Project report submitted in partial fulfilment for the Degree of B. Tech in Applied Electronics & Instrumentation Engineering under Maulana Abul Kalam Azad University of Technology

Ionic Polymer Metal Composite as Taste Sensor

By

Abhisek De	**Roll No 11705515001**
Anirban Pal	**Roll No 11705515004**
Debarshi Ash	**Roll No 11705515014**
Kaushik Das	**Roll No 11705515021**
Kaustav Mondal	**Roll No 11705515022**
Pritam Dhar	**Roll No 11705515030**
Rajanya Chakraborty	**Roll No 11705515032**

Under Supervision of

Dr. Srijan Bhattacharya

श्रमम् बिना न किमपि साध्यम्

DEPARTMENT OF APPLIED ELECTRONICS
& INSTRUMENTATION ENGINEERING,
RCC INSTITUTE OF INFORMATION TECHNOLOGY, CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700015

MAY 2019

Acknowledgement

It is a great privilege for us to express our profound gratitude to our respected teacher Dr. Srijan Bhattacharya, Applied Electronics &Instrumentation Engineering, RCC Institute of Information Technology, for his constant guidance, valuable suggestions, supervision and inspiration throughout the course work without which it would have been difficult to complete the work within scheduled time. We would like to express our gratitude towards other faculty members of Applied Electronics & Instrumentation Engineering, RCC Institute of Information Technology for their kind co-operation and encouragement which helped us in completion of this project.

We are also indebted to Prof. Arijit Ghosh, Head of the Department, Applied Electronics & Instrumentation Engineering, RCC Institute of Information Technology for permitting us to pursue the project.

We would like to take this opportunity to thank all the respected teachers of this department for being a perennial source of inspiration and showing the right path at the time of necessity.

Date: 13th May, 2019

Abhisek De
Anirban Pal
Debarshi Ash
Kaushik Das
Kaustav Mondal
Pritam Dhar
Rajanya Chakraborty

RCC INSTITUTE OF INFORMATION TECHNOLOGY
CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700 015 PHONE : 2323 2463 FAX : (033)2323 4668
E-mail : campus@rcciit.in Website : www.rcciit.org

CERTIFICATE OF APPROVAL

The project report titled "**Ionic Polymer Metal Composite as Taste Sensor**" of Mr. Abhisek De, Mr. Anirban Pal, Mr. Debarshi Ash, Mr. Kaushik Das, Mr. Kaustav Mondal, Mr. Pritam Dhar, Mr**.** Rajanya Chakraborty is hereby approved and certified as a creditable study in technological subjects performed in a way sufficient for its acceptance for partial fulfilment of the degree for which it is submitted.

It is to be understood that by this approval, the undersigned do not, necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the project only for the purpose for which it is submitted.

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Dr. Srijan Bhattacharya	Prof. Arijit Ghosh
[Supervisor]	[Head of the Department]
Applied Electronics & Instrumentation Engineering	Applied Electronics & Instrumentation Engineering

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Examiner

Examiner

RCC INSTITUTE OF INFORMATION TECHNOLOGY
CANAL SOUTH ROAD, BELIAGHATA, KOLKATA – 700
015 PHONE : 2323 2463 FAX : (033)2323 4668
E-mail : campus@rcciit.in Website : www.rcciit.org

RECOMMENDATION

I hereby recommend that the project report titled "**Ionic Polymer Metal Composite as Taste Sensor"** of Mr. Abhisek De, Mr. Anirban Pal, Mr. Debarshi Ash, Mr. Kaushik Das, Mr. Kaustav Mondal, Mr. Pritam Dhar, Mr**.** Rajanya Chakraborty be accepted in partial fulfillment of the requirement for the Degree of Bachelor of Technology in Applied Electronics & Instrumentation Engineering, RCC Institute of Information Technology.

Dr. Srijan Bhattacharya
[Supervisor]

Prof. Arijit Ghosh
[Head of the Department]
Applied Electronics & Instrumentation Engineering

List of Figures

List of Tables

Table of Contents

CHAPTER 1
INTRODUCTION

Over the years, various studies have been made to study or measure the taste of different substances. These have been categorized into the basic four quadrants of taste: salty, bitter, sweet, sour. But in order to record data of tastes with respect to a particular unit of measurement, we need some specific arrangement. In this study, a correlation has been made between the different tastes and their output from a sensory arrangement (which includes IPMC sensors) has been made. This has been done so that we can obtain a set or range of readings in electrical signals corresponding to the different tastes. The main objective is to maintain or regulate the different tastes of substances (raw or packed food) to check the quality standards. The main application has been used in FMCG industries.

