Identification of Vinegar Acid, Ammonia and Alcohol using Conducting Polymer Sensors and Artificial Neural Network (ANN)

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Abstract

Testing on organic solutions aims to test the system in identifying an organic solution correctly. The organic solutions tested were vinegar acid, ammonia and alcohol. The author discusses in this research how a system can identify 3 types of organic solutions based on the odor produced by the three organic solutions. Data on the smell of vinegar acid was obtained from acetic acid samples taken on the first day. Ammonia odor data was obtained from ammonia samples taken on the second day. Alcohol odor data was obtained from alcohol samples taken on the third day. In this study the author used a series of conducting polymer sensors consisting of eight sensors and used polymer materials, namely silicon DC-200, PEG-20M, 0V-101, 0V-17, DEGA, PEG-200, PEG-1540, and PEG -6000 are mixed with carbon black. A two-layer artificial neural network consisting of eight input nodes and three output neurons, was trained using the Kohonen algorithm with the training process completed in 50 iterations. Of the 20 tests, 2 tests were wrong, and 18 tests were correct, so that from this test the success rate in identifying vinegar acid, ammonia and alcohol was 90%.

Keywords: - Conducting polymer, 8 row sensor, Kohonen network, odor, organic solution, ANN

1. Introduction

Vinegar acid is an organic acid chemical compound known as giving sour taste and aroma to food. Vinegar acid has a formula empirical C2H4O2. This formula is often written in the form CH3COOH. Vinegar acid pure is a colorless hygroscopic liquid and has a freezing point of 16.7^{o}C. Vinegar acid is the result of food processing through fermentation. Fermentation glucose anaerobically using the yeast Saccharomyces cerevicae produces ethanol. Aerobic ethanol fermentation uses bacteria Acetobacter aceti produces acetic acid (Buckle, 2010).

Ammonia or ammonia is a chemical gas with the formula NH3. The characteristics of ammonia gas are clear, colorless, but emit a pungent odor. Ammonia, which is naturally present in the surrounding environment, is produced from remaining organic material in the soil such as plants, carcasses and animal waste which is decomposed by bacteria.

This substance is used as a cooling gas to purify water, used in making plastics, as an explosive, textiles, pesticides, dyes and other chemicals. Ammonia is also found in many household cleaning fluids. Characteristics of Ammonia are:

1. Ammonia is a colorless gas but has a very strong odor.
2. Very easily soluble in water, under standard conditions, 1 liter of water can dissolve 1180 liters of ammonia.
3. Ammonia melts easily, liquid ammonia freezes at a temperature of (-) 78 degrees Celsius to become a liquid/normal condition at a temperature of 30-40 degrees Celsius and boils at a temperature of -33 degrees Celsius. Store ammonia in tanks at a pressure of 15-20 atm and the best temperature is 30-40 degrees Celsius.
4. Ammonia is corrosive to copper and tin.
5. Ammonia is used as an ingredient in beauty tools such as a mixture of hair dye and straightening hair.

Alcohol is often used to refer to ethanol, which is also called grain alcohol, and sometimes to drinks that contain alcohol. This is because ethanol is used as the basic ingredient in these drinks, not methanol or other groups of alcohol. Likewise with alcohol which is used in the pharmaceutical world. The alcohol in question is ethanol. Actually, alcohol in chemistry has a broader meaning. Of the important groups of alcohols, methanol and ethanol are among the simplest, including all compounds having the general formula CnH2n+1OH.

Polymer is a material that has high resistance, so to reduce its resistance, a carbon black mixture is needed. If the polymer is exposed to steam from meat odor, the steam molecules diffuse onto the polymer surface causing changes in the size of the polymer surface. This change will change the conductivity value. Conductive polymers are conjugated polymers that exhibit changes in single and double bonds between carbon atoms in the main chain of the polymer.

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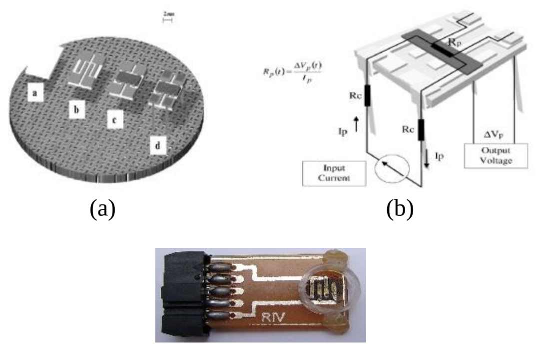
Double bonds are obtained from carbon which has four valence electrons, but conjugated molecules only have three (sometimes two) other atoms. The remaining electrons form π bonds, electrons that are delocalized throughout the molecule. A substance can be a conductive polymer if it has conjugated double bonds. Examples of conjugated polymers are traditional plastics (polyethylene), while conductive polymers include: polyacetylene, polypyrrole, polythiopene and polyaniline.

The sensor used in this case is a series of sensors used to obtain patterns of voltage changes from exposure to several odor vapors. The sensor circuit used consists of eight sensors and is connected in series with a variable resistor and forms a voltage divider circuit to obtain a pattern of voltage changes due to changes in resistance.

