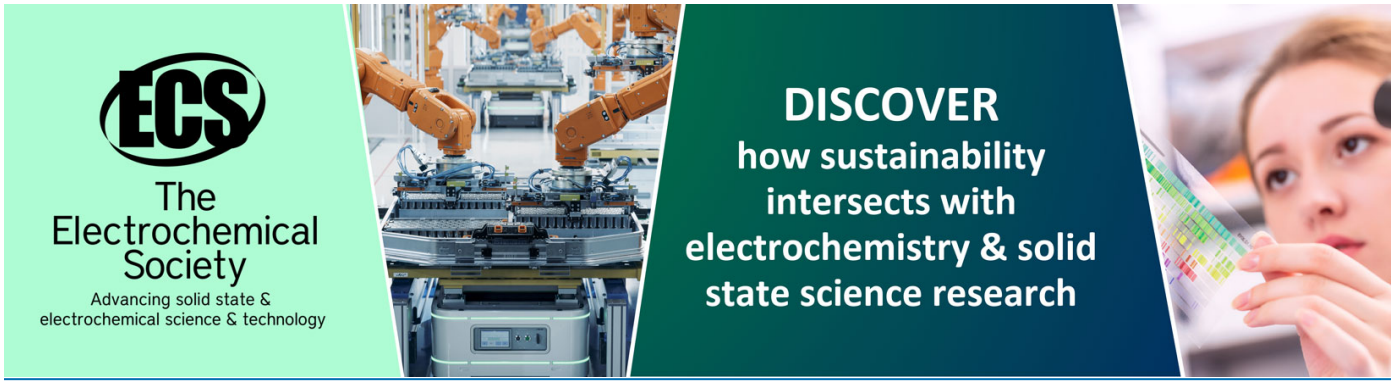
# The detection of organic solvent vapor by using polymer coated chemocapacitor sensor





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# The detection of organic solvent vapor by using polymer coated chemocapacitor sensor

**Apik Rusdiarna Indrapraja*, Muhammad Rivai, Achmad Arifin and Djoko Purwanto**

Department of Electrical Engineering, Institut Teknologi Sepuluh Nopember (ITS), Surabaya

*Corresponding email address: lku@uad.ac.id

**Abstract.** A chemocapacitor consists of planar interdigital electrodes (IDE) made by two comb electrodes on a substrate. A dielectric film was applied on the electrodes in which the absorbed vapor will modify its permittivity. This study has fabricated chemocapacitor with the IDE distance of 0.5 mm, while the dielectric film was a sensitive layer consisting of a polymeric material. The deposition of the polymeric film was accomplished by drop casting. A sensor array consisting of four chemocapacitors coated with different polymers namely PEG-1540, PEG-20M, PEG-6000, and PVP was used to obtain the pattern of shift in the capacitance. The integrated circuit AD7746 was used as the capacitance to-digital converter (CDC). The organic solvents of ethanol, benzene, and aceton were used as the vapor samples in this experiment. The results showed that the change in the capacitance value increases proportionally to the concentration of vapour where sensors coated with PEG-1540 and PVP have higher sensitivity, i.e. 0.0028pF/part per thousand and 0.0027pF/part per thousand, respectively. Based on the capacitance to digital conversion capabilities, the system provides there solution of 0.4084ppm. The sensor array could produce a different pattern for each of the vapor sample. The Neural Network pattern recognition system could identify the type of vapor automatically with the root mean square error of $10^{-5}$

## 1. Introduction

Organic solvents are widely used in industries such as paints, adhesives, cosmetics, fragrances, etc. Due to its volatile and less polar nature, the solvents will easily enter bodies through inhalation or skin absorption. It is dangerous for health because it can cause eye irritation, skin irritation, respiratory problems and cancer. In the solvent storage, leakages must always be detected to avoid pollution and fires. Therefore, it is necessary to have a type of sensor that can recognize the type of solvent vapor and measure its concentration.

The detection of organic solvent vapors using a type of lock and key can only recognize one type of vapor. To recognize a lot of organic solvent vapors, it will require a huge number of sensors. The other method is to use a sensor array consisting of sensor elements having overlapping responses. The type of sensor will produce a different pattern for each vapor.

The use of polymers as the material for the detection of organic solvents has been widely applied to various types of gas sensors because they have rapid adsorption and desorption at room temperature, low power consumption, and resistant to poisoning by other compounds [1].

