MARS ROVER PROOF OF LIFE

by

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ABSTRACT

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The existence of extraterrestrial life has always been a fascinating topic for human beings, and the discovery of water on Mars reignited the debate over whether life on the planet is possible. This project describes the methods of proving life from a soil sample. Biuret and Benedict reagents are used for protein and carbohydrate tests, which are the essentials of life. The presence of protein and carbohydrate is indicated by the purple or deep blue and light green color change of the reagents; however, after testing the soil with reagents, it was discovered that the color change might be challenging to distinguish in the muddy solution. Therefore, it was decided that the soil solution should be decanted for 5-10 minutes to see a noticeable color change.

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CHAPTER 1

INTRODUCTION

1.1 Proof of Life Module

Is life possible on other planets? This is the current question that curious mankind is working hard to answer. The exploration of the solar system and other planets have led human beings to the discovery of water on Mars. This has increased the probability of existence of life on Mars. Inspired from this, the University Rover Challenge (URC), held in Utah, challenges participants to design a Rover Capable of exploring the Red Planet. According to the competition requirements, the Rover must complete tasks like navigating to a desired location safely, picking up objects, typing on keyboards, and proving the life in the collected soil sample [1]. Figure 1.1 shows the proof of life module designed for the competition. The module will be attached to the rover as shown in Figure 1.2. The rover is responsible for navigating to the designated area so that the module could collected the soil sample. The module is responsible for testing the soil sample onsite and sending the results of the tests to the base stations. The module has four sub-systems: pulley subsystem, drill subsystem, vacuum subsystem, and testing-bin subsystem.

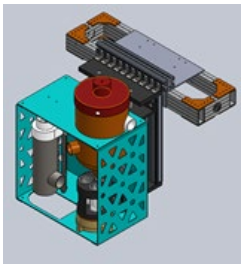

Figure 1.1: Proof of Life

Figure 1.2: UTA Rover

1.1.1 Subsystems

Figures 1.3 and 1.4 show the pulley subsystem to translate the module up and down on the rails. The pulley keeps the module up during the navigation so the collision with unwanted obstacles could be avoided. Figure 1.5 shows the drill bit. The drill bit is further translated using the gear rack kit until it reaches the ground. The drill is responsible for drilling the soil. The vacuum is shown in Figures 1.7 and 1.8. The vacuum is used to collect the soil sample and drop it in the testing bin. The testing bin contains the three different beakers filled with the reagents as shown in Figures 1.9 and 1.10.

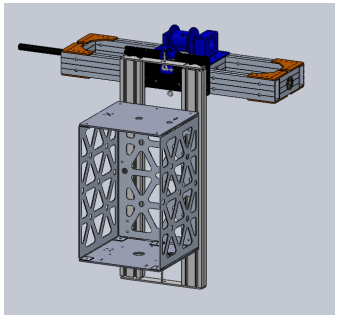

Figure 1.3: Pulley System 3D Model

Figure 1.4: Pulley System

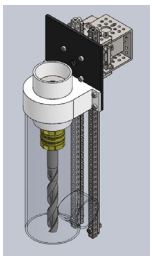

Figure 1.5: Drill System 3D Model

Figure 1.6: Drill System

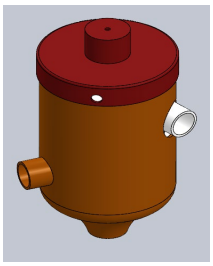

Figure 1.7: Vacuum 3D Model

Figure 1.8: Vacuum System

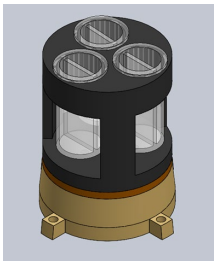

Figure 1.9: Test Bin 3D Model

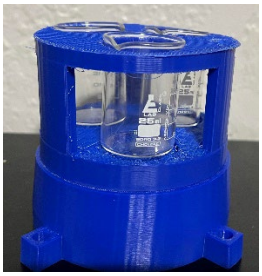

Figure 1.10: Test Bin

The purpose of the senior design project was to design and build a module for collecting and testing the soil sample at three different locations. I was tasked with designing the pulley system for the senior design project, and my contribution for the Honors research was to find the correct methodology to test the soil sample. Selecting the correct method to test the soil sample became the most challenging part of the project. In this project, the two best methodology of testing the soil sample using Biuret and Benedict's reagents is explained. These reagents are the best way to test the presence or absence of protein and carbohydrates. The test bin is designed for only one reagent since it has three testing chambers for three different locations as shown in Figure 1.10. This project explains about the best reagents for the soil sample testing based on the design of the module.