1.2 Literature Survey

This paper describes about the applications and devices for liquid analysis. Electronic tongue for analysis of liquid is based on the principle of sensory systems. The relation between the output of the electronic tongue and human sensory assesments of food and flavours and tastes are enabled which makes us easier to detect. However, there is a proper description of food stuffs . Analytical results can be mentioned with various types of sensors. Multi-dimensional data processing and multi sensor devices are not considered in this paper. Chemical sensors are widely known as analytical instruments. The first potentiometric sensor is an ion-selective electrode (ISE) was a glass selective pH sensor. The number of sensors for analytical purposes is limited. Development of electronic nose and the electronic tongue is based on biological systems especially mammals olfactory. It consists of a large number of sensors that react with volatile compound which transfer the stimuli via nervous system to the brain. Mammals can recognize a lot of noises and odours. The impressive performance of the olfactory system is the product of a different receptors and the specific processing of their signals in the brain. The olfactory level of the mammals are less developed because of the survival of them. Although the electronic tongue works well on liquid media, the sensitivity of the artificial system goes higher making the performance of the electronic tongue closer to olfactory system. The electronic tongue can be analogue to both olfaction and taste senses. The electronic tongue can be used for detecting the various compound. Most often used data-processing methods is an artificial neural network. Electrolytic substances like HCl (Sourness), NaCl (saltiness) has large response magnitude, where Non-Electrolytic substances like Sugar (Sweetness), Caffeine (Bitterness) has low response magnitude. Bitterness can also be elicited by Alkaloids. “Umami” is another type of taste which is commonly found in Meat, fish and vegetables (it is also the taste of Monosodium Glutamate (MSG), Disodium Inosinate (IMP) etc.) [1]. Lipid membranes can transform test information into electrical substance. To do that so a Lipid Monolayer Membranes is made by absorbing Lipid Materials to the hydrophobic surface of a Polymer Membranes. Thus this membrane is made sensitive to taste substances. To overcome this problem a modification of the membrane is made. The membrane is made of PVC where the lipid materials were dissolved in the plasticizer. Thus the surface don’t have a uniform hydrophilic structure. Non-electrolytes affect the membrane by physical absorption. The surface electric density and the permeability to ions are changes by adsorption. Lipids are adsorbed to the hydrophobic surface of the membrane by means of the hydrophobic effect. Thus a uniformly oriented lipid monolayer could be constructed on the membrane surface. Thus the sensitivity to non-electrolytes can be achieved.

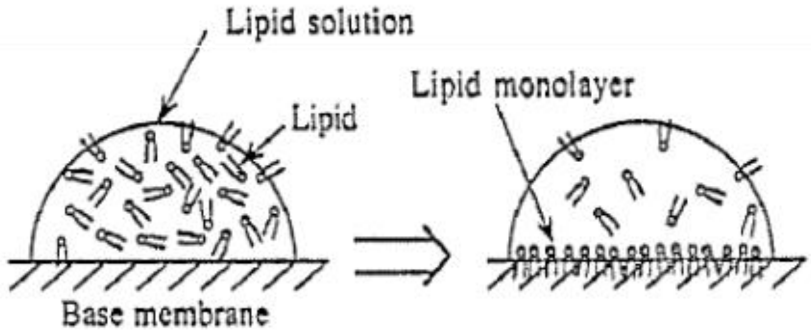


Figure 1: Process of modifying the membrane by lipids

Interactions between tasting substances, such as Synergistic and Suppression effects is an important part to determine Human taste Sensation.

Taste quality is enhanced by co-existing taste substances in Synergistic taste effects as found in MSG & IMP. It is weakened in the suppression effect that appears between Bitterness and Sweetness [2]. A sensor is a device through which we can measure various senses, by using it in various machines. We can classify sensors into two types first one is physical sensor and second one is chemical sensor. A physical sensor detects physical properties (Hear, Watch, Smell,Taste,Touch). But a chemical sensor is a device which is used for providing the information of the chemical composition of it's environment. We can use physical sensor as taste sensor. We can classified taste into four types A. HCL, ACETIC ACID etc. produce sourness., B. Quinine, Caffeine etc. produce bitterness. C. NaCl, KCL etc. produce saltness. D. Nonelectrolytes of sucrose and glucose show sweetness. Here we will discuss about taste sensor, and this sensor can be built by using potential changes in lipid membrane. The lipid bilayer is a thin polar membrane made of two layers of lipid molecules. These membranes are flat sheets that form a continuous barrier around all cells.

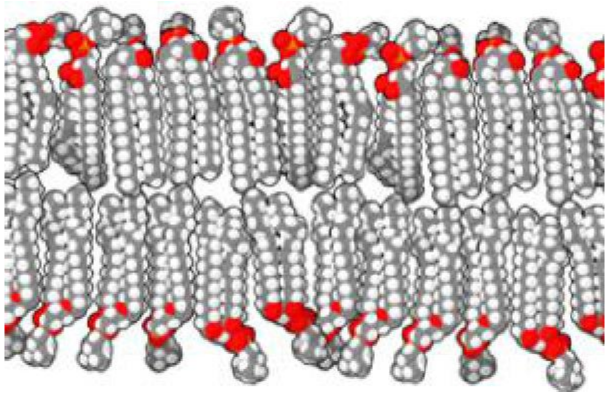


Figure 2: Lipid Membrane

The lipid membrane, which is attached together with poly vinyl chloride (PVC) and dioctylphenylphosphonate. The eight kinds of lipid membranes are attached on a multichannel electrode. It is 8 channel electrode. It is Transparent, colourless and soft film with cu. 150 pm thickness. The 8 channel electrode is connected to a scanner. The selected electric signal from the sensor was converted to a digital code by a digital voltmeter and will be sent to a computer. We can calculate the voltage difference between the membrane electrode and a reference electrode (Ag/AgCl with saturated KCl). Taste solution is the mixed solution of four basic taste substances, beer, coffee, commercial aqueous drink.c By the out we can study the taste of the taste solution.[3]

