

Silica as biologically transmuted source for bacterial growth similar to carbon

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Abstract

Under specific conditions cells are capable of forming elements which did not exist before in the environment and this is referred as biological transmutation. Fungi and bacteria can solubilize insoluble silicates to support growth as case with the biological weathering of rocks. In the present study bacteria capable of silica solubilisation were isolated from soil, river water, pond sediment and talc mineral. These isolates were screened *in vitro* in medium containing magnesium trisilicate (0.25%) for zone of solubilization. *Pseudomonas stutzeri* was capable of growth in mineral media supplemented with and without glucose (0.1% level) and uses silicon-based autotrophy as a source of energy to support CO₂ fixation. Experiments conducted eliminating the head space CO₂ in mineral medium (with silica) supplemented with and without glucose showed that the *Pseudomonas stutzeri* could grow under silica and mineral nutrients alone and produce 84.1% biomass in 7 d. SEM-EDAX of the bacterial culture revealed the presence of carbon in the cells grown exclusively on silica suggestive of bacterial transmutation of silica to carbon. This may be due to that, silicon though a bigger atom making longer and weaker bonds has four bonding electrons available like carbon. Similar to carbon, silicon also has four open slots in its outer electron shell which may also from a basis for complex biological life.

Introduction

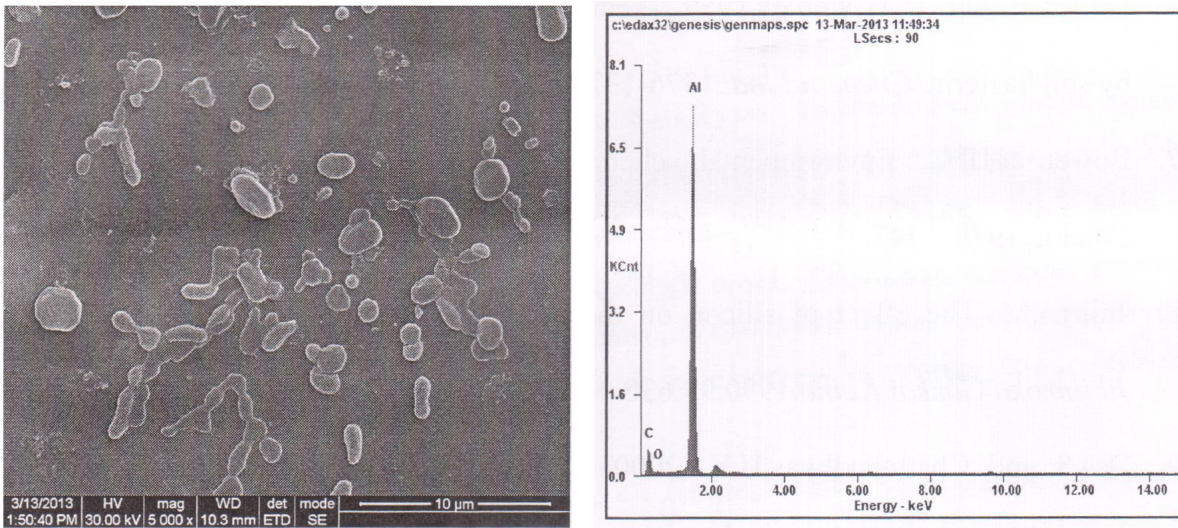
At the end of the 18th century Antoine Lavoisier demonstrated that chemical elements cannot be created nor destroyed. He performed a number of chemical experiments that showed that various elements can combine with each other, but without any change in their elemental compositions [1]. In 1891 Julius Sheiner wrote about the possibility of extraterrestrial life built with Silicon.

Silica is the second most abundant element found on earth. Although silicon itself (Si) is a glassy insoluble solid, the various oxides (primarily SiO₂) are somewhat soluble in water. Indeed, all natural water supplies contain some dissolved “silica”. Many supplies also contain suspended or colloidal silica. Silica, like its sister element carbon, has four covalent bonding sites and can, therefore, form a very large number of potential molecules. Silica chemistry is quite complex, second only to the chemistry of carbon compounds. Because the silica nucleus is larger than the carbon nucleus, silica does not easily form double or triple bonds, and silica does not readily form chains more than 6 silica atoms long. Unless 100% efficient thermodynamic systems operate, (something impossible in Universe), it would be extremely hard the passage of silica crystals through soft membranes. Fungi and bacteria can solubilize insoluble silicates as case with the biological weathering of rocks.