CHAPTER 2

LITERATURE REVIEW

2.1 Reagents

The microbial activity in a soil sample can be detected using the Gas sensors and study rocks for the evidence of past life. Gas sensors gives the concentration of the gases like methane, oxygen, ammonia, and carbondioxide [2]. Similarly, the presence of these gases inside the soil indicates the microbial activity or increases the possibility of presence of microbes. However, the use of gas sensors was not suitable according to the design of the proof of life module. Therefore, the more direct method of testing the soil sample to detect the components of life was used in the project. There are four essential components of life: proteins, carbohydrates, lipids, and nucleic acids. If the test result of soil testing is positive for any of the components of life, then the presence of life in the soil sample can be confirmed. However, the testing for lipid and nucleic acids are not feasible. Lipids tests do not produce distinct color change to be captured by the camera. Furthermore, the nucleic acid tests are expensive and are not feasible onsite. However, the test of protein and carbohydrate are more likely candidates for soil testing since their testing in the soil are more sensitive compared to lipids and nucleic acids.

2.1.1 Biuret Reagent

Proteins are the combinations of two or more amino acids. The amino acids have both the carboxyl (C=O) and amino ($-NH_2$) groups. The amino acids act as both acids and bases. Two amino acids bond together two form peptide bonds. Many peptide bonds

constitute a protein. Figure 2.1 shows the peptide bond. This peptide bonds reacts with the Biuret reagents to produce a distinct color change. Biuret agent is a mixture of sodium hydroxide (NaOH) or potassium hydroxide (KOH), hydrated copper (II) sulfate, and potassium sodium tartrate. Alkaline Biuret reagent have copper II ion resulting in the blue colored solution. When the copper ions react with the peptide bonds, a violet color change or deep blue is observed. There must be at least two peptide bonds for the reactions to occur. The reaction is explained more in Chapter 3 [3].

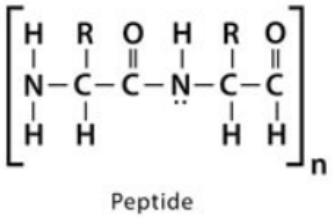

Figure 2.1: Protein [4]

2.1.1 Benedict's Reagent

Benedict's reagent is a solution of copper sulfate ($CuSO_4$. $5H_2O$), sodium citrate ($Na_3C_6H_5O_7$), and sodium carbonate (Na_2CO_3) in the presence of water. The reagent is used for testing the presence of carbohydrates. The presence of sodium carbonate makes the reagent alkaline. The presence of copper (II) ions in the reagent gives it a blue colored solution. The carbohydrate has free aldehyde (−RHO) or ketone functional group. When the copper (II) ions of the reagent react with the aldehyde, it forms carboxylic acids and cuprous oxide. The cuprous oxide is formed after the reduction of copper (II) ions and gives a red precipitate. The color of the solution depends on the concentration of carbohydrates present. The color change starts from green to brick red as shown in Figure 2.2. The reaction is further explained in Chapter 3 [4].

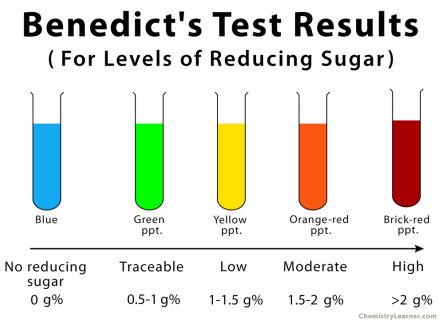

Figure 2.2: Color Change Based on Concentration [4]

CHAPTER 3

METHODOLOGY

3.1 Protein Test

The protein test was carried out using the 7ml of Biuret reagent diluted with water in a test-tube. The soil sample is mixed with the reagent in the solution. A deep blue color change was observed. The schematic of the reaction is shown in the Figure 3.1.

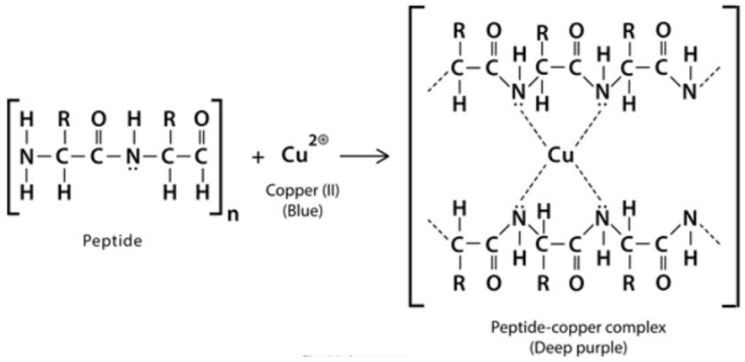

Figure 3.1: Biuret Test

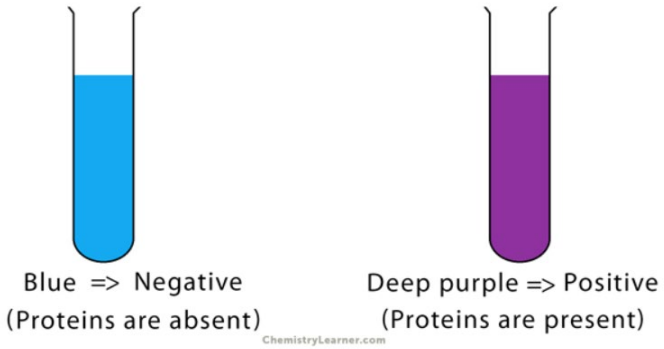

Figure 3.2: Biuret Test Result [3]

The color change was expected to be purple. However, the color change was observed to be deep blue. This also represents the presence of peptide bond. Figure 3.3 shows positive test for the presence of protein.

