Phosphine: A Signature for Venusian Life?

If we were to rank the planets and the satellites of the Solar system based on the probability of the existence of life, Venus would undoubtedly rank somewhere at the bottom. Its high temperature, extremely dense atmosphere filled with thick Sulfuric Acid gas clouds and roaring volcanoes that continuously contribute to Venus's GreenHouse Effect is a hell when compared to life probable sites like Mars, Saturn's moon Titan and others. Despite this fact, the recent discovery of Phosphine (PH_3) may well position Venus right at the top. In this article we'll see how the discovery of a single compound at its atmosphere might be such a strong proof after all.

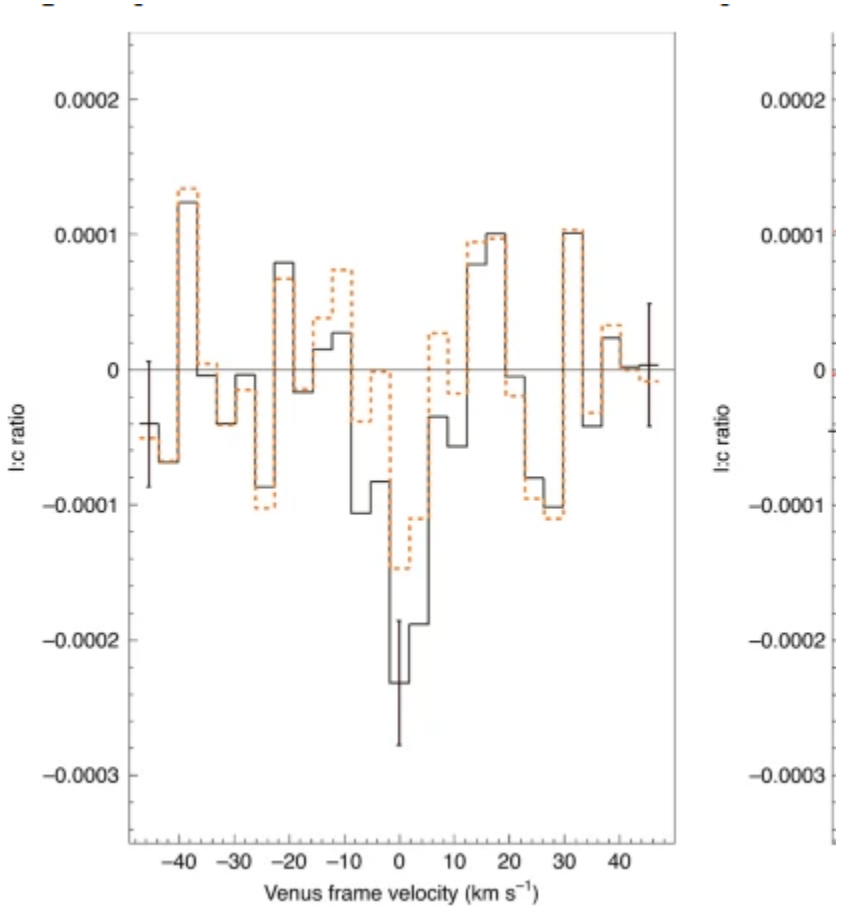
Before diving into the subtle proof, let's talk a bit about Venus. Venus is the 3rd brightest object in the sky after the Sun and the moon. It hangs around the sun just before sunset and sunrise. It has a diameter 90 percent of Earth's and is even inside the Goldilocks Zone: The Zone capable of harboring liquid water. Despite these similarities, Venus has long been thought to be one of the least favorable places for harboring life. Its atmosphere undergoes something that is known as the runaway GreenHouse effect. Extreme Volcanism throughout ages has given rise to pressure exceeding 100 times that of the Earth and an atmosphere filled with CO_2 gas. Besides that, it also contains poisonous Sulfuric acid too. As a result, scientists have been forced to look outwards, to places like Mars, Titan, Europa and planets outside the solar system in the recent decades.

However, Venus wasn't ready to give up. The probes sent by us, namely Pioneer and Magellan, discovered chemical components based on Sulfur, to be at an excess rate than expected. This could be explained via abiotic processes and the extreme volcanism that pervades all over Venus. Even keeping that aside, Venus absorbs a larger amount of short wavelength radiation from the Sun which makes it look yellow with dark patches that change over time. This could be explained by Dust churned up from the Venus's atmosphere or it could be 'Gigantic' colonies of Microbial life that may well live in the Venusian atmosphere.