Researchers have tried to create a device that can detect vapors from a variety of materials such as polymer coated Chemocapacitor [2][3][4], chemoresistor [5], Quartz Crystal Microbalance [6] and metal oxide semiconductors[7] with satisfactory results. This study investigates an organic solvent detection system using chemocapacitor sensor array coated with polymermaterial.

## 2. Experimental

Chemopacitor is a capacitor which has a selective absorbent material such as a polymer that serves as the dielectric material. The chemicals absorbed in the dielectric will change the capacitance of the sensor [4]. Chemocapacitor consists of planar inter digital electrodes (IDE), which was two comb electrodes on substrate.

The design of IDC is shown in Figure 1. The sensor was made of Printed Circuit Board (PCB) with a fiber substrate. The IDC has 20 electrodes, the length (L) is 10 mm, the metallization ratio (η) is 0.5 and the spatial wavelength (λ) is 2 mm. Series chemocapacitor sensor used in this study consisted of four IDC, each sensor was coated with a different polymer, i.e. PEG-1540, PEG-20M, PEG-6000, and PVP.

The hardware system in this study is shown in Figure 2. Silica gel is used to produce the reference air having low humidity. The flow rate was set at 0.1 LPM regulated by valves K1. Material samples were ethanol, acetone, and benzene. IC AD7746 was used as Capacitance to Digital Converter (CDC). The 24- bit monolithic converter has a high resolution of 0.5 fF, high linearity of ± 0.01%, I2C interface mode, and supports the expansion of the input range with an external circuit. The Chemocapacitor sensor array consisted of 4 sensors which requires analogue multiplexer to select the capacitor to be accessed. Data of each sensor was sent to the computer via serial communication.

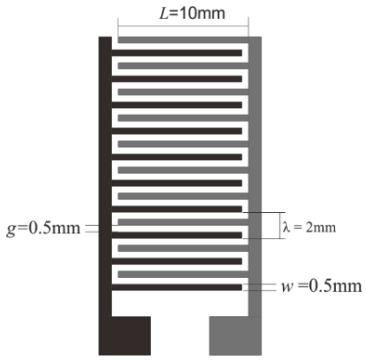


**Figure 1.** The layout design of IDE.

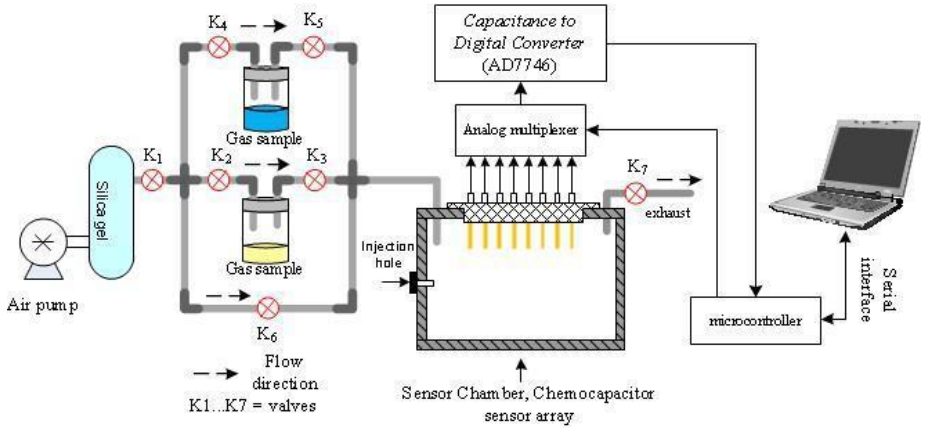


**Figure 2.** The hardware system used in the experiment.

## 3. Result and discussion

Sensor calibration was performed by observing the value of digital data to the capacitance value for each channel of the multiplexer. The relationship between the digital data to the capacitance is shown in Figure 3. This showed that the calibration curve of digital data and the capacitance was linear and the maximum value that can be measured was 32pF. Linear regression equation was used to convert digital data to the capacitance value.

