus* sp. and *Serratia* sp. [4,5] as well as fungal strains such as *Aspergillus* sp. and *Fusarium* sp. [6,7] have all shown proficiency in utilising cyanide as a carbon and/or nitrogen source. These organisms were grown on whey, coconut shell, *Citrus sinensis*, and *Beta vulgaris*, showing the feasibility of the application of agro-waste as a nutrient source for microbial proliferation in cyanide-containing wastewater. Recently, *F. oxysporum* proliferation was observed to be higher in *Beta vulgaris* waste compared with glucose [8], a process which was proven to be thermodynamically feasible [9]. Despite the robustness and environmentally friendliness of the microbial remediation of cyanide, chemical treatment methods are still favoured by the industry. This is due to the lack of published information on the impact of cyanide on physical properties of microorganisms. Presently, there is only one report on the thermodynamic data of lyophilized microbial biomass, which used an adiabatic calorimeter to quantify the heat capacity of lyophilized *Saccharomyces cerevisiae* biomass [10]. However, owing to the irreproducibility of results, preference is given to a differential scanning calorimeter (DSC) over an adiabatic calorimeter in the quantification of thermodynamic properties of biological materials [11–13]. Therefore, this study used a differential scanning calorimeter (DSC) equipped with a modulation to measure the thermodynamic properties of dried biomass of *Fusarium oxysporum*.

This dataset presents the thermodynamic data of lyophilized *Fusarium oxysporum* biomass harvested over a month in a 1-L, continuously stirred bioreactor containing synthetic gold mine wastewater. Earlier, bioenergetic parameters associated with microbial growth was found to be enthalpically driven for all substrates examined [9]. This data provides further insight into the capability of microorganisms to manage their environment under unfavorable conditions, even when organic waste (agro-waste) is used as the sole supplement to support such a remediation process.

## 2. Data Description

The thermodynamic property of a material is critical for the prediction of feasibility of any chemical and biological reaction, including processes such as the microbial growth and the biomass conversion of nutrient media to useful products. Thermodynamic properties of biological molecules such as starch, glucose, proteins, and amino acids reportedly measured based on rudimentary heat capacity quantifications and adiabatic calorimetric measurements based on the third law of thermodynamics have been used at low temperatures (0 to 298.15 K); however, there is high uncertainty associated with these estimates [11,13,14].

This data describes the thermal analysis of *F. oxysporum* grown on different carbon substrates in gold mine wastewater. *Fusarium oxysporum*, like other cyanide-degrading organisms, have been shown to use different enzymatic pathways to degrade cyanide, depending on the operating conditions (pH, temperature, cyanide concentration) [15–17]. Thermodynamic information will substantiate the viability of this enzymatic conversion of cyanide to less hazardous products such as formamide. Tables S1–S3 show data derived from biomass grown on glucose, *Beta vulgaris*, and *Beta vulgaris* with free cyanide, respectively. The heat flow and the impact of modulated temperature on heat flow is shown. This can be used to determine the durability of the sample. The heat capacity of the biomass material increased steadily up to 316 K for glucose, 302 K for *Beta vulgaris*, and 300 K for *Beta vulgaris* with free cyanide. At 298.15 K, the specific heat capacity from the glucose substrate was found to be highest (0.978 J/g·K). The entropy of the samples can be derived from this heat capacity data over the temperature range including the Gibbs free energy, based on the application of the third law of thermodynamics, since biomasses are not completely crystalline materials.

## 3. Methods

### 3.1. Sample Preparation

*Fusarium oxysporum* was cultivated in gold mine wastewater with carbon sources including glucose, *Beta vulgaris*, and *Beta vulgaris* with cyanide, as shown in Akinpelu et al [9]. A sample of dried biomass was resuspended in sterile distilled water in a 1:1, weight:volume ratio and incubated at 298.15 K for 16 h to ferment any residual carbohydrates. An aliquot of the suspension was tested for any residual carbohydrates using the Durham tube method [18]. Once the metabolic activity had ceased, the biomass was centrifuged and lyophilised [10]. All procedures were repeated until a suitable quantity of dry biomass was obtained. The elemental analysis of the dried biomass samples were determined by a Thermo Flash EA 1112 series analyser in a Helium carrier gas (Thermo Fisher Scientific Inc., Waltham, MA, USA), as presented in Akinpelu et al [9].

### *3.2. Thermal Analysis*

Thermal analyses were conducted on a Discovery DSC® (TA Instruments, Inc., New Castle, DE, USA) equipped with modulated Differential Scanning Calorimeter (MDSC$^{TM}$, New Castle, DE, USA) using a Liquid Nitrogen Cooling Accessory (LNCA, New Castle, DE, USA) at atmospheric pressure. For the purge, helium gas was used at a flow rate of 50 mL/min. Temperature and specific heat calibrations were performed with a MDSC$^{TM}$ certified Indium reference material (Part No. 915061.901) and a sapphire for the specific heat capacity determinations (Part No. 9703790.901), respectively. The MDSC$^{TM}$ equilibrated at a temperature of 123 K and the scans were performed at an underlying heating rate of 3 K/min up to a temperature of 373 K. An amplitude of 1 K and a modulation period of 60 s were used for the sample mass of 2 mg (dry biomass weight). The data were analysed using a TRIOS software v4.1.1.33073 (TA Instruments Inc.). All procedures were performed in triplicate.

**Supplementary Materials:** http://www.mdpi.com/2306-5729/2/3/24/s1.

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