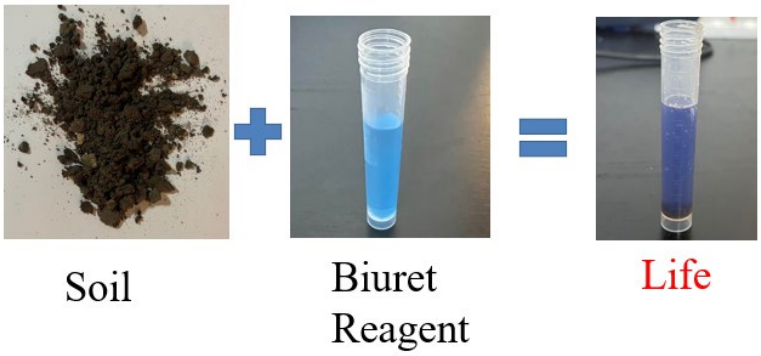

Figure 3.3: Protein Test Result

3.2 Carbohydrate Test

The carbohydrate test was done using the 8 ml of Benedict's reagent diluted with water. A soil sample was mixed with the reagent solution and the color change was observed. Figure 3.4 shows the schematic of the reaction. After the reaction, the sugar was reduced resulting in the cuprous oxide precipitates. The precipitates resulted in the green color as shown in Figure 3.5. This represents the traces of carbohydrates in the soil solution.

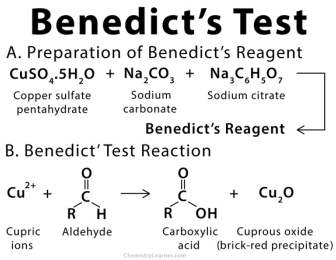

Figure 3.4: Benedict's Test Reaction [4]

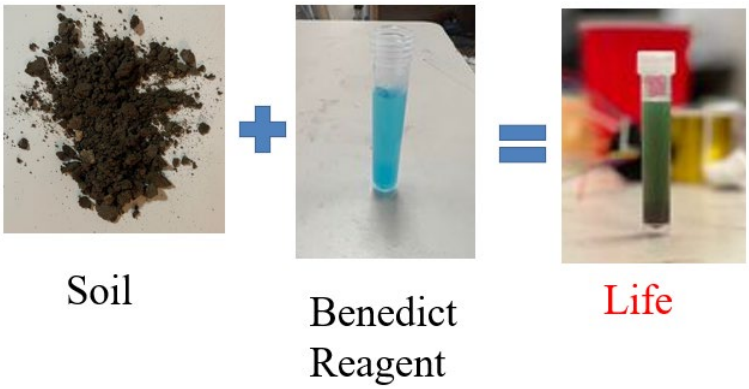

Figure 3.5: Benedict's Test Result

CHAPTER 4

DISCUSSION

The concentration of the protein and carbohydrate matters more than the amount of the soil used for the reaction. For example, 2 grams of soil might not contain two peptide bonds for the reaction to happen and vice versa. When it comes to the carbohydrate test, the test is very sensitive. The test shows the positive results even if the soil contains trace amount of glucose. The carbohydrate test is highly sensitive compared to the protein test. During the experiment, some soil samples did not give the positive test for the protein. However, each soil sample shows the positive result for the carbohydrate. Furthermore, the mixture of soil and reagents were heterogeneous. The distinct color change was not visible very fast. The mixture should be decanted for 3-5 minutes so that the soil sample settles down to the bottom of the beaker. After the soil particles settle down, the color change was observed very clearly.

CHAPTER 5

CONCLUSION

The methodology for testing the protein and carbohydrate using the Biuret and Benedict reagent is the best way to test life in the soil sample based on the proof of life module developed by the senior design team. However, the Benedict's test is preferable since the reaction shows a positive result even for traces amount of glucose present in the soil. The soil containing life must have the glucose contained in it. Furthermore, the mixture of the soil and the reagents must be decanted for 3-5 minutes to capture the distinct color change of the reaction. The purple or deep blue color change of the Biuret reagent gives positive result for protein. Similarly, the light green color change of the Benedict's reagent shows the presence of glucose proving the contents of life in the soil sample. The limitation of the project is that the conclusion that the soil sample does not contain life in the absence of protein and carbohydrate would be wrong if the soil sample contains lipids or nucleic acids. Furthermore, the gas sensors could be used to observe the microbial activity in the soil.

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BIOGRAPHICAL INFORMATION

The Honors College brought very interesting projects during Rakesh's whole undergraduate career; however, the three most interesting projects were the simulation of variable mass system analogous to rockets, approximation of one cycle of real aortic blood pressure morphology, and geometrical reverse engineering of a racecar wheel component called hub. Along the way, Rakesh developed a very keen interest in aerospace engineering. After Rakesh's undergraduate degree, the future plan is to complete a master's in aerospace engineering and then a doctorate in aerospace engineering, specifically in-flight dynamics and controls.