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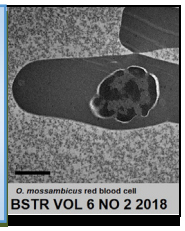

Short communication

Temperature Coefficient and Q_{10} Value Estimation for the Growth of Molybdenum-reducing S*erratia* sp. strain HMY1

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HISTORY

Received: 7th Oct 2018
Received in revised form: 15th Nov 2018
Accepted: 5th of Dec 2018

KEYWORDS

Arrhenius plot
Q_{10} value
Theta value
molybdenum-reducing bacterium
Serratia sp.

ABSTRACT

A relative 10 ˚C increase in the surrounding temperature, usually results in doubling the reaction rate, with corresponding Q_{10} value of 2, which is true for a number of biological reactions. Molybdenum reduction to molybdenum blue by bacteria is one of the methods to combat the toxicity of soluble molybdenum to the bacteria. The Q_{10} values for molybdenum bioreduction, which can be determined from the Arrhenius plots has not previously been reported. A logarithmic plot of growth rate or reduction rates for *Serratia* sp. strain HMY1 against 1000/temperature (Kelvin) and the slope of the Arrhenius curve was used to obtain the Q_{10} value in this study. The Q_{10} value of 2.038 and a theta value of 1.08 obtained in this work, are within the normal range for many biological values.

INTRODUCTION

Incubation temperature is amongst the key factors influencing microbial growth and degradation of toxic compounds [1,2]. The vast majority of microorganisms suffers directly by environmental temperature due to their small size and ectothermic nature. Consequently, temperature influences the physiology and adaptation of microbes on exposure to the new environment by modulating their cellular biochemical pathways. Importantly, temperature control is an ultimate consideration in bio-detoxification of xenobiotics.

Perhaps, in modelling and design, Arrhenius function described the effect of temperature on maximum growth rate of bacteria on their substrates. Currently, a universal temperature dependence theory (UTD) has been proposed to ascribe a limited range of values between 57.9 and 67.5 kJ/mol of Arrhenius activation energy (E_a) for all metabolic activities.

This range falls between 2.3 and 2.7 when translated into Q_{10} values. However, there is heated debate concerning the adoption of this range [3–5] as less than 20% of reported works on biodegradation of xenobiotics have Q_{10} values that fall within this range [5].

The Q_{10} values for biological reactions usually ranged between 2 and 3 [6]. As a standing rule, for every 10 °C rise in temperature, the reaction rates doubled, resulting in an estimated Q_{10} value of 2. A reaction with Q_{10} value of less than 2, suggests that the rate at the particular temperature is higher than what is predicted by the Q_{10} equation. This study presented for the first time the Q_{10} values for molybdenum-reducing *Serratia* sp. strain HMY1. The values obtained indicated that this bacterium is an efficient molybdenum-reducer, thus could be employed for bioremediation.

MATERIALS AND METHODS

Determination of the specific growth rates at various temperatures on low phosohomolybdate medium (LPM)

The growth kinetics was studied in a batch culture of *Serratia* sp. strain HMY1 grown in low phosphomolybdate (LPM) broth containing 10 mM sodium molybdate (**published elsewhere**). The initial inoculum of the bacterium was standardized at an OD_{600} nm of 0.1. The maximum specific growth rate of the bacterium (μ_m) used for the estimation of Q_{10} value was calculated using modified Gompertz model [7–9] rather than the commonly linearized models as follows;

$$y=A\exp\left\{-\exp\left[\frac{\mu_m e}{A}(\lambda-t)+1\right]\right\} \quad \text{[Eqn. 1]}$$