This review is based on the taste sensors in the form of electronic tongues which is another idea derived from the biomimetic features and principles of living beings. This process uses the principle of electrochemical measurement which is used in electronic tongues. Electronic tongues have wide range of applications such as in the food industry, paper and pulp, industry, household appliances and agriculture. Basically the process of their use is the information collecting units which will be used in the aqueous phase, connected to a routine for multivariate data processing. The taste sensor system is an approach to specially mimic the basic taste sensations of the tongue. The electronic tongue classifies the quality of the measured sample and the various measurement principles has been associated with electrochemistry such as voltammetry or potentiometry. This idea gave rise to the commercialization of continuous measurement system for Chemical Oxygen Demand (COD). The sensor when generates an output pattern that represents a synthesis of all the individual components related to taste of the sample which consists of different compounds. It specifically mimics the basic tastes of the human tongue and generates the output. In Voltammetry, a potential is applied to the working electrode and the resultant current is obtained in the form of output when redox active species are reduced or oxidized based on the electrode surface which is being measured. The most commonly used methods are Large Amplitude Pulse Voltammetry (LAPV) and Small Amplitude Pulse Voltammetry (SAPV). The transient response is obtained in the amount of diffusion coefficients of both. This method has found several commercial applications and it is an important step in the measurements in the biological fields for microbial activity and water quality.[4] Here in this review the working of an electronic tongue is explained in details. The name of the instrument is TS-5000Z. The sensor works on the principle of diffusion and membrane potential. The difference in potential responses of different solutions having different taste is obtained and accordingly the tastes are identified and also quantified. There is a reference electrode and an electrode containing a lipid polymer membrane. The difference between the sample and reference is known as the relative value ($Vs - Vr$). The change in membrane potential is known as CPA ($Vr' - Vr$).Where Vr is the membrane potential of the reference solution measured again.Thus the study of this Relative value and their CPA helps us to identify the different solutions according to their taste.[4].

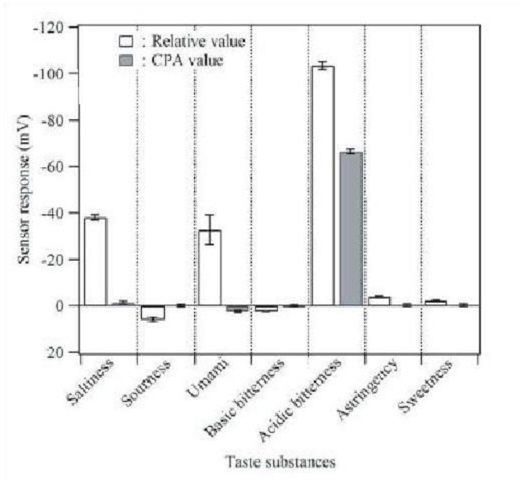


Figure 3: The figure shows us the sensor response and the corresponding values (Relative and CPA) for each type of taste.

In this paper, an electronic tongue has been developed to study the human gustatory system. The key features of this analysis is based on the high sensitivity, stability and high selectivity. The cellular mechanism of taste sensation has been reviewed to study the mechanism of the five basic tastes. An analogous taste sensors has been developed and the responses are recorded as electrical signals. It can be effectively applied for food safety purposes. Thus, the fabrication of artificial taste sensors are evaluated by calibration which is a result from the transducer in sensor. This research paper provides a brief reaction of beef infected with Salmonella virus and it’s results. A lipid polymer membrane is chosen that acts as taste buds or taste receipting organs. A computer propagates the signals. The readings are recorded over time. As the chosen material, i.e. beef degrades, the salmonella virus changes the taste gradually. This gradual change of taste has been noted. The algorithm used for data processing is based on artificial neural network which functions according to the learning and recognition pattern utilized by the human brain.[6]

CHAPTER 2

INGREDIENTS USE IN EXPERIMENT

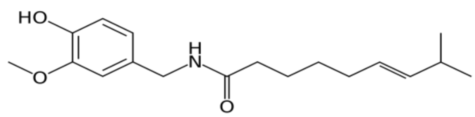
Chill, Lemon, Salt, Bitter Gourd & Sugar . All are dissolved in distilled water.

2.1 Chili Composition

The name of the main component present in chili: Capsaicin (make spicy).

Systematic Name: (E)-N-(4-Hydroxy-3-methoxybenzyl)-8-methylnon-6-examide

Molecular formula: $C_{18}H_{27}NO_3$



SMILES: CC(C)/C=C/CCCCC (NCC1=CC (0C)=C(0)C=C1)=0

CAS Number: [404-86-4]

Molecular Man: 305.41 g/mole

Also Contains: Ascorbic Acid, Vitamin-C, Beta-Carotene and Folic Acid.

Figure 4(a). Green chilly solution

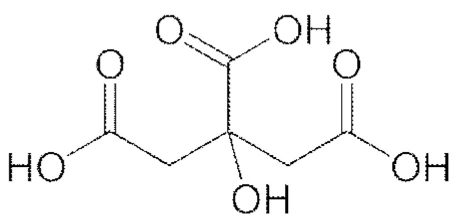
Figure 4(b). IPMC dipped in green chill Solution

2.2 Lemon Composition

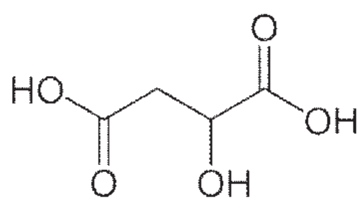
The compounds present in Lemon are:

α-Thyjene(0.22%), α-Pinene(1.47%), Camphene(0.12%), Fenchene(0.04%), β-Pinene(5.08%),β-Myrcene(1.75%), α-Phellandrene(0.19%), Cymene(0.74%),DL-Limonene(53.57%), α-Terpinolene(4.33%), β-Linalool(1.14%),Terpinen-4-ol(3.554%), L-α-Terpineol(15.15%), Decanal(0.38%),Z-Citral(1.28%), E-Citral(2.38%),Neryl Acetate(0.20%),Geranyl Acetate(0.35%), Isocaryophllene(0.245), α-Bergamatene(0.50%), Valencene(0.04%), β-Bisabalene(1.18%)

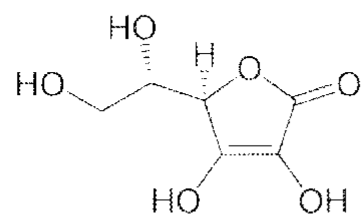
Acidic Compound:



1. Citric Acid (5-6%)-



2. Malic Acid-



3. Vitamin C (Ascorbic Acid)-

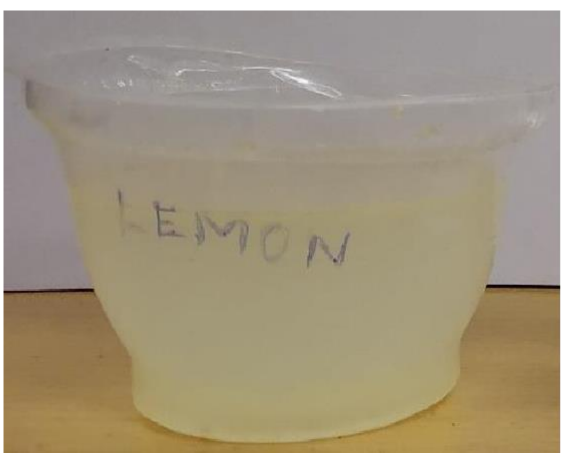


Figure 5(a). Lemon Solution

Figure 5(b). IPMC dipped in Lemon Solution

2.3 Salt Composition

Salt is a mineral composed of Sodium Chloride (NaCl), a chemical compound belonging to the larger class of salt. Salt generally is a crystalline mineral known as Rock Salt or Halite. The open ocean has about 35gms of solids per liter of sea water, a salinity of 3.5%.

Its primary constituents are Sodium (Na), Chloride, Calcium, Magnesium, Potassium and Sulphate. Rock Salt generally contains between 90% - 98%.

$2Na + Cl_2$

Figure 6(a). Salt Solution

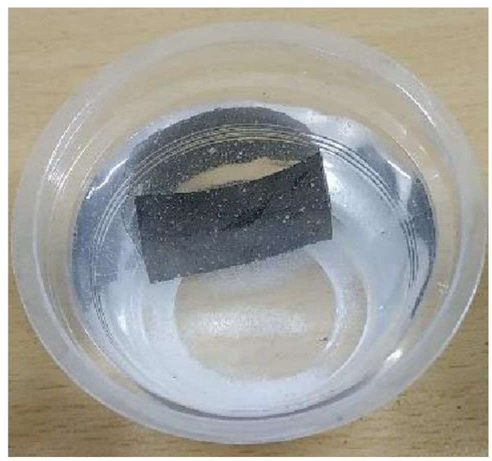


Figure 6(b). IPMC dipped in Salt Solution

2.4 Bitter Gourd Composition

Chemical Composition:

- Fruits have much higher in folate & Vitamin C. The vine tips are an excellent source of Vitamin A.
- Steroids
- Charantin
- Momordicine glycoprotiens, α-Momorcharin and β-Momorcharin

Scientific Name: Momordica charantia

pH Value: 9 - 10

The bitterness of bitter groud is due to the cucurbitacin like alkaloid momordicine and tritepene glycosides.

Bitter gourd is yielded on extraction with chloroform Methanol 0.76% lipids which were separated into non-polar lipids (38.81%), glycolipids (35.80%) and Phospolipids (16.46%) by Silicic Acid column chromatography.

Figure 7(a). Bitter Gourd Solution

Figure 7(b). IPMC dipped in Bitter Gourd Solution

2.5 Table Sugar

Table Sugar is basically Sucrose which is a mixture of Glucose and Fructose. Sucrose is naturally obtained but Table Sugar is a refined product.

Sucrose: It’s a disaccharide, molecule composed of two monosaccharides, Glucose & Fructose.

Chemical Composition: $C_{12}H_{22}O_{11}$

Molar Mass: 342.3g/mol, white solid

Density: 1.587gm/cc

Solubility: 2000gm/litre (25℃)