Fig. 1 (a) shows the fabrication of the conductive polymer sensor. Part a shows the preparation of the Aluminum substrate that forms the sensor support material, b and c are the sensor after placing the electrode and polymer traces, d shows the sensor at the end of the manufacturing process.



(a) (b)

(c)

Fig. 1. Conducting polymer sensor (a) sensor creation, (b) sensor equivalent circuit and (c) conducting polymer sensor mixed with carbon black

2. Methodology

The block diagram used in creating the overall system research tool is explained in Fig. 2 which consists of an organic solution sample, a sensor circuit, a signal conditioning circuit (in the form of an amplifier), an ATMega16 microcontroller which contains an ADC and serial communication, and an artificial neural network running on the computer. The research tools used in this research as a whole are shown in Fig. 3.

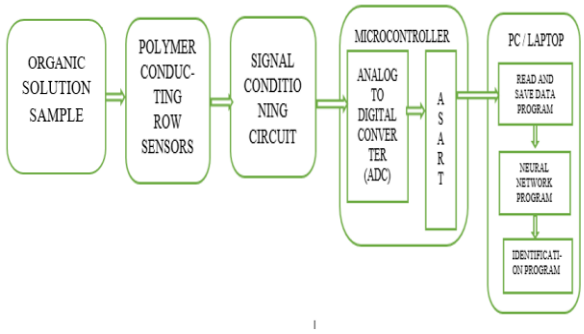


Fig. 2. Block diagram of this system

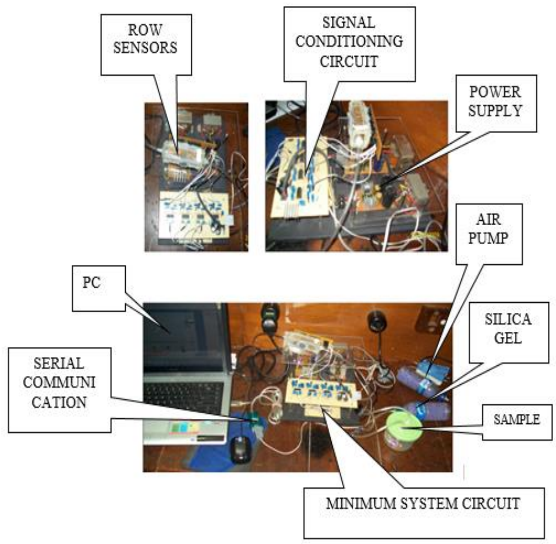


Fig. 3. Photo of the overall research tool

When the odor of organic solution sample is exposed to a conducting polymer, the odor will hit the surface of the conducting polymer and diffuse into the mixture of polymer material and carbon black. By exposing the odor to the conducting polymer, the surface size of the conducting polymer will change, resulting in a change in resistance and will cause a change in voltage in the conducting polymer.

In Fig. 4, R_8 is a representation of the sensor array. R_7 functions to adjust the sensor series voltage when there is no exposure to steam from organic solution odor to around 2.5 Volts. R_9 is used to adjust the value of R_4 with R_3 so that the voltage gain at the non-inverting input is the same as the voltage gain at the inverting input. R_7 and R_8 (sensors) are a voltage divider network. The resistance value R_7 is set to be close to the resistance value R_8 when there is no exposure to steam from organic solution odor. The 2.5 volt voltage functions to reduce the initial voltage value on the sensor when there is no exposure to steam from organic solution odor.

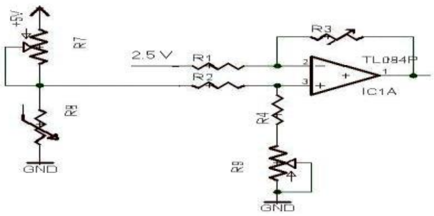


Fig. 4. Signal conditioning circuit

3. Result and Discussion

The response to changes in row sensor voltage from these three organic solutions can be seen in Fig. 5 to 7.