The effect of molybdate on bacterial growth rate can be modelled according to the Arrhenius equation [10] as follows,

$$\mu = Ae^{-\frac{E_a}{RT}} \quad \text{[Eqn. 2]}$$

Where R is the universal gas constant (8.314 J $mol^{-1}K^{-1}$), T is the absolute temperature (Kelvin = ^oC + 273.15), E_a is the activation energy (kJ mol^{-1}) and A physically signifies the rate constant at which all the participating molecules possess sufficient energy prior reaction (Ea = 0). A logarithmic plot of normal growth rate against 1/T give rise to the linearized form, the equation as follows;

$$\ln\mu = \ln A - \frac{E_a}{R}.\frac{1}{T} \quad \text{[Eqn. 3]}$$

Coefficient of Q_{10} estimation

The temperature dependence of biological reaction often reported as Q_{10} value, is the number of times that a 10 ^oC change in temperature results in changing the rate of the said reaction. The Q_{10} value relates to the activation energy via the following equation;

$$Q_{10} = e^{\left(\frac{Ea}{R}\right)\left(\frac{10}{T_2T_1}\right)} \quad \text{[Eqn. 4]}$$

Following rearrangement,

$$\ln Q_{10} = \left(\frac{E_a}{R}\right)\left(\frac{1}{T_1T_2}\right) \quad \text{[Eqn. 5]}$$

The coefficient of temperature or theta (Θ) value (simplified Arrhenius temperature coefficient) is another important biological constant obtained from substitution of the obtained values into the reaction rates equation governed by the Q_{10} rule;

$k_T = k_{20}\Theta^{(T-20)}$ [Eqn. 6]

RESULTS AND DICUSSION

The Q_{10} values can be determined either from the Arrhenius plots or as a ratio of growth rates measured at various incubation temperatures with ten degrees difference [11]. In the earlier case, the logarithmic value of the growth or bioreduction rates is plotted against 1000/temperature (Kelvin), while the slope of the Arrhenius curve is the value of the *Ea* (**Fig. 1**), which was calculated to be 53.48 kJ/mol (**data published elsewhere**). Conversion of Q_{10} from *Ea* value is then calculated according to **Eqn. 1**. The Q_{10} value of 2.038 obtained in this work, is within the normal range of 2 to 3 for many biological values. The theta value of 1.08 is also within the range for many biological processes [5]. Values range from 1.1 to 16.2 have been reported for the degradation of other xenobiotics [5]. Until present, the Q_{10} value for molybdenum bioreduction has not been reported.

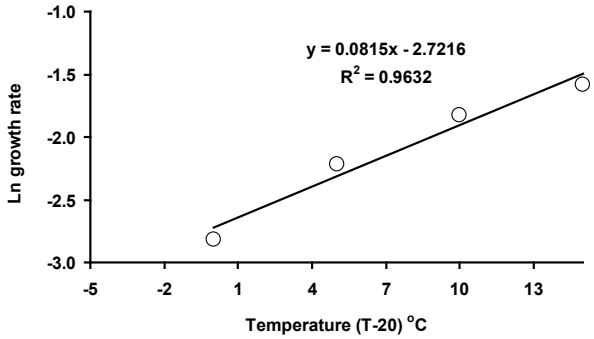

Fig. 1. Growth rate of strain HMY1 against incubation temperature.

The validity of Q_{10} value holds for a range of studied temperature, though biological process may have more than one Q_{10} values for a range of different temperature under investigation. For example, a Q_{10} value of 2.7 was obtained for the biodegradation of oil in a beach gravel column [12] while a bioventing study on decane and toluene contaminated soil exhibits a Q_{10} value of 2.2 [13]. Similarly, the effect of temperature on bacterial degradation of petroleum showed a Q_{10} value of 2.2 [14]. Whereas, acrylamide production by an immobilized bacterial system at temperature range between 25 and 45 ^oC gives a Q_{10} value of 2.8 as calculated for the free and immobilized cells [15]. Generally, Q_{10} value increase with decrease in temperature [16,17].

The Q_{10} value of this bacterium is within the range of biological activities, reported for the first time for growth on molybdate medium. This value is important in assigning the growth process to a characteristic biological activity.

CONCLUSION

Temperature generally affect microbial growth and metabolic activity on their substrates. The small nature of microbes makes them susceptible to change in surrounding temperature. The Q_{10} value for molybdenum bioreduction obtained in this work, is slightly lower than the normally reported range, suggesting that strain HMY1 could be a better candidate for bioremediation.

ACKNOWLEDGEMENT

This research was supported by the University Research grant 05-01-09-0846RU (UPM).

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