$\log_e$P: -3.76

Melting Point: None, decomposes at 186℃

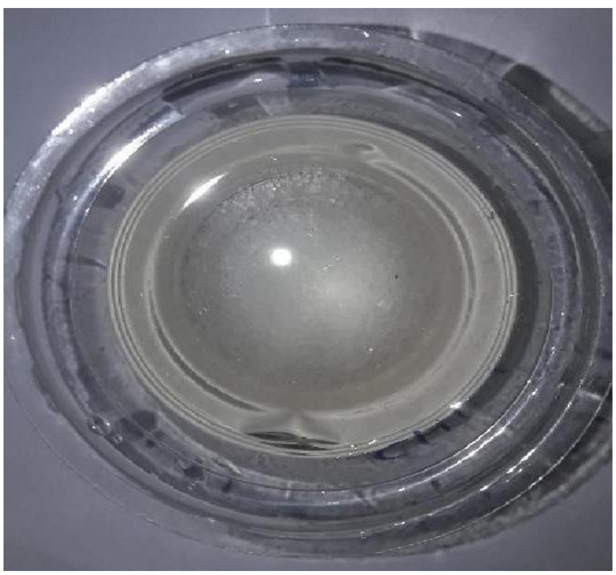


Fig 8(a). Sugar Solution

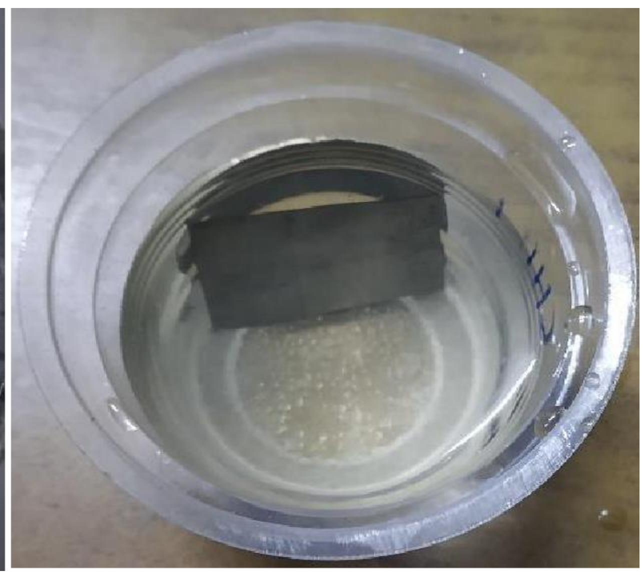


Fig 8(b). IPMC dipped in Sugar Solution

CHAPTER 3

EXPERIMENTAL SETUP

In this experiment, we at first dipped the IPMC strip in different test solutions for 10-15minutes. Then the strip was taken out, soaked and mounted to a metal clip. Both sides of the IPMC strip are in contact with two respective contact wires which are connected to a digital multi-meter. A graph sheet was at first scaled from 0-90 degrees clockwise and counter-clockwise on a 180 degree axis as shown in the above figure. The IPMC strip along with the clamp was fixed at the null position and slowly turned along difference of 10degrees across both directions and the output was observed and the readings were recorded accordingly.

Components Used:

Sl. No.	Name of Apparatus	Quantity	Range	Maker's Name
1.	IPMC sensor	1		
2.	Digital Multi-meter	1	10A/1000V	METRAVI
3.	Graph Sheet	5		
4.	Taste Solutions	5		
5.	Distilled Water	5units		
6.	Connecting Wires	2		

