**Experiments Date:** 2020\_11\_05 **Experiment Code**: EX2020110501

**File: 20201105-1\_AS**

**Experiment Name**: 1. Design of experiment to manufacture the strip

2. Design of experiment to test the response of strip

**Location**-Virtual Lab

**Analysis technique** –Measurement the response of the strip in term of Resistance

1. **Apparatus used in manufacturing strip**

* Acid free paper
* Beaker 500 ml and 40 ml
* DI Water
* Ethanol
* 1 M HCl
* 1 M NaOH
* PH Meter
* Analytical Balance
* Bath sonicator
* Magnetic Stirrer
* Pipette and tips
* Burette (10 ml)
* Measuring cylinder (20 ml)
* Low molecular weight chitosan (loss of drying max 10 %, viscosity (200c) 10-150 mPa.s, Deacetylated degree min 90 %)
* Multiwall carbon nanotube (cataloged no 412988 sigma Aldrich)

1. **Apparatus used in testing strip**

* Mass Flow Controller (MFC), (Alicat Scientific, 10 SLPM range)
* PCB circuit board for signal collection
* Acrylic gas chamber (20 (+/-) 1mm \*56 (+/-) 1mm \*25 (+/-) 1mm)
* Glass enclosure (100ml)
* USB based Strip
* Nitrogen Gas Cylinder (99.9%)
* Teflon tube (4.8 (+/-) 0.2 mm)
* Rota meter (0 to 100 ml/min and 0 to 400 ml/min)
* Temperature (+/-) 1 and humidity sensor (+/-) 3 %
* Stand
* Acetone Canister [3 ppm] (+/-) 2 %
* Laptop/Desktop with Arduino software
* Laptop/Desktop with Flow vision software

**Related Parameter**

1. Experiment Performed inside the closed acrylic chamber (20mm (+/-) 1% \*40mm (+/-) 1% \*25mm (+/-) 1%).
2. Flow Rate of cleaning strip: 0.1 SLPM (100 ml/min) (1.67 ml/sec) [see in procedure point 5].
3. Flow Rate of acetone introducing into enclosure through MFC: 12ml/sec.
4. Humidity inside the acrylic chamber: 57 (+/-) 2%
5. Temperature inside the acrylic chamber: 28.3 (+/-)10C
6. Base value of strip: 279.7564 Ohm

**Preparation of strips:**

1. At very first step, taken three grams of chitosan (low molecular weight) and dissolved in 300 ml DI-water in 500 ml beaker.
2. Prepare 1M HCL solution from stock solution.
3. In the next step, place chitosan solution on magnetic stirrer and rotated at 800 rpm and apply heat 70 0C to magnetic stirrer plate.
4. Added drop by drop 1 M HCl to chitosan solution through burette and rotated at 800 rpm until it dissolved properly.
5. Placed this solution in microwave for 180 sec to get properly dissolved chitosan solution.
6. Then measure the ph. of chitosan solution and got PH 4.8.
7. Next day, prepares chitosan solutions in a beaker.
8. Added 3ml of chitosan solution from stock chitosan solution in a beaker and added 17 ml of DI-water to make total solution 20 ml in beaker, respectively.
9. In the next step, chitosan solution was sonicated for 30 min to mix properly.
10. Once it was mixed then 60 mg of MWNT was added to the chitosan solution.
11. This chitosan and MWNT solution were stirred for 3 hr. to dispersed properly and maintaining temperature 700C of bath sonicator.
12. The solution kept stirring up to the half of the solution get evaporate.
13. Once the ink was prepared then, took ink in air spray gun, and start spraying on acid free filter paper.
14. 20 ml of ink sprayed on acid paper of area 9.9 cm2 and at each spray leave 10 min to dry strip and repeated this spray until all 20 ml sprayed on strip.
15. In the same day, prepare the cassette of strip and measure the resistance of strip is 279.7564 Ohm

**Procedure:**

1. At very first step, mount the prepared strip on USB epoxy material based flat platform and given electrical contact through copper plate and then place it into a smaller glass enclosure (capacity 100 ml).
2. Keep this glass enclosure inside the acrylic chamber
3. Give the power supply through USB and connect to the laptop/desktop
4. Start the Arduino software to collect the strip signal.
5. Start the Flow vision software (Alicat) to perform and set up the MFC parameter.
6. In the next step, clean the strip by passing N2 gas for 10 min at the rate of 0.1 Standard Liter Per Minute (SPLM) (100 ml/min) through MFC.
7. After cleaning strip, acetone gas diluted with N2 (Diff. conc. dilution of Acetone mentioned in the table below) introduced into the glass enclosure through two different MFC at the same time of 10 sec (at the rate of 12 ml/sec) and leave it for next 280 sec. [MFC (A) - Nitrogen gas carrier gas, MFC (B) - Acetone cylinder].
8. At the time of 300 sec, N2 gas passes through cylinder into enclosure for next 300 sec at the rate of 0.1 SLPM using MFC (A).

(strip cleaning to get base value).

1. In the next step, next concentration of diluted acetone in N2 gas (dilution of acetone mentioned in the table 1) introduced into the glass enclosure in next cycle for 10 sec at the rate of 12 ml/sec using both MFC and leave it for next 280 sec.
2. At the time of 300 sec, N2 gas passes through cylinder into enclosure for next 300 sec at the rate of 0.1SLPM using MFC.

(strip cleaning to get base value.)

1. Repeated this procedure for different acetone concentration.
2. Total time of one cycle was 10 min (600 sec).

**Note: For the present experiment electricity power supply got switch off during the experiment running during the night.**

Table-1: Acetone diluted with the Nitrogen gas

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sr. No** | **Conc. Acetone** | **Acetone 3ppm** | **N2 Cylinder** | **Flow Rate Ar/AC** | **Flow Rate N2** | **Time** | **Chamber** | **Flow rate Ar** | **Flow rate N2** |
|  | **(ppm)** | **(ml)** | **(ml)** | **(ml/s)** | **(ml/s)** | **sec** | **Vol. ml** | **SLPM** | **SLPM** |
|  |  |  |  |  |  |  |  |  |  |
| 1 | 0.1 | 4.6 | 127.4 | 0.46 | 12.74 | 10 | 132 | 0.0276 | 0.7644 |
| 2 | 0.5 | 21.4 | 110.6 | 2.14 | 11.06 | 10 | 132 | 0.1284 | 0.6636 |
| 3 | 1 | 42.4 | 89.6 | 4.24 | 8.96 | 10 | 132 | 0.2544 | 0.5376 |
| 4 | 1.5 | 63.4 | 68.6 | 6.34 | 6.86 | 10 | 132 | 0.3804 | 0.4116 |
| 5 | 2 | 84.4 | 47.6 | 8.44 | 4.76 | 10 | 132 | 0.5064 | 0.2856 |

**Hypothesis:** The resistance of strip should change by changing the concentration of acetone

**Conclusion:**

According to the graph,

When the concentration of acetone increases the slope of the graph decreases.

When the concentration of acetone increases the change in resistance (Delta R) of the graph decreases.