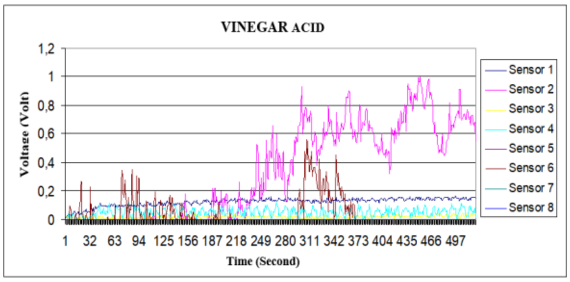


Fig. 5. The voltage response on 8 sensors to vinegar acid solution vapor

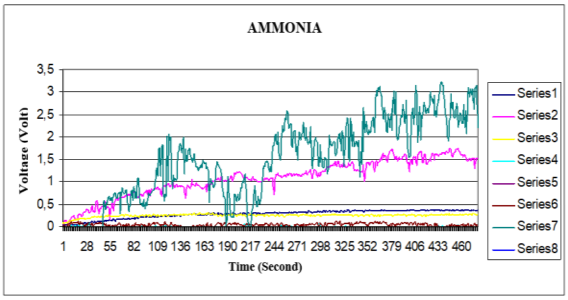


Fig. 6. The voltage response on 8 sensors to ammonia solution vapor

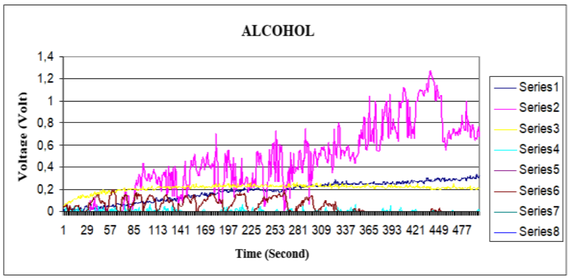


Fig. 7. The voltage response on 8 sensors to alcohol solution vapor

The Kohonen algorithm is trained using normalized stress patterns. The training process is limited by 2 conditions, namely the maximum number of iterations and the absence of weight changes. Training will stop if any of these conditions are met. The Kohonen network was trained using 27 normalized stress pattern data from exposure to 3 types of organic solution vapor. The number of iterations is limited to 50 iterations. Weight changes are calculated by subtracting the weight in one iteration from the weight in the previous iteration. The average of the weight differences between iterations is shown in Fig. 8.

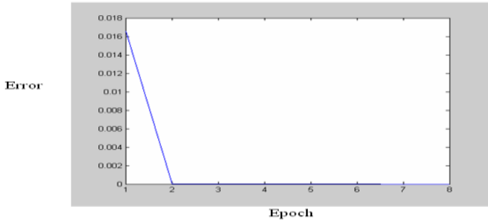


Fig. 8. Average weighted difference between iterations for organic solutions

The Kohonen network training process was completed in 8 iterations. To check the weights generated during the training process, the Kohonen network is simulated with input in the form of all the data used in the training process. The training result weights for the first to third rows are in Table 1. The simulation results are shown in Table 2.

Table 1. Kohonen network weights for organic solution vapors

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8
0,000004	0.323603	0,000001	0.427392	0,000000	0.248943	0,000000	0.000073
0,000005	0.297157	0,000001	0.534505	0,000000	0.146382	0,000000	0.028498
0,000005	0.260210	0,000000	0.548180	0,000000	0.151132	0,000000	0.028498

Table 2. Kohonen Network Simulation Results for organic solution vapor

Data	Group	The Kind of Odor
1	1	Ammonia
2	1	Ammonia
3	1	Ammonia
4	1	Ammonia
5	1	Ammonia
6	1	Ammonia
7	1	Ammonia
8	1	Ammonia
9	1	Ammonia
10	2	Alcohol
11	2	Alcohol
12	2	Alcohol
13	2	Alcohol
14	2	Alcohol
15	2	Alcohol
16	2	Alcohol
17	2	Alcohol
18	2	Alcohol
19	3	Vinegar Acid
20	3	Vinegar Acid
21	3	Vinegar Acid
22	3	Vinegar Acid
23	3	Vinegar Acid
24	3	Vinegar Acid
25	3	Vinegar Acid

26	3	Vinegar Acid
27	3	Vinegar Acid

After obtaining data from measuring the voltage difference on each sensor, the next stage is to identify the organic solution vapor using the Kohonen algorithm. In training this artificial neural net, two layers are used, consisting of eight input nodes and three output neurons. The system test results are shown in Table 3.

Table 3. Experiment to identify the type of organic solution vapor with artificial neural network

Type of Odor	1 (Vinegar Acid)	2 (Ammonia)	3 (Alcohol)	4 (Vinegar Acid)	5 (Ammonia)	6 (Alcohol)	7 (Vinegar Acid)	8 (Ammonia)	9 (Alcohol)	10 (Vinegar Acid)	11 (Vinegar Acid)	12 (Ammonia)	13 (Alcohol)	14 (Vinegar Acid)	15 (Ammonia)	16 (Alcohol)	17 (Vinegar Acid)	18 (Ammonia)	19 (Alcohol)	20 (Vinegar Acid
Vinegar Acid	√			√			√			√	√			√			√			√
Ammonia		√			√	√		√				√			√			√		
Alcohol			√						√				√			√			√	
Results	True	True	True	True	True	False	True	True	True	True	True	True	True	True	True	True	True	True	True	True

From the experimental Table 3 for testing gas vapor identification using artificial neural nets, it has been carried out 20 times with the results of 2 incorrect tests and 18 correct tests, so that from this test the success rate in identifying vinegar acid, ammonia and alcohol is 90%.

4. Conclusion

This research succeeded in identifying vinegar acid, ammonia and alcohol and was able to differentiate between the three types of organic solutions. This research was carried out using 8 rows of sensors using sensors made from conducting polymer. This research also uses an artificial neural network with the Kohonen algorithm with 8 inputs and 3 outputs which is trained to recognize sensor response patterns to vapors of the three types of organic solutions. After testing and identifying the odor vapors of the three types of organic solutions, this tool succeeded in identifying vinegar, ammonia and alcohol that passed through the sensor. The identification success rate is 90%.

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