Dimension of IPMC: Thickness: 0.2mm, Length: 27mm, Breadth: 18mm

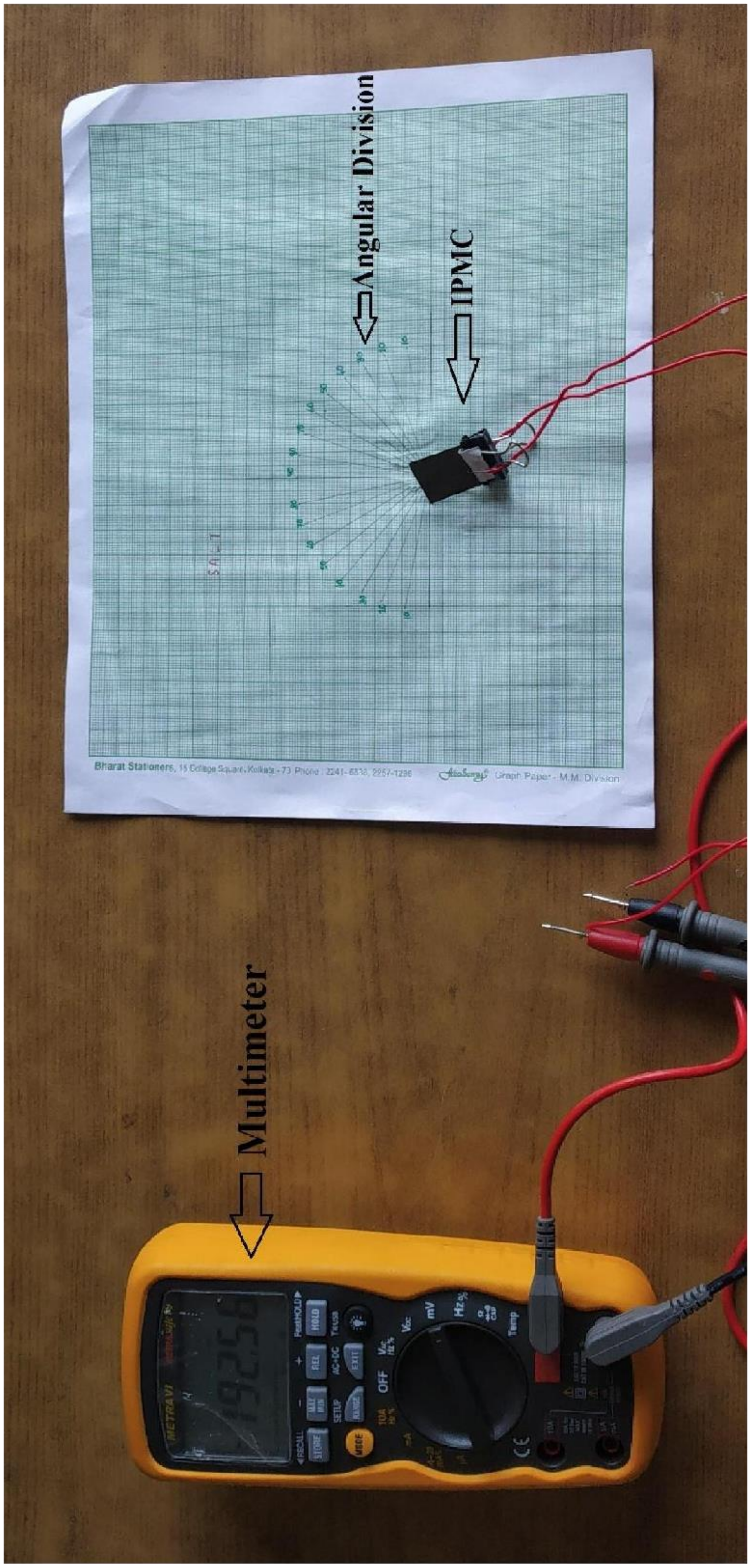


Figure 9: Experimental Setup

CHAPTER 4

EXPERIMENTAL RESULT

Case I:

SALT- We use salt for testing the saltiness of a solution, by using IPMC sensor**.**

SET 1-

CLOCK WISE	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	94.66	54.31	96.13	68.05	38.37	77.3
80	58.64	47.84	84.92	64.58	42.4	84.21
70	67.27	47.87	82.27	63.34	44.03	83.05
60	56.3	46.55	79.3	62.49	46.35	75.12
50	51.27	45.52	75.48	64.54	71.24	70.07
40	48.61	46.31	74.54	61.79	82.18	79.13
30	47.28	49.31	73.38	60.87	102.35	86
20	46.65	48.28	72.81	60.27	107.24	91.13
10	46.94	47.75	72.79	58	116	95
ANTI CLOCKWISE	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	57.95	87.82	84	66.73	72	87.02
80	65.99	44.42	69.29	60.89	77.5	77.15
70	48.01	42.55	68.68	60.19	90.37	68.3
60	84.12	42.2	69.35	59.35	107.15	80.13
50	50.37	43.66	72.5	59.31	110	86.02
40	49.26	44.07	72.6	60.38	98	89
30	49.57	43.03	74.93	61.22	110	88
20	54.08	49.25	76.07	63.07	110.2	90.01
10	56.08	48.54	81.98	63.98	98	90.77

Table 1: Clockwise and anticlockwise reading of a salt solution in mV

Case 2:

Lemon – we use lemon for testing sourness of a solution, by using IPMC sensor**.**

CLOCK WISE	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	1.15	3.12	0.29	1.89	0.48	1.23
80	0.09	3.59	0	1.51	0.33	6.64
70	0.35	3.4	0.03	1.7	2.1	1.55
60	0.56	3.73	0.04	1.05	2.11	1.58
50	0.13	3.37	0.04	0.77	2.15	1.09
40	0.02	0.89	0.02	0.46	2.17	0.92
30	0.04	0.86	0.05	0.85	1	0.84
20	0.01	0.68	0.05	0.79	0.58	0.75
10	0.01	0.64	0.06	0.91	0.45	0.69
ANTI CLOCKWISE	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	0.56	1.05	0.22	2.58	2.47	0.2
80	0.78	0.9	0.13	0.5	0.6	0.15
70	0.63	0.42	0.12	0.62	0.77	0.14
60	0.25	0.34	0.09	0.56	1.82	0.16
50	0.12	0.22	0.02	0.37	1.09	0.06
40	0	0.59	0.04	2.43	0.2	0.12
30	0.05	0.06	0.03	0.76	1.16	0.11
20	0.01	0.05	0.12	1.95	0.09	0.12
10	0	0.04	0.1	1.15	1.18	0.18

Table 2: Clockwise and anticlockwise reading of a lemon solution in mV

Case 3-

Chili – we use chili for testing spiciness of a solution, by using IPMC sensor

CLOCK WISE	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	0.86	0.47	0.13	0.1	0.22	0.1
80	0.49	0.31	0.05	0.23	0.14	0.13
70	0.46	0.29	0.08	0.21	0.18	0.14
60	0.44	0.41	0.06	0.21	0.31	0.11
50	0.44	0.48	0.09	0.27	0.25	0.18
40	0.39	0.48	0.03	0.23	0.26	0.21
30	0.72	0.41	0.01	0.18	0.28	0.24
20	0.98	0.27	0.02	0.11	0.27	0.12
10	0.62	0.46	0.38	0.04	0.29	0.14
ANTI CLOCKWISE	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	0.59	0.28	0.06	0.04	0.32	0.1
80	0.38	0.33	0.09	0.05	0.29	0.08
70	0.36	0.27	0.05	0.09	0.28	0.09
60	0.38	0.3	0.04	0.07	0.3	0.06
50	0.5	0.34	0.07	0.04	0.12	0.08
40	0.63	0.23	0.09	0.05	0	0.11
30	0.7	0.22	0.13	0.11	0.03	0.02
20	0.65	0.46	0.08	0.08	0.02	0.05
10	0.79	0.45	1.2	0.22	0.03	0.01

Table 3: Clockwise and anticlockwise reading of a chili solution in mV

Case 4-

Bitter Gourd - We use bitter gourd for testing the bitterness of a solution, by using IPMC sensor.