It is true that the surface of Venus is absolutely hellish and so is its atmosphere, but around about 50 kilometers of Altitude we see that it has a pressure and conditions similar to that of the Earth but with a trace amount of Sulfuric Acid rain. The probability of life persisting (on a micro level) was first coined by Carl Sagan. He even hypothesized the possibility of 'Venusian Jellyfish' in that atmospheric zone. However, the idea was a mere fringe at that time and the 'Extra-terrestrial Hunt' remained outwards.

In order to determine the existence of life scientists search for something known as 'Bio signatures'. These are chemical compounds that are very hard to explain without any living activity. We can detect such compounds as the light rays from the planet's host star passes

through its atmosphere. Certain absorption lines at precise wavelengths from such ray's spectrograph tell us about its presence. Another similar way is to spectrograph the infra-red radiation emitted only by the planet itself. Such a bio-signature detectable at 1.1 mm range is Phosphine (PH_3). A team of researchers led by Deane Greeves was interested in using Phosphine as a possible biosignature for planets outside the solar system. However, they decided to take a look at once via the James Clark Maxwell Telescope. To their utmost surprise they found the excess existence of Phosphine! Soon after ALMA's observations followed and it was indeed the presence of Phosphine.



Result of Phosphine Detection via JCMT telescope

Greeves et. Al. 2020

So, although there's an abundant presence of Phosphine, how does it infer the presence of life? In fact, the tetrahedral 3 hydrogen attached to 1 phosphine might be formed easily with a relative abundance of Hydrogen and Phosphorus. Scientists have detected its presence in the atmosphere of Jupiter and Saturn long ago. However, none screamed the existence of life back then as we already knew the exact abiotic process that was fuelling its presence and the relative abundance

of phosphine decently matched to it. However, in the case of Venus its expected abundance is thousands of times more than expected.

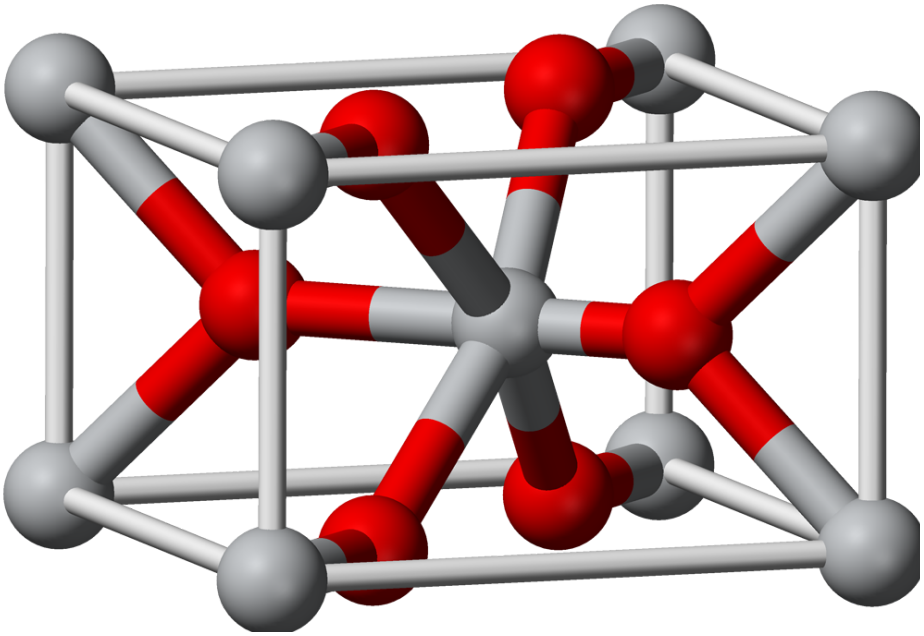
Phosphine is a substance that oxidizes itself extremely quickly. In atmospheres like Venus where Sulphuric Acid is abundant, Phosphine is soon oxidized to produce oxides as soon as it forms. Sure, high pressure and frequent thunderbolts in the Venusian atmosphere might produce Phosphine, but its amount is vastly reduced owing to oxidation of PH_3. Therefore, we need a process to define the excess production of Phosphine that outnumbers its degradation. In fact, there is only one known process to produce such a huge amount of it, and that's the presence of Biotic substances. In other words, living organisms.