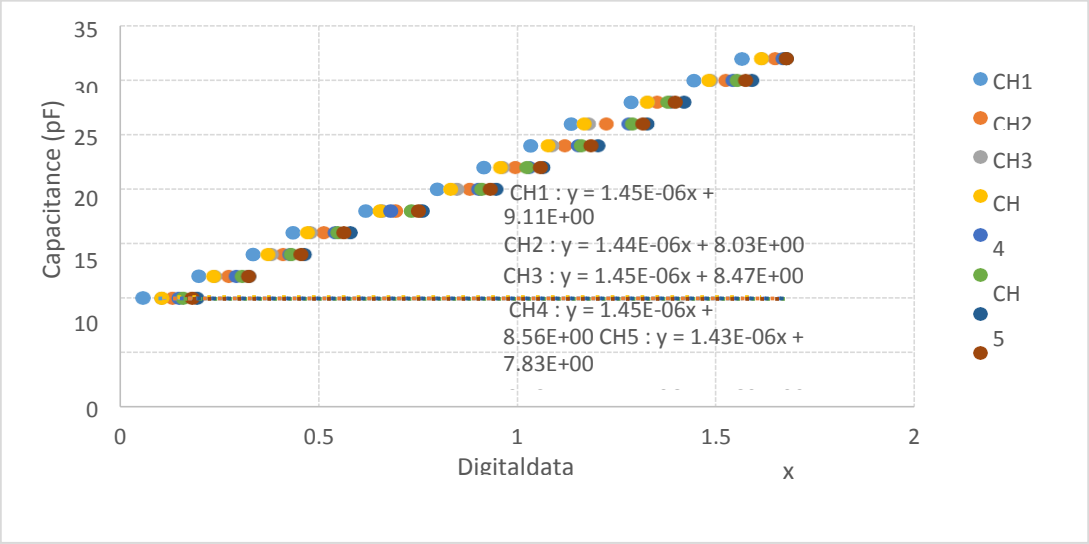


**Figure 3.** The relationship between the digital data and the capacitance.

The dry air was flowed into the test chamber until a stable capacitance value was reached. Then the sample gas was fed into the chamber. Each capacitance sensor changed in time domain is shown in Figure 3. When the sample gas is injected continuously, it will reach steady state and for each sensor will have a different response. The pattern of change in capacitance is normalized to the maximum value, shown in Figure 5. Each gas could produce a typical pattern for each sample.