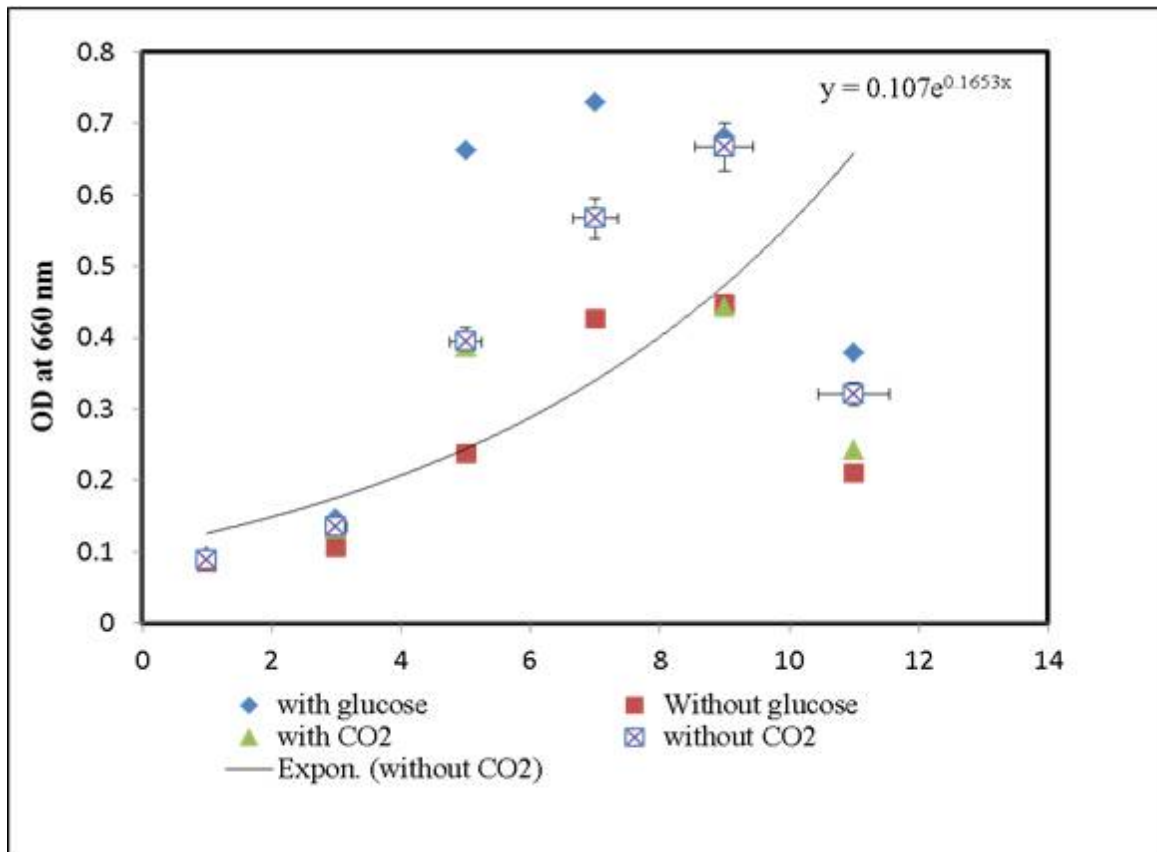
Silicon compounds also increase bacterial growth and have been implicated in aggravating tubercular infections of the lung in patients suffering from silicosis [2]. Hence, the present work was aimed to study the silica as biologically transmuted source for bacterial growth similar to carbon.

Objective

Silica as biologically transmuted carbon source for bacteria capable of silica solubilization.



b



a

Figure Legend

Figure 1. Growth of *Pseudomonas stutzeri* in silica medium supplemented with and without glucose/CO₂.

Figure 2. SEM-EDAX of *Pseudomonas stutzeri*.

Isolation and screening of silica solubilizing bacteria

Silica solubilising bacteria were isolated from soil, river water, pond sediment and talc mineral (Zhou *et al.*, 2006). Isolates screened *in vitro* in medium containing magnesium trisilicate (0.25%) for zone of solubilization ([Vasanthi *et al.*, 2012).