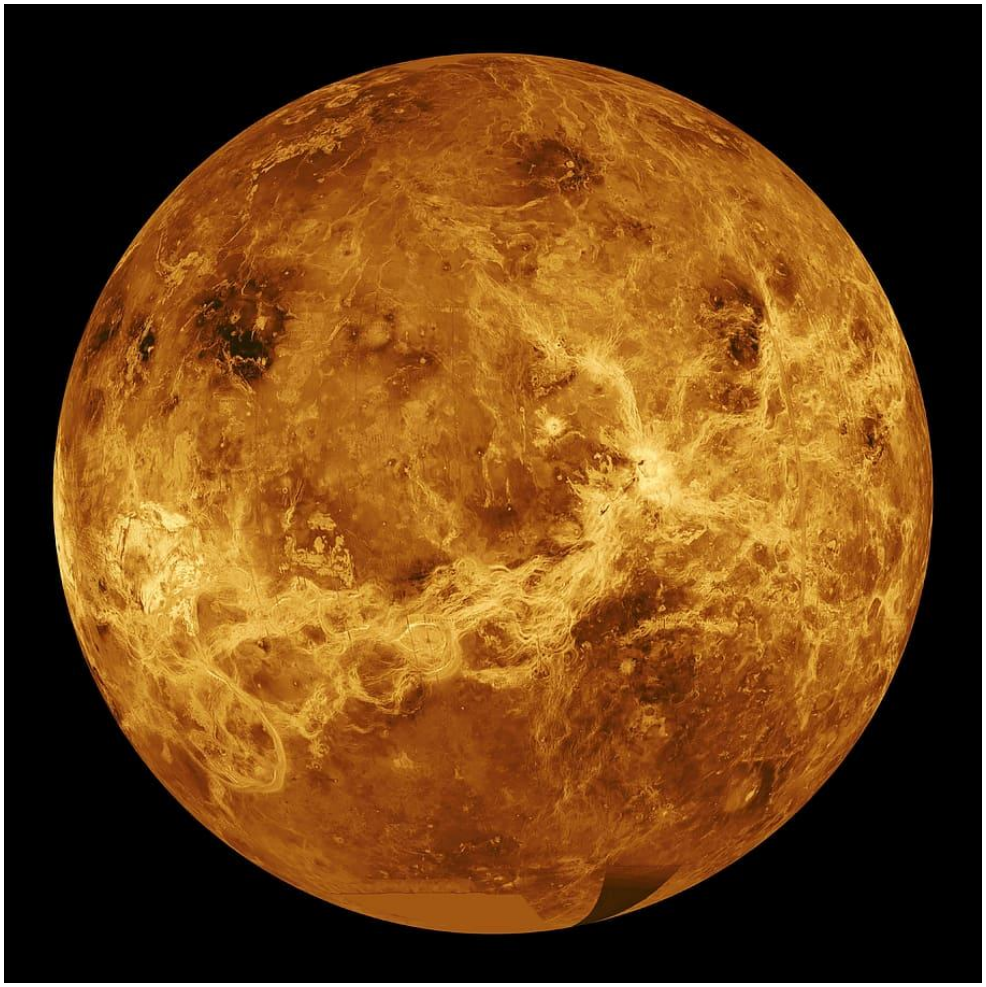
So, what would these living creatures look like? In order to answer it, we'll have to look back to the Venusian atmosphere again. Life, if it exists, has to exist in the atmosphere (to be precise, only within a certain range of the atmosphere) and will have an unthinkable capability to survive Sulfuric acid conditions as high as 85 percent concentration. On Earth, we find the most surviving organisms to cope with at best 5 percent concentration of Sulfuric acid. Sarah Seager from the MIT suggested such a microscopic organism to be 'Droplet-Dwelling'. This means the microbes on Venus would form droplets out of their own in order to survive such extreme conditions. But it poses a problem. The problems would tend to merge with each other and as a result, it would soon form heavier droplets. Soon, the droplets would become heavy enough and as a result, fall straight through the atmosphere into the hellish grounds. However, in such critical situations, the microbes are likely to enter a stage known as 'Spore Formation,' such a technique is seen in many of the microbes on Earth and it helps them to survive the toughest conditions in outer space. Such spore formation techniques will help the Venusian microbes to stay alive even in the absence of droplets. When the droplets are shredded off the microbes at a lower altitude, the will eventually go up into the habitable zone where it will merge, reproduce, form the droplet layer and presumably release an abundance of our cherished Phosphine.

So, how true is it? First of all, we would need more back up observations and data. Secondly, upon further confirmation, scientists may even send satellites to Venus to collect samples of the atmosphere and thus, make it possible to confirm its existence. Whatever the results may be, it surely has made us think again about our own place within the grand vicinity of the Cosmos.

References:

1. **https://www.youtube.com/watch?v=nNdy-LJWNQs&t=765s**
2. **https://www.washington.edu/news/2021/01/27/phosphine-venus-so2/**
3. **Greaves et al 2020**
4. **https://arxiv.org/ftp/arxiv/papers/2011/2011.08176.pdf**





Name: Sayed Shafaat Mahmud
Institution: Rajuk Uttara Model College
Class: 11
Email: smshafaatmahmud@gmail.com