CLOCK WISE	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	3.44	3.12	2.4	4.41	111.62	41.16
80	0.83	3.77	2.01	4.22	64.62	52.63
70	1.27	2.69	0.65	4.38	53.94	59.62
60	3.16	2.14	0.55	3.9	46.32	55.74
50	4.41	2.94	1.75	4.23	43.3	58.14
40	5.5	1.77	1.07	4	41.29	49.63
30	5.11	1.61	1.58	3.5	38.16	58.85
20	5.25	1.32	1.99	3.36	39.99	57.37
10	6.04	0.99	2.09	3.11	29.02	57.55
ANTI CLOCKWISE	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	4.1	0.17	0.65	2.55	25.98	54.68
80	3.67	0.77	1.98	1.6	24.25	48.97
70	3.63	1.05	4.96	1.02	23.16	61.76
60	3.4	1.27	7.09	0.81	25.84	53.66
50	3.06	1.83	6.66	0.86	23.4	33.53
40	2.72	1.64	6.43	0.73	21.86	40.48
30	2.66	0.57	6.11	0.63	21.64	36.37
20	2.28	0.79	5.72	0.6	21.3	35.39
10	2.11	0.48	5.5	0.53	21.95	31.2

Table 4: Clockwise and anticlockwise reading of a bitter gourd solution in mV

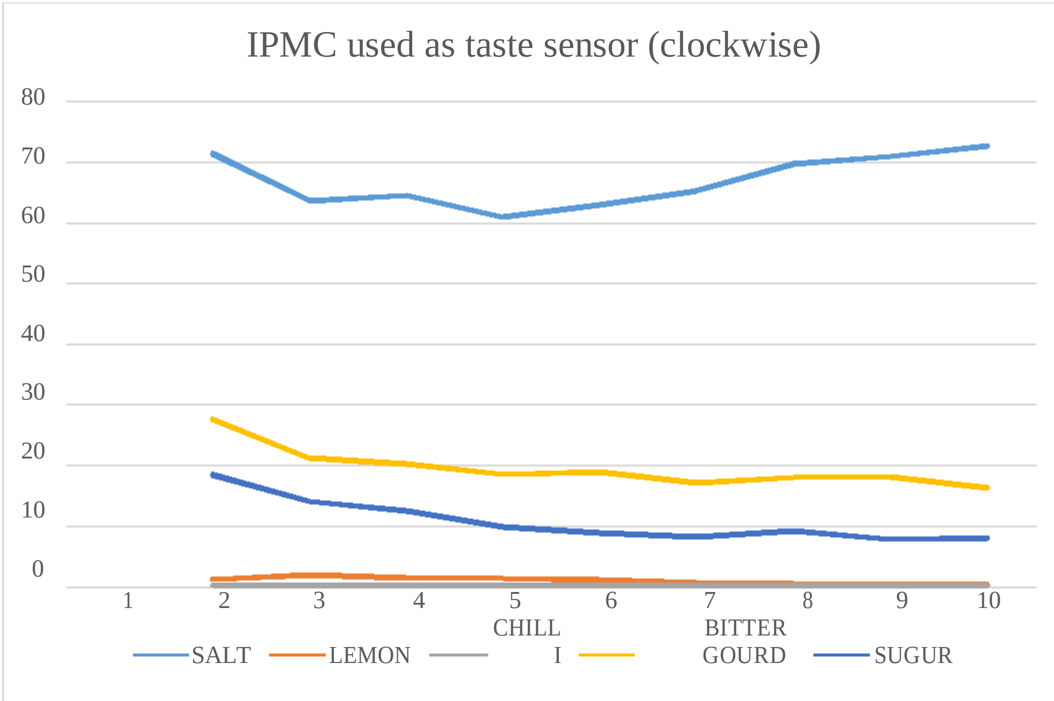
Case 5-

Sugar - We use sugar for testing the sweetness of a solution, by using IPMC sensor**.**