Bacterial strain and culture growth conditions

The bacterial cells were grown in Nutrient agar (NA) medium. The culture was routinely maintained at 4°C on slants. Before use, the culture was transferred to NA broth and incubated for 24 h at 27°C. To study the growth characteristics of the isolate, it was subjected to the following treatments-

1. Minimal medium + with carbon (0.1% glucose concentration)
2. Minimal medium + without carbon (0.5% silicate & 0.25% Magnesium trisilicate)

Both open and closed experiments were carried out with and without carbon. For closed system experiment the vials with broth were autoclaved, then purged with CO₂ and inoculated with 5% *Pseudomonas stutzeri* overnight grown culture. It was then incubated up to 72 h. Growth, pH changes and organic carbon were estimated for both of the experiments. **Results & Discussion**

In an attempt to isolate bacteria solubilizing of silicates in soil, several bacterial isolates were found capable. The isolate TNAU-S was capable of silicate solubilization *in vitro*. An almost complete 16S rRNA gene sequence of TNAU-S was obtained. The 16S rRNA sequence based phylogenetic analysis of TNAU-S revealed that the isolate were more closely related to *Pseudomonas stutzeri* and exhibited 100 % homology with type strain of *Pseudomonas stutzeri* ATCC 17588 NR041715. The 16S rRNA sequences of *Pseudomonas stutzeri* TNAU-S was deposited in the GenBank database with accession no. KP099588. Evolutionary tree based on 16S rRNA with neighbor-joining method, strain TNAU-S formed a stable clade with *Pseudomonas stutzeri* ATCC 17588 NR041715, which was supported by strong bootstrap value (100%). The ability of *Pseudomonas stutzeri* to dissolve silica from different silicate minerals (Talc, Feldspar and Magnesium trisilicate) were studied by *in vitro* dissolution method. The results showed that maximum dissolution was found in magnesium trisilicate (7.5 mg.l⁻¹ at 16DAI) supplemented with glucose. But in case of Feldspar, maximum dissolution was observed in medium without glucose (6.3 mg.l⁻¹).

Preliminary experiments showed that *Pseudomonas stutzeri* may have used the silicon compounds as an energy source, enabling them to fix CO₂ from the atmosphere. Hence, the *Pseudomonas stutzeri* culture was grown in silica medium supplemented with and without CO₂. The results showed that silica medium supplemented with CO₂ had maximum biomass and dissolution of silica (1.5 mg.l⁻¹) when compared to without CO₂ (Table 2; Fig. 1). The possibility that bacteria can grow autotrophically under oligotrophic conditions (using energy obtained from hydrogen oxidation) was suggested [3]. Bigger et al. [4] [5] observed that silicon compounds might adsorb ammonia and CO₂ from the atmosphere, thereby allowing bacteria to fix CO₂, using energy obtained from the oxidation of ammonium. Similar results also obtained by Chakrabarty et al [6]. Although it is generally thought that silicon compounds are biologically unreactive, [7] stated that there is no theoretical reason why the reaction of Si-Si-Si with oxygen or oxygen compounds could not act as an energy-yielding reaction. However, the possibility that fungi and other microorganisms might use silicon-based autotrophy clearly remains speculative. Whatever the mechanism involved, it is clear that silicic acid and other silicon-containing compounds, promote bacterial growth under oligotrophic conditions, a fact which helps explain the ability of bacteria to grow on nutrient-free silica [8].

SEM-EDAX analysis of the bacterial culture revealed the presence of carbon in the cells grown exclusively on silica (Fig. 2) and this was in agreement to [9]. This is suggestive of bacterial transmutation of silica to carbon [10]. This may be due to the reason that, silicon has four bonding electrons available, like carbon, while Si is a bigger atom and makes longer and weaker bonds. Like that of carbon, silicon also has four open slots in its outer electron shell which may also form a basis for complex biological life.

To further confirm, experiments using minimal broth supplemented with and without carbon under both open and closed conditions was performed. *P. stutzeri* put forth half of biomass in minimal broth with magnesium trisilicate only as compared to in a medium with glucose. However, minimal broth supplemented with silicate source recorded the highest organic carbon (Table 3). There was no significant changes in pH during the growth of *P. stutzeri* (data not shown; pH ranged from 6.8–7.1). *P. stutzeri* grown in a

laboratory scale fermenter with 0.25% magnesium trisilicate was producing 0.8 g.l⁻¹ of dry biomass on 4th day. This shows that *P. stutzeri* is capable of solubilizing silicate in the medium and biologically transmutating it to form carbon.

Conclusions

Silicon resides next to carbon on the periodic table of chemical elements. Like carbon, silicon has four valence electrons, implying that Silicon can link to four other atoms. Silicon is a metalloid, while carbon is a non-metal and hence no viable comparison between the chemical properties of carbon and silicon. Silicon can form a compound that acts like a kind of semi-permeable membrane very similar to the membranes formed by organic compounds because it permits the passage of some substances and prevent the passage of other substances. Nature tends to trail the most spontaneous way, although it would not be the simplest. If the Silicon-based living beings had been viable to happen in the Universe, the Earth would have them.

Additional Information

Methods

Isolation and screening of silica solubilizing bacteria

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Supplementary Material

Please see <https://sciencematters.io/articles/201511000005>.

Ethics Statement

Not applicable.

Citations

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