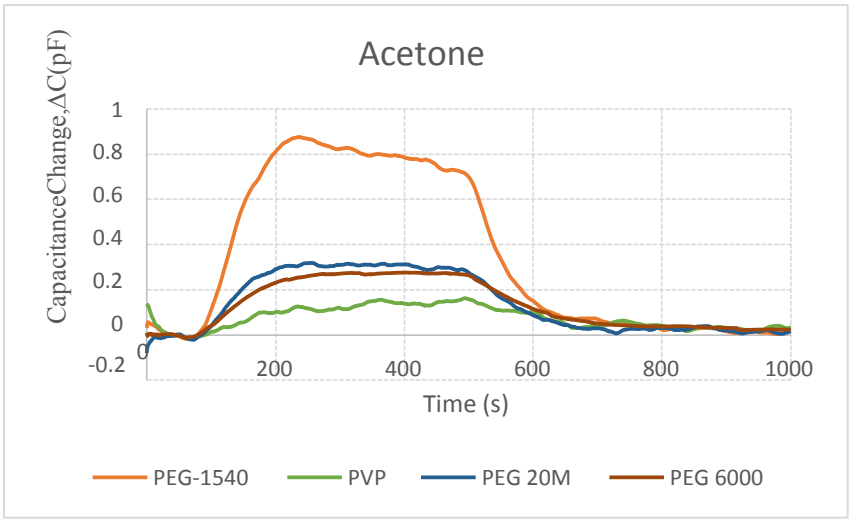


**Figure 4.** Capacitance changes to acetone vapor.

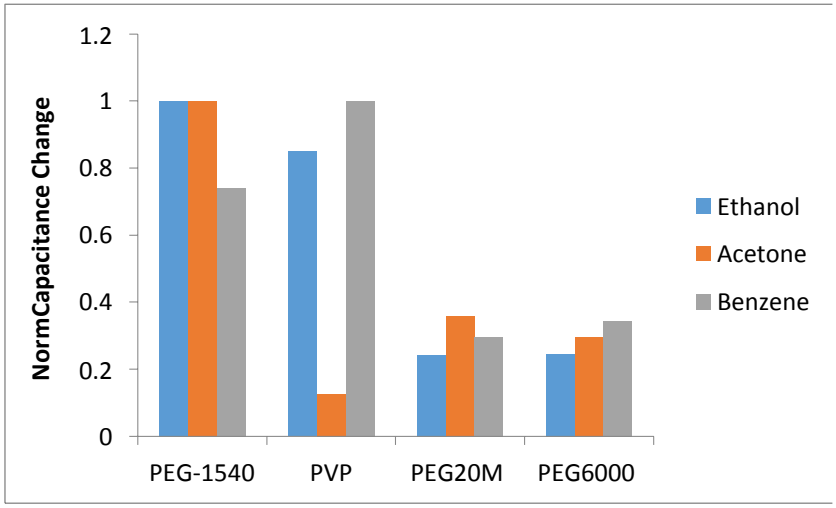


**Figure 5.** The pattern of change in capacitance to the vapors.

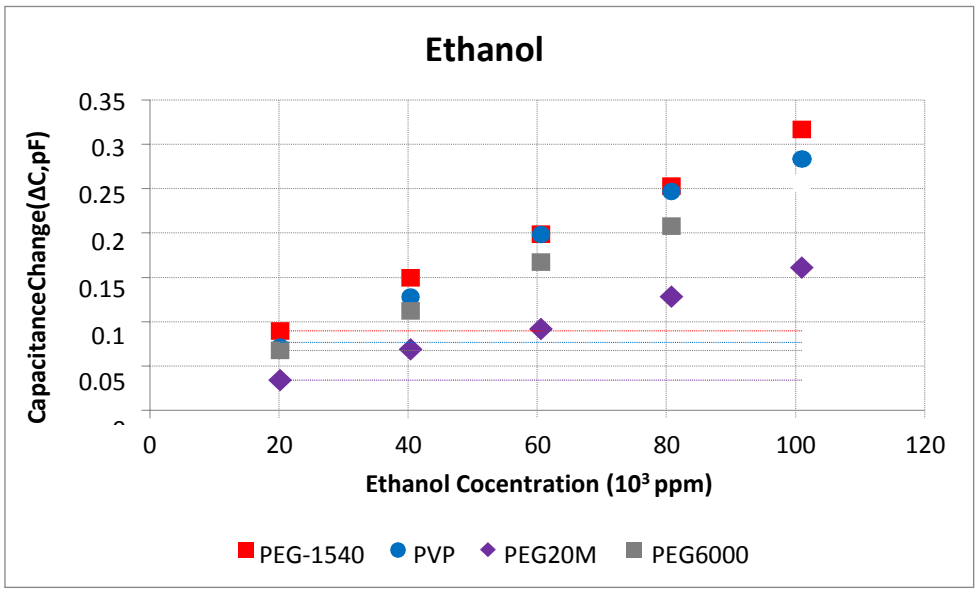


**Figure 6.** The relationship between ethanol vapor concentration and the capacitance change.

## References

[1] Persaud K C 2005 *Polymersfor Chemical Sensing Material Today* **8** page.38-44.

[2] Oikonomou, P Raptis I and Sanopoulou M, 2014 Monitoring and Evaluation of Alcoholic Fermentation Processes Using a Chemocapacitor Sensor Array *Sensors* **14** page 16258-16273.

[3] Botsialas, A Oikonomou, P Goustouridis, D Ganetsos, Th Raptis I and Sanopoulou M, 2013 A iniaturized Chemocapacitor System for The Detection of Volatile Organic Compounds *Sensors and Actuators B* **177** p.776–784.

[4] Patel S V, Mlsna T E, Fruhberger B, Klaassen E, Cemalovic S and Baselt D R 2003 Chemocapacitive Microsensors for Volatile Organic Compound Detection *Sensor and Actuator B* **96** p.541-553.

[5] Gunawan B, Rivai M, and Juwono H, 2012 Characterization of Polymeric Chemiresistors for Gas Sensor *Telekomunika* **10** 2 p.275-280.
[6] Kimura M, Liu Y, Sakai, Sato S, 2011 Detection of Volatile Organic Compounds by Analyses of Polymer-Coated Quartz Crystal Microbalance Sensor Arrays *Sensor and Materials* **23** 7 p.359-368.
[7] Edward J, Wolfruma, Robert M, Meglen, Darren Peterson, Justin Sluiter, 2006 Metal oxide sensor arrays for the detection, differentiation, and quantification of volatile organic compounds at sub-parts- per-million concentration levels *Sensor and Actuator B* **115** p.322-329.