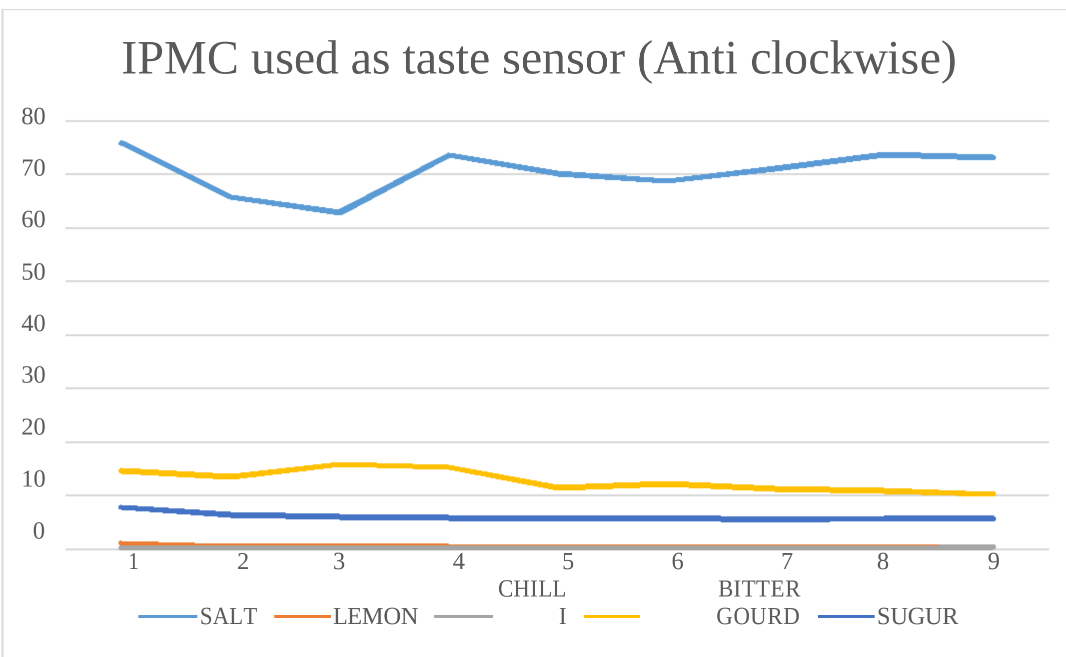
CLOCK WISE	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	43.16	7.12	14	17.58	20.46	9.04
80	32.93	5.9	11	17.45	10.98	7.03
70	27.85	5.86	10.02	17	9.08	6.03
60	13.53	5.5	10	14.87	8.47	7.21
50	7.98	5.35	9.26	14.51	9.23	7.56
40	4.85	5.16	8.75	14	9.53	7.6
30	8.85	5.22	8.48	14.36	10.51	8.49
20	9.26	5.37	9.95	4.01	10.98	8.1
10	9.29	5.07	8.76	3.9	12.38	9.41
ANTI CLOCKWISE	**Set 1**	**Set 2**	**Set 3**	**Set 4**	**Set 5**	**Set 6**
	Voltage (mV)	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**	**Voltage (mV)**
NULL (90)	8.16	5.47	6.35	4.4	14.49	8.42
80	7.46	4.9	5.56	3.21	9.82	7.7
70	7.94	4.69	5.43	2.91	8	7.42
60	7.65	4.73	5.41	2.76	7.53	7.34
50	7.32	4.57	5.07	2.66	8.05	7.09
40	7.49	4.71	5.56	2.67	8.31	6.94
30	7.39	4.38	5.41	2.62	6.92	6.86
20	7.85	4.87	5.3	2.74	7.13	6.91
10	7.03	4.78	5.24	2.86	7.2	7.15

Table 4: Clockwise and anticlockwise reading of a sugar solution in mV

4.1 Response of the IPMC for Different Taste



10(a) Figure: Response of the IPMC in different Taste (clockwise)



10(b) Figure: Response of the IPMC in different Taste (anti clockwise)

CHAPTER 5

CONCLUSION

1) We are using IPMC as a taste sensor in our experiment. We have tested it with five types of different solutions. (1. Salty 2. Sour 3. Spicy 4. Bitter 5. Sweet) and have used salt, lemon, chili, bitter gourd and sugar respectively for making the solutions. We have taken six set readings (In Clock wise and Anti Clock wise manners) for each sample. From the experiment we have got total thirty sets of readings. We have plotted graph for each reading (Degree vs Microvolt). We also studied the chemical compositions of each used elements. Through this experiment we are trying to develop a system by which we can get the particular taste of a random solution, when we will dip the IPMC into it.
2) IPMCs are ionic type Electroactive Polymers (EAP) which need electrolytes to be functional. Normally the ions inside the polymers are immobile and the polymer is neutralized with certain counter ions that balance the electrical charge of the anions covalently fixed to back bone membrane. Under deformation (i.e. bending) the transport of the hybrid cations inside the IPMC generates a voltage. Depending on this property we'll be going to use IPMC as a taste sensor.

   In this experiment various test solutions of different tastes are taken as electrolytes instead of simple water. The organic and inorganic ions (cations) present in the solution will affect the voltage when deformed. From the experimental graphs we can see that some solutions have the higher response w.r.t. to deformation while some has very minimal. As electrolytes we chose the water solution of Table Salt (for Saltiness), Bitter Gourd (for Bitterness), Sugar (for sweetness), Lemon (for Sourness) and Chilli (for Spiciness). And for each solution an IPMC strip was immersed in those solutions and for each 10° of deformation (bending) the voltage reading was taken.

We know that the inorganic compounds (generally salts) are strong electrolytes and the inorganic compounds are weak electrolytes, so from the graph we can see that the NaCl solution has the highest voltage output while the others have a lower output voltage which are close to each other.

We can assume from that as Sodium is a strong electrolyte which gives Na^{+} as Cation (Nernst voltage of +55mV) affects to boost up the overall output voltage (60 – 80mV). Where Bitter Gourd takes the second position (10-20mV) because the extract has very small amount of minerals (Cu, Fe, Mg, Zn, Ca) in it which produces cations as an electrolyte which affects the output voltage to raise up a little but not as much as Sodium. But surprisingly sugar takes the third position (5

– 10mv) even though it can't be used as an electrolyte as the sugar molecule completely dissolves in water and gives no ions so far. And the remaining two solutions i.e. Lemon and Chilli extract solutions gives almost the same output (0 - 5mV) as those both have Vitamin – C (Ascorbic Acid) in common which is a very weak electrolyte and Lemon has Citric Acid as extra which is also a weak electrolyte sets the output voltage slightly above of the output voltage of Chilli. Thus by considering the different output voltage ranges for different taste materials IMPC may have a chance to be used as a taste sensor.

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