Could microorganisms cause the absorption of solar radiation in the Venus clouds?

S.S. Limaye[1*]; *R. Mogul*[2], *A. Ansari*[3], *D.J. Smith*[4], *P. Vaishampayan*[5], *and A. Yamagishi*[6]

[1]*U of Wisconsin, Madison, Wisconsin, United States of America*
2 California State Polytechnic University, Pomona, California, United States of America
[3]*Birbal Sahni Institute of Palaeosciences*
[4] *NASA Ames Research Center*, Moffett Field, *California, United States of America*
[5]*Jet Propulsion Laboratory, Pasadena, California, United States of America*
[6]*Tokyo University of Pharmacy and Life Sciences, Tokyo, Japan*

1. Introduction

Two key questions remain regarding the Venus global cloud cover which deserve further investigation. The planet's global cloud cover is highly reflective at wavelengths longer than the peak solar radiation (~ 0.9) and decreases to as low as ~ 0.3 at shorter wavelengths (200-400 nm) [1]. Cloud contrasts peaks are also higher in the shorter wavelengths and in reflected sunlight, the planet is nearly featureless at longer wavelengths. What substances in the Venus clouds are responsible for the albedo decrease below 600 nm remains an on-going mystery. It has been suggested that at least two different substances are needed to explain both the decrease in albedo at the shorter wavelengths and the dependence of contrasts [2]. On the nightside contrast features in the cloud cover are seen in the near infrared windows between between1.7 to about 5 µm. The first question pertains to the causes of the observed spectral dependence of the solar energy absorption below 500 nm. The second question investigates the causes of the observed contrasts in the clouds first identified at the ultraviolet (UV) wavelengths. The absorption at UV wavelengths by the Venus clouds represents a dominant deposition of incident solar energy that drives the atmospheric superrotation. The global structure of the superrotation in turn has been mostly discovered from tracking cloud contrasts from UV to NIR wavelengths. It is thus necessary that we learn about the nature of the UV absorption and the generation of the cloud contrasts on Venus to better understand the planet's atmosphere.

2. Identity of the shortwave absorber

Over the decades a several molecular absorbers have been proposed to explain the observed spectrum [3]. Below 330 nm, sulfur dioxide has been identified as one of the two substances likely responsible for the ultraviolet (uv) absorption [4] but the available information regarding its spatial distribution and temporal evolution [5] and contribution to the albedo appear to be somewhat counter-indicative as the clear primary absorber below 330 nm. Most candidates for the second absorber [6] have been discarded after analysis of limited data from in-situ measurements [7]. $FeCl_3$ has also been proposed [4, 8] and remains the most likely candidate [9] however, in the presence of sulfuric acid its lifetime is short and continuous replenishment is problematic. Recently another substance (OSSO) has been proposed as a possible ultraviolet absorber to explain the observed absorption between 320-400 nm [10], however the lifetime of the two isomers of OSSO proposed as sulfur reservoirs is very short (a few seconds) and the estimates of opacity are very uncertain [10] and not compatible with the sulfur abundance [11]. From probe measurements it is known that the uv absorption takes place above 62 km and likely begins at the cloud tops [12]. The uv absorbers may however be present in deeper levels, at least down to 47 km based on VeGa lander measurements [13].

Against this uncertainty regarding the nature of the uv absorber, the possibility for biologic origins of the absorption and contrasts have not received much attention. The detection of hydroxyl ions by Venus Express is consistent with this interpretation. It has been suggested that Venus may have been the first habitable planet as it could have harbored liquid water on the surface for more than a billion years in its past [14]. The possibility of life in the clouds of Venus was suggested by Morowitz and Sagan [15] and also discussed by Cockell [16] and followed up by Shulze-Makuch et al. [17] and Grinspoon and Bullock [18] as *acid and uv resistant* bacteria. Limaye et al. [19, 20] speculate as to whether microorganisms with uv absorptive properties such as those found on Earth could have evolved on Venus when liquid water was present on the surface, and then subsequently migrated to the clouds. The possibility that microorganisms may be extant in the clouds of Venus, perhaps in the lower cloud region where large particles have been detected [21], and where there is more water vapor and suitable temperatures for some terrestrial organisms such as *A. thiobacillus ferroxidans* cannot be easily discarded, given the similarities of its chemical, physical and spectral properties with those of the Venus cloud particles.

Laboratory measurements and new observations of the cloud particles from long lived aerial platforms sampling different altitudes of the Venus clouds during day and night are needed. Desired observations include microscopic images of the cloud particles, with ability to detect live or dead microorganisms [22], ambient atmospherictrace species and meteorological parameters. Laboratory experiments are needed to consider the survival and life cycles of microorganisms that can survive in the chemical and physical conditions found in the clouds of Venus, particularly in the lower atmospheric region. Spectral characteristics of different acid resistant bacteria over the 200 – 4000 nm range are needed, particularly for uv absorptive, sulfuric acid resistant species.

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Short Summary

The nature and identity of the absorbers of incident solar radiation between about 330-600 nm ij the clouds of Venus have been a mystery for decades. We explore the possibility of microorganisms being responsible for the absorption and the observed contrasts